Chemical method : notation, classification and nomenclature / by Auguste Laurent... ; translated by William Odling...

Contributors

Laurent, Auguste, 1807-1853.
Odling, William, 1829-1921
Cavendish Society.
Royal College of Physicians of London

Publication/Creation

London : Printed for the Cavendish Society by Harrison and Sons, 1855.

Persistent URL

https://wellcomecollection.org/works/mwe8fxpm

Provider

Royal College of Physicians


CAVENDISH SOCIETY


COLL. REG. MED. LOND.
MDXVIII
Ο ΒΙΟϹ
ΤΕΧΝΗ
ΒΡΑΧΥϹ Η
ΔΕ
ΜΑΚΡΗ

41

WORKS

OF THE

CAVENDISH SOCIETY.

FOUNDED 1846.

CHEMICAL METHOD,

NOTATION, CLASSIFICATION, & NOMENCLATURE,

BY

AUGUSTE LAURENT,

CORRESPONDING MEMBER OF THE INSTITUTE (ACADEMY OF SCIENCE, CHEMICAL SECTION),
ENGINEER OF MINES, FORMERLY PROFESSOR OF CHEMISTRY AT THE FACULTY
OF SCIENCES OF BORDEAUX, ASSAYER AT THE MINT.

TRANSLATED BY

WILLIAM ODLING, M.B., F.C.S.,

PROFESSOR OF PRACTICAL CHEMISTRY AND OF NATURAL PHILOSOPHY AT GUY'S HOSPITAL.

PRINTED FOR THE CAVENDISH SOCIETY,
BY
HARRISON AND SONS, ST. MARTIN'S LANE.

MDCCCLV.

TRANSLATOR'S PREFACE.

THE collection of the materials for this work extended over a considerable period of time, the subjects were arranged by the author when on his death bed, and the posthumous publication, with the revision of the proofs, was intrusted to the care of a friend. Under these circumstances, it is not surprising that some slight discrepancies should here and there exist; that a rigid uniformity of treatment, an exact adaptation of parts to one another, should occasionally be wanting.

Knowing that the majority of English students are almost unacquainted with Laurent's views; feeling the great importance of these views, and seeing how opposed they are to the opinions most prevalent in this country; I have endeavoured, while giving a clear and truthful representation of the author's meaning, to put his ideas in such a form as should least estrange the mind of the reader; and, by avoiding any confusion of symbols or want of uniformity in expression, have sought to render the work acceptable to as large a class of chemists as possible.

In the original work, four different systems of proportional weights are employed.

1°. The system of equivalents, ordinarily made use of in this country.

Hydrochloric acid $= H\,Cl$ Water $= HO$
Chloride of sodium $= NaCl$ Oxide of silver $= AgO$.

2°. The atomic system of Berzelius, in which the proportional weights of hydrogen, nitrogen, chlorine, &c., are halved.

Hydrochloric acid $= H^2Cl^2$ Water $= H^2O$
Chloride of sodium $= NaCl^2$ Oxide of silver $= AgO$

3°. The 4 volume system of Gerhardt, who employs Berzelius's weights for the non metallic, but halves the weights of the metallic elements, so as to make them correspond with hydrogen.

Hydrochloric acid $= H^2\,Cl^2$ Water $= H^2O$
Chloride of sodium $= Na^2Cl^2$ Oxide of silver $= Ag^2O$

The great majority of chemical compounds when expressed by these formulæ, correspond to 4 volumes of vapour. The exceptions are occasionally made to correspond by doubling; thus $H^2Cl^2 = 4$ vol. $H^4O^2 = 4$ vol.

4°. The 2 volume system of Gerhardt. This is the notation finally adopted by Laurent, and most generally employed throughout the work. The proportional weights of the elements are the same as in the preceding system, but all bodies (minus some few special exceptions) are represented by 2 volumes of vapour, thus: HCl, H^2O, $NaCl$, KHO, Ag^2O, NH^3, C^2H^6O, &c.

In the first of these systems, we have the ratios

$$\begin{array}{lrcrcr} & \text{H} & : & \text{Cl} & : & \text{O} \\ :: & 1 & : & 35{\cdot}5 & : & 8 \\ :: & 12{\cdot}5 & : & 443{\cdot}75 & : & 100 \end{array}$$

In the other three, we have the ratios

$$\begin{array}{lrcrcr} & \text{H} & : & \text{Cl} & : & \text{O} \\ :: & 1 & : & 35{\cdot}5 & : & 16 \\ :: & 6{\cdot}25 & : & 221{\cdot}87 & : & 100 \end{array}$$

The first ratio occurs but very seldom, and when it does, I have imitated the custom of Berzelius, and have placed a dash through the letters, H, Cl, N, &c. (~~H~~, ~~Cl~~, ~~N~~), to indicate that these symbols express the proportional values usually employed in this country, and the doubles of those accorded to them in other parts of the book.

I have occasionally introduced a parenthetical observation, when I thought that some uncertainty might occur as to which of the other three systems was intended, thus (Berzelius's notation, ED.), and now and then in elucidation of some other point, thus (Othyl, ED.). Moreover, in some parts of the work, where the transitions from the 4 volume to the 2 volume notation are very frequent, I have represented the formulæ according to both systems.

The distinctions between the system of equivalents ordinarily employed in this country, and the 2 volume notation adopted in this work, may be thus expressed. In the new system, the atomic weight of carbon is 12, of oxygen is 16, of sulphur, is 32; and similarly with selenium and tellurium; all the other atomic weights are unaltered. The atomic expressions for all bodies not containing carbon, oxygen, or sulphur, are unchanged; thus, H, N, HCl, KI, NH^3, &c. When in an atomic formula the atoms of carbon, oxygen, and sulphur, form even numbers, these numbers are halved; thus, alcohol $C^4H^6O^2$ becomes C^2H^6O, ethyl C^4H^5 becomes C^2H^5, cyanogen C^2N becomes CN, &c. When the atoms of carbon, oxygen, or sulphur, form uneven numbers, these numbers continue unchanged, while the number of the other atoms is doubled; thus, sulphuric acid HSO^4 becomes H^2SO^4, water HO becomes H^2O. It is observable, that though the atoms of hydrogen and the radicals are respectively represented by H, Cl, C^2H^5, CN, &c., their two-volume molecules consist of H.H, Cl.Cl, $C^2H^5.C^2H^5$, CN.CN, &c.

Laurent has represented uranic, bismuthic, and other oxides, sometimes as teroxides, sometimes as sesquioxides,—mercuric and cupric oxides, sometimes as protoxides, sometimes as binoxides, a proceeding which has led to some little confusion. For the sake of uniformity, and in accordance with English custom, I have always represented bismuthic oxide as a teroxide, uranic oxide as a sesquioxide, cupric and mercuric oxides as protoxides; whence a slight change in the representation of some few formulæ has been occasioned. Laurent considering salts as derived from their acids by a substitution of metal for hydrogen, has used indifferently the terms sulphate of barium and sulphate of baryta, &c., a proceeding which I have retained.

In the original work the signs, *plus*, *point*, and *parenthesis*, are indifferently made use of. Unless there was some reason to the contrary, I have preferred making use of the *point* to indicate combination, and the *plus* to indicate addition; thus I have preferred the second method of writing the succeeding equation, as being more simple and more in accordance with English custom.

$$(C^4H^{10}O+C^4H^6O^3)+(KO+H^2O)=(KO+C^4H^6O^3)+(C^4H^{10}O+H^2O)$$

$$C^4H^{10}O.C^4H^6O^3+KO.H^2O=KO.C^4H^6O^3+C^4H^{10}O.H^2O$$

Laurent generally gives the preference to empiric formulæ. In the earlier part of the book where rational formulæ are introduced for purposes of illustration, no definite sequence of symbols is adopted; thus O^3Fe^2, Fe^2O^3, OK, KO, are used indiscriminately. In the translation I have been more uniform, and have generally employed the arrangement most usual in this country.

Although adopting the above described slight alterations in expression, I am not conscious of having modified a single idea of the illustrious author's; and believing the generalities of Laurent to be in our day as important as those of Lavoisier were in his, I leave this translation in the hands of English chemists, in the earnest hope that it may tend to the substitution of that which is rational and experimental in chemical science, for that which is speculative and arbitrary.

I cannot conclude these remarks without thanking the Council of the Cavendish Society, and Mr. Graham in particular, for the confidence so kindly reposed in me as editor: nor must I neglect to apologize to the society for the delay which has occurred in the production of the work. This delay was caused partly by circumstances for which I am not responsible, and partly by the duties of an appointment of which I had no anticipation at the time of my undertaking this translation.

W. O.

INTRODUCTION BY M. BIOT.

THIS work, abounding with new ideas, oftentimes fruitful in their results to the author himself, presents us with the intimate convictions of a man who has enriched science by numerous and unlooked-for discoveries. It is a summary of the thoughts of his whole life; and so great an interest did he attach to the bestowal of this heritage, that he laboured to effect its completion until within the very grasp of death. That his work deserves to be received with serious attention, exempt from any preconceived notions, is sufficiently evident from the above considerations. But to read it with advantage, to appreciate it with justice, we must place before our eyes the object which Laurent proposed to himself by its composition.

He wished, he hoped, to place in the hands of chemists a grouping of symbolical analogies, deduced from experiment, which should guide them with the strongest probability, if not with certainty, in the interpretations to which they are continually obliged to have recourse.

The operations of chemical analysis, applied to any product, whether natural or artificial, make us acquainted only with the nature, and the proportions of the relative weights, of the simple, or reputedly simple, bodies, of which it is composed. They do not inform us, whether the material molecules of these constituent principles exist in a state of general combination, alike for all; or whether they are arranged in distinct groups, mutually combined, without individual decomposition, and coexistent with their proper qualities in the entire product.

Nevertheless, it is of extreme importance that this point should be decided, and established in all its details. For we may well expect, that the reactions of a material system will be different, accordingly as its molecular constitution is homogeneous or heterogeneous; and, in the latter case, according to the nature of the associated groups.

Thus, there are many examples of bodies which, though formed of the same simple elements, and in the same proportions by weight, are very dissimilar both in their physical properties and their chemical characters.

But, concerning this, the most elevated point of rational chemistry, chemical analysis cannot afford us any immediate indication, since its results represent each particular compound only by means of the elements abstracted therefrom, whether isolated or combined in groups, of which the pre-existence cannot be affirmed. This has caused it to be said with justice, that a chemist does not judge of bodies until after their existence has ceased.

The pre-existent state, then, can only be arrived at by induction, founded upon analogy of properties and reactions, or upon speculative ideas, which give a simple conception of each product considered, and associate it by certain points of similarity, with those to which it appears to bear the greatest resemblance in its molecular constitution.

But this freedom of interpretation, which each chemist employs for his own use in each particular series of his researches, throws the science into a confusion, which is already very great, and which must necessarily increase, especially in proportion to the further advances we make in the study of organic products, where the combinations of a small number of simple principles, always the same, present themselves with a variety of association nearly infinite.

Laurent's object was, to regulate the exercise of this liberty, by subjecting it to uniform and general laws.

In the infinite multitude of symbolic forms, by which we may theoretically represent the bodies of which chemical analysis has taught us the composition, he endeavoured to discover and point out those which, in the actual state of science, merited the preference, as offering the most general advantages for the classification and practical study of organic compounds; so that, by associating analogous and separating dissimilar bodies by characters sufficiently numerous and decided, we might, from the simple inspection of their symbolic formulæ, foresee the greatest possible number of the reactions they could experience, and the products they could originate. In a word, he undertook to do, for the entire collection of actual chemical researches, according to a general and uniform method of classification, that which at the present day each chemist does for his own proper discoveries, with an arbitrary diversity of views and expressions.

Has he completely succeeded in this great undertaking, for which perhaps chemistry does not yet afford a collection of sufficiently numerous and well-assured materials? We dare not give an unhesitating affirmative; and it would be an injustice to require one. But what each must propose to himself in reading this work, is to see if, in the greatest number of examples upon which it is founded, the views of Laurent are conformable to experiment; so that each may have well-grounded chances of finding them productive for himself, as they were for the author, and frequently for others. Should they have this effect, limited though it be, we shall best applaud his views by labouring to perfect them.

To repel or reject them, at first sight, because they are strange, or enounced with a too absolute hardihood of expression, would be a policy but little profitable for science. If occasionally he has shaken somewhat too rudely this great edifice, formed of parts progressively added to one another, it is, that from observing the incoherence of the materials of which it was composed, he thought it would be more profitable to labour at its reconstruction, than to persevere in conserving it such as it is.

He only wished to aid this achievement, by pointing out the relations of forms and of symbols which, in default of intimate notions, should offer generally well founded motives for association or disjunction.

Chemistry might, in many cases, be able to extend beyond this empiricism, in which it has hitherto been confined.

The rotatory power possessed by the constituent molecules of a great number of substances, up to this time exclusively organic, furnishes us with a certain character for the confirmation or refutation of the abstract speculations which we may form concerning the constitution of the bodies into which they enter, whether existing therein naturally, or introduced by art.

The application of this character, thus directed, offers a direct and certain means, for the resolution of a multitude of controversial questions in relation to rational chemistry, such as those of which Laurent has treated. But its use is as yet but little diffused, although it has always been fruitful for those who have employed it in their researches.

J. B. BIOT.

June 12th, 1854.

AUTHOR'S PREFACE.

When we consider the great number of organic substances that have been discovered during the last dozen years, and the increasing rapidity with which chemists daily discover fresh ones; when we see, that from a simple hydrocarbon and chlorine, we may produce a hundred different compounds, and that from them we may obtain a great number of others: lastly, when we reflect upon the absence of all system, all nomenclature, for the classification and denomination of this multitude of bodies, we demand with some anxiety, whether, in a few years' time, it will be posssible for us to direct ourselves in the labyrinth of organic chemistry.

The confusion which reigns in the ideas is even greater than that which obtains in the facts; for the principles upon which the majority of chemists rely, for the explanation and co-ordination of facts, are so vague, so uncertain, that not only do two chemists explain the same phenomena in two different manners, but even one and the same person abandons the explanation he gave yesterday, for a new one that he proposes to day, and which he will abandon to-morrow for a third. This uncertainty in the principles re-acts upon the facts, of which it singularly augments the confusion. And indeed, to give an idea of the composition of a real body, we are accustomed to imagine two or three hypothetical bodies, to which we assign new names and special compositions, so that the study of chemistry, has not only for its object the properties, the compositions, and the names of thousands of real bodies, but in addition, the properties, the compositions, and the names of a great number of purely fictitious ones.

It is the introduction into science of this host of hypothetical beings, which some time back caused me to say, that chemistry had now become the science of bodies which had no existence.

Has the time for attempting a new method yet arrived, and is not such an enterprise rash, in the actual state of science?

I address myself to these questions, before submitting my system, that is to say, my notation, classification, and nomenclature to the judgment of chemists; and although I have comprehended all the difficulty of the undertaking, yet the nature of the researches to which I have devoted myself, has shadowed forth to me the possibility of arranging organic substances, according to an order at once rational and mnemonic. But whenever I attempted to put my plan into execution, I met with difficulties which ought first of all to be resolved. This I endeavoured to do, by undertaking certain researches in my laboratory. During this time, the number of discoveries increased rapidly, new difficulties supervened, and I was constantly obliged to modify the details of the plan which I had purposed following.

From time to time I have published certain sketches of my system, but the successive developments I have given thereto, have finished by throwing my Memoirs into such confusion, that several of my friends exacted from me a promise to put a stop to this state of things. They affirmed, that by endeavouring to render my work too perfect, I met incessantly with fresh difficulties, which postponed its publication indefinitely; and that I was not required to produce a perfect work, but simply a useful *method*, which I could at any subsequent time improve upon.

Deprived for some years past of a laboratory in which to pursue my researches, I decided upon taking advantage of the opportunity, to unite and co-ordinate the materials of my work. In putting the last touches thereunto, I perceived more than ever the imperfections of the undertaking I had attempted; and if, nevertheless, I venture to publish it, it is from a conviction that this imperfection depends in part upon the actual state of organic chemistry, the majority of the substances included therein being too little known.

Before entering into the subject matter of the work, I believe it will be advisable for me to indicate briefly, the plan I have pursued in its composition.

In the establishment of a chemical system, we proceed between two stumbling blocks, facts and their causes.

By relying wholly upon the first, we are induced to represent the composition of ammoniacal alum by the formula $S^4O^{40}N^2H^{56}Al^4$, to accept the names, ruby, emerald, chrichtonite, aldehyde, mercaptan, chloral, &c., and to distribute the substances designated, in the class of precious stones, or of schorls, spars, balsams, essences, resins, colouring matters, &c.

By setting out from the idea of causality, or of atoms and their arrangement, we must determine in any particular body, which of its atoms are combined simply, which of them are combined intimately, whether they are copulated or conjugated. In this way we are led to represent the composition of epidote by this formula.

$$\begin{gathered} 2[3\,(\mathrm{Si\,O^2}+2\,\mathrm{RO})+2\,(3\,\mathrm{Si\,O^2}+2\,\mathrm{R^2\,O^3})] \\ +3[2\,(\mathrm{Si\,O^2}+2\,\mathrm{RO})+\ \ (3\,\mathrm{Si\,O^2}+2\,\mathrm{R^2\,O^3})]. \end{gathered}$$

to create the names *nitrite of oxide of ico-deca-tesseryle*, of *sub-hypochlorite of susporrindinous oxide;* instead of alum, we must say, *atolan-telmin-ojafin-weso;* mercaptan becomes *lifavinaf*, and chloranilam, *ama-chloro-phenusic acid.* Lastly, we are led to the creation of as many as a dozen different formulæ, and a dozen imaginary beings for the representation of one of the most simple of all bodies, namely, acetic acid.

But intermediate between facts and their causes, we have generalities and laws. Would it not be possible, by relying upon them, to establish a *method*, that is to say, a system of formulæ, a classification and a nomenclature, having the advantages of systems based upon facts, and of those based upon hypotheses, but without their inconveniences.

This is what I have attempted to do in this work, by endeavouring to render it as much as possible independent of all hypotheses. Such of them as are to be met with are isolated, and may be left entirely on one side, without any detriment to the progress of the work.

The method that I propose cannot be the production of one single person; it is a neutral ground to which I invite chemists to repair, so that they may understand one another in the midst of the various existing systems, and of those which, in the course of a short time, may be produced. I do not, on this account, reject the research after causes, although these may form perhaps but a perpetual mirage, destined to impel us incessantly to an exploration of new countries.

To effect the acceptation of a new system, it is necessary, in the first place, to point out the vices and errors of that which is in use. I therefore commence by a criticism on the equivalents and atomic weights which are generally received; not, indeed, that I have any observation to make against their institution and usage; but only upon the convenience of the numbers by which they are generally expressed. I then discuss the manner in which the arrangement of atoms, and the composition of bodies, are represented. Lastly, I pass in review the classifications and nomenclature that are generally employed.

After an examination of the reasons that have led chemists to choose the equivalents in ordinary use, I see in these same reasons a motive for seeking some other system, and I finally adopt that of Gerhardt, which allows a simplification of the notation, and a better generalisation of the facts.

Then, by relying upon a special law, which presides over the number of equivalents entering into compound bodies, and to which I have given the name of the law of even numbers, I deduce various consequences concerning gaseous volumes, polybasic acids, anhydrous acids, radicals, bi-acid bases, the combinations of the R^2O^3 oxides, and the composition of neutral, double, acid, basic, and hydrated salts.

Then, I examine the relations which exist between the crystalline form and the composition of certain bodies.

Subsequently, I study the subject of metamorphoses and substitutions. I seek to determine the relations which exist between the formative equations of compound bodies and their properties; and I consider principally the equations of complex bodies.

Having glanced at the different theories concerning the arrangement of atoms, radicals, and types, I come at last to the means for formulating the composition of bodies,—to the classification and nomenclature.

The work is terminated by tables (synoptic?), which represent the composition of all known bodies, as well of mineral as of organic chemistry: all anhydrous and hydrated salts are found therein.

These tables are arranged according to my classification. Each body is placed in a separate series and genus. Each body bears two names, one chosen from among the ordinary names, and the other a new name in accordance with my nomenclature. Opposite to the ordinary name is placed the ordinary formula, opposite to the new name the new formula.

I have endeavoured to render these tables as convenient as possible; and I have detached them from the body of the work so that they may be employed with greater facility. I have inserted several general tables which may serve as a key, and allow the place of any particular body sought for to be readily discovered. I have submitted the majority of the formulæ to new calculations, and I have caused a great number of them to undergo certain changes, which render the reactions of the bodies to which they apply more easily comprehensible. These tables form, in this manner, an inventory of all compounds which have been analysed, and of which the number amounts to about seven or eight thousand.*

---

* *Note by French Editor.*—This collection of tables, which ought to terminate the work and complete its utility, was efficiently revised by the author, and found in order in his manuscript. But it was not possible to comprise it in the present volume. We hope to have the means of publishing it at some future time. Meanwhile we have thought it right to preserve the announcement which the author had given.

TABLE OF CONTENTS.

PART FIRST.

GENERAL CONSIDERATIONS.

APPENDIX.

PART SECOND.

EVEN NUMBERS AND DIVISIBILITY OF ATOMS.

PART THIRD.

METAMORPHOSES.

CHEMICAL METHOD.

PART FIRST.

GENERAL CONSIDERATIONS

SECTION FIRST.

Proportional Numbers—Equivalents—Atomic Weights.

PROPORTIONAL NUMBERS.

Chemists have successively employed atoms, and proportional numbers or equivalents, to represent the composition of bodies. But seeing the degree of uncertainty and of changeability, to which the atomic notation is liable, the majority of chemists have abandoned it, and have adopted in its stead the notation by equivalents, as this latter represents simply the results of experiment, and unlike the former, does not appear to be subject to such changes as depend upon individual opinions, and upon the progress of science. This subject is of sufficient importance to demand our attention for a moment. We will proceed at once to examine it, establishing however, a difference between *proportional numbers* and *equivalents*—a difference which does not exist in the notation.

Experiment manifests to us, that the combinations of oxygen with the simple bodies, take place in the following ratios:

100 parts of oxygen combine with

12·5	and	6·25					parts of hydrogen.
442·0	and	221·0	and	88·5			parts of chlorine.
200·0	and	100·0	and	66·6			parts of sulphur.
175·0	and	87·5	and	58·3	and	43·7	parts of nitrogen.
75·0	and	37·5					parts of carbon.
350·0	and	233·3					parts of iron.
2600·0	and	1300·0	and	866·0	and	650·0	parts of lead.

40

Experiment demonstrates moreover, that 6·25 *parts of hydrogen* can combine with 221 parts of chlorine, with 100 and 200 parts of sulphur, and with 75 and 37·5 parts of carbon; and that 221 *parts of chlorine* can combine with 100, 200, and 66·6 parts of sulphur, with 75 and 37·5 parts of carbon, with 350 and 233·3 parts of iron, &c.; that is to say, that whenever combination takes place between two simple bodies, it is always in 1, 2, 3, 4, or 5 different proportions, which proportions are precisely represented by the numbers inscribed in the table of the combinations of oxygen, or by multiples or submultiples of those numbers.

Let us take *arbitrarily*, for each simple body, any *one of the numbers* indicating the proportions according to which it combines with 100 parts of oxygen; let us call this number *the proportional number* of the body, and let us represent it by the initial of the name of this same body. Let us choose for example the highest numbers, that is to say, those which are inscribed in the first column: then we shall represent the combination formed of 100 parts of oxygen and 12·5 parts of hydrogen by the formula

$$OH,$$

and consequently that which is formed of 100 parts of oxygen and 6·25 parts of hydrogen by $OH\frac{1}{2}$ or by O^2H. We shall represent in the same manner the combination which contains 442 parts of chlorine and 200 of sulphur by ClS, and that which contains 442 parts of chlorine and 66·6 parts of sulphur by $ClS\frac{1}{3}$, or by Cl^3S, and so on.

This notation or mode of writing is at once intelligible, and not liable either to change or to any special construction, since it rests upon a convention universally adopted by chemists.

For a language to be perfect, it is not sufficient that each substance, each idea, each modification of form, time, place, &c., should be represented by one word or by one invariable symbol; it is necessary in addition, both to aid the memory and to facilitate the operations of the mind, that analogous words should designate analogous substances, analogous ideas, and modifications of ideas, &c. It is thus that the words of our language represent to us, by similar terminations or augments, similar modifications of the ideas represented, as when we say, *Je vois, j'aperçois, je reçois; nous voyons, nous apercevons, nous recevons.* In like manner do chemists make use of the expressions sulphate, nitrate, chlorate, chloride, bromide, iodide, &c.

Now if, as we have supposed, we choose *arbitrarily* any one of the numbers of the table of the combinations of oxygen, for the proportional number, this choice may be such that the sulphate, the seleniate, and the tellurate of potassa shall be represented by the formulæ,

$$KSO^4, \qquad K^2SeO^8, \qquad K^3Te^2O^{12};$$

and the chlorides, bromides, and iodides of potassium and lead, by these:

$$K\,Cl, \qquad K\,Br^2, \qquad K\,I^3,$$
$$Pb\,Cl^2, \qquad Pb\,Br^4, \qquad Pb\,I^6.$$

This notation would be as intelligible and as invariable as the preceding; but we perceive directly that it would greatly embarrass the memory, and that it would conceal from us a multitude of relations, which the ordinary notation permits us immediately to seize.

Suppose then, that instead of fixing the proportional numbers arbitrarily, we select those which satisfy the two following conditions:

1°, That of representing the series of all the combinations by the most simple formulæ;

2°, That of attributing analogous formulæ to analogous combinations.

We shall then have the actual numbers that chemists decided upon, when they arranged the table of proportional numbers.

This table being accepted by all chemists, it follows of course that the proportional numbers are invariable, that they give the most simple formulæ, and that they permit the representation of analogous bodies by analogous expressions; at least such is the opinion of those who employ these numbers.

Nevertheless in examining this question more closely, we shall see, that the numbers adopted are not invariable; that we can choose others which shall give more simple formulæ for nineteen out of every twenty compounds; and lastly, that the analogies which have been declared between such and such bodies at any given period are more or less incorrect.

The last part of this proposition is incontestable; to suppose that the analogies have been thoroughly well established, is to admit that science has no more progress to make, that there are no more errors to rectify.

That it is possible to have simpler formulæ with other proportional numbers is also incontestable, in the presence of Gerhardt's proportional numbers, and of those which I in my turn propose.

But it must seem absurd to contest the invariability of a number admitted by convention as invariable.

Let us see however, whether such is actually the case, and for this purpose, let us divide the proportional numbers into two classes, the one comprising those of simple, the other those of compound bodies. For the first class of substances I grant that the numbers are invariable, that is to say, that the table has been arranged, and that all chemists have adopted it. But even this unanimity does not really exist, for if we look into different tables for the proportional numbers of bismuth and aluminum, for example, we shall find values that correspond, sometimes to the formulæ

$$BiO \quad \text{and} \quad Al\,O,$$

sometimes to

$$Bi^2O^3 \quad \text{and} \quad Al^2O^3,$$

and even to

$$Bi\,O^3.$$

As regards compound bodies, we are far from being agreed. Is the proportional number

of peroxide of iron, $F_{\frac{2}{3}}O$ or F^2O^3?
of phosphoric acid, $\cancel{P}_{\frac{1}{3}}\,O_{\frac{5}{3}}$ or $\cancel{P}O^5$?
of bisulphate of potash, $\cancel{H}KS^2O^8$ or $\cancel{H}_{\frac{1}{2}}K_{\frac{1}{2}}SO^4$?
of perchloride of carbon, $C^2\cancel{Cl}^3$ or $C^4\cancel{Cl}^6$?

It may indeed be said, that the representation of peroxide of iron by the formula

$$F_{\frac{2}{3}}O, \text{ or } F^2O^3$$

is a matter of indifference, because both represent the same centisimal composition,—and that such a representation is the sole object of these formulæ.

The following question however, will manifest the great importance of exactly defining the sense, that ought to be attached to the proportional number of a compound body.

We wish to prepare some persulphate of iron with a proportion of acid and a proportion of peroxide; how much by weight is it necessary to take of each substance? All chemists are agreed with regard to the acid—it will be necessary to take SO^3 or 500 parts, but as to the oxide, some will reply F^2O^3 or 650 parts, and others $F_{\frac{2}{3}}O$ or 217 parts.

I know very well that we can adopt a convention, and thus solve the difficulty, which however, will reappear in the case of each new substance. And indeed, when a chemist at the present day discovers a new compound, how does he proceed to give to it a proportional number? Either he may act arbitrarily—which proceeding, in organic chemistry especially, will lead to utter confusion,—or he may allow himself to be guided by the properties and analogies of his compound. His appreciation of these may be correct, or incorrect, or uncertain. Consequently, some chemists will adopt his proportional number,—others will reject it, and propose a different one. Who is to decide the question?

Moreover, the representation of the composition of bodies in the most simple manner, is not the sole object of proportional numbers, for there not unfrequently exist very remarkable relations between these numbers and the properties of certain bodies,—relations which would be completely masked, if in the determination of proportional numbers nothing was regarded but the centesimal composition of the bodies.

To render this apparent, I propose to represent, according to three different notations, the composition of certain bodies proceeding from bihydro-carbon (etherine), which bodies have with one another most curious relations of composition, properties, volume, generation, &c. For the simple bodies, I employ in all three columns the atoms of Berzelius, considering them, of course, as the proportional numbers. For the first column, I choose the most simple formulæ; for the second, the formulæ of Berzelius; for the third, the formulæ employed by Gerhardt and myself.

Bihydro-carbon	$C\,H^2$	$C\ H^2$	C^2H^4
Monochloro- ,, ...	C^2H^3Cl	$C^4\,H^6\,Cl^2$	C^2H^3Cl
Bichloro- ,, ...	$C\,H\,Cl$	$C^2\,H^2\,Cl^2$	$C^2H^2Cl^2$
Trichloro- ,, ...	$C^2H\,Cl^3$	$C^4\,H^2\,Cl^6$	$C^2H\,Cl^3$
Perchloro- ,, ...	$C\quad Cl^2$	$C\quad Cl^2$	$C^2\quad Cl^4$
Dutch liquid ,, ...	$C\,H^2Cl$	$C^2\,H^4\,Cl^2$	$C^2H^4Cl^2$
Monochloro- ,, ...	$C^2H^3Cl^3$	$C^4\,H^6\,Cl^6$	$C^2H^3Cl^3$
Bichloro- ,, ...	$C\,H\,Cl^2$	$C^2\,H^2\,Cl^4$	$C^2H^2Cl^4$
Trichloro- ,, ...	$C^2H\,Cl^5$	$C^4\,H^2\,Cl^{10}$	$C^2H\,Cl^5$
Perchloro- ,, ...	$C\quad Cl^3$	$C^2\quad Cl^6$	$C^2\quad Cl^6$
Aldehyde	$C^2H^4\quad O$	$C^4\,H^8\quad O^2$	$C^2H^4\quad O$
Chlor-aldehyde	$C^2H^3Cl\,O$	$C^{12}H^{18}Cl^6O^6$	$C^2H^3Cl\,O$
Perchlor-aldehyde....	$C^2\quad Cl^4O$	$C^2\quad Cl^4O$	$C^2\quad Cl^4O$
Acetic acid....	$C\,H^2\quad O$	$C^4\,H^8\quad O^4$	$C^2H^4\quad O^2$
Alcohol	$C^2H^6\quad O$	$C^2\,H^6\quad O$	$C^2H^6\quad O$

One half of the formulæ of the first, are more simple than those of the other two columns.

By examining the first two columns, who could conceive why the first five bodies are unattackable by potash—why their point of ebullition increases gradually from the first to the fifth—why the five following bodies are decomposable by potash, and why their point of ebullition increases progressively—why the first ten bodies can be prepared from one another, and that in an extremely regular manner?

Why is chloraldehyde neutral, and acetic acid not so—why do all the bodies of the first two columns metamorphose themselves one into another, by passing from C through C^2, C^{12}, C^4, to return again to C or C^2; why are some of them represented by 1 or 2 volumes of vapour, and the others by 4, 8, and 12 volumes?

On looking at the third column, we perceive 1°, that the weight of the carbon is constant; 2°, that the volume is the same for all the compounds; 3°, that if the boiling point increases from the first term to the fifth, and then from the sixth to the tenth, it is because in each series of five, the quantity of hydrogen diminishes regularly, while the quantity of chlorine regularly augments; 4°, that the five bodies unattackable by potash contain, in addition to the carbon, the constant number of equivalents, *four*,—while the five following contain another constant number, *six;* 5°, that if aldehyde and chlor-aldehyde are neutral, whilst acetic acid is acid, such difference depends upon the numbers of oxygen atoms which these bodies respectively contain.

At present I shall not enter more into detail upon this subject; what I have just now said is sufficient to show, that we ought not always to take for the proportional number, that number which leads to the most simple formula, and that proportional numbers can represent to us something more than the component weights or centesimal composition of the body.

I ought not in this place to omit remarking, that in a proportional-number point of view, bibasic acids cannot possibly exist; because if so, the bibasity must rest entirely upon convention.

It is difficult then to conceive why some chemists, who reject the atomic theory as being too hypothetical, and in consequence make use of proportional numbers, nevertheless admit the existence of polybasic acids, such as the pyrophosphoric. This acid might be rendered monobasic by altering certain proportional numbers; for example, by halving those of phosphorus and oxygen, the pyrophosphates, from being $M^2\text{Ꝑ}O^7$, would become $M^2\text{Ꝑ}^2O^{14}$ divisible, or $M\text{Ꝑ}O^7$ monobasic.

I sum up by saying: It is necessary that the proportional numbers of the simple bodies (the letters of the alphabet) should be fixed for at least a period of ten, twenty, or thirty years, and that all chemists should employ these numbers. With regard to compound bodies, their proportional numbers cannot be fixed, as they are daily under the necessity of being adapted to the progress of science.

EQUIVALENTS.

If we take a quantity of nitrate or sulphate of silver containing 1350 parts of metal, and if we add thereto copper, lead, iron, or potassium, we shall see that these

1350 parts of silver are replaced by
1300 parts of lead;
400 parts of copper;
350 parts of iron; and by
490 parts of potassium.

As the nitrates of lead, copper, iron, and potassium, thus produced, have properties analogous to those of the nitrate of silver, we may say that 1300 parts of lead, 400 parts of copper, 350 parts of iron, and 490 parts of potassium, play the same part, fulfil the same functions, as 1350 parts of silver, or in other words, are the *equivalents* thereof.

500 parts of sulphuric acid are neutralised by
1450 parts of oxide of silver;
1400 parts of oxide of lead;
500 parts of oxide of copper;
450 parts of oxide of iron; and by
590 parts of oxide of potassium.

The resultant sulphates being analogous, we may conclude that these 1450 parts of oxide of silver, 1400 parts of oxide of lead, &c., fulfil the same functions, and are the respective *equivalents* of these oxides.

We should have the equivalents of the acids in a similar manner, by determining the quantity of sulphuric, nitric, and carbonic acid, &c., that would saturate a certain weight of oxide of potassium taken as the measure of comparison. Setting aside the difficulties connected with the neutralisation of salts, we may say, that the preceding methods are sufficient for determining the equivalents of metals, oxides, and acids. But chemists go much further, for they give the equivalents of all simple bodies, acids, and chlorides; protoxides, deutoxides, and peroxides; neutral, acid, and basic salts; hydrocarbons, alcohols, ethers, amides, &c. &c.

It is evident that the table of equivalents has been arranged according to various methods, which have not any relation with one another. From what we have just seen however, it is clear that in order to determine the equivalents of any two bodies, there *must* be some analogy between them.

What relation exists between oxygen and carbon, between oxygen and oxide of potassium, between oxygen, oxide of potassium, and sulphuric acid? Do they perform the same functions? Can one consequently determine their equivalence?

If we take nitrate of silver, and endeavour to displace the metal, by oxygen, or by chlorine, or by carbon, or by silicon, we shall not succeed. If we take chloride of mercury, and endeavour either directly or indirectly to replace the metal by iodine, or by phosphorus, carbon, or silicon, we shall also fail; or at any rate, if we succeed in eliminating the mercury, and combining its chlorine with the iodine or carbon, the chlorides of iodine and carbon will not manifest any analogy with the chloride of mercury. We could not say that we had thus determined the *equivalents* of mercury, iodine, and carbon; we should have obtained by this means the *proportional numbers* only.

If we admit that the equivalents of oxygen and potassium are really O 100, K 490, how can we thence deduce the equivalent of oxide of potassium KO? It is evidently by a convention. We are accustomed to take the sum of the equivalents of two simple bodies for the equivalent of the compound body, but this is in reality not an *equivalent* at all, but only a *proportional number*.

The *proportional number* KO 590, being admitted as the *equivalent* of oxide of potassium, I grant that we can deduce from it the equivalents of other oxides which play the same part; but it is clear that we cannot associate with it the equivalent of oxide of carbon, CO 175, because this last, with respect to oxide of potassium, is simply a proportional number.

In order to determine the equivalent of oxide of sodium, we ascertain what quantity is required to saturate SO^3; but this method can only give the *proportional number* of the oxide as regards that of the acid, because there are no relations of similarity between the two bodies. SO^3 is the measure adopted by convention to determine the equivalents of the oxides in respect to one another. To deduce the equivalents of the oxides by means of the equivalents of the acids, would be to determine the relation between the superficies of a cloth and the metre which is employed to measure its length.

In examining the table of equivalents, we perceive that some have been deduced from proportional numbers, and others from equivalence of functions, but that by far the greater number have been derived from atomistic notions—notions which depend upon specific heat, isomorphism, vapour-densities, &c. This influence of atomistic ideas manifests itself at each step. Thus, if the perchloride of carbon be considered as corresponding to oxalic acid, we represent its equivalent as $C^2\cancel{Cl}^3$—if we consider it as a derivative of Dutch liquid, then its equivalent becomes $C^4\cancel{Cl}^6$.

Similar ideas cause the equivalent of chloroform to be represented sometimes as $C^2\cancel{H}\cancel{Cl}^3$, sometimes as $C^6\cancel{H}^3\cancel{Cl}^9$,—chlorosulphuric acid sometimes as $SO^2\cancel{Cl}$, sometimes as $S^3O^6\cancel{Cl}^3$, &c.

These atomic notions have so great an influence, that even where it is easy to determine an equivalent by the fundamental method of displacements, or what comes to the same thing, by the capacity of saturation, we neglect this method, and resort in its stead to hypotheses. Thus we see, in treatises on chemistry written from an *equivalent* point of view, that tartaric acid is bibasic, and that consequently the equivalent of the tartrates ought to be represented by $2\,MO.C^8H^8O^{10}$. I must here apply to the system of equivalents the observations already made with regard to proportional numbers: according to the doctrine of equivalents, it is perfectly nonsensical to talk of a bibasic acid, for by simply halving the formula the bibasity is at once made to disappear. Whether or not this division necessitates the use of fractional numbers is a matter of little consequence, since the relations are not in any way altered.

I ought perhaps to have explained at first, what I understand by the term *function of a body:* for the present it will suffice to cite certain groups of bodies which perform the same functions. 1°, the majority of the metals; 2°, oxygen, sulphur, selenium, and tellurium; 3°, fluorine, chlorine, bromine, iodine, and *manganese;* 4°, the salifiable oxides; 5°, the acids; 6°, the methylic, ethylic, and amylic alcohols; 7°, the formic, acetic, and butyric amides, &c.

I admit then, that we can determine the equivalents of the bodies which compose each of these groups, but that we can never determine the equivalent of a metal in respect to that of an acid, or the equivalent of an oxide in respect to that of an amide. Simple bodies, oxides, acids, salts, alcohols, amides, &c., fulfil entirely different functions, and it is quite impossible to establish an equivalence among them.

Nevertheless, in the above list I have adduced as belonging to the third group, the metal manganese—a substance which also appears in the first group, or that appropriated to the metals. This equivalence of manganese with chlorine is shown by certain analogies which we know to exist between the perchlorates and the permanganates. I might also have placed cyanogen, a compound body, by the side of chlorine and bromine. From this it might seem possible, by passing successively from any particular body to its analogues, to establish one scale of equivalents for all bodies, simple or compound. Thus we could determine the equivalents of the metals in respect to that of manganese, thence we could pass to that of chlorine, thence to bromine, to iodine, to oxygen, to sulphur, to selenium, to tellurium, to antimony, to arsenic, to phosphorus, to nitrogen, &c. From chlorine moreover, we might pass to cyanogen, and so on. We should then have a table arranged solely according to the system of equivalents.

Let us see if this conclusion is correct.*

Let us take a quantity of perchlorate of potash containing 442 parts of chlorine. We could replace this last either directly or indirectly by 978 parts of bromine, or by 1579 parts of iodine, or by 700 parts of manganese; and as the perchlorate and permanganate of potash present obvious analogies, we conclude that 442 and 700 are the respective equivalents of chlorine and manganese. From chlorine we might proceed to oxygen, by comparing chlorides with oxides; we should thus find 100 for the equivalent of oxygen, and consequently 200 for that of sulphur. Passing then from the sulphates to the manganates, we should find 350 for the equivalent of manganese, that is to say, we should arrive at a number different from the one previously assigned. By taking the last number 350, we could determine the equivalents of the metals, and comparing the salifiable bases with one another, we should

---

* Even if bodies are capable of being arranged in a series, every term of which passes to the succeeding by an insensible gradation, such a series is at present unknown to us; thus, in the list I have just given, some of the transitions are too abrupt; as for example, that from iodine to oxygen, and also that from tellurium to antimony. Moreover, if there are resemblances between chlorine and manganese, there are also enormous differences.

conclude that the equivalent of manganese being 350 in manganous salts, it became 233 in manganic; because 350 and 233 parts of manganese respectively displace 1350 parts of silver, to origiginate the two fresh normal salts. Thus, *solely by the method of equivalents* we arrive at this conclusion, that manganese has at least the three equivalents, 700, 350, and 233, which conclusion appears to me to be correct. I have already said that the equivalent of a body depends upon its function; consequently if a body fulfils several functions, it must have several equivalents.

It must therefore be said that the equivalent of manganese is 700 when it performs the functions of chlorine, 350 when it plays the part of the metals in manganous salts, and 233 when it plays the part of the same metals in manganic salts. To the question, then, What is the equivalent of such and such a body? we ought always to add the words, "When it fulfils such and such a function."

Hitherto we have purposely neglected, in our determination of the equivalent of a metal, oxide, or acid, those difficulties which result from the neutrality of salts. Let us now briefly consider this point. What is a neutral salt? To this question there are two principal replies which do not accord with one another.

1°. A neutral salt is a salt that is without action upon the colour of blue and red litmus: thus $KO.SO^3$, $U^2O^3.SO^3$, $KO.2CO^2$, and $NaO.2CO^2$, are neutral salts; whilst $CuO.SO^3$ and $F^2O^3.3SO^3$ are acid salts, and $KO.CO^2$ and $NaO.CO^2$ are basic salts.

2°. To establish the neutrality of a salt, we must first of all form as many categories of salts as there are sorts of acids. Then we agree to call every sulphate that contains three times as much oxygen in the acid as in the base, a neutral sulphate; thus $KO.SO^3$, $NaO.SO^3$, $CuO.SO^3$, and $F^2O^3.3SO^3$, are neutral sulphates, and $U^2O^3.SO^3$ is a tribasic sulphate. We also agree to call every carbonate that contains in the acid, twice as much oxygen as in the base, a neutral carbonate; thus $KO.CO^2$ and $NaO.CO^2$ are neutral salts, whilst $KO.2CO^2$ and $NaO.2CO^2$ are acid salts. We perceive that the two systems are at variance with one another; in the first case it is an experiment, in the second a convention, that serves to determine the neutrality of a salt, and consequently the equivalents of metals, acids, and oxides.

In conclusion, we perceive that in the construction of a table of equivalents, we avail ourselves of equivalence of functions, of conventions, of isomorphism, of the density of vapours, of speculations upon the arrangement of atoms, &c. Let us add moreover, that these conventions are not well defined, and that the equivalence of functions in the case of neutrality, depends upon two conditions that are often contradictory.

It seems then from this, that we ought to give the preference to proportional numbers. Nevertheless it may be said, that the tables of proportional numbers and of equivalents are identical. To establish a difference however, it is sufficient to consider one of these tables, that of equivalents, as of necessity variable, and the other, that of proportional numbers, as definitely fixed; but as this fixation is scarcely possible, except for the simple bodies, we must say that at the present day chemists do not recognize any difference between equivalents and proportional numbers.

ATOMIC WEIGHTS.

We can deduce the weights of atoms, either from proportional numbers and equivalents, or from the volume of gases, specific heat, isomorphism, &c.

In the first case, it is sufficient to consider proportional numbers as representing precisely the relative weights of the atoms, both of simple and of compound bodies; or what comes to the same thing, that the determination of atomic weights is founded upon the two following ideas:

1°, Atoms combine with one another in the most simple ratios.

2°, Analogous compounds contain the same number of atoms, or have an analogous constitution.

Bearing in mind that proportional numbers rest upon conventions, we see of course that atomic weights deduced therefrom, must be equally conventional or hypothetical. All that can be said however, is, that the ideas of simplicity and of analogy, upon which the determination of atomic weights is founded, give a certain degree of probability to the correctness of the relations that have been established between these weights.

It is to be observed however, that the proportional number cannot always correspond to the atom, as in the cases where fractions are introduced: thus the proportional number of peroxide of iron is $F_{\frac{2}{3}}O$; but to be converted into the atomic number, it must be trebled. The same is the case with pyrophosphoric acid, the salts of which have for their proportional number $M\cancel{P}_{\frac{1}{2}}O_{\frac{7}{2}}$, but for their atom $M^2\cancel{P}O^7 = 2MO.\cancel{P}O^5$.

I avail myself of this opportunity to point out, that here we have for the first time a clear notion of the polybasic acids. Pyrophosphoric acid for instance must be bibasic, in consequence of the formulæ of the pyrophosphates being indivisible; at least such is the opinion of chemists. I say such is the *opinion*, for it is indeed nothing more. And in order to prove this position it is sufficient to remark, that atomic weights being hypothetical, we could if we chose accord to the atoms of oxygen and phosphorus but one-half of their present values; then the pyrophosphates would become $M^2\rlap{-}P^2O^{14}$, and being divisible $= M\rlap{-}PO^7$; that is to say, they would be monobasic. I do not purpose explaining in this place my views with regard to polybasic acids; I rest satisfied with declaring, that the existence of such bodies is easily conceivable according to the atomic system, but that in the system of proportional numbers or equivalents it is absurd.

Chemists perceiving that the atomic weights deduced from proportional numbers rest upon a convention, have sought in the physical properties of bodies; in their volumes in the solid, liquid, and gaseous state; in their specific heats; in their boiling points; in their isomorphism, &c., for a more certain means of effecting their determination.

The numbers obtained by these various methods do not always agree: thus where the gaseous volume gives one number, the specific heat of the body gives another; by isomorphism we frequently arrive at contradictory results; the specific heat is not the same for the same body in its different isomeric modifications; and the volume of vapours gives such results, that chemists allow one and the same simple body, for example, sulphur, to have in the state of vapour, different volumes corresponding to its different isomeric modifications. We may remark also, that in the majority of cases it is impossible to resort to the preceding methods, and that then we are compelled to rely upon proportional numbers.

Lastly, to crown the uncertainty, we have recourse to hypotheses of the greatest possible variety, concerning the arrangement of the atoms in compound bodies. Thus some chemists consider the chloride of benzoyl as a combination of anhydrous benzoic acid with a species of chloro-benzoic acid ($C^{14}H^{10}Cl^6$), and represent its atom by $C^{42}H^{30}O^6Cl^6$. Other chemists regard it as a combination of chlorine with benzoyl, and consequently represent it by $C^{14}H^{10}O^2Cl^2$. Moreover, although it is admitted that gases contain the same number of atoms within the same volume, yet do we find one atom of a simple body represented by one volume, and one atom of a compound body represented by 2, 3, 4, 6, 8, and even 12 volumes.

It was by building upon all these considerations that Berzelius arranged his remarkable atomic tables. But his hypotheses upon the arrangement of atoms induced him to admit for certain combinations, principally in organic chemistry, formulæ so complicated that it is impossible for us to adopt them. When it is added, that this eminent chemist has frequently varied in the deductions he has drawn from the arrangement of atoms, it may be conceived why for some years past, many persons have abandoned atoms altogether, and have returned to proportional numbers. What however, we cannot conceive is, why all chemists should continue in their formulæ to give expression to atomic arrangements.

We know that chemists are accustomed to represent reactions by the aid of hypothetical bodies. Thus, when they want to explain the decomposition of acetic ether by potash, they make use of the following equation,

$$\begin{aligned} &C^4H^{10}O.C^4H^6O^3 + KO.H^2O \\ = \; &KO.C^4H^6O^3 + C^4H^{10}O.H^2O \end{aligned}$$

which although one of the most simple, nevertheless introduces two or three hypotheses.

Gerhardt having conceived the happy idea, of writing all reactions without employing any hypothesis whatever, quickly perceived that the majority of them could be much simplified, by making use of new atomic weights, to which he gave the names of *volumes*, *equivalents*, or *atoms*, considering all these terms as synonymous.

It may be remarked in passing, that he ought to have used the term *proportional number*, instead of the term equivalent; because by convention, we can always take the atom for the proportional number but not for the equivalent. Thus 1 *atom* of a bibasic acid will, according to the definition, always represent 2 *equivalents* of a monobasic one.

Gerhardt makes use of the atoms of Berzelius for all simple bodies excepting the metals, and for these he halves the ordinary atomic weights. Thus he writes water and potash as:

$$H^2O \text{ and } K^2O.$$

For compound bodies he always takes 2 volumes. Nothing we perceive, can be more simple than his system. Nevertheless, it may with advantage undergo certain modifications, which we shall point out further on.

Is it then advisable to adopt these new atoms? are the advantages they present sufficiently great, to warrant their substitution for those, which have for so long a time been used in science? Is not change in old usages attended with serious inconvenience?

I put aside this last objection altogether, *we must seek in the first place for* TRUTH, *the rest will follow as a matter of course.*

Let us only see whether these atoms do, as I think, offer greater advantages than the others; whether by their means, phenomena are more easy of explanation; whether the formulæ become more simple, and translate the analogies of the combinations more lucidly; and whether the determination of the atoms themselves is less subject to arbitrary considerations, &c.

It is clear, that considered as proportional numbers, these atoms are as invariable as the ordinary proportional numbers themselves. It is not necessary as for the atoms usually employed, to make a special convention for each known body, and for each body as it becomes known. The rule is simple: we take 2 volumes to represent all compound bodies.

These atoms, considered as proportional numbers, give rise to formulæ more simple than those in ordinary use. Thus, nineteen out of every twenty of the ordinary formulæ become halved in the new system.

I will adduce as examples the following:—

	Ordinary atoms.	In Gerhardt's atoms.
Nitric acid	H̶O.N̶O^5	HNO^3
Formic acid	$\text{H̶O.C}^2\text{H̶O}^3$	CH^2O^2
Margaric acid	$\text{H̶O.C}^{34}\text{H̶}^{33}\text{O}^3$	$C^{17}H^{34}O^2$
Potash bisulphate .	$\text{KO.H̶O.S}^2\text{O}^6$	$KHSO^4$
Oxamethane	$\text{C}^2\text{O}^2\text{H̶}^2\text{N̶.C}^6\text{O}^4\text{H̶}^5$	$C^4H^7NO^3$

Analogy of properties also becomes more clearly represented by these new atoms. Thus chlorhydric, nitric, bromic, acetic, and margaric acids, are represented by

$$H.Cl,\quad H.NO^3,\quad H.BrO^3,\quad H.C^2O^2H^3,\quad H.C^{17}O^2H^{33},$$

whilst sulphuric, carbonic, phosphoric, and oxalic acids are represented by

$$H^2.SO^4,\quad H^2.CO^3,\quad H^3.PO^4,\quad H^2.C^2O^4,$$

the first class of acids being monobasic, the second polybasic.

Some persons may find here, a contradiction of what I have previously said—since I am now considering Gerhardt's atoms, simply as proportional numbers, and have before remarked that in a proportional-number point of view, the polybasity of acids is absurd. But I am now using the term polybasic in a totally different sense. An acid is polybasic in consequence of its manifesting certain properties which are not possessed by monobasic acids; this difference of properties being expressed in the formulæ of the acids which have been respectively alluded to as *mono-* or *poly-basic.* I shall refer to this subject further on, in much greater detail.

The numbers proposed by Gerhardt, possess similar advantages when considered as atoms. Their determination is not subject to a host of conventions, neither does it rest upon hypotheses concerning the arrangement of the atoms. The superior simplicity of the new formulæ is rendered even more apparent, by a comparison with the atomic formulæ of Berzelius. Thus if we make use of the preceding examples—according to the notation of Berzelius we shall have for the representation of nitric, formic, and margaric acids, bisulphate of potash, oxamethane, &c., the respective formulæ:

$$H^2N^2O^6, \quad C^2H^4O^4, \quad C^{34}H^{68}O^4, \quad KH^2S^2O^8, \quad C^8H^{14}N^2O^6, \text{ \&c.}$$

I have quoted only the most common examples, and have neglected entirely a whole host of very complicated bodies, such for instance as the chloride of benzoyl, which Berzelius writes as $C^{42}H^{30}O^6Cl^6 = 12$ volumes, and Gerhardt as $C^7H^5ClO = 2$ volumes.

For the representation of reactions by the aid of equations, the system of Gerhardt is still more convenient. I am unable however, to adduce at this moment sufficiently conclusive examples of my assertion; since in order to render evident how simple, elegant, and symmetrical, the reactions of the new system are, it would be necessary to have arranged several tables of bodies fulfilling the same functions. I confine myself for the present to the above considerations, which I believe warrant me in affirming that the atoms or proportional numbers of Gerhardt, are preferable to those in ordinary use. Further on, we shall see that they lead us to conclusions of the highest interest, and we shall then consider, whether or not they ought to be generally adopted.

SECOND SECTION.

DUALISM AND ATOMIC ARRANGEMENTS—CLASSIFICATION—NOMENCLATURE.

DUALISM AND ATOMIC ARRANGEMENTS.

I propose to examine in this chapter the different systems that have been proposed, concerning the arrangement of atoms in compound bodies.

The opinions of chemists upon this subject differ very materially; nevertheless they may be reduced to two principal ones.

According to some, compound bodies are formed of two groups of atoms, maintained in connection with one another by an electrical force, one of the groups being positive, the other negative.

According to others, the atoms form but one single group, are arranged therein in a symmetrical manner, and have a certain relation to the crystalline form of the body.

I will not stop to inquire whether the atom of sulphur is positive towards that of oxygen, and negative towards that of potassium; whether two atoms, when brought into union by their opposite electricities, can *remain* indefinitely attached to one another by means of the same force; whether atoms have, like the tourmaline, two poles, the one positive, the other negative; and whether or not they are surrounded by an electric atmosphere. Still less do I intend to examine whether in the opianates, the negative pole is occupied by the base, while the two atoms of water acting as a copula, belong to the positive pole.

One primary question controls the whole inquiry. In order to determine the arrangement of the atoms, which constitute a compound body, it is evident, that we must first of all be acquainted with the number of those atoms, and consequently with their weights.

Thus, for example, if the chloride of acetyl (othyl), contained $C^{12}H^{18}O^{6}Cl^{6}$, we might regard it as a combination of anhydrous acetic acid, with a sort of chlor-acetic acid $C^{4}H^{6}Cl^{6}.2C^{4}H^{6}O^{3}$, while such a supposition would become impossible, if the chloride contained only $C^{4}H^{6}O^{2}Cl^{2}$.

We should arrive at similar conclusions by changing the weights of certain atoms; thus, by adopting those of Gerhardt, we might allow the reduction of the nitrates to the formula MNO^3, whilst with the ordinary atoms these salts cannot contain less than MN^2O^6. While then, with this last formula, it is admissible to consider the nitrates as formed by the union of an acid N^2O^5, with an oxide MO, such a supposition is no longer tenable with the formula MNO^3.

But we have said above, that there are greater probabilities in favour of the atoms of Gerhardt, than in favour of those of Berzelius; consequently, it is probable that nitric acid does not contain water, and that dualism is leading us into error concerning the arrangement of atoms.

The chemists who uphold dualism are far from being agreed among themselves; nevertheless, all of them in maintaining their opinion, rely upon the phenomena of chemical reactions. For a long time the uncertainty of this method has been pointed out: it has been shown repeatedly, that the atoms put into movement during a reaction take at that time a new arrangement, and that it is impossible to deduce the old arrangement from the new one.

It is as if, in the middle of a game of chess, after the disarrangement of all the pieces, one of the players should wish, from the inspection of the new place occupied by each piece, to determine that which it originally occupied.

It is, however, reiterated everywhere and at every moment, that salts are obtained by combining acids with bases; that we can decompose them by separating the acid from the base, and that consequently, they contain two groups, the one negative, and the other positive; the one acid and the other alkaline.

Let us remark at starting, that there is scarcely one salt in a thousand that has been obtained by the direct combination of its acid with its oxide, and still fewer that can be decomposed into acid and oxide; for even in making sulphate of potash, it is always sulphate of hydrogen and hydrate of potash that are employed. Not that I deny the possibility of preparing this salt by means of the anhydrous acid and oxide, I only mean to affirm that this often quoted illustration has never been submitted to experiment, and that the majority of salts cannot be made in this way with the anhydrous oxides and acids. And besides, what is proved by this possibility of preparing certain salts, by combining directly the acids and bases? If the manner in which a salt was formed and decomposed, allowed us to determine immediately the arrangement of its atoms, we might maintain: 1°. That sulphate of potash is a combination of the sulphite with oxygen. 2°. That it is a combination of the sulphide with oxygen, since it can be prepared from these two bodies, and, moreover, when heated with charcoal, is transformed into sulphide. 3°. That it contains $K.SO^4$, &c.

Of all these hypotheses, there is not a single one incapable of having *reactions* adduced in its support. Thus, if we choose to adopt the theory of Longchamp, according to which, the oxy-salts contain the metals in the state of binoxides, we could prove, by uniting sulphurous acid with binoxide of potassium, that sulphate of potash contains $KO^2.SO^2$; and we could explain its decomposition with chloride of barium by the aid of this equation,

$$KO^2.SO^2 + BaCl^2 = BaO^2.SO^2 + KCl^2.$$

If we had to explain the formation of sulphate of potash from the sulphide of potassium and oxygen, we should say that this last body acted upon the sulphur and burned *it*, as if it had been uncombined, and at the same time acted upon the potassium and converted *it* into the binoxide.

We could prove, by synthesis, that hydrated nitric acid is a combination of peroxide of nitrogen with binoxide of hydrogen; we could prove the same thing analytically, by decomposing the acid by heat, when it would be resolved into peroxide of nitrogen, water, and oxygen, and in this case, we should remark, that the occurrence of water and oxygen was due to the binoxide of hydrogen having undergone decomposition by reason of the heat employed.

An objection might be raised to Longchamp's view, inasmuch as many of the acids, admitted to be present in the salts, do not exist in the free state; but precisely the same objection could be advanced against his adversaries.

The partisans of dualism do not, however, yield to these reasons, but contrive the following means to combat them.

In order to study the constitution of a binary compound, we cannot, say they, react upon it with any substance that first presents itself, but *we must* employ for the purpose a simple body; and in order to study the constitution of a saline compound, *we must* employ a base or an acid. Then, as bases replace bases, and acids replace acids, it is clear that salts consist of bases and acids.

We must employ a base and an acid! And why must we so? This it is which they do not tell us. But for my part, *I choose* to employ simple bodies in my study of the constitution of salts; I choose to put iron into contact with sulphate of copper, and as the first metal replaces the second, I embrace the system of Davy, and I conclude with him, that sulphate of copper is thus constituted: $Cu.SO^4$.

I now choose to take binoxide of barium, and to react with it upon the same salt, and as by this means binoxide of copper is formed, I maintain with Longchamp, that sulphate of copper contains sulphurous acid, and binoxide of the metal, $CuO^2.SO^2$.

I now choose to carry out your method: I pour sulphuric acid into hyposulphite of potash, and as the reaction gives rise to sulphur and sulphurous acid, I conclude that the salt is formed of three groups, $S.KO.SO^2$, and that the trinitary system ought to replace the dualistic.

I have previously remarked, that there is scarcely one case in a thousand, where anhydrous oxides or acids can be employed for the preparation or decomposition of salts. To overthrow this objection however, several experiments have been recently made, and the old inference arrived at; that is to say: chemists have succeeded in decomposing a carbonate by anhydrous sulphurous, and sulphuric acids; and as the carbonic acid is displaced from its combination without the concurrence of water, they have concluded that it existed ready formed in the carbonate.

It is astonishing how at this day, we should be compelled to direct attention to the most ordinary phenomena of chemistry, and should be obliged to point out, that one metalloid can displace another analogous metalloid; that a metal can drive out a metal, an oxide drive out an oxide, and a peroxide expel or originate another peroxide; that an anhydrous acid displaces another anhydrous acid; that a hydrated acid gives origin to another hydrated acid; that a salt produces another salt, &c.: in one word, that a body which fulfils a certain function, always does, by its action upon a salt, tend to displace or give origin to another body fulfilling the same function. And if this displacement does not invariably take place, it is easy to see that the exceptional cases arise solely from the instability of the body intended to be thus displaced. For instance, at a certain temperature, sulphuric acid, by its action upon nitrate of potash, gives rise to hydrated nitric acid; but at a higher temperature this last acid can no longer exist, and consequently, other products are formed.

If from such simple combinations as the sulphates and the carbonates we pass to the phosphates, the borates, and the double silicates, we shall still recognise the endeavour to construct binary groups, each of which is itself composed of other binary groups;

but the number of atoms becoming greater, the number of hypotheses concerning their arrangement increases in the same proportion.

We have a silicate that contains

$$Si^{13}\,O^{81}\,Mg^{21}\,Al^{4}\,H^{30},$$

and we discuss seriously whether the atoms have this arrangement:

$$(11\,Si\,O^{3} + 21\,Mg\,O) + 2\,(Si\,O^{3} + Al^{2}\,O^{3}) + 15\,Aq,$$

or this:

$$7\,(Si\,O^{3} + 3\,Mg\,O) + 2\,(3\,Si\,O^{3} + Al^{2}\,O^{3}) + 15\,Aq,$$

or:

$$7\,(Si\,O^{3} + 3\,Mg\,O + 2\,H^{2}O) + 2\,(3\,Si\,O^{3}, Al^{2}\,O^{3}) + Aq,$$

or a hundred others similar. Nevertheless, it appears that we cannot well surpass this:

$$[3\,(Si\,O^{3}+3\,Mg\,O)+2\,(Si\,O^{3}+Al^{2}\,O^{3})+3\,Aq]+4\,[2\,(Si\,O^{3}+3\,Mg\,O)+3\,Aq.$$

What is there to prove that the silica is distributed into three principal groups, that the magnesia forms two distinct combinations, that the water occupies two different places? (I believe that I am mistaken, and that the water occupies one and twenty different places.) Does this salt by its reactions split up into a magnesian silicate on the one hand, and an alumino-magnesian silicate on the other? &c.

I have often read the discussions that have taken place upon this subject, and I avow that I have never found anything but what was either arbitrary or according to routine: what I saw most clearly was, that, in general, the greatest regard was had to authority.

If from mineral we pass to organic chemistry, we shall see that in this division the arbitrary reigns supreme. Here also are reactions appealed to as a means for discovering the arrangement of atoms; but, like the ancient oracles, one single reaction serves two purposes, proving both the for and the against. I have no intention of calling to my aid the composition of any complex or imperfectly known body, as an illustration of the disorder that prevails in organic chemistry; I shall merely take the simplest and most common of all the acids, namely, the acetic, the arrangement of the atoms of which has been represented by:

$$\begin{array}{ll} C^4H^6O^3. & H^2O \\ C^4H^6O^4. & H^2 \\ C^4H^6O^3. & H^2O \\ C^4H^6O.\ O^2. & H^2O \\ (C^2H^6)\ C^2O^3. & H^2O \\ (C^2H^6)\ C^2O^4. & H^2 \\ (C^3H^6O)\ C\,O^2. & H^2O. \end{array}$$

I have still omitted two or three, namely,

$$C^4H^8.\ O^4$$
$$C^2H^4.\ O^2$$

I do not see why I should neglect that of Longchamp,

$$C^4H^6O^2.\ H^2O^2.$$

or that of Graham,

$$C^4H^2.\ O^4\ H^6.$$

Lastly, I know that a new formula will shortly appear, which, should we some day be permitted to discover the arrangement of atoms, will in my opinion be preferable to any of the others. For the support of every one of these formulæ certain reactions have been invoked; and curiously enough, in several cases the reactions that are contrary to the hypothesis, are precisely those which have been adduced for its confirmation.

Thus, the formulæ

$$(C^2H^6)\ C^2O^3.\ H^2O$$

represents a combination of oxalic acid with an imaginary compound C^2H^6, and nevertheless we know very well that we cannot by any reaction demonstrate the presence of oxalic in acetic acid. It must not be thought that, for the maintenance of my cause, I have adduced the obscure hypothesis of an obscure chemist: no, the above is the hypothesis of Berzelius and of his school.

Lastly, for the discovery of the arrangement of the atoms in a body, chemists do not even wait until it has been submitted to a certain number of reactions; its centesimal composition alone suffices for them.

Some years back the discovery of an essence* was announced, which essence contained $C^9H^{10}O^3$; at the same instant, without waiting for further inquiries, it was at once set down as a hydrated oxide,

$$3\ C^3H^2.\ O.\ 2\ H^2O.$$

---

* Salicylic ether.—(WO).

Subsequently we were told that the substance was an acid, and its formula quickly became

$$C^{18}H^{18}O^{5}. H^{2}O.$$

Some days after, the essence was announced to be an ether, and in the twinkling of an eye the following arrangement was given,

$$C^{14}H^{10}O^{5}. C^{4}H^{10}O,$$

or, better still, this,

$$C^{2}O^{4}(C^{12}H^{10}). C^{4}H^{8} + H^{2}O,$$

from which we learn that C^{12} and H^{10} are in intimate combination, while C^{2} and O^{4} are united in an ordinary manner,—that $C^{2}O^{4}$ is copulated with $C^{12}H^{10}$,—that $C^{2}O^{4}$ $(C^{12}H^{10})$ is conjoined with $C^{4}H^{8}$,—and lastly, that the whole forms a marriage of convenience with $H^{2}O$! !

Have we at least, I will not say a rule, but even a convention, which can determine in this way the arrangement of atoms? No: every chemist follows his own particular course, and changes his formulæ as often as he obtains a new reaction. We should arrive at results quite as satisfactory by putting the atomic letters of a formula into an urn, and then taking them out, hap-hazard, to form the dualistic groups.

Next to reactions, chemists thought they had discovered in the galvanic battery a sure means of discovering the arrangement of atoms; and here we perceive an almost incredible example of the influence of theories upon our appreciation of facts.

Among the thousand reactions produced by the battery, this much is certain, that there is not a single one which can be adduced in support of dualism; nevertheless, the chemists who adopt this system have found means, by their own interpretations, to persuade themselves that all these various reactions prove that salts are composed of acid and oxide. They repeat incessantly that nearly all salts, under the influence of an electric current, are decomposed into acid and oxide. The experimental proof is made daily in every course of chemistry.

I was present lately at the lecture of a learned professor; before him was placed a U tube, containing a solution of sulphate of potassa, coloured with litmus.

After having passed an electric current through this tube, and having pointed out that one of the limbs had become red, and the other blue, the professor proceeded nearly in these words:—

"You perceive in the most obvious manner that the sulphate has been decomposed; the red colour of this limb proves to you that the sulphuric acid is transported to this side, whilst the oxide of potassium is carried into the other limb, which is consequently coloured blue. Now, gentlemen, all salts are decomposed in the same manner, and nevertheless, in the presence of this glaring fact, you will meet with persons who venture to deny in the sulphate the existence of sulphuric acid and of potash, and to reject the system of dualism."

What would the learned professor have said, if one of his auditors had risen and replied as follows:—"By saying that all salts decompose themselves in this manner, your intention, without doubt, is to teach us that such is the case with the great majority; but for my part, I think the contrary. I think that there is not *a single one* that is decomposed in the manner you describe, not even the one that is under our eyes. You yourself know very well that the hypochlorites, the chlorates, the perchlorates, the bromates, the nitrates, the phosphites, the salts of gold, platinum, manganese, lead, &c., give results differing extremely one from another, and very different from that which you have just announced to us. With regard to the tube which is before us, it contained two substances, water and sulphate of potash, and at this moment one of the branches contains, not as you say, sulphuric acid SO^3, but instead, the sulphate of hydrogen, or rather, the bisulphate of potash: in the other branch is found, not oxide of potassium, but hydrate of oxide of potassium. So that under the influence of an electric current there results, not a simple decomposition, but a double decomposition. And remark, moreover, that this double decomposition occurs similarly, when chloride of potassium is decomposed in the presence of water. The reactions take place in the manner indicated by the following equations, which I write with Gerhardt's atomic weights.

1st *case.*—Formation of sulphate of water,

$$K^2SO^4 + 2\,H^2\,O.$$
$$= H^2SO^4 + 2\,KHO.$$

2nd *case.*—Formation of bisulphate of potash,

$$K^2\,SO^4 + H^2\,O.$$
$$= KHSO^4 + HKO.$$

Decomposition of a chloride,

$$KCl + H^2\,O.$$
$$= HCl + KHO.$$

"Here are the facts without hypothesis. By making use of hypothesis however, we can prove anything we choose. We will first prove with Davy, that sulphate of potash contains K, SO^4. We therefore say, that in reality, under the influence of the battery SO^4 and K do separate from one another. The potassium in the presence of water decomposes it, forming a hydrate, and the hydrogen of the water takes the place of the potassium that was set free.

"Let us now prove that Longchamp's theory is correct. We shall say, that in reality sulphurous acid separates from binoxide of potassium; and that under the influence of these two bodies an atom of water is decomposed; the oxygen unites with another atom of water to form the binoxide of hydrogen, which combines with the sulphurous acid to form the hydrated sulphuric acid; while the hydrogen unites with the binoxide of potassium to form the hydrate of potash.

"We could prove quite as easily, that the sulphate of potash consists of $SK.O^4$ or $S.O^4.K$.

"Nay, more; replace in your tube the sulphate of potash by sulphate of copper, and at pleasure you can cause copper, or oxide of copper to be deposited on the negative pole; that is to say, that you can at pleasure prove either the for or the against.

"Lastly, we may say, that it is not the salt at all, but the water that is decomposed by the action of the galvanic current, and that the nascent oxygen and hydrogen decompose the sulphate, the oxygen seizing upon the potassium, and the hydrogen supplying its place."

Let us, however, dismiss the battery and its reactions, because they can teach us nothing concerning the constitution of salts. What we have said above does not prove that sulphate of potash is not a compound of acid and oxide, but simply that we do not know what is the arrangement of the atoms in the salt. We propose now to go still further, and to demonstrate that salts cannot contain either the anhydrous acids or radicals, which the ordinary theory, and that of Davy suppose.

Fifteen years have now elapsed since I first put forward the arguments I am about to reproduce. I do not know that they have been answered hitherto. Time has only added to the force of the reasoning. I ought, however, to premise, that my arguments rest upon the existence of bibasic acids; acids which are not bibasic, because, according to their formulæ, they contain two atoms of base, but because they are possessed of certain characteristic properties. I admit then, that we can by experiment discover whether an acid is, or is not, bibasic; the manner of so doing will be demonstrated further on. Let us divide the acids into two classes, and for the present occupy ourselves with such as are monobasic. Let us take at first the series of acids, which commences with formic acid, and terminates with the margaric, stearic, melissic, &c.

This is the manner in which their formulæ are represented according to the ordinary theory.

Acid formic	$C^2H^2 . O^3 + H^2O$
,, acetic	$C^4H^6 . O^3 + H^2O$
,, propionic	$C^6H^{10} . O^3 + H^2O$
,, butyric	$C^8H^{14} . O^3 + H^2O$
,, valeric	$C^{10}H^{18} . O^3 + H^2O$
,, caproic	$C^{12}H^{22} . O^3 + H^2O$
,, cetic	$C^{32}H^{62} . O^3 + H^2O$
,, margaric	$C^{34}H^{66} . O^3 + H^2O$

I was struck then by observing, that the hydrocarbons C^2H^2, C^4H^6, C^6H^{10}, C^8H^{14}, ..., $C^{32}H^{62}$, $C^{34}H^{66}$, $C^{36}H^{70}$, which are supposed to exist in the acids, constantly approach to the ratio $C : H^2$, and more nearly according as they are more elevated in the scale; but that they never attain thereto. I have remarked, on the other hand, that the ethers which correspond to these acids present a relation equally singular:

Ether methylic	$C^2H^6 + O$
,, vinic	$C^4H^{10} + O$
,, amylic	$C^{10}H^{22} + O$
,, cetic	$C^{32}H^{66} + O$

Thus in the first class of bodies, by adding H^2 to all the compounds, we have the ratio $C : H^2$; and we have the same ratio by subtracting H^2 from the compounds of the second class.

I remarked, moreover, that the hydrocarbons C^2H^4, C^4H^8, C^8H^{16}, $C^{10}H^{20}$, $C^{32}H^{64}$ existed in the free state, while these same hydrocarbons, plus or minus H^2, were unknown.

The same remarks may be made concerning the benzoic, salicylic, cinnamic, eugenic, and other acids. By adding H^2 to each of the anhydrous acids, we obtain a hydrocarbon more simple than that of the hypothetical anhydride.

No matter what the cause, to which I then attributed these ratios between the carbon and the hydrogen, my remarks upon them were not the less correct. I shall draw from them the following conclusion: — *The free hydrocarbons always present a more simple relation than the corresponding hypothetical hydrocarbons; we must thence infer that these last are incapable of existing.*

In the illustrations that I was able to adduce at that epoch, there was a considerable number of errors. But more lately Gerhardt's equivalents and further experiments have enabled me to remove them, and even to ascertain the cause of the singular relations by which I had been so struck in respect to the hydrated and anhydrous acids. Let us put all hypothesis aside, and represent simply the formulæ of the so-called hydrated acids by

$$C^2 H^4 O^4$$
$$C^4 H^8 O^4$$
$$C^6 H^{12} O^4$$
$$C^{10} H^{20} O^4,$$

and so on. We see then that the two atoms of hydrogen of the atom of water separated from the anhydrous acid, are precisely what the hypothetical hydrocarbon requires, in order to have the ratio $C : H^2$, which ratio does exist in the real free acid.

Can this remark be applied to the other acids, the cuminic for example? (I leave the nitrogenised acids aside for the present; hereafter we shall see that, despite the appearance to the contrary, they actually corroborate the remark.) Yes, if the following proposition, to which we shall revert further on, is correct.

In all non-nitrogenised organic compounds, the number of the atoms of hydrogen is a multiple of four, and that of the atoms of oxygen and of carbon a multiple of two, or an even number. Cuminic acid contains $C^{20}H^{24}O^4$, and the hypothetical anhydride $C^{20}H^{22}O^3$. In the first, $20 : 24 :: 5 : 6$; in the second, $20 : 22 :: 10 : 11$. It cannot be otherwise for all the other acids, since all Gerhardt's formulæ for the hydrated acids are at least divisible by two, whilst those for the anhydrides are never so. I conclude from this that the anhydrous acids cannot exist; and I draw the same conclusion with regard to the radicals, as cacodyl, methyl, &c., and also the radicals of Davy. Thus for instance in acetic acid the radical of Davy would be $C^4H^8O^4—H^2$, that is to say, it would present for the hydrogen a sum not divisible by four.*

---

* This was written before Gerhardt's discovery of the anhydrous acids. Nevertheless I have nothing whatever to alter.

From all this, I do not wish to infer that bodies whose centisimal composition might be represented by C^4H^{10}, $C^{10}H^{22}$, $C^{30}H^{62}$, and $C^4H^6O^3$, are incapable of existing; but simply that their formulæ would have to be converted into C^8H^{20}, $C^{20}H^{44}$, $C^{60}H^{124}$, and $C^8H^{12}O^6$.

Such for example is the case with cacodyl, which is not $C^4H^{12}As^2$, but as will be shown elsewhere $C^8H^{24}As^4$. It must not be thought that this is an arbitrary interpretation, adopted for the purpose of rendering the hydrogen always divisible by four. Chemists know very well that aldehyd and butyric acid ought not to be represented by the same formula, although they have the same composition. Thus if $C^4H^8O^2$ is the formula of aldehyd, that of butyric acid necessarily becomes $C^8H^{16}O^4$. We shall prove further on, that if $C^4H^{10}Cl^2$ represents the chloride of ethyl, and that if the removal ofthe Cl^2 be effected, then C^4H^{10} will not be the formula for ethyl, but in its stead C^8H^{20}.

Up to the present time chemists have admitted that the oxidised compounds which give rise to salts, contain a quantity of water which corresponds exactly to their capacity of saturation. They admit, on the other hand, that oxamide, carbamide, benzamide, &c., do not contain water.

Latterly, however, we have succeeded in obtaining with several amides a considerable number of salts. We should conclude from the composition of these salts that the amides do contain water, which water represents exactly their capacity of saturation. So far there is nothing contrary to the dualistic theory, only we perceive that we have been in error concerning the formulæ of the amides, and that these compounds do contain water, and that oxamide for example has for its formula

$$(C^2O.\ H^2N^2).\ H^2O$$

and carbamide

$$(C\ H^2N^2).\ H^2O.$$

But we can also combine amides with acids without the amides experiencing any loss of water. Thus asparagine and glycocine, on the one hand, exchange an atom of water for an atom of oxide, and, on the other hand, combine with acids without losing any water whatever. Now we know that all the hydrated organic bases, or the oxides of the different ammoniums (oxides of tetrethylium tetramethylium), always combine in the anhydrous state with acids: consequently we conclude that aspargine, glycocine, and the amides do not contain water. But if oxygenised bodies, such as the amides, although not containing water, can yet give rise to salts, why do we suppose that water is necessarily contained in the sulphuric, formic, and acetic acids? Here are other facts. Citric acid is tribasic, and consequently contains, according to the dualistic doctrine, three atoms of water. By cautious heating, it can be made to lose one of these three atoms. Will it have then become bibasic? Not at all. We put it into contact with three atoms of potash, and although it only contains two atoms of water ready formed, yet it disengages three atoms thereof in order to take up the three atoms of potash.

Isatinic acid is monobasic, consequently it contains $C^{16}H^{12}N^2O^3$, H^2O. We can cause this body to give up not only the atom of ready formed water, but also another atom which is produced at the expense of the anhydrous acid. There remains then a neutral compound isatine $C^{16}H^{10}N^2O^2$, which certainly cannot any longer contain water. Nevertheless put into contact with oxide of potassium, it seizes upon this base, and abandons yet another atom of water. I will not say that all these reactions are impossible, but simply that they are in the highest degree improbable, and that the only means we have for explaining all these reactions consists in a simple admission of this fact, namely, that sulphuric, formic, acetic, citric, and isatinic acids, isatine, asparagine, glycocine, &c., are capable of exchanging 1, 2, or 3 equivalents of hydrogen for 1, 2, or 3 equivalents of potassium, lead, copper, &c., without supposing that the hydrogen necessarily existed in the state of water.

I shall examine elsewhere whether or not any predisposed arrangement of the atoms really exists, whether or not we must of necessity give to alum this formula:

$$S^4O^{40}H^{48}K\,Al^2.$$

Supposing, however, that we had not advanced further in our knowledge of the arrangement of atoms than the point to which I have just now alluded, it is evident that the most suitable means for representing the composition of bodies, would be that of employing empiric formulæ. Nevertheless, certain persons, though acknowledging that the dualistic theory totters in all its parts, admit that it is very convenient for teaching, and that its formulæ afford a great aid to the memory. If these formulæ were given to us simply as an artificial system intended to assist the memory, I should make less objection to them. Nevertheless, even from this point of view, I must dispute absolutely the advantage of the formulæ in general use.

If the question were simply, whether the sulphates should be represented by $MO.\ SO^3$, or $M.\ SO^4$, it would be folly to waste time over the matter; but if we represent the sulphates by $MO.\ SO^3$, and the chlorides by MCl, we create such an inconvenience, that out of half a score candidates for the degree of Bachelor, there are not more than three or four capable of replying without hesitation to the following question. What is the action that sulphuric acid, oxide of potassium, and sulphate of potash, exercise upon the chlorides?

Salts are divided into two classes; we examine under separate heads the action of metals upon oxides, acids, and salts; the action of acids upon oxides and salts; the action of bases upon salts; and, lastly, the reaction of salts upon haloid and oxy-salts respectively.

If we confined ourselves to empiric formulæ, we should have but one single point to examine, namely, whether or not the metal or hydrogen of the one compound takes the place of the metal or hydrogen of the other compound? The law of Berthollet would give the reply. Are the formulæ in the first column less advantageous for the memory than those of the second?

Acid chlorhydric	$H\,Cl$	—	$Cl^2.\ H^2$
,, hypochlorous	$H\,Cl\,O$	—	$Cl^2O.\ H^2O$
,, chlorous	$H\,Cl\,O^2$	—	$Cl^2O^3.\ H^2O$
,, chloric....	$H\,Cl\,O^3$	—	$Cl^2O^5.\ H^2O$
,, perchloric	$H\,Cl\,O^4$	—	$Cl^2O^7.\ H^2O$

In teaching a pupil the composition of the acids of phosphorus and of their salts, these are the explanations into which we are obliged to enter.

Phosphorus, we say, has three degrees of oxydation that give rise to acids, we have hypophosphorous acid P^2O, phosphorous acid P^2O^3, and phosphoric acid P^2O^5.

Hypophosphorous acid combines with one equivalent of oxide to give rise to salts having the formula $P^2O.\ MO$; but these salts contain in addition two equivalents of water, which cannot be driven off, and which form an integral part of the hypophosphites, so that we are obliged to represent their formulæ by

$$P^2O.\ MO.\ H^4O^2,$$

with or without the eliminable water of crystallisation. Phosphorous acid combines with two equivalents of oxide, to give rise to salts having the formulæ $P^2O^3.M^2O^2$; but these salts contain in addition one equivalent of water, so that we are obliged to represent them by $P^2O^3.\ M^2O^2.\ H^2O$. The remaining water in these salts, is merely the eliminable water of crystallisation; the hydrated salts then have the following composition:

$$(P^2O^3.\ M^2O^2.\ H^2O) + 1, 2, 3 \dots H^2O.$$

Phosphoric acid is tribasic, and in combining with oxides gives rise to three kinds of salts, which contain respectively

$$\begin{array}{l} P^2O^5.\ \ MO.\ 2\,H^2O \\ P^2O^5.\ 2\,MO.\ \ H^2O \\ P^2O^5.\ 3\,MO, \end{array}$$

the water being incapable of elimination without the production of a total alteration in the constitution of the salts. As regards formic acid, which contains $C^2H^4O^4$, and which is monobasic, we could if we chose, represent it in a manner similar to that of hypophosphorous acid, as $C^2O^2.\ H^2O.\ H^2O$, and the formates by $C^2O^2.\ MO.\ H^2O$. But we choose, for a reason we will not explain to represent these salts by

$$C^2H^2O^3.\ MO.$$

Instead of giving this terrific explanation to the pupil, would it not be preferable to place before him the following table?

	PH^3		Salts.
Acid hypophosphorous....	PH^3O^2	monobasic....	$PH^2\,M\,O^2$
„ phosphorous	PH^3O^3	bibasic	$PH\ M^2O^3$
„ phosphoric	PH^3O^4	tribasic	$P\ \ M^3O^4$,

and simply to point out to him, that in this instance, the degree of basity increases with the quantity of oxygen.

If we proceed to organic chemistry, what conventional formulæ shall we adopt? We have a dozen for acetic acid, and, consequently the same number for the majority of the acids. Which then are we to choose, and why prefer this one to the other?

Berzelius is the only chemist who has given a complete system of formulæ, based upon a single principle.

Must we then follow him to extremes, and for the assistance of the memory adopt his copulæ? Must we for this simple series of acids:

$$\begin{array}{l} C\,H^2\,O^2 \\ C^2H^4\,O^2 \\ C^3H^6\,O^2 \\ C^4H^8\,O^2 \\ C^5H^{10}O^2, \end{array}$$

substitute this one:

$$\begin{array}{r} (H^2)\,C^2O^3.H^2O \\ (C^2H^6)\,C^2O^3.H^2O \\ (C^4H^{10})C^2O^3.H^2O \\ (C^6H^{14})C^2O^3.H^2O \\ (C^2H^{18})C^2O^3.H^2O. \end{array}$$

Must we for this series of aldehyds:

$$\begin{array}{l} C^2H^4\quad O \\ C^2H^3Cl\,O \\ C^2H^2Cl^2O \\ C^2H\,Cl^3O \\ C^2\quad Cl^4O \end{array}$$

substitute the following:

$$\begin{array}{l} C^4H^6.O + H^2O \\ (C^4H^6.Cl^6) + 2(C^4H^6.O^3) \\ C^2Cl^6 + (C^4H^6.O^3) \\ (C^4H^6)\,2\,C^2O^3 + 3\,C^2Cl^6 \\ C^2O^3 + 2\,C^2Cl^6. \end{array}$$

I repeat that I have not chosen rare and confused formulæ, and thus caused my own opinion to triumph by an exaggerated contrast. No: the cases which I adduce are the most simple and the most common, they are the formulæ proposed by the chiefs of doctrinal chemistry; they are those represented to us as incontrovertible, or, at least, *which we cannot reject, without suffering from the imputations of having false and twisted imaginations, or of being blind or lunatic.* What then would be the complexity, were I to bring forward copulated, conjugated, and intimately combined formulæ, such as those of citric acid and citranilide?

I quote verbatim an appreciation of these formulæ: "A very ingenious idea has been put forth concerning the constitution of citric acid. In accordance therewith, the anhydrous acid would be formed of 1 molecule of anhydrous aconitic acid, and 2 molecules of $C^4H^4O^4$ intimately conjugated. Consequently, citranilide ought to have the following constitution:

$$\left\{\begin{array}{l}
\left.\begin{array}{l} C^{12}H^{10} \\ C^4\,H^2\,O^2 \\ \quad H^2 \end{array}\right\} N^2 \\
\left.\begin{array}{l} C^{12}H^{10} \\ C^4\,H^4\,O^3 \\ \quad H^2 \end{array}\right\} N^2 \\
\left.\begin{array}{l} C^{12}H^{10} \\ C^4\,H^4\,O^3 \\ \quad H^2 \end{array}\right\} N^2
\end{array}\right.$$

Is it, indeed, by such formulæ, taken simply from a conventional point of view, that we can hope to facilitate the study of chemistry? And even when we take the most simple example, that which all chemists admit, namely, the formulæ of the cyanides; what is there to prove that these salts are better represented by CN.M, than by CNM?

I have no hesitation in saying, that for representing the composition of acids, salts, and the majority of organic substances, empiric formulæ are infinitely preferable to those in ordinary use.

With regard to the salts of the alcaloids, to the ethers and to the amides, something may be done for the assistance of the memory, in permitting us to seize upon the relations which exist between the bodies constituting each of these classes. We might even avail ourselves of certain examples which are found here and there throughout organic chemistry. Thus we might, with Dumas, represent the composition (not the atomic arrangement) of the vinic ethers by saying that they all contain a hydrated or hydrogenised acid, plus C^4H^8; or what comes exactly to the same thing, that they contain a hydrated or hydrogenised acid minus one equivalent of hydrogen (H^2), and plus one equivalent of a constant group, C^4H^{10}, or even that they contain an anhydrous acid plus a constant group, $C^4H^{10}O$, &c.

CLASSIFICATION.

In the natural sciences, classifications reflect up to a certain point the systems which prevail in these sciences. In mineral chemistry the classification is intimately bound up with the system of Lavoisier; it has, however, been somewhat modified by dualistic notions. This classification, as it exists at the present day, is sufficient for the requirements of science: some few substances, indeed, are not included in it, but these do not form any part of elementary instruction. But if we pass to organic chemistry, we perceive that the classification reflects, at one and the same time, all the systems which have been successively proposed, and presents such disorder, such discordance, that there is scarcely a single body which cannot be arranged successively in every class.

The confusion does not arise from the fact of one chemist following one classification, and another chemist following a different one; the confusion prevails equally in the classification of one and the same author. Let us take as an example that of Berzelius, since it is the one which, with some unimportant modifications, is employed in the majority of treatises on chemistry.

Bodies are divided at first into two great classes,—those which belong to mineral and those which belong to organic chemistry. But this division is altogether arbitrary; thus there are included among mineral substances carbonic, oxalic, rhodizonic, cyanhydric, sulphocyanhydric, mellitic, &c., acids, and consequently we are surprised at not finding stearic acid comprised in the same category.

Organic substances include the following principal groups:—acids, alkaloids, neutral bodies, ethers, fats, essential oils, resins, and colouring matters; products of destructive distillation, fermentation, putrefaction, &c. One class contains natural and another artificial products.

Some bodies are classed according to the manner in which we suppose the atoms to be arranged; and as we have before seen that six or seven different formulæ have been proposed, as representing the arrangement of the atoms of acetic acid, it is clear that this body can occupy six or seven different places in such a classification.

Lastly, since I proposed the first rough sketch of my classification, the majority of chemists have adopted some of my series, founded upon the metamorphoses which substances undergo.

To manifest the impossibility of discovering the position of a body in such a classification, I would ask into what class ought we to put the oil of winter green (*Gaultheria procumbens*), an extremely well known substance,

1°, It is an acid; 2°, it is a natural volatile oil; 3°, it can be prepared artifically; 4°, it is an ether; 5°, it is a salicylate; 6°, it is a combination of one of the products of the distillation of wood; 7°, we can suppose that it contains methyl or methylene; 8°, it is a product of the metamorphosis of salicine and of hydruret of salicyl; 9°, it may be classed as a carbophenate of methyl; 10°, among the products of distillation of oil; 11°, among the carbonates; 12°, by the side of benzoic acid, which itself belongs to the carbophenates, &c.

But this is not all. Where are we to place the chloro, bichloro, nitro, binitro derivatives, &c.? Among the chlorides, the oxychlorides, yellow colouring matters, the nitrites, the nitrates, &c. Lastly, by considering that we may regard it as a copulated combination, we shall be able to find for it a great many other places: *ab uno disce omnes.*

Liebig endeavoured to make a classification, based simply upon the existence of organic radicals, but he found himself unable to carry it out, for after having given the combinations of ethyl, methyl, cacodyl, formyl, and oxide of carbon, he returned very nearly to the divisions of Berzelius.

Graham distributes organic substances in the following manner: 1°, amide combinations; 2°, amylaceous and saccharine substances; 3°, products of the fermentation of sugar; 4°, products of the distillation of wood, oil, &c,; 5°, amygdaline; 6°, glycerine and the fats; 7°, the essential oils and resins; 8°, the proximate principles of certain plants; 9°, albumen and vegetable casein; 10°, colouring matters; 11°, acids; 12°, alkaloids; 13°, cyanogen and its combinations; 14°, uric acid; 15°, animal principles.

Thenard's classification is distinguished from the preceding by manifest tendency to classify bodies according to their composition and their functions: its principal divisions are the volatile acids, the fixed acids, the alkaloids, substances whose composition is represented by carbon *plus* water (gum, sugar, starch), the methylic, vinic, and amylic ethers, the amides, the combinations of cyanogen, &c. It was not at that time possible to construct a better arrangement.

Dumas's classification resembles Thenard's; but it is to Dumas that we owe an element of the utmost importance, and one which has been introduced into all classifications; I speak of his theory of ethers, by which he was induced to put into one and the same class olefiant gas, Dutch liquid, ether, alcohol, and all the vinic combinations.

Gmelin's classification being based upon mine, I shall not further allude to it. That of Gerhardt, which has no relation to the preceding, will be spoken of further on.

NOMENCLATURE.

Having seen the confusion which prevails in chemical classifications, we shall not be surprised at seeing a similar condition obtain in the nomenclature; since this latter, not only bears to an equal degree with the former, the imprint of various systems, but even that of various conceptions, which I willingly declare to be foreign to chemistry.

The nomenclature of mineral chemistry has, up to this day, scarcely satisfied the requirements of science: after having employed such names as the hypersulphomolybdate of potash, the sesquibasic ammoniaco-sulpharseniate of soda, the tungstic oxyfluoride of ammonium, and a thousand others similar to them, we have been obliged to resort, for certain classes of more complex bodies, to unmeaning or empiric names, such as topaz, ruby, emerald, spinelle, chrichtonite, arfwedsonite, andreasbergolite, &c.

But such as it is, even at the present day, it is perfect order and harmony, in comparison with that which we see employed in organic chemistry.

This is the mode in which these names have been formed; regard has been had:

1°, To the origin of the body; as in the names of the malic, capric, and benzoic acids.

2°, To colour, appearance, brilliancy, odour, &c.; as in the names of the xanthic, euchroic, margaric, and stilbic acids, of cacodyl, odmyl, &c.

3°, To the names of the authors; hence we have the sulphates, nitrates, chlorides of the salts of Gros, Reiset, Raewsky.

4°, To the mode of preparation or decomposition of the body; hence we have the pyrotartaric, pyrocitric, and pyroterebilic acids.

5°, To the manner in which the atoms are supposed to be arranged; hence we have the names, sulphate of ethyl, chloride of decahexyle, nitrite of oxide of icodecatesseryle, susporrindenous sub-hypochlorite, fulvindinous hypochlorite, &c.*

This last method is the one most generally employed, and the one which leads to the greatest confusion in the nomenclature, since a body has in this way as many different names, as there have been different arrangements of the atoms proposed.

What name ought to be applied to the body, which consists of $C^{14}H^{10}O^{2}Cl^{2}$? the component atoms have been arranged as follows:—

1°, $C^{14}H^{10}O^{2}.Cl^{2}$, the chloride of benzoyl.

2°, $2\ C^{14}H^{10}O^{3}.C^{14}H^{10}Cl^{6}$, the bibenzoate of chloro-benzoyl, or benzoic oxichloride.

3°, $C^{14}H^{10}\left\{\begin{matrix}O^{2}\\Cl^{2}\end{matrix}\right.$, another kind of benzoic oxichloride, or chloro-benzoic acid; another body has, however, been already called by this name.

4°, $C^{14}H^{8}Cl^{2}O^{2}.H^{2}$, the hyduret of chloro-benzoyl.

5°, $C^{14}H^{10}Cl^{2}.O^{2}$, the binoxide of chloro-benzine.

6°, $C^{14}.H^{10}Cl^{2}.O^{2}$, for which no name has been proposed.

7°, The formulæ may be subdivided by copulæ. Each imaginary copula that we might choose to introduce, would require a new name for the body.

We could conclude our examination at this point, by saying, that we have not any systematic nomenclature for the designation of organic substances.

Nevertheless, I ought not to pass over in silence, the very remarkable nomenclature which has been published by Gmelin, and which enables us, from the name of a body, to determine its composition, and reciprocally from its composition to determine its name.

Dumas had conceived the idea of representing the number of the atoms of chlorine, which entered into a combination, by means of the vowels a, e, i, o, and u, equal to 1, 2, 3, 4, and 5, respectively.

In following out this primary idea, I had endeavoured to frame a nomenclature, in which the names employed should indicate the composition of the bodies. I obtained in this manner, ethene, chlorethase, chlorethese, chloride of chlorethase, ethum, oxide of ethene, ethous acid, ethic acid, chlorethisic acid, &c., which are undoubtedly quite as convenient as the corresponding names

---

* Names proposed by Berzelius for bichloronapthalin, nitronapthalin, chlorisatin, and chlorisathyd respectively (WO).

bicarburetted hydrogen, chloride of aldehydene, aldehydic acid, chloracetic acid, &c.

Nevertheless, I arrived unfortunately at several names of the following description: amachlorephemusic acid, sulfindate of sulfechlorindilum, chloride of chloré-illose, &c., which although not more barbarous than the hypersulphomolybdate of potash, or the susporrindinous subhypochlorite, had not any chance of being accepted by chemists.

The nomenclature of Gmelin has certain analogies with mine, inasmuch as the letters which compose the names have a numerical value, but these letters have another advantage, namely, that of designating the actual substances which enter into each combination. Here, again, and even to a greater degree than in my system, do we arrive at names so extraordinary, that notwithstanding their brevity, they have not any chance of being adopted. I will adduce the following as illustrations.

Alan .... = $\cancel{H}O$
Afen .... = $S\,O^2$
Afin .... = $S\,O^3$
Efun .... = S^2O^5
Ofun .... = S^4O^5
Apuk .... = $\cancel{P}\,\cancel{Cl}^5$
Arilf .... = $\cancel{B}\,\cancel{Fl}^3$
Atolak .... = $\cancel{N}\,\cancel{H}^4\,\cancel{Cl}$
Patan .... = $K\,O$
Mertin .... = F^2O^3
Mertick .... = F^2Cl^3
Patak-platek .... = $K\,\cancel{Cl}$, $Pt\,\cancel{Cl}^2$
Targan-atun .... = $Ag\,O$, $\cancel{N}O^5$
Patan-afin-talkan-afin .... = $KO\,SO^3$, $MgO\,SO^3$
Atolan-telmin-ojafin-weso = Alum ammoniacal
Nefunirth .... = Picric acid
Nevinamtick .... = Chloracetamide
Novinepat .... = Potash acetate
Linavinan .... = Alcohol
Lifavinaf .... = Mercaptan.

APPENDIX.

ON ACIDS, OXIDES, AND SALTS.

We have just seen that the dualistic system rests upon a very uncertain foundation, namely, upon the arrangement of atoms, and that the facts are far from agreeing with the theory.

We have seen moreover, at least as regards organic chemistry, that we have neither classification nor nomenclature, and that the attempts which have been made to classify certain compounds by means of the compound radical theory, have not been carried beyond certain groups of bodies, that had already been associated from another point of view. I believe then, I may venture to propose another system, without incurring the imputation of having thrown confusion into a regularly constituted science.

Before explaining my ideas upon this subject, it is necessary that the reader and I should be perfectly agreed concerning one of the most fundamental points in chemistry. I wish to show that all the combinations of a certain metal, present more analogy to the salts of zinc, than do the salts of potassium to those of silver, gold, or platinum.

In order to avoid the influence invariably exercised on our judgments, by prejudice and habit, I shall call this metal, some of the most common salts of which I am about to examine, by the name of X.

It possesses several degrees of oxidation; there is, however, only one oxide XO, which forms salts. These salts are generally colorless; the majority of them are soluble, crystallisable, and frequently contain water of crystallisation. We find the same properties manifested by the salts of zinc, while the salts of silver are generally anhydrous, and many of the corresponding salts of gold and platinum have no existence.

The action of heat upon certain salts of X zinc, potassium, silver, gold, and platinum, is as follows:

Action of heat upon the chlorides, bromides, and iodides

of potassium	none; very slightly volatile
of X	none; very volatile
of zinc....	none; moderately volatile
of gold and platinum	decomposed

Action of heat upon the sulphates

of potassium	none
of X	$SO^2 + O + XO$
of zinc	$SO^2 + O + ZO$
of gold, silver, and platinum	$SO^2 + O^2 + M$.

Action of a feeble red heat on the nitrates

of potassium	none; or a nitrite
of X	$N^2O^4 + O + XO$
of zinc	$N^2O^4 + O + ZO$
of silver	$N^2O^4 + O^2 + Ag$

Action of heat on the formates

of potash	$KCO^3 + H^2 + CO$
of X	$C^2O^2 + H^2O + XO$
of zinc	$C^2O^2 + H^2O + ZnO$
of silver	$CO^2 + CO + H^2O + Ag$

Judging from its affinities, X ought to be placed upon a level with zinc; thus X can decompose the oxide and chloride of zinc, and reciprocally, zinc can decompose the oxide and chloride of X. Zinc and X can alike displace copper, lead, bismuth, silver, gold, and platinum, from their salts.

Like zinc, X forms fluo-, chloro-, and iodo-bases, which are capable of combining with other fluorides, chlorides, &c. Thus we are acquainted with a fluoborate, a fluosilicate, an auro-chloride, and a platino-chloride of X. Like zinc, it gives rise to numerous double salts, with potassium, sodium, barium, &c. All the salts of X, like those of zinc, combine directly with ammonia and the other volatile alcaloids.

The oxide of X, like that of zinc, forms a soluble combination with potash. We may add, nevertheless, that the salts of X appear to be isomorphous with those of potassium.

It is useless to pursue further the above comparison, which is sustained under all circumstances, and which conducts us to the conclusion, that the salts of X have a greater resemblance to those of zinc, than have the salts of potassium, to those of silver, gold, or platinum, and that, consequently, X ought to be placed in the third section of the metals, along with zinc. Nevertheless, we are accustomed to arrange this body among the simple non-metallic bodies, and to exclude its salts altogether from the class of salts.

If we seek for the cause of this error, we shall find that it consists in the physical state of the body, and of its oxide, X itself being a gas, and its oxide being a very volatile liquid. In a word, by X we mean hydrogen.

If we examine this question attentively, we shall see, that if hydrogen had been a comparatively fixed body, and its oxide fixed and solid, no one would have thought of excluding it from the metals, but it would have been classed among the most electropositive of them. And indeed chlorhydric acid for example, which is placed, we do not know why, at the head of the negative chlorides, so far from having any tendency to combine with the basylous chlorides, is never found united with other than a chlorous chloride; the fluorhydric acid is a basylous fluoride, which combines only with chlorous fluorides, in a manner precisely similar to that of fluoride of potassium.

For some years past several chemists have considered corresponding salts and acids as bodies appertaining to one single type; thus, for instance, sulphuric acid and sulphate of potash have been formulated in this manner:

$$\begin{matrix} H^2O.SO^3 \\ K\ O.SO^3 \end{matrix}$$

or in this:

$$\begin{matrix} H^2.\ SO^4 \\ K.\ SO^4. \end{matrix}$$

Dumas has even gone so far as to conceive, that if we could but condense hydrogen, it would present a metallic aspect.

Nevertheless these chemists, although admitting the identity of type, have constantly separated the functions of acids and salts, or rather they have always divided compound bodies into three principal classes: *acids*, fulfilling electronegative functions; *bases*, fulfilling electropositive functions; and *salts*, in which these two functions are neutralised.

For my part I do not see any difference between acids (meaning thereby the salts of hydrogen) and ordinary salts; neither do I recognise any difference between these two kinds of bodies, and the group of oxides in general.

The distinctions that may be pointed out between acids, oxides, and salts, are certainly not greater, but frequently much less, than those which exist between a potash, and a platinum salt, on the one hand, and between a chloride and a carbonate, or between a cyanide and a margarate on the other.

Reactions are ordinarily appealed to, as warranting this separation of the acids from all other bodies. Seeing the energy with which the ordinary acids attack metals, oxides, and salts, we have been led to consider acids as perfectly distinct from oxides, which are said to have opposite properties, and from salts, which are said to manifest no particular action upon other bodies. But if, avoiding hypothesis, we reduce these reactions to the equational form, we shall not recognise any difference between such as are produced by the agency of an acid, and such as are produced by the agency of a salt.

We can moreover affirm, that there are salts equally energetic, nay, even more energetic than are the acids themselves.

Thus the chlorhydric and sulphuric acids are very far from attacking all the metals; but if we replace the acids by the chlorides or sulphates of silver, gold, or platinum, the metals unattackable by the acids become instantly dissolved, whilst the silver, gold, or platinum is set free.

Sulphuric acid attacks metallic oxides; but does it in this respect differ from the sulphates of silver or platinum, which also attack the same oxides?—Are not the two reactions precisely similar?

$$H^2SO^4 + KO = KSO^4 + H^2 O$$
$$AgSO^4 + KO = KSO^4 + Ag O.$$

Are not the nitrates as energetic in their character as nitric acid itself? Do not the nitrates of silver, copper, and lead, act rapidly upon iron, zinc, and manganese?

Does not nitrate of potash attack a host of bodies which resist the action of nitric acid?

In all treatises on chemistry the authors examine separately:— 1°, The action of acids upon oxides; 2°, The action of acids upon salts; 3°, The action of oxides upon salts; 4°, The action of salts upon salts. In what do these actions differ from one another? Ought not they all to be comprised under one single head,—that of the action of salts upon salts? And indeed, whether the salts are combinations of *hydrogenium* or of potassium, whether oxides or chlorides, whether carbonates or margarates, the reactions are always of the same character.

$$\begin{array}{ll} Pt\,Cl^2 + F & H^2Cl^2 + F \\ = F\;Cl^2 + Pt & = F\,Cl^2 + H^2 \\ & \\ Cu\,SO^4 + F & H^2SO^4 + F \\ = F\;SO^4 + Cu & = F\;SO^4 + H^2 \end{array}$$

$$\begin{array}{llll} CuSO^4 + K\ O & & H^2SO^4 + K\ O \\ = K\ SO^4 + CuO & & = K\ SO^4 + H^2O \end{array}$$

$$\begin{array}{llll} CuCl^2 + BaO & & H^2Cl^2 + BaO \\ = BaCl^2 + CuO & & = BaCl^2 + H^2O \end{array}$$

I admit that the acids or salts of hydrogen are possessed of well marked special properties, which do not allow them to be compounded with the salts of potassium or of silver. The oxides, also, have characteristic properties, by which they are strongly contradistinguished from nitrates, or margarates. But are not the salts of potassium also possessed of characteristic properties? Who could confound a salt of gold with a salt of any other metal? If a difference does exist between the oxide and the carbonate of potassium, is not the difference which exists between this last body and the nitrate, cyanide, or picrate of potash, much greater? If alumina and its phosphate, which resemble one another so much as to be often confounded, are nevertheless removed by chemists to a great distance one from the other; where pray will they place the chloride of gold, which has so little resemblance either to alumina or to its phosphate? If I had to classify these three bodies, I would rather put the oxide of aluminum and its phosphate into one class, and the chloride of gold into another; or even put the oxide of aluminum and the chloride of gold into one class, and the aluminous phosphate into another; rather than put the oxide of aluminum apart, and arrange the phosphate of aluminum with the chloride of gold.

If we examine this question in every point of view, we shall see that chlorhydric acid, potash, and chloride of potassium belong but to one single class, namely, the class of salts.

The origin of the extreme distinctions that chemists have established between these three bodies is simply due: to the physical states of hydrogen and of water; to the abundance of the latter; to the facility with which it can be eliminated by desiccation; to the indifference which chemists and operatives attach to its presence in the majority of chemical compounds and reactions; and lastly, to the circumstances of its being employed as a solvent.

The influence which the rarity or abundance of a substance exercises upon our classifications is much greater than we should at first sight imagine. Thus with regard to the classification of the salts of potash, all chemists are indifferent whether they are placed together, or whether they are separated and partitioned out in the different categories of salts, as chlorides, sulphates, nitrates, &c.; this is a point which does not trouble them much.

But with regard to the salts of palladium, we prefer having them all placed in the same class; we like to have the molybdates together, and we would not willingly separate cinchonine from its combinations. Whether the acetates be partitioned among the salts of potassium, sodium, ammonium, &c., or whether they be united in the same class, is a matter of small consequence, because acetic acid is not expensive; but with regard to the picrates, we should not like to distribute them in any such manner.

Having thus associated certain compounds, which chemists separate, I proceed now to separate certain other compounds which they associate. The anhydrous and the hydrated acids are always confounded and employed, theoretically at least, the one for the other. Nevertheless, these bodies do not present any analogy; under no circumstance whatever, do they comport themselves in the same manner: their functions are entirely different. Take for example the anhydrous sulphuric acid and the sulphate of hydrogen. The first does not combine with metals; the second does combine with them, at the same time liberating hydrogen. The first unites directly with metallic oxides; the second gives rise to a double decomposition. The first does not decompose chlorides, and even combines with some of them; whereas the second decomposes them. The first, by acting upon the anhydrous carbonate of ammonia, does not give rise to the sulphate of ammonium; but the second does. The first forms, with the volatile alkaloids, amides or amidic acids; the second gives rise to salts. The first combines with chloride of ammonium; the second decomposes it. The first behaves in one manner with the alcohols, amides, and hydrocarbons; the second behaves in another. The parallel may be pursued as far as we please, and under no circumstances shall we discover any analogy between the reactions. If in opposition to this opinion any one were to advance the decomposition of carbonate of potash by the anhydrous and the hydrated sulphuric acid, I would ask in reply if the action of oxamide upon potash is the same as that of oxalate of ammonia upon the same base, and whether it is always necessary to neglect, on account of its cheapness, the water which is added or eliminated?

The anhydrous and the hydrated acids, then, have not any analogy with one another, and ought to be placed in two perfectly distinct classes. Nevertheless it is not without reason that chemists have associated them together. It is indeed true that these bodies are not without some community of properties; but the relations which exist between them are of the same order as those which exist between the sulphide of copper and its sulphate,—between sulphuric acid and sulphur,—between anhydrous sulphuric acid and sulphate of potash,—between an integrant molecule and its constituent molecules, but nothing more.

The above relations have nothing in common with the relations we observe between sulphur, selenium and tellurium —between the sulphurous and selenious acids—between the sulphate of potash and that of soda. The bodies of the former class are associated with one another by the presence of sulphur in each of them. The bodies of the second class are correlated by a similitude of functions.

The anhydrous and the hydrated sulphuric acid have this in common, they both contain sulphur and oxygen; but with regard to analogy of properties, they do not manifest any whatever.

SECOND PART.

EVEN NUMBERS AND DIVISIBILITY OF ATOMS.

FIRST SECTION.

Even Numbers.

UPON THE EVEN NUMBERS OF THE ATOMS.

Having thus criticised the system of chemistry generally followed, I proceed now to demonstrate the principal facts which serve as a foundation for the one I am about to propose.

By the term *atoms* I understand the equivalents of Gerhardt, or, what comes to the same thing, the atoms of Berzelius, with the exception of those of the metals, which are halved. Thus, I shall write H^2O, K^2O, H^2Cl^2, K^2Cl^2, $H^2N^2O^6$, $K^2N^2O^6$, &c. In order to avoid all hypothesis, I shall not attach to the term *atom* any other sense than that which is included by the term proportional number.

I apply the words *molecules* or *atoms* to the equivalents or atoms of compound bodies, such as they are admitted by nearly all chemists, employing, however, Gerhardt's numbers, as above referred to. I shall have to propose considerable alterations further on.

First Proposition (made by Gerhardt).

In every organic substance, the number of the atoms of each simple body is an even number. To this proposition I add the following.

Second Proposition.

In every substance, mineral or organic, the number of the atoms of each simple body is even; and, moreover, the sum of the atoms of *hydrogen, the metals, chlorine and its analogues, nitrogen and its analogues, is a multiple of* 4.

These two propositions can be reduced to a single one; but for that purpose it is necessary to make a classification of the simple bodies. I divide them into two classes:—

First.	Oxygen Sulphur Selenium Tellurium	Carbon Silicon	
Second.	Hydrogen Metals	Fluorine Chlorine Bromine Iodine	Nitrogen Phosphorus. Arsenic Antimony.

I call the bodies of the first class *monads*, and those of the second class *dyads.*

It may be remarked that, according to the notation of Berzelius, the dyads, with the exception of the metals, only enter into combination by double atoms.

The atoms of the metals being halved, it will be seen that I apply the term monads to the simple atoms of Berzelius, *minus* those of the metals—and the term dyads to the double atoms of Berzelius, *plus* those of the metals.

We can now replace the preceding two propositions by the following one:

In every molecule of a mineral or organic substance, the monads and the dyads are represented by even numbers, and the sum of the dyads is a multiple of 4.

The following are examples of the application of this proposition. (The dyads are placed in parentheses.)

Acid formic	.... $C^2 O^4 (H^4)$
Aldehyd	.... $C^4 O^2 (H^8)$
Alcohol	.... $C^4 O^2 (H^{12})$
Acid nitric	.... $O^6 (N^2 H^2)$
Acid cyanhydric....	.... $C^2 (N^2 H^2)$
Ammonia cyanhydrate	.... $C^2 (N^4 H^8)$
Potash chlorate	.... $O^6 (Cl^2 K^2)$

To so singular a proposition a host of objections may be offered; thus some of the bodies best known to chemists, as water, sulphurous, sulphuric, carbonic, and oxalic acids, have compositions which do not accord with the rule.

Be this as it may, let us divide compound bodies into two series; let us put into the first such bodies as conform to the proposition, and into the second such as are contrary to it.

First Series.

Fluorhydric acid	$(Fl^2 H^2)$
Chlorhydric acid	$(Cl^2 H^2)$
Hypochlorites	$O^2 (Cl^2 M^2)$
Chlorites	$O^4 (Cl^2 M^2)$
Chlorates	$O^6 (Cl^2 M^2)$
Perchlorates	$O^8 (Cl^2 M^2)$
Nitric acid	$O^6 (N^2 H^2)$
Ammonia	$(H^6 N^2)$
Ammonia nitrate	$O^6 (H^8 N^4)$
Phosphuretted hydrogen	$(H^6 Ph^2)$
Formic acid	$C^2 O^4 (H^4)$
Cyanhydric acid	$C^2 (H^2 N^2)$
Marsh gas	$C^2 (H^8)$
Chloroform	$C^2 (H^2 Cl^6)$
Acetic acid	$C^4 O^4 (H^8)$
Perchloride of carbon	$C^4 (Cl^{12})$
Propionic acid	$C^6 O^4 (H^{12})$
Butyrene	$C^8 (H^{16})$
Butyramide	$C^8 O^2 (H^{18} N^2)$
Butyric nitryle	$C^8 (H^{14} N^2)$
Butyric aldehyd	$C^8 O^2 (H^{16})$
Butyramine	$C^8 (H^{22} N^2)$
Benzamide	$C^{14} O^2 (H^{14} N^2)$
Nitro-benzamide	$C^{14} O^6 (H^{12} N^4)$
Picric acid	$C^{12} O^{14} (H^6 N^6)$.

Second Series.

Water	$O (H^2)$
Sulphuretted hydrogen	$S (H^2)$
Anhydrous sulphurous acid	SO^2
Anhydrous sulphuric acid	SO^3
Anhydrous nitric acid	$O^5 (N^2)$
Anhydrous phosphoric acid	$O^5 (P^2)$
Anhydrous carbonic acid	CO^2
Carbonates	$CO^3 (M^2)$

Carbamide	$CO^2 (H^4 N^2)$
Cyanogen	$C^2 (N^2)$
Oxalic acid	$C^2 O^4 (H^2)$
Anhydrous acetic acid	$C^4 O^3 (H^6)$
Oxamide	$C^2 O^2 (H^4 N^2)$
Methylic oxalate	$C^4 O^4 (H^6)$
Tartaric acid	$C^4 O^6 (H^6)$
Itaconic acid	$C^5 O^5 (H^6)$
Anhydrous camphoric acid	$C^{10} O^5 (H^{14})$
Kakodyl	$C^4 \quad (H^{12} As^2)$
Ethyl	$C^4 \quad (H^{10})$
Amyl	$C^{10} \quad (H^{22})$
Flavine	$C^{13} O \ (H^{12} N^2)$
Benzone	$C^{13} O \ (H^{10})$
Ether	$C^4 O \ (H^{10})$
Pthalic acid	$C^8 O^4 (H^6)$.

To these two series, I must yet add the two following, which do not accord with our propositions.

One of them contains bodies which are crystallisable or susceptible of being purified, but the analyses of which are anterior to the period at which Gerhardt and I put forward our propositions.

The other series consists of impure or uncrystallisable bodies.

Third Series.

Stearic acid	$C^{68} O^7 (H^{136})$
Gelatine sugar	$C^8 O^7 (H^{18} N^4)$
Nitrosaccharic acid	$C^8 O^{19} (H^{22} N^3)$
Quinone	$C^{25} O^8 (H^{16})$
Furfuramide	$C^{15} O^3 (H^{12} N^2)$
Essence of estragon*	$C^{32} O^3 (H^{40})$
Anisic acid	$C^{16} O^6 (H^{14})$
Nitranisic acid	$C^{16} O^{10} (H^{12} N^2)$
Orcine	$C^{16} O \ (H^{22})$
Amylosulphamic acid	$C^{10} S^2 O^6 (H^{32} N^2)$
Oleic acid	
Chlorisatine	

Fourth Series.

Protein	$C^{48} O^{15} (H^{74} N^{12})$
Chondrin	$C^{16} O^7 (H^{26} N^4)$

---

* Tarragon—Artemisia Dracunculus.—(W.O.)

Pectin	$C^{28} O^{24} (H^{42})$
Emulsin	$C^{7} O^{11} (H^{16} N^{2})$
Fibrin	$C^{39} O^{17} (H^{62} N^{12})$
Crenic acid	$C^{7} O^{6} (H^{16} N)$
Apocrenic acid	$C^{7} O^{3} (H^{14} N^{3})$
Glucic acid	$C^{24} O^{15} (H^{30})$
Melenic sulphide	$C^{7} S^{6} (H^{8} N^{8})$
Xanthenic sulphide	$C^{3} S^{2} (H^{4} N^{4})$
Phaienic sulphide	$C^{8} S^{4} (H^{10} N^{12})$
Thebaine	$C^{25} O^{3} (H^{28} N^{2})$
Sabadilline	$C^{20} O^{6} (H^{28} N^{2})$.

I shall put the two latter series aside, and for the present confine myself to the two former. I shall proceed in a succession of remarks, to point out the very great differences which exist between the bodies of the first, and those of the second series.

REMARKS.

I.—Volumes of the Bodies.

The number of the bodies of the first, is perhaps twenty times greater than that of the bodies of the second series. But setting aside this consideration, let us direct our attention to the following remark, which was made by Gerhardt and which merits our utmost attention.

The bodies of the first series are represented by 4 *volumes, those of the second by* 2 *volumes of vapour.*

Such a coincidence between even and uneven numbers, and 4 and 2 volumes respectively, cannot be due to chance. Thus when we meet with a body, of which the monads form an odd number, or of which the sum of the dyads is not a multiple of 4, we can predicate that its molecule will be represented by 2 volumes.

Nevertheless I have a slight modification to make in the above remark: to this point I shall revert further on.

II.—Volumes of the Ethers.

The acids of the first series produce 4 *volume ethers ; those of the* *second* 2 *volume ethers* (Gerhardt). I do not know of any exception to this rule. It must not be forgotten that I apply the term acids, exclusively to the salts of hydrogen; consequently, the above remark does not refer to the nitric and acetic anhydrides, which are inscribed as members of the second series.

III.—Acid Salts.

In general, the acids of the first series do not give rise to acid salts, whilst those of the second do so readily.

Thus we do not know of a single acid nitrate, nitrite, chlorate, chloride, or bromide. It is only with considerable difficulty that we can obtain in the concentrated acids, one or two very unstable acid formates and acetates.

We might also adduce a very small number of acid salts similar to the acid iodate of potash; but several observations have to be made upon this subject, which will find their place elsewhere.

We know on the other hand, that nearly all the sulphites, sulphates, carbonates, borates, chromates, oxalates, tartrates, alloxanates, &c., can be obtained in the form of acid salts.

IV.—Double Salts.

In general, the acids of the first series do not give rise to double salts (1 in 100 perhaps), *whilst those of the second series form them readily, and in very great number.*

The most simple salts of chemistry must however be excepted from this remark, since the fluorides, chlorides, bromides, iodides and cyanides, very easily produce double salts.

V.—Hybrid Salts.

I call by the name hybrid, the double, triple, and quadruple salts, &c., of which the bases are united in all proportions, as is the case with granites, epidotes, certain carbonates, phosphates, silicates, oxides, sulphides, &c.

The acids of the first series do not give rise to hybrids, these compounds being met with exclusively among the bodies of the second series.

VI.—Number of the Ethers.

The acids of the first series have but one ether, those of the second have two.

Thus we have but one of each of the nitrous, nitric, hydrochloric, formic, and acetic ethers, &c., while we have two of each of the sulphydric, sulphuric, carbonic, and oxalic ethers, &c.

VII.—Alcoholidic Acids.

The acids of the first series do not produce alcoholidic acids, those of the second do.

Thus we are not acquainted with any nitro-, chlorhydro-, formio-, aceto-............methylic, vinic, or amylic acids; whilst the sulphydro-, sulpho-, phospho-, carbo-, oxalo-, succino-............ vinic, and methylic, amylic acids, are well known to us.

VIII.—Number of the Amides.

The acids of the first series are capable of giving origin to only two kinds of amides; whilst those of the second series can produce four kinds.

Thus the acids of the first series form amides, and imides or nitryls, such as acetamide and acetonitryl, benzamide and benzonitryl. Oxalic acid which belongs to the second series, produces oxamide, oxamic acid, cyanogen, and oximide.* It would be more exact to say, *That the acids of the first series give origin to amides corresponding to neutral salts; while the acids of the second series can form amides corresponding both to neutral and to acid salts.*

IX.—Amidic Acids.

The acids of the second series only, give rise to amidic acids.

We are not acquainted with any nitramic, chloramic, formamic,

---

* I believe that leucoturic acid is no other than oximide, moreover we are acquainted with melanilic oximide.—(L.)

Oximelanile or melanilic oximide, is melaniline in which two atoms of hydrogen are replaced by one atom of oxalyle:

Melaniline $= C^{13} H^{13} N^{3}$
Oxamelanile $= C^{13} H^{11} (C^{2} O^{2}) N^{3}$

Oximide would be ammonia in which two atoms of hydrogen were replaced by one atom of oxalyle, and would result from the equation

$$\left.\begin{matrix} NH^{4}.H.O \\ C^{2}O^{2}.O \end{matrix}\right\} - 2\,H^{2}O = NH\,C^{2}O^{2},$$ which compound

does not at all agree with the published formula for leucoturic acid. In the latter part of this work Laurent shows that more than four amides may be produced from one single acid.—(W. O.)

acetamic, benzamic, &c., acids; whilst sulphamic, phosphamic, carbamic, oxamic, phtalamic, &c., acids, are well known to us.

X.—Double Ethers.

The acids of the second series only, give rise to double ethers.

There is no double nitrate, chloride, formate or acetate, of methyl and ethyl; while the double oxide, double carbonate, double xanthate, and double oxalate are well known.

XI.—Double Amides.

The acids of the second series only, give rise to double amides.

I may adduce as examples the anilo-ammonio-carbamide, the ammonio-ethylaminic-carbamide, the anilo-ammonio-oxamide.

XII.—Etheramides.

The acids of the second series only, give rise to bodies which may be considered as double combinations of amides and ethers.

Such for instance are urethane, oxamethane, sulphamethane, xanthogenamide, the allophanate of methyl, &c.

XIII.—Copulate Acids.

Copulate, congugate, or complex acids belong exclusively to the first series of acids, but are produced exclusively from acids of the second series.

Such for instance are the sulphobenzidic,* sulphophenic, sulphamic, oxalovinic, carbamic acids, &c.

XIV.—Anhydrides.

Nearly all the anhydrides of the second series may be obtained in a direct manner, by abstracting water from the hydrated acid, either by heat alone or by means of substances powerfully attractive of water; whereas the anhydrides of the first series can only be obtained indirectly.

Thus we can obtain in a direct manner the sulphurous, sulphuric, arsenious, arsenic, carbonic, boric, silicic, chromic, tungstic, molybdic . . . tartaric, camphoric, succinic, phtalic, &c., anhydrides; whilst it is only by indirect means that we can succeed in preparing the nitric, acetic, benzoic, &c., anhydrides. Nevertheless anhy-

---

* This compound is ordinarily called *hypo*sulphobenzidic acid, and is represented by the formula $C^{12}\bar{H}^{5}.\ S^{2}O^{5}.\ \bar{H}O$. Laurent's formula is $C^{6}H^{6}SO^{3}$.—(W.O.)

drous iodic acid may be obtained directly from the hydrated acid. Moreover,

The anhydrides of the second series, by acting upon gaseous ammonia, give rise to amidic acids, while the anhydrides of the first series form neutral amides only.

XV.—Anhydro-Salts.

Acid anhydro-salts, such as the anhydrous bisulphate and bichromate of potash, have been produced from the acids of the second series only. Not a single authentic example can be cited of similar salts being obtained in the presence of water, from acids of the first series.* Since anhydrous sulphuric acid is capable of combining with several kinds of dry salts, such as the chlorides, the anhydrides of the second series may possibly give origin to analogous combinations.

XVI.—Para-Salts.

Up to this time the acids of the second series only, have given origin to para-salts, such as the para-, meta-, pyro- ....phosphates, &c.

Thus we are acquainted with para-, meta-, iso-, poly-............ phosphates, stannates, tellurates, titanates, antimoniates, tungstates, tartrates, citrates, malates, &c.†

XVII.—On the number of Atoms of Water in Salts.

As a rule, in the salts of the first series of acids, the number of the atoms of water is EVEN, *whilst in those of the second series it may be either even or uneven.*

Thus all the chlorides, chlorates, nitrates, formates, and acetates contain 1, 2, 3, 4 . . . times H^4O^2 (rarely $\frac{1}{2}$, $\frac{3}{2}$, $\frac{5}{2}$, H^4O^2). The simple salts of the second series contain 1, 2, 3, 4 . . . times H^2O (very rarely $\frac{1}{2}$, $\frac{3}{2}$, $\frac{5}{2}$, H^2O). I shall return to this subject further on, as also to the number of the atoms of water in acid, double, and basic salts.

XVIII.—Solubility of Salts.

All circumstances being as far as possible analogous, we may say,

---

* An exception, however, must be made in the case of iodic acid. This compound presents many peculiarities; its salts are but little known, and much discrepancy exists with regard to their formulæ.

† The hydroleic, metoleic, and metamargaric acids might be adduced as contrary to this conclusion; but the formulæ that have been attributed to these acids are undoubtedly inexact.

that in general the salts of the first series of acids are soluble, whilst those of the second series are insoluble.

Thus all the nitrites, nitrates, chlorites, chlorates, perchlorates, bromates, formates, acetates,—all the amidic, alcoholidic, and copulated salts,—nearly all the chlorides, bromides, iodides, and fluorides, are soluble; whilst nearly all the oxides, sulphides, sulphites, phosphites, phosphates, arsenites, arseniates, chromates, tungstates, &c.,—borates, silicates, carbonates, oxalates, tartrates, &c., are insoluble.

It is clear that the elementary composition of a salt must exert a great influence upon its solubility, and consequently, in some cases, may negative the remark I have just made. Thus we know that the augmentation of carbon and hydrogen in alkaline, neutral or acid bodies, diminishes their solubility. So we may pass from the formates or acetates, which are very soluble, to the propionates, which are less so, and thence rising in the scale to the caprates, cetates, and margarates, &c., which are perfectly insoluble, though belonging to the first series.

XIX.—VOLATILITY.

In general the acids (i. e. hydrated acids) of the first series are more volatile than those of the second, the majority of which latter indeed, cannot be distilled without decomposition.

Thus the chlorhydric, bromhydric, iodhydric, fluorhydric, nitric, perchloric, formic, acetic, propionic, margaric, benzoic, &c., acids, are volatile (the chloric and iodic acids are not so, but for this there is a definite reason): whilst the sulphuric (boils at a high temperature), hyposulphurous, sulphurous, chromic, tungstic, &c., arsenious, arsenic, phosphoric, boric, silicic, carbonic, oxalic, tartaric, succinic, phtalic, malic, citric, gallic, &c., acids, are not volatile.

It is true that in the first series there may be found a great number of acids, which cannot be distilled without decomposition, but these are the copulated acids, all of which bodies it must be observed are combinations of the acids of the second series.

If it were possible to choose bodies of nearly identical composition, we should still see that the bodies of the second series are less volatile than those of the first. Thus if we compare

Formic ether .... $C^6O^4H^{12}$
with oxalic ether .... $C^6O^4H^{10}$

Acetic ether .... $C^8 O^4 H^{16}$
with succinic ether .... $C^8 O^4 H^{14}$

Benzoic acid .... $C^{14} O^4 H^{12}$
with benzone .... $C^{13} O\ H^{10}$,

we shall see that the first combinations are much more volatile than the second. It would have seemed however, that benzone, which is benzoic acid *minus* carbonic acid and water, ought to be less volatile than the original acid.

XX.—Water, Carbonic Acid, and Chlorine.

When we desire to express in an equation, the reaction of chlorine, bromine, &c., upon one of the bodies of the first series, we are obliged to employ 4 Cl, 4 B, or some multiple of 4. For the second series we can employ 2 Cl, or a multiple of 2 (Laurent). When the reactions of the first series of bodies are expressed in equations, we perceive in nineteen out of every twenty instances that the quantities of water, carbonic acid, or carbonic oxide absorbed or disengaged, are represented by H^4O^2, C^2O^4, and C^2O^2, or some multiple, whilst in all the equations of the second series it is H^2O, CO^2, and CO, or some multiple (Gerhardt).

Preparation.

of Dutch liquid .... $C^4H^8 + Cl^4 = C^4H^8Cl^4$
of perchloride of carbon $C^4H^8 + Cl^{20} = C^4Cl^{12} + H^8Cl^8$
of chloracetic acid .... $C^4H^8O^4 + Cl^{12} = C^8H^2Cl^6O^4 + H^6Cl^6$.

Decomposition.

of formic acid .... $C^2H^4O^4 = C^2O^2 + H^4O^2$
of acetic acid .... $2\ C^4H^8O^4 = C^2O^4 + H^4O^2 + C^6H^{12}O^2$.

On the contrary, we have in the decomposition

of oxalic acid by heat $C^2H^2O^4 = CO + CO^2 + H^2O$
of a carbonate by chlorine $C\ M^2O^3 + Cl^2 = CO^2 + M^2Cl^2 + O$.

XXI.—On the Bodies of the Third Series.

I have arranged in this series certain bodies which do not possess any of the properties I have just pointed out in the compounds of the second series, and of which, the formulæ *did* not correspond with our propositions at the time when they were first announced. Thus the anisic acid for example, of which the dyads are not divisible by 4, gives rise neither to an anhydride, nor to double or acid salts; it has but one ether; it forms neither an amidic, nor an alcoholidic acid; its ether is represented by 4 volumes, &c. This third series at that time comprised one-tenth part of all known bodies, nevertheless Gerhardt and I did not hesitate to declare that all their formulæ would prove to be inexact. Since then, it has been proved that all these formulæ must be replaced by others which are in accordance with our propositions. If these propositions had been false, it would have been ten thousand to one against all the original formulæ proving to be erroneous, and all the corrections coming precisely to the support of our views.

XXII.—On the Bodies of the Fourth Series.

The compounds of this series are uncrystallisable; we do not know whether or not it is possible to purify them: the majority of them contain sulphur and phosphorus; whether these elements form an integral part of the chemical molecule, or whether they enter into the constitution of some other body, which exists in a state of mixture therewith, is unknown: at any rate their composition appears to be extremely complex. It is worthy of remark, that out of the two or three hundred formulæ given to these bodies there are not perhaps more than ten, of which, the monads form an even number and the sum of the dyads is divisible by 4. This is exactly what chance would give rise to, if no law presided over the number of the atoms of compound bodies. If we endeavoured to construct formulæ by drawing hap-hazard even or uneven numbers for the carbon and oxygen, and even numbers for the hydrogen and nitrogen, out of sixteen formulæ one only would have an even number of monads, and the sum of its dyads divisible by 4.

We shall see in an instant that the compounds of the second series accord with our proposition; but if we take all known bodies, pure or impure, we shall see that their formulæ afford results precisely contrary to those which chance would give, that is to say, that the bodies in which the monads exist in an uneven number, and in which the sum of the dyads is indivisible by 4, do not amount to one-sixteenth part of the whole; and, moreover, that this part consists exclusively of impure or uncrystallisable bodies, or else of bodies which are but little known, as thebaine, sabadilline, &c.

XXIII.—Hypothetical Bodies.

All the hypothetical bodies whose existence in combination is admitted *by most chemists, such as formyl, acetyl, ethyl, benzoyl, &c., are contrary to our proposition. Not one of them is in accordance therewith, and we shall presently see why such must be the case.*

The majority of the preceding remarks refer principally to the acids; they apply equally well to nearly all of the neutral bodies, since oxamide, oxalic ether, cyanogen, and oxamethane for example, are combinations which appertain to oxalic acid.

To kakodyl, ethyl, caprone, benzone, &c., I shall revert further on.

Conclusions.

It is very difficult to conceive why bodies having even formulæ should differ so much from those having uneven formulæ; and why to the presence of an uneven number of atoms, there should correspond two-volume vapors, acid or double salts, amidic acids, etheramides, &c.

Now if we cause the uneven numbers to disappear by doubling the formulæ of the second series, all will become generalised—all will be explained, and the paradoxical character of the preceding observations will disappear. By doubling these formulæ,

1°. Our proposition will be free from exceptions;

2°. All bodies will be represented by the same volume of vapour (4);

3°. The sulphydric, sulphurous, sulphuric, carbonic, oxalic, and tartaric acids, &c., will become bibasic. Taking oxalic acid for example: with the formula

$$C^2O^8H^2H^2$$

we can conceive

4°. That it should give rise to an acid oxalate $C^2O^8K^2H^2$.

5°. That it should give rise to a double oxalate $C^2O^8K^2Mg^2$.

6°. That it would no longer present any anomaly in the volume of its neutral ether.

7°. That it should give two ethers, the one corresponding to the neutral salts $C^2O^8Et^2Et^2$; the other corresponding to the acid salts $C^2O^8Et^2H^2$.

8°. That it should form an amidic acid and an alcoholidic acid.

9°. We can conceive why the bibasic acids can transform themselves directly into anhydrides by losing H^4O^2, whilst the monobasic acids cannot behave in the same manner; since if these last should lose an atom or molecule of water, H^4O^2, they would give rise to a body differing from the anhydrous acid. Thus for example formic acid, by the liberation of H^4O^2 gives rise to carbonic oxide and cannot form the anhydrous acid by the loss of H^2O, since H^2O is, according to our agreement, no longer water.[*] Nevertheless we might reverse the reasoning, and say that free anhydrous acetic acid, $C^4H^6O^3$, has only to absorb H^2O in order to form the hydrated acid. But from what we have just now said, the formula for anhydrous acetic acid is $C^8H^{12}O^6$, and with water it can only give rise to the following equation:

$$C^8H^{12}O^6 + H^4O^2 = 2\,C^4H^8O^4.$$

10°. For the same reason the transformation of acetic acid into acetone must be represented by

$$2\,C^4H^8O^4 = C^6H^{12}O^2 + H^4O^2 + C^2O^4,$$

and not by

$$C^4H^8O^4 = C^3H^6O + H^2O + CO^2.$$

All the world is agreed upon this subject, since C^3H^6O does not constitute acetone. I shall return to this subject further on.

11°. We understand now, why the salts of the first series combine with 2, 4, 6, 8 . . . . molecules of water, whilst the salts of the second series can only combine with 1, 2, 3, 4 . . . . molecules. By doubling the formulæ of these last bodies, the number of the molecules of water becomes the same in both cases. We shall presently see why this is always an even number.

12°. By the duplication of the formulæ, the compounds of both series in all their reactions give rise to H^4O^2, C^2O^2, C^2O^4, Cl^4, or multiples thereof.

13°. Lastly, we conceive why in general, the bodies of the second series are less volatile than those of the first, since they now contain a double number of atoms. Thus, in comparing

Benzoic acid, $C^{14}\,H^{12}\,O^4$
with benzone, $C^{13}\,H^{10}\,O$,

---

[*] Water is a bibasic acid which like its analogue sulphydric acid, gives rise to

An acid salt	....	....	$O^2\,K^2\,H^2$	$S^2\,K^2\,H^2$
A double salt	....	....	$O^2\,K^2\,Z^2$	$S^2\,Cu^2\,F^2$
A neutral ether	....	....	$O^2\,Et^2\,Et^2$	$S^2\,Et^2\,Et^2$
An acid ether	...	....	$O^2\,Et^2\,H^2$	$S^2\,Et^2\,H^2$
A double ether	....	....	$O^2\,Et^2\,Me^2$	$S^2\,Et^2\,Me^2$
A hydrovinate	....	....	$O^2\,Et^2\,K^2$	$S^2\,Et^2\,K^2$.

Moreover H^4O^2, like H^4S^2, = 4 volumes.

we were astonished to see this latter so little volatile; but our surprise ceases on writing the formulæ of the two bodies thus:—

Benzoic acid, $C^{14}H^{12}O^4$
Benzone, $C^{26}H^{20}O^2$.

At last, then, we understand what it is that constitutes a bibasic acid.

According to Berzelius, an acid is bibasic in consequence of the indivisibility of its formula: such, for example, is the pyrophosphoric acid, $P^2O^5.2\,H^2O$. I have already shown that by making use of other atomic numbers we could alter the basity of the acids.

According to Liebig, an acid is bibasic when it is capable of forming double salts with certain metals. Liebig was in the right direction, but he stopped short on the road. Thus, he considered the tartaric and alloxanic acids as bibasic, because they can form certain double tartrates and alloxanates. The definition is uncertain, in consequence of the nature of the salts which render an acid bibasic not being pointed out in a sufficiently precise manner,—this precision, moreover, being impossible.

According to Gerhardt, an acid is bibasic when it forms acid salts, or double salts, no matter with what bases. Thus, according to him, sulphurous, sulphuric, carbonic, and oxalic, &c., acids are bibasic. But as even this character is not absolute, since here and there we meet with monobasic acids which give rise to double or acid salts, Gerhardt has added the following axiom:—

Bibasic acids give ethers which correspond to 2 volumes; thus, in the ordinary notation the atom of oxalic ether corresponds to 2 volumes.

The character that Liebig attributes to the bibasic acids appertains in the highest degree to the sulphurous, sulphuric, carbonic, and oxalic acids. Nevertheless, Liebig does not consider these acids as bibasic.

All chemists (even those who rely exclusively upon the doctrine of equivalents) have adopted the opinion of Liebig. Gerhardt has demanded of them, for a long time past, why they consider the tartaric, malic, alloxanic, uric, &c., acids, to be bibasic, whilst they regard the sulphuric, simply as a monobasic acid.

Gerhardt has not yet obtained an answer; nevertheless, it is not difficult to find him one: *an acid is monobasic or bibasic, according to the repute of the chemist who considers it such.*

To the characters given by Gerhardt I would add the following. Bibasic acids can form two ethers, four amides, an alcoholidic acid, an amidic acid, an anhydride (directly), salts with 1, 2, 3, 4 . . . . molecules of water, para- and meta- acids, &c. Thus, according to us, the basity of an acid does not depend entirely, as Berzelius contends, upon the indivisibility of its formula, but upon the nature of its properties. According to Berzelius, Liebig, and indeed to most chemists, stearic acid $C^{68}H^{132}O^{5}.2\,H^{2}O$, is bibasic in consequence of the indivisibility of its formula, whilst margaric acid $C^{34}H^{66}O^{3}.H^{2}O$ is monobasic. But, according to Gerhardt and myself, if this last is monobasic, the first is certainly monobasic likewise. It is impossible to meet with any two bodies which resemble one another so much as do these two acids. They have the same point of fusion, or at least a difference of but a few degrees to distinguish them; their salts and their ethers are nearly indentical; and lastly, stearic acid does not possess any of the characters of the bibasic acids. We have not the least hesitation then, in considering it as monobasic, and consequently we affirm positively that its formula is inexact.

No one can help being struck with all the remarks which I have just made. No one can refuse to admit the necessary consequence, namely, the duplication of the formulæ of the second series of bodies.

Nevertheless, one would without doubt, feel a degree of repugnance thus to complicate all these formulæ; one would object, for instance, to represent sulphuric acid by $S^{2}O^{8}H^{4}$.

I comprehend this repugnance; but we must be logical, and consequently either put up with the complication, or else follow Gerhardt, who proposes to leave intact the ordinary formulæ of the second series, and to simplify all those of the first by dividing them by 2. We should in this manner arrive at a result essentially the same, only instead of representing all bodies by 4 vapor volumes, we should represent them by 2 volumes. The acids of the first series would be monobasic, those of the second would remain bibasic. For example, the nitrate of potash in becoming KNO^{3} would continue monobasic, and the sulphate of potash in becoming $K^{2}SO^{4}$ would continue bibasic.

Not only would the formulæ of the first series, constituting nineteen-twentieths of the whole, be in this manner simplified, but a great number of the formulæ of the second series would be similarly affected. Thus, sulphovinic acid is ordinarily represented by $Et^{2}SO^{4}.H^{2}SO^{4}$. This formula would become according to the 2-volume notation, $EtHSO^{4}$.

The bisulphate of potash $K^2SO^4.H^2SO^4$, would become $KHSO^4$, &c.

Lastly, the remark we have made concerning the molecules of water, which are always found in even numbers, is now easily explained, since in dividing the formulæ by 2, the number of the molecules follows the ordinary progression, 1, 2, 3, 4.

We conceive in the same manner, why in our reactions, we always see C^2O^4, C^2O^2,Cl^4, H^4O^2, make their appearance.

In consequence of this new convention then, our fundamental proposition will become simplified, and will receive the following form:—

In compound bodies, the monads and dyads are expressed by an even or uneven number, but the sum of the dyads is always an even number; or still more simply, *the sum of the dyads is an even number.*

Thus the law of Gerhardt, that all bodies contain an even number of atoms, no longer exists, but is replaced by an equivalent advantage, namely, the simplification of all the formulæ.

We call the formulæ, as simplified in the above manner, *unitary*, in opposition to the dualistic or additive formulæ, since it becomes impossible in the unitary notation to represent the formulæ of the monobasic acids by water *plus* anhydrous acid. Indeed we now write

Water....	H^2O
Nitric acid	HNO^3
Chloracetic acid	$HC^2Cl^3O^2$.

The nitric and chloracetic acids, which have but one equivalent of H, cannot then contain H^2O.

As hereafter I shall employ exclusively the 2-volume notation of Gerhardt, I must here call particular attention to the difference which exists between it and the notation of Berzelius.

For the simple bodies, Gerhardt employs the atoms of Berzelius, excepting those of the metals, which he halves.

For the compound bodies, he halves all the formulæ of Berzelius.

It is evident that the formula of sulphuric acid remains the same in the two notations, that is to say, that no alteration is made in the formulæ of those bibasic acids which were not considered as bibasic by Berzelius.

I have said above, that Gerhardt* considers his atoms either

---

* Gerhardt, in his later writings, always considers one volume of oxygen as equivalent to two volumes of chlorine or hydrogen.—(W.O.)

as volumes or equivalents. Thus, according to him, 1 volume of hydrogen, or 1 volume of chlorine, is the equivalent of 1 volume of oxygen.

Experiment constantly demonstrates, that in a compound body 1 volume of hydrogen can be replaced by 1 volume of chlorine, or by 1 volume of bromine. Experiment demonstrates equally, that the new chloro- or bromo-compound is analogous to the primitive substance, and that consequently 1 volume of hydrogen is really the equivalent of 1 volume of chlorine or of bromine. But experiment does not assist us, at least in organic substances, when we wish to ascertain whether 1 volume of hydrogen or of chlorine is or is not the equivalent of 1 volume of oxygen. I do not know of a single body in which we can effect an actual substitution of hydrogen or chlorine for oxygen. (*Vide article* "SUBSTITUTION.")

We might, indeed, adduce the conversion of alcohol into acetic acid,

$$C^2H^6O + O^2 = $$
$$C^2H^4O^2 + H^2O,$$

to prove that 1 volume of oxygen has replaced 2 volumes of hydrogen, and that consequently 1 volume of oxygen is the equivalent of 2 volumes of hydrogen: but what relation exists between alcohol and acetic acid? And moreover, there is in this case no substitution or direct replacement of one of these bodies by the other, since the alcohol at first loses hydrogen without any substitution giving rise to aldehyde, which latter body subsequently absorbs oxygen and produces acetic acid.

If, because oxide of barium exchanges one volume of oxygen for two volumes of chlorine, we could thence conclude that one volume of oxygen is the equivalent of two volumes of chlorine, we might maintain with greater reason that one volume of oxygen is the equivalent of one volume of chlorine, since the peroxide of barium gives up all its oxygen in exchange for an equal volume of chlorine; and the neutral chloride of barium thus formed has a greater analogy with the neutral peroxide than with the basic oxide of the metal.

Nevertheless, as we know that in organic substances it is impossible to replace 1 volume of hydrogen or of chlorine by 1 volume of oxygen,* and that in certain substances that may be

---

* We might cite as an example of the replacement of 1 volume of

considered as oxides in which the oxygen has been replaced by chlorine, it is always one volume of the former that is replaced by two volumes of the latter (example, Dutch liquid $C^2H^4.Cl^2$, and aldehyde $C^2H^4.O$), we are naturally led to adopt the ordinary opinion, that 1 volume of oxygen is the equivalent in weight of 2 volumes of chlorine or of hydrogen.

Here arises a difficulty which I shall endeavour to resolve, and for this purpose shall be obliged momentarily to restore to their ordinary meanings the words *atom* and *molecule.*

Chemists do not know whether the molecule of chlorhydric acid is HCl, or H^2Cl^2, or H^3Cl^3, &c.; but they believe themselves warranted in affirming, that if the molecule of nitric acid consists of $H.NO^3$, that of chlorhydric acid ought to contain H Cl, and that consequently the formula of cyanhydric acid should be H.CN, that of cyanogen CN, that of chlorine Cl, that of hydrogen H. Although this deduction is admitted without hesitation by every one, yet I shall endeavour to show, that the molecules of these bodies ought properly to be represented in the following manner:—

	2 Vol.		
Chlorhydric acid	H Cl	chlorine	Cl^2
Nitric acid	H NO^3	nitrogen	N^2
Cyanhydric acid	H Cy	cyanogen	C^2N^2,

that is to say, I am desirous of proving that the molecule of free chlorine is *binary,* but that this molecule can divide itself into two when it enters into combination.

There does not exist a single organic compound upon which we can effect any reaction by employing Cl, Cl^3, Cl^5, &c.; that is to say, an uneven number of atoms of chlorine. In every case it is Cl^2, or a multiple thereof, which determines the reaction. A body can indeed contain an uneven number of atoms of chlorine, but in order to form it, we must, I repeat, employ an even number of atoms.

Let us bring forward some examples of this statement, proceeding from complex to simple instances.

hydrogen for 1 volume of oxygen, the transformation of the nitro-hydrocarbons into alkaloids by the action of sulphuretted hydrogen; for instance, nitro benzine, $C^6H^5N\,(O^2)$, which produces aniline $C^6\,H^5\,N\,(H^2)$; but in these instances 2 volumes of oxygen are replaced by 2 volumes of hydrogen, and not 1 volume replaced by 1 volume.

	2 vol.	+ n 2 vol. =	2 vol.	+ n 2 vol.
Naphthaline	$C^{10}H^8$	$+ Cl^2 =$	$C^{10}H^8Cl^2$	
"	$C^{10}H^8$	$+ 2Cl^2 =$	$C^{10}H^8Cl^4$	
"	$C^{10}H^8$	$+ Cl^2 =$	$C^{10}H^7Cl$	$+ HCl$
"	$C^{10}H^8$	$+ 2Cl^2 =$	$C^{10}H^6Cl^2$	$+ 2HCl$
"	$C^{10}H^8$	$+ 3Cl^2 =$	$C^{10}H^5Cl^3$	$+ 3HCl$
"	$C^{10}H^8$	$+ 8Cl^2 =$	$C^{10}Cl^8$	$+ 8HCl$
Valyle	C^8H^{18}	$+ 2Br^2 =$	$C^8H^{16}Br^2$	$+ 2HBr$
"	C^6H^{14}	$+ 2Br^2 =$	$C^6H^{12}Br^2$	$+ 2HBr$
Valerene	C^5H^{10}	$+ Br^2 =$	C^5H^9Br	$+ HBr$
Butyrene	C^4H^8	$+ Cl^2 =$	C^4H^7Cl	$+ HCl$
Propylene	C^3H^6	$+ Cl^2 =$	C^3H^5Cl	$+ HCl$
"	C^3H^6	$+ 2Cl^2 =$	$C^3H^4Cl^2$	$+ 2HCl$
"	C^3H^6	$+ 6Cl^2 =$	C^3Cl^6	$+ 6HCl$
Etherine	C^2H^4	$+ Cl^2 =$	$C^2H^4Cl^2$	
"	C^2H^4	$+ Cl^2 =$	C^2H^3Cl	$+ HCl$
Methylene	CH^2	$+ Cl^2 =$	$CHCl$	$+ HCl$
whence	H^2	$+ Cl^2 =$	HCl	$+ HCl$
	H^2	$+ C^2N^2 =$	HCN	$+ HCN$
or	H^2	$+ Cy^2 =$	HCy	$+ HCy.$

If C^2H^4 represents a molecule of etherine, CH^2 a molecule of methylene, H^2 must necessarily represent a free molecule of hydrogen, Cl^2 a free molecule of chlorine, and C^2N^2 a free molecule of cyanogen.* These free molecules, H^2, Cl^2, C^2N^2, halve themselves in the act of combination.

When CH^2 is put in the presence of Cl^2, it loses H, which is replaced by Cl; in the same manner, when H^2 is put in the presence of Cl^2, it loses H, which is replaced by Cl. In one word, when chlorine and hydrogen react upon one another, it is not a *combination*, but a *double decomposition* that takes place.

Moreover, Ampere a long time back considered the atoms of hydrogen and of chlorine as divisible, in consequence of one volume of chlorine, in combining with one volume of hydrogen, giving rise to two volumes of chlorhydric acid. For if we admit that gases

---

* We can prove in another way that free cyanogen is C^2N^2. Benzoate of ammonia, benzamide, and benzonitryl are respectively represented by

$$C^7H^9NO^2,\quad C^7H^9NO^2-H^2O,\quad C^7H^9NO^2-2\,H^2O,$$

and in the same manner oxalate of ammonia, oxamate of ammonia, oxamide, and cyanogen are represented by

$$C^2O^4H^8N^2,\quad C^2O^4H^8N^2-H^2O,\quad C^2O^4H^8N^2-2\,H^2O,\quad C^2O^4H^8N^2-4\,H^2O=C^2N^2,$$

or cyanogen; moreover cyanogen in the presence of water regenerates oxalate of ammonia.

contain the same number of atoms in the same volume, then one atom of chlorine, in combining with one atom of hydrogen, must give rise to two atoms of chlorhydric acid, and consequently the atoms of chlorine and of hydrogen must be binary and divisible by combination.

Chemists take 1, 2, 4, 6, 8, and even 12 volumes to represent the atoms as well of simple as of compound bodies.

Gerhardt * takes one volume for simple, and two volumes for compound bodies. From the considerations which I have just now submitted, we are necessarily led to adopt the same volume as representative of all bodies, whether simple or compound.

If we reduce all bodies to two volumes, we shall arrange the table of molecules in the following manner:

1 molecule = 2 volumes.

Oxygen .... $O^2 = 200 = 100 \times 2$
Hydrogen .... $H^2 = 12{\cdot}5 = 6{\cdot}25 \times 2$
Water .... $H^2O = 112{\cdot}5$
Potassium .... $K^2 = 490 = 245 \times 2$
Oxide of potassium $K^2O = 590.$

The molecules of hydrogen and of chlorine constitute then *homogeneous combinations* (H H) (Cl Cl) (K K), &c.†; these homogeneous combinations put in the presence of one another, can give rise to a double decomposition, and in this way form *heterogeneous combinations:* thus we have—

$$ClCl + KK = K\,Cl + K\,Cl,$$

just as we have—

$$K\,Cl + Na\,I = K\,I + Na\,Cl.$$

The molecule of the dyads being always binary, it can never lose an atom without receiving an atom of some other dyad in exchange, so as to reconstruct a new molecule with an even number of dyads.

As regards the molecules of the monads, they can divide themselves in the act of combination; but the atom need not

---

* At the present time Gerhardt represents hydrogen by HH, and hydrochloric acid by H Cl.—(W. O.)

† Mr. Brodie, who has paid much attention to this question, has arrived at similar conclusions, though by different methods of reasoning and experimenting. —*Vide* his papers in the 3rd, 4th, and 5th volumes of the Quarterly Journal of the Chemical Society.—(W. O.)

necessarily combine with the complementary atom of another monad, to form a new even-numbered molecule. This may be illustrated by the formation of sulphurous acid.

$$(SS) + (OO) + (OO) = S(OO) + S(OO).$$

Since a dyad atom necessarily demands a complementary atom of another dyad, whilst this complement is not necessary for the monad atoms, it follows that the table of molecules I have just given may be replaced by the succeeding one, in which the molecules of all compound bodies are represented by two volumes, the molecules of the dyads by two volumes, and the molecules of the monads by one volume.[*]

One volume molecules—MONADS.

Oxygen	O	$= 100$	$= 16$
Sulphur	S[†]	$= 200$	$= 32$
Carbon	C	$= 75$	$= 12.$

Two volume molecules—DYADS.

Hydrogen	H^2	$= 2 \times 6{\cdot}25$	$= 2 \times 1$
Chlorine	Cl^2	$= 2 \times 221$	$= 2 \times 35{\cdot}5$
Nitrogen	N^2	$= 2 \times 87{\cdot}5$	$= 2 \times 14$
Potassium	K^2	$= 2 \times 245$	$= 2 \times 39$

Two volume molecules—COMPOUND BODIES.

Chlorhydric acid	$H\,Cl$	$= 227{\cdot}25$	$= 36{\cdot}5$
Water	H^2O	$= 112{\cdot}5$	$= 18$
Oxide of potassium	K^2O	$= 590$	$= 94.$

---

[*] We might even represent all bodies, simple or compound, by one volume; but in this case nearly all the formulæ would become fractional. In order to avoid this, it would suffice to consider the molecules of simple bodies as divisible into two atoms; then each of these atoms or ½ volumes, would be represented by the letters O, H, Cl, &c., and we should write

1 volume of oxygen	O^2
1 volume of hydrogen	H^2
1 volume of nitric acid	$H.NO^3$.

The notation by 1 volume would then be exactly the same as the notation by 2 volumes. In the 1 volume notation the formula $H.NO^3$ would affirm that 1 volume of nitric acid contains H or ½ volume of hydrogen, N or ½ volume of nitrogen, and O^3, or $\frac{3}{2}$ volume of oxygen. In the 2 volume notation the same formula would indicate that 2 volumes of nitric acid contain 1 volume of hydrogen, 1 volume of nitrogen, and 3 volumes of oxygen.

[†] We have said all along that we adopted the volume notation of Berzelius; it was consequently understood that sulphur and phosphorus formed exceptions.

Let us now return to the consideration of atoms and equivalents.

What do Gerhardt's simple atoms represent?

The smallest quantity of a simple body which can exist in combination.

What do my molecules of the last table represent?

The smallest quantity of a simple body that can be employed to effect a combination, which quantity, as regards the dyads, is divisible in the act of combination.

My molecules of the simple bodies are then the ordinary equivalents. The molecule H^2 is the equivalent* of the molecule O, but the first is divisible into two atoms: thus we arrive at the following proposition, which, like all that precede it, is only another form of the original proposition: "The sum of the dyads is an even number."

To express any reaction in an equation, we must employ molecules or equivalents; but the results of the reaction may present atoms, or demi-molecules, or demi-equivalents of the dyads.

Examples:—

$$\begin{array}{rclclcl}
Cl^2 & + & K^2O & = & O & + & 2\,K\,Cl \\
3\,Cl^2 & + & H^3N & = & Cl^3N & + & 3\,H\,Cl \\
O & + & K^2 & = & K^2O & & \\
O & + & CO & = & C\,O^2 & & \\
3\,O & + & H^2S & = & H^2O & + & S\,O^2 \\
Cl^2 & + & C^2H^4 & = & C^2H^3Cl & + & H\,Cl \\
3\,Cl^2 & + & C^2H^4O & = & C^2H\,Cl^3O & + & 3\,H\,Cl \\
4\,Cl^2 & + & C^2H^4O & = & C^2Cl^4O & + & 4\,H\,Cl \\
O & + & C^2H^6O & = & C^2H^4O & + & H^2O \\
3\,H^2 & + & C\,H\,Cl^3 & = & C\,H^4 & + & 3\,H\,Cl.
\end{array}$$

If we adopt the first table of molecules, we may generalize the idea of Ampere, according to which all simple gases contain the same number of atoms in the same volume (leaving out of consideration the irregularities which depend upon the variable coefficients of dilatation). We may say that all bodies, simple and compound, contain the same number of molecules in the same volume.

If we adopt the second table, we should say,—

1° *For the monads.*

One volume contains one atom, or one molecule, O, S, C, &c.

---

* This equivalent does not refer to the functions of the bodies.

2° *For the dyads.*

Two volumes contain two atoms, or one molecule, H^2, Cl^2, N^2, &c.

3° *For compound bodies.*

Two volumes contain one molecule, H^2O, HCl, $H.NO^3$, &c.

In this manner the dyads hold an intermediate place between simple and compound bodies. They are, as I have already said, homogeneous combinations. Considered as simple bodies, they contain, like the monads, the same number of atoms in the same volume; considered as compound bodies, their molecules occupy two volumes, as do those of the true compound bodies.

ARRANGEMENT OF THE DYADS.

This proposition "The sum of the dyads is an even number" would lead us to a theoretical deduction of a very singular character. In the dualistic notation nitric acid is represented by $N^2O^5.\ H^2O$. We have already seen that according to the unitary notation this acid cannot contain water. We may even go further and say, not only that the hydrogen is not combined with the oxygen, but that it actually is united to the nitrogen. This results from the impossibility of removing one atom of a dyad without replacing it by a complementary atom of another dyad. This absolute necessity for a complement, can scarcely be conceived, if we refuse to admit that the atoms of the dyads are combined with one another, at least in pairs.

The following table would indicate, according to the above point of view, not the arrangement of all the atoms in a single body, but that of some of them only.

Water	$(HH)\ O$
Chlorides	(ClM)
Hypochlorites	$(ClM)\ O$
Chlorates	$(ClM)\ O^3$
Nitrates	$(NM)\ O^3$
Phosphuretted hydrogen	$(PH)\ (HH)$
Hypophosphites	$(PH)\ (HM)\ O^2$
Phosphates	$(PM)\ (MM)\ O^4$
Chloracetates	$(ClCl)\ (ClM)\ C^2O^2$
Acetonitryl	$(HH)\ (HN)\ C^2$.

This binary association of the atoms enables us to account for the affinities manifested by bodies in the *nascent state.*

If we present to one another free molecules of bromine and hydrogen, (BB′) and (HH′) respectively, the affinity of B for B′ and of H for H′, suffice to prevent the combination of B with H and of B′ with H′. But if the atoms B and H only are presented to one another, there being no affinities to be overcome, the two bodies combine very readily. This is what will take place for instance, when hydrogen, as disengaged in the nascent state from the action of sulphuric acid upon a metal, is put in presence of bromide of silver : we shall have :

$$\begin{aligned} &\mathrm{HH\ SO^4 + Zn + Ag\,Br} = \\ &\mathrm{HZn\,SO^4 + H\ + Ag\,Br} \\ &\qquad\quad \text{and } \mathrm{H\ + Ag\,Br = Ag + H\,Br.} \end{aligned}$$

The atom H has a tendency to reconstitute a molecule by uniting with another atom H. When the molecule HH is reconstituted, the hydrogen is no longer in the nascent state. But if H encounters Ag Br, then it carries away the Br to reconstitute a binary molecule.

It is scarcely worth while to remark, that if sulphuric acid contains H^2, these two atoms are not at one and the same time set free in the nascent state by the zinc, but that only one atom of H is disengaged ; since at first the bisulphate of zinc $HZnSO^4$ is formed, and that this subsequently loses its last H, still however in the atomic or nascent state.

We might explain in a similar manner the spontaneous decomposition of chloride of nitrogen.

$$\begin{aligned} &\mathrm{(Cl\ Cl)(Cl\ N) + (Cl'\ Cl')\,(Cl'\ N')} \\ &= \mathrm{(Cl\ Cl) + (Cl'\ Cl') + (Cl\ Cl') + (N\ N').} \end{aligned}$$

That is to say : that the affinity of Cl for N and of Cl′ for N′ is overcome by the affinity of Cl for Cl′ and of N for N′. This affinity of Cl for Cl′ and of N for N′, is even sufficiently strong to give rise to a violent disengagement of heat.

ANOMALIES OF THE RADICALS AND ANHYDROUS ACIDS.

I propose in this, and the succeeding chapters, to pass in review the composition of certain bodies such as the radicals, monobasic anhydrides, sesquioxides and their salts, &c., which appear to offer anomalies to the law of even numbers. This review will give me an opportunity of entering into considerations which are I think not entirely devoid of interest.

We have agreed to consider as *molecules,* the atoms or equivalents of compound bodies, such as they are generally admitted by chemists; further on however, some few modifications will have to be made.

The principal alteration we have hitherto made, refers to the bibasic acids, and to the combinations corresponding therewith.

If our manner of viewing these compounds were adopted, we might affirm even now, that we are almost at accord with the majority of chemists. That all the 6, 8 and 12 volume formulæ made use of by some persons, do not in any way correspond with the molecules of the bodies to which they are attributed, is too obvious to require a proof. These formulæ are constructed exclusively in accordance with theoretical speculations concerning the arrangement of atoms: such for instance are the following, which belong to the dualistic school.

Aldehyde	$C^4H^6 + O + H^2O = 4$ vols.
Chloraldehyde	$(C^4H^6.Cl^6) + 2\ (C^4H^6.O^3) = 12$ vols.
Bichloraldehyde	$(C^2Cl^6) + (C^4H^6.O^3) = 6$ vols.
Trichloraldehyde	$(C^4H^6)\ 2\ CO^3 + 3\ (C^2Cl^6) = 12$ vols.
Perchloraldehyde	$CO + CCl^4 = 2$ vols.

They represent a score of hypotheses and nothing else whatever.

Despite this accordance, there will remain some degree of vagueness, in our selection of the molecule for certain compound bodies, and consequently in the law of even numbers. We might say that this selection should be made, by taking for any given body, *that formula which afforded the greatest degree of simplicity; which best illustrated the analogies of the body; which allowed its metamorphoses to be explained in the most simple manner; which accorded with its equivalent considered functionally; which was deduced from its gaseous volume, its atomic volume, its boiling point, its isomorphism, &c.* Nevertheless, if only in consequence of there being several processes, and of those several processes not always leading to the same result, we should desire to replace them by some other which should be less uncertain. Such is precisely that of Gerhardt, which consists in taking the gaseous volume as the sole guide for the determination of the weight of the molecules. We conceive readily, that an uniform process cannot give rise to many contradictory results; but nevertheless, it may not be capable of satisfying the requirements of chemists. Thus, supposing that by taking 2 volumes for all bodies, we were to arrive at such results as the following :

Acetic acid	$C^2H^4O^2$	= 2 vols.
Chloracetic acid	$C^4H^2Cl^6O^4$	= 2 vols.
Aldehyde	$C^8H^{16}O^4$	= 2 vols.
Alcohol	$C^4H^{12}O^2$	= 2 vols.
Bihydrocarbon	CH^2	= 2 vols.
Dutch liquid	$C^3H^6Cl^3$	= 2 vols.

it is certain that no person would accept the law of volumes as a means of determining the molecules.

But experience proves that such is not the case, and that by this means we arrive at most satisfactory results, for by following out the system of volumes, we obtain *the formulæ which afford the greatest degree of simplicity ; which best recall the analogies of the bodies ; which accord best with the boiling point and isomorphism ; which allow the metamorphoses to be explained in the most simple manner, &c. ; and in a word, satisfy completely the requirements of chemists.* In support of this last assertion, I will adduce as an example the two short lists which I have just now given. The bodies there contained, when represented by 2 volumes, ought to be formulated as follows :

Aldehyde	C^2H^4O
Chloraldehyde	C^2H^3ClO
Bichloraldehyde	$C^2H^2Cl^2O$
Trichloraldehyde	C^2HCl^3O
Quadrichloraldehyde	C^2Cl^4O
Bihydrocarbon	C^2H^4
Dutch liquid	$C^2H^4Cl^2$
Acetic acid	$C^2H^4O^2$
Chloracetic acid	$C^2HCl^3O^2$
Alcohol	C^2H^6O.

It is unnecessary for me to observe that all these bodies belong to the same series, passing and repassing from one to the other, and that in a certain sense they are but varieties of one and the same substance, as the thousand forms of carbonate of lime are but varieties of the rhombohedron.

I believe that after a contest of fifteen years, I have at length gained my cause, and that very small indeed is the number of chemists, who at this time admit the formulæ of the first list, where molecules are represented by 2, 4, 6, 10 and 12 volumes.

We will now proceed to grapple with the radicals and monobasic anhydrides.

If we revert for a moment to the ordinary notation (that of Berzelius), we shall see that the radicals, such as ammonium H^8N^2, amidogen H^4N^2, cyanogen C^2N^2, ethyl C^4H^{10}, methyl C^2H^6, amyl $C^{10}H^{22}$, formyl C^2H^2, kakodyl $C^4H^{12}As^2$; and the monobasic anhydrides, such as the nitric N^2O^5, the acetic $C^4H^6O^3$, the benzoic $C^{14}H^{10}O^3$, &c., contain an uneven number of monads and that the sum of the dyads is not a multiple of 4.

I might at starting observe, that the thousands of radicals and anhydrides, with which chemistry is encumbered, are but imaginary bodies so to speak. But, as cyanogen, kakodyl, and even ethyl (according to some) exist free, and as we are acquainted with the nitric, acetic, and benzoic anhydrides, I am willing to admit, that all the other hypothetical radicals and anhydrides are capable of existing in a free state.

We would now remark, that if all these radicals and anhydrides, free or hypothetical, do have formulæ contrary to the law of even numbers, such an anomaly must necessarily be presented by them.

And indeed all (the so-called) hydrated acids contain, as we have seen, an even number for the carbon and oxygen, and a multiple of 4 for the hydrogen. If in imagination we abstract from these bodies H^2O, the remainder or anhydride will obviously contain an uneven number of oxygen atoms, and an even number of hydrogen atoms, but never a multiple of 4.

Let us examine the radicals of Davy. Since nitric, formic, and acetic acids are represented by $H^2.N^2O^6$, $H^2.C^2H^2O^4$, $H^2.C^4H^6O^4$, it is clear that by the abstraction of H^2 the remainder or radical, will not present a multiple of 4 for the dyads.

If we pass to such radicals as ammonium, methyl, ethyl, &c., we shall arrive at the same conclusion. For these bodies may be considered respectively as resulting from the union of ammonia N^2H^6, methylene C^2H^4, of etherine C^4H^8, &c., with H^2, that is to say as resulting from the union of bodies, the dyads of which form multiples of 4, with 2 atoms only of hydrogen.

If I unhesitatingly admitted the preceding results, although the law of even numbers would then have to undergo a modification, it would nevertheless remain as a very remarkable law, which, having arranged the radicals and monobasic anhydrides in one group, and all other substances in another, might be expressed as follows:—

In the bodies of the latter group the sum of the dyads is always, in those of the former never, a multiple of 4.

However I reject this modified law, since in its establishment I have omitted to take into consideration the conventions which have hitherto guided me. I said above that I adopted the same volume for all bodies, consequently, still retaining the ordinary notation, I must represent

Hydrogen by	H^4	=	4 vols.
Chlorine	Cl^4	=	„
Cyanogen	C^4N^4	=	„
Methyl	C^4H^{12}	=	„
Ethyl	C^8H^{20}	=	„
Kakodyl	$C^8H^{24}As^4$.	=	„
Chlorhydric acid	$H^2. Cl^2$	=	„
Cyanhydric acid	$H^2. C^2 N^2$	=	„
Chlorides....	$C^2H^6. Cl^2$	=	„
„ „	$C^4H^{10}. Cl^2$	=	„
„ „	$C^4H^{12}As^2. Cl^2$	=	„

Now in these formulæ the dyads are represented by multiples of 4. But I have said that the molecules I adopted ought to satisfy the requirements of chemists. Chemists however, will be disposed at first sight to refuse to the radicals the above formulæ, because they appear to destroy the very natural ties which exist between cyanogen and the cyanides, methyl and the combinations of methyl, kakodyl and the combinations of kakodyl, &c.; and because they seem to be in opposition to the theories of ethyl, kakodyl, &c.

I should be justified in putting these theories altogether on one side, since the law I am seeking to establish ought to repose exclusively upon facts, but I am willing for the present to pay them some little attention, and I now wish to demonstrate that my formulæ are perfectly in accordance with the compound radical theory, and even rivet still more closely the ties which unite the radicals with their combinations.

To facilitate the comparision it is preferable to revert to the unitary notation, that is to say, to divide the preceding formulæ by 2. Chlorhydric acid will be then represented by $H\,Cl$, and we have seen above that in the liberation of the radical hydrogen, *two atoms* of this gas unite to form *one dyad molecule* of free hydrogen $H^2 = 2$ vol.

In the same way, when the radical methyl, supposed to exist in the chloride of methyl $CH^3.Cl$ is set at liberty, *two atoms* of the radical ought to unite to form *one free dyad molecule* $(CH^3)^2 =$ 2 volumes.

Also when the radical kakodyl, supposed to exist in the chloride of kakodyl $C^2H^6As.Cl$ is set at liberty; two atoms of the radical ought to unite to form *one free dyad molecule* $(C^2H^6As)^2$ = 2 volumes.

If we represent the molecule

of hydrogen by	....	H^2
“ methyl $(CH^3)^2$	....	Me^2
“ ethyl $(C^2H^5)^2$	....	Et^2
“ kakodyl $(C^2H^6As)^2$	....	Kk^2

we could then establish the following parallel between the combinations of *hydrogen, potassium,* and the *radicals* playing the part of hydrogen and potassium.

Metals	Hydrogen	H^2
	Potassium	K^2
	Methyl	Me^2
	Ethyl	Et^2
	Kadodyl	Kk^2
Alloys	Zinco-potassium	ZK
	Zinc-methyl	ZMe
Oxides	Hydric	H^2 O
	Potassic	K^2 O
	Methylic	Me^2 O
	Ethylic	Et^2 O
	Kakodylic	Kk^2 O
Hydrates	Potassic	K H O
	Methylic	Me H O
	Ethylic	Et H O
Double oxides	Zinco-potassic	Z K O
	Methyl-ethylic	Me Et O
	Ethylo-potassic	Et K O
Chlorides	Hydric	H Cl
	Methylic	Me Cl
	Ethylic, &c.	K Cl

Sulphates	Hydric	$H^2 \ SO^4$
	Methylic	$Me^2 \ SO^4$
	Ethylic, &c.	$Et^2 \ SO^4$
Double sulphates	Methylo-potassic	$Me \ K \ SO^4$
	Ethylo-potassic	$Et \ K \ SO^4$
	Methyl-ethylic, &c.	$Me \ Et \ SO^4$
Acid, or bi-sulphates	Potassic	$K \ H \ SO^4$
	Methylic	$Me \ H \ SO^4$
	Ethylic, &c.	$Et \ H \ SO^4$

It is now seven or eight years ago, since I proposed the above formulæ to the advocates for the existence of compound radicals, and although these formulæ do away with the anomalies presented by the bodies in question, and even strengthen the analogy of the ethers to ordinary salts, yet have they not, up to the present time, been adopted by any one.

It is almost useless for me to show that these formulæ satisfy equally well the theory of etherine, as in the following examples:

Bihydrate	$C^2H^4.H^2 \ O.$
Hydrate	$2 \ C^2H^4.H^2 \ O.$
Hydrochlorate	$C^2H^4.H \ Cl.$
Sulphate	$2 \ C^2H^4.H^2SO^4.$
Sulphovinic acid, &c.	$C^2H^4.H^2SO^4$, &c.

When Gerhardt published his table of equivalents, he represented alcohol by $C^2 \ H^6 \ O = 2$ volumes, and ether by $C^4 \ H^{10} \ O =$ 2 volumes, and he thence concluded that ether could not belong to the vinic combinations. This apparent discordance between alcohol and ether was one of the principal circumstances that estranged many chemists from Gerhardt's views. They could not resolve upon adopting equivalents which destroyed connections so natural as those subsisting between ethers, alcohols, and their combinations.

For my own part, I was for some time arrested by this difficulty. At last I perceived, that in order to restore ether to a place among the vinic combinations, it would suffice to consider it, not as alcohol *minus* water, but as alcohol *plus* etherine.

Alcohol	$C^2H^4.H^2O$
Ether	$2 \ C^2H^4.H^2O$,

which view translated into the ethyl theory becomes as we have already seen:

Alcohol	H Et O
Ether	Et Et O.

This manner of associating the vinic combinations did not receive the assent of chemists, who however, since the late researches of Williamson and Chancel upon the above subject, have felt their opinions forcibly shaken, and will I believe at this time, have no hesitation in adopting my formulæ; not that I wish to defend either the ethyl or the etherine theory. I hold to neither of them.

Dumas was the first to point out the remarkable relations which associated alcohol and ether with the other vinic combinations. He colligated these relations into a theory, by saying that *the vinic combinations* CONTAIN *a hydrated acid* plus *etherine.* In the ethyl theory, it is said that *the vinic combinations* CONTAIN *an anhydrous acid* plus *oxide of ethyl.* If for the expression *contain*, we substitute *may be represented by*, the two theories will express exactly the same thing. What concerns me, however, is this, that the new formulæ have respect to the relations pointed out by Dumas. Here then is one point well established: the new formulæ accord with the law of even numbers, and satisfy in a most complete manner the requirements of chemists.

It now remains for us to examine the monobasic anhydrides. On several occasions Gerhardt and I have maintained that the radicals, despite the existence of cyanogen, kakodyl, and the monobasic anhydrides, despite the existence of anhydrous nitric, and iodic acids, were entirely imaginary bodies.

Nevertheless in these later times, methyl, ethyl, and amyl have been successfully isolated, and Gerhardt himself has succeeded in obtaining the acetic, benzoic, and other anhydrides.

Notwithstanding these facts I persist in my opinion. Here is an observation I published on the subject seven or eight years ago. "Amidogen, ammonium, kakodyl, ethyl, &c., cannot exist (according to the 4 volume notation), because they would present an uneven number of monads, and dyads of which the number would not be a multiple of 4. But though these radicals cannot exist, nothing prevents our discovering bodies which shall have the same centesimal composition; but then their formulæ would be H^8N^4, instead of H^4N^2, C^8H^{20} instead of C^4H^{10}, $C^8H^{24}As^4$ instead of $C^4H^{12}As^2$, &c."

I might also have said, C^2H^4O cannot exist; but there is nothing opposed to the discovery of a body having the same centesimal composition; but this would consist of $C^4H^8O^2$ (aldehyde).

We have seen above how far experiment is in accordance with this mode of viewing the subject.

Lastly, and for the same reason, I maintain even now, that the nitric, acetic, and butyric anhydrides, &c., N^2O^5, $C^4H^6O^3$, $C^8H^{14}O^3$, cannot exist; but that nothing hinders us from discovering bodies which have the same composition; but they will consist of N^4O^{10}, $C^8H^{12}O^6$, $C^{16}H^{28}O^6$, &c.

There is no subtlety in all this; it is the same argument that I have just made use of with regard to the radicals. May acetic acid $C^4H^8O^4$, contain amylene C^4H^8? No, it is impossible; for though amylene has the same centesimal composition as C^4H^8, its molecule can only be represented by $C^{10}H^{20}$. All the world is agreed upon this point. In what then does the above conclusion differ from the following one?

May hydrous acetic acid $C^4H^8O^4$, contain acetic anhydride $C^4H^6O^3$? No, it is impossible; for though the centesimal composition of the anhydride may be presented by $C^4H^6O^3$, yet its molecule consists of $C^8H^{12}O^6$.

We have already proved, that the molecule of water is H^4O^2, and consequently, that acetic acid cannot contain $C^4H^6O^3$ *plus* H^2O. It might however, be represented as $C^4H^4O^2$ *plus* H^4O^2, but then the anhydride could not be considered to pre-exist.

But let us set this kind of argument aside, and endeavour to prove directly that the acetic anhydride contains C^8 and not C^4.

We will admit that the chloride of benzoyl is a combination of chlorine Cl^2, with the radical benzoyl $C^{14}H^{10}O^2 = Bz^2$.

We will also admit that the nitric, acetic, propionic, butyric, and benzoic acids, &c., are respectively the nitrates, acetates, propionates, butyrates, and benzoates, &c., of hydrogen, equal to $H^2.N^2O^6$, $H^2.C^4H^6O^4$, $H^2.C^6H^{10}O^4$, $H^2.C^8H^{14}O^4$, $H^2.C^{14}H^{10}O^4$, &c.

In acting upon these last bodies by the chloride of benzoyle, we effect a saline double decomposition, which we may represent thus:—

Nitrate of benzoyl.

$$H^2.\ N^2O^6 + Bz^2.Cl^2 = Bz^2.\ N^2O^6 + H^2Cl^2$$

Acetate of benzoyl.

$$H^2.\ C^4H^6O^4 + Bz^2.Cl^2 = Bz^2.\ C^4H^6O^4 + H^2Cl^2$$

Propionate of benzoyl.

$$H^2.\ C^6H^{10}O^4 + Bz^2.Cl^2 = Bz^2.\ C^6H^{10}O^4 + H^2Cl^2$$

Butyrate of benzoyl.

$$H^2.\ C^8 H^{14} O^4 + Bz^2.Cl^2 = Bz^2.\ C^8 H^{14} O^4 + H^2 Cl^2$$

Benzoate of benzoyl.

$$H^2.\ C^{14} H^{10} O^4 + Bz^2.Cl^2 = Bz^2.\ C^{14} H^{10} O^4 + H^2 Cl^2.$$

As we are still employing the ordinary notation, it is clear that the nitrate of benzoyl being indivisible, for the sake of analogy the other salts, acetate, propionate, butyrate, and benzoate of benzoyl must be likewise indivisible.

Moreover, the acetate of benzoyl, propionate of benzoyl, &c., transform themselves in the presence of water into acetic and benzoic, propionic and benzoic, &c., acids. Thence it is clear that—

The first salt or the nitrate contains	C^{14}
The second salt or the acetate contains	$C^{14} + C^4$
The third salt or the propionate contains .	$C^{14} + C^6$
The fourth salt or the butyrate contains	$C^{14} + C^8$
The fifth salt or the benzoate contains	$C^{14} + C^{14}$.

I believe that this reasoning is rigorously exact. We see, moreover, that these five salts may be supposed to consist of—

The first of anhydrous benzoic and nitric acids	$C^{14}H^{10}O^3 + N^2 O^5$
The second of anhydrous benzoic and acetic acids	$C^{14}H^{10}O^3 + C^4 H^6 O^3$
The third of anhydrous benzoic and propionic acids....	$C^{14}H^{10}O^3 + C^6 H^{10}O^3$
The fourth of anhydrous benzoic and butyric acids....	$C^{14}H^{10}O^3 + C^8 H^{14}O^3$
The fifth of anhydrous benzoic and benzoic acids	$C^{14}H^{10}O^3 + C^{14}H^{10}O^3$.

But these synoptic formulæ are of no further use than to display the analogies of the bodies. We may content ourselves with the simple fact which they express, namely, that the aceto-benzoate contains $C^4 + C^{14}$, and that the benzo-benzoate contains $C^{14} + C^{14}$, or $C^{28}H^{20}O^6$. Thus the real molecule of benzoic anhydride weighs double that which is supposed to exist in the so-called hydrated acid.

We might probably obtain a proof equally pointed by causing the chloride of benzoyl to react upon the chloro- bromo- and nitro- benzoic acids, &c.

We ought to have with the—

Chloro-acid	$C^{14}O^4Cl^2 H^{10} + C^{14}H^{10}O^2.\ Cl^2 = C^{14}O^4Cl^2 H^8.\ Bz^2 + H^2Cl^2$
Bichloro-acid	$C^{14}O^4Cl^4 H^8 + C^{14}H^{10}O^2.\ Cl^2 = C^{14}O^4Cl^4 H^6.\ Bz^2 + H^2Cl^2$
Bromo-acid	$C^{14}O^4Br^2H^{10} + C^{14}H^{10}O^2.\ Cl^2 = C^{14}O^4Br^2H^8.\ Bz^2 + H^2Cl^2$
Nitro-acid	$C^{14}O^4X^2 H^{10} + C^{14}H^{10}O^2.\ Cl^2 = C^{14}O^4 X^2 H^8.\ Bz^2 + H^2Cl^2$
Binitro-acid	$C^{14}O^4X^4 H^8 + C^{14}H^{10}O^2.\ Cl^2 = C^{14}O^4 X^4 H^6.\ Bz^2 + H^2Cl^2$
Normal acid	$C^{14}O^4 H^{12} + C^{14}H^{10}O^2.\ Cl^2 = C^{14}O^4 H^{10}.\ Bz^2 + H^2Cl^2$.

The benzoates of chloro-, bromo-, and nitro-benzoyl being indivisible, the others by analogy ought not to be halved, although containing an even number of equivalents.

But the first benzoate might be represented by anhydrous benzoic and chloro-benzoic acids; the second by anhydrous benzoic, and bichloro-benzoic acids; the third by anhydrous benzoic, and bromo-benzoic acids; the fourth by anhydrous benzoic, and nitro-benzoic acids; the fifth by anhydrous benzoic, and binitrobenzoic acids, and, consequently, the sixth would be represented by anhydrous benzoic, and benzoic acids, and therefore, must contain C^{28}, and not C^{14}.

But it may be said that $C^{14}H^{10}O^{3}$ ought to be the equivalent of benzoic anhydride, since $C^{14}H^{10}O^{3}$ saturates $K^{2}O$, which has been taken as the term of comparison.

I have already said that $K^{2}O$ is but the conventional measure adopted for measuring or determining the equivalents of the anhydrous acids; but we cannot thence logically conclude that $K^{2}O$, $N^{2}O^{5}$, and $C^{14}H^{10}O^{3}$ are the equivalents of one another.* To be correct we must say that $K^{2}O$, $N^{2}O^{5}$, and $C^{14}H^{10}O^{3}$ are *proportional numbers*, and that $N^{2}O^{5}$, and $C^{14}H^{10}O^{3}$, or rather $N^{4}O^{10}$ and $C^{28}H^{20}O^{6}$ represent an *equivalent* of each of these two bodies, because they are comparable one to the other, whilst $K^{2}O$ and $N^{2}O^{5}$ are not so. Moreover the ordinary equivalents have not any relation with the *weights of the molecules*, which are the points we are endeavouring to determine.

ANOMALY OF FRACTIONAL FORMULÆ.

Up to this time we have taken the volumes as determining the weight of the molecules. Let us now see if we can *in every case* accept the results obtained in this manner.

In representing the composition of all substances by 2 volumes, the chlorhydrate of ammonia, and chlorhydric acid would be formulated, thus:

$$\begin{aligned} &Cl\tfrac{1}{2}H^{2}N\tfrac{1}{2} = 2 \text{ volumes} \\ &Cl\ H \quad = 2 \quad ,, \end{aligned}$$

The cyanhydrate of ammonia, and cyanhydric of acid, thus:

$$\begin{aligned} &C\tfrac{1}{2}H^{2}N = 2 \text{ volumes} \\ &C\ H\ N = 2 \quad ,, \end{aligned}$$

---

* In the 4-volume notation, $K^{4}O^{2}$ represents the molecule of anhydrous potash, $N^{4}O^{10}$ that of anhydrous nitric acid, and $K^{2}O.N^{2}O^{5}$ that of nitrate of potash arranged as a dualistic compound.—(W. O.)

These two instances suffice to manifest the impossibility of adopting the law of volumes, as an absolute method of determining the weight of the molecules. Moreover if they were in every instance adopted, exceptions to the law of even numbers would be produced.

Let us unite in a single table, all the bodies which are exceptional both to Gerhardt's law of volumes, and to the law of even numbers.

*Hydrated sulphuric acid	$H\,S\frac{1}{2}\,O^2$	= 2 vols.
Chlorhydrate of ammonia	$H^2\,Cl\frac{1}{2}N\frac{1}{2}$	= 2 vols.
Cyanhydrate of ammonia	$H^2\,C\frac{1}{2}\,N$	= 2 vols.
Anhydrous carbonate of ammonia	$H^3\,N\,C\,O\frac{1}{2}$	= 2 vols.
Perchloride of phosphorus	$P\frac{1}{2}\,Cl\frac{5}{2}$	= 2 vols.
Oxichloride of phosphorus	$P\frac{1}{2}\,Cl\frac{3}{2}\,O\frac{1}{2}$	= 2 vols.
Sulphochloride of phosphorus	$P\frac{1}{2}\,Cl\frac{3}{2}\,S\frac{1}{2}$	= 2 vols.

First it may be remarked, that all these bodies afford fractional numbers, and present a peculiarity which in some degree confirms the law of even numbers. All of them indeed contain fractional numbers; but in all of them the sum of the dyads is a *whole* number, whilst that of the monads is sometimes whole, sometimes fractional.

Gerhardt's rule therefore, cannot be applied to any of these bodies; not because they would then afford fractional numbers (we are not talking of atoms at present), but because in following the rule (taking 4 volumes for all bodies) we should represent hydrated sulphuric acid, chorhydrate of ammonia, and anhydrous carbonate of ammonia, by

$$\left.\begin{array}{l} H^2\,O : SO^3 \\ H^3\,N . H\,Cl \\ H^6\,N^2 . CO^2 \end{array}\right\} = 4 \text{ volumes,}$$

(in which the sum of the dyads is not divisible by 4,) while at the same time we should formulate chlorhydric acid, and the sulphuric and carbonic anhydrides by

$$\left.\begin{array}{l} S^2\,O^6 \\ H^2\,Cl^2 \\ C^2\,O^4 \end{array}\right\} = 4 \text{ volumes.}$$

To avoid this difficulty, I propose to modify Gerhardt's rule in the following manner:

---

* I believe that this, and the succeeding observations are incorrect as regards sulphuric acid, inasmuch as H^2SO^4 like $H\,Cl$=2 volumes. *Vide* table in Graham's Elements of Chemistry.—(W. O.)

To determine the weight of the molecule or compound atom of any substance, we must take 2 *volumes, excepting when the formula thus deduced presents fractional numbers, in which case we must take* 4 *volumes.*

Thus modified, the rule of volumes does not offer any ambiguity in its application, and the weight of the molecules being in this manner determined, the exceptions to the law of even numbers will disappear. We may still maintain then, that *in every molecule the sum of the dyads is an even number.*

It must not be thought that by doubling the formulæ of anomalous bodies we necessarily obtain even numbers. This would be an error, for if any body contained in 2 volumes $C^2H_{\frac{3}{2}}N$, by doubling it we should still have for the dyads an uneven number.

Anomalies of Nitric Oxide and Peroxide of Nitrogen.

The process for determining the weights of the molecules being thus modified, still the law of even numbers presents two exceptions, namely, nitric oxide and peroxide of nitrogen. Do these two bodies however, form *real* exceptions to the law? That will depend upon what definition is given to a molecule. If we take that of Gerhardt, with the modification I have introduced, the two exceptions are real, positive, for NO and NO^2 represent 2 volumes, and do not present fractional numbers. But by paying attention to the grouping of all their characters, by having regard to all their analogies, we may possibly arrive at another conclusion, and may demand whether nitric oxide and peroxide of nitrogen ought not, like chlorhydrate of ammonia, to be represented by 4 volumes, that is to say, by N^2O^2, and N^2O^4 respectively? Then the exceptions to the law of even numbers would disappear, to reappear in the law of volumes.

To reply to this question we must have recourse to analogy. Unfortunately nitric oxide and peroxide of nitrogen are such singular bodies,* that it appears somewhat difficult to discover their analogues.

---

* There is no substance which presents such singular properties as nitric oxide. Thus, although it contains more oxygen than the nitrous oxide, it is far from supporting combustion so well as this last, and even many substances which burn in the nitrous, are extinguished in the nitric oxide. It is perhaps the only body which in the dry state, and at the ordinary temperature, can combine suddenly with oxygen. This combination moreover, takes place without the evolution of heat, and the body which results, far from retaining the oxygen which it has so readily absorbed, is perhaps of all bodies the one which is deoxidised most easily.

We shall see further on, that in real substitutions (potassium displacing the hydrogen of nitric acid, chlorine displacing the hydrogen of acetic acid), the body eliminated is always replaced by its equivalent of the body by which it was driven out. We shall see also, that a great number of substitutions can be effected by the replacement of hydrogen by peroxide of nitrogen as in the following examples:

Naphthaline	$C^{10} H^{8}$
Nitro-naphthaline	$C^{10} H^{7} (NO^{2})$
Binitro-naphthaline	$C^{10} H^{6} (NO^{2})^{2}$
Trinitro-naphthaline	$C^{10} H^{5} (NO^{2})^{3}$
Phenic acid	$C^{6} O H^{6}$
Trinitro-phenic acid	$C^{6} O H^{3} (NO^{2})^{3}$
Mannite	$C^{8} O^{6}H^{14}$
Sexnitro-mannite	$C^{8} O^{6}H^{8} (NO^{2})^{6}$.

Now in all these cases we see NO^{2} constantly replacing H. Then if H^{2} represent the *molecule* of hydrogen, $N^{2}O^{4}$ ought to represent the molecule of peroxide of nitrogen.

With regard to the substitutions effected by nitric oxide, they are more rare, nevertheless we may adduce:

Alcohol	$C^{2} O H^{6}$
Nitroso-alcohol (hyponitrous ether)	$C^{2} O H^{5}(NO)$
Amylic alcohol	$C^{5} O H^{12}$
Nitroso-amylic alcohol	$C^{5} O H^{11} (NO)$
Azobenzide	$C^{12} H^{10} N^{2}$
Nitroso-azobenzide (azoxibenzide)	$C^{12} H^{10} N(NO)$.

Here also NO replaces H or N, therefore, $N^{2}O^{2}$ is the equivalent of H^{2} and of N^{2}, and represents the molecule of nitric oxide.

To these examples I can add one still more conclusive; I refer to the nitro-prussiates.

We know, that when by a double decomposition the peroxide of uranium combines with acids, it conserves a part of the oxygen which it contained, and that in consequence it may be considered as an oxide of uranyle ($U^{4}O^{2}$) O uranyle $U^{2}O$ fulfilling the function of a metal. It matters little to us whether or not uranyle has any existence, whether or not it is identical with the protoxide of uranium. We are here considering proportional numbers only, and we accept Peligot's theory as a means of generalising the facts.

This theory may be applied not only to all the salts of the peroxide of uranium; but even to certain combinations of peroxide of iron, teroxide of antimony, arsenious acid, boric acid, and as I am about to show, to nitrous (that is hyponitrous) acid, which has a formula similar to those of the above-named compounds.

Let us call

Uranic oxide,	.... oxide of uranyle	$(U^4\ O^2)O = Uy^2\ O$
Ferric oxide,	.... oxide of ferryle	$(Fe^4 O^2)O = Fy^2\ O$
Antimonious oxide,	.... oxide of antimonyle	$(Sb^2O^2)O = Sby^2\ O$
Arsenious acid,	.... oxide of arsenyle	$(As^2O^2)O = Asy^2O$
Anhydrous boric acid,	.... oxide of boryle	$(B^2\ O^2)O = By^2\ O$
Anhydrous nitrous acid,	.... oxide of nitryle	$(N^2\ O^2)O = Ny^2\ O.$

This double function that I accord to the arsenious, boric, and nitrous acids, is not more singular than the double function attributed to the oxides of antimony, aluminum, and zinc, &c. I may say moreover, that I have obtained an extremely well crystallised sulphate of arsenious acid, and that arsenious acid being so strikingly correlated with antimonious oxide, we cannot refuse to consider its sulphate as belonging to the class of salts, rather than to that of double acids.

This being admitted, let us see what takes place when two atoms of cream of tartar react upon these oxides or acids, we shall have with

$$\begin{aligned}
&\text{Oxide of uranyle} && 2(C^4\ O^6\ H^5\ K) + Uy^2\ O \\
& && = 2(C^4\ O^6\ H^4\ Uy\ K) + H^2\ O \\
&\text{Oxide of ferryle} && 2(C^4\ O^6\ H^5\ K) + Fy^2\ O \\
& && = 2(C^4\ O^6\ H^4\ Fy\ K) + H^2\ O \\
&\text{Oxide of antimonyle} && 2(C^4\ O^6\ H^5\ K) + Sby^2O \\
& && = 2(C^4\ O^6\ H^4\ SbyK) + H^2\ O \\
&\text{Oxide of arsenyle} && 2(C^4\ O^6\ H^5\ K) + Asy^2O \\
& && = 2(C^4\ O^6\ H^4\ Asy\ K) + H^2\ O \\
&\text{Oxide of boryle} && 2(C^4\ O^6\ H^5\ K) + By\ {}^2O \\
& && = 2(C^4\ O^6\ H^4\ By\ K) + H^2\ O
\end{aligned}$$

May we not also have—

$$\begin{aligned}
&\text{Oxide of nitryle} && 2(C^4\ O^6\ H^5\ K) + Ny^2\ O \\
& && = 2(C^4\ O^6\ H^4\ Ny\ K) + H^2\ O.
\end{aligned}$$

This last instance will not seem impossible, when compared with that afforded to us by the nitro-prussiates.

We know that in the cyanides MCy, the platino-cyanides

$M\,Pt\,Cy^2$, the ferro-cyanides $M^4\,Fe^2\,Cy^6$, and indeed, in all the poly-cyanides,* the number of atoms of cyanogen is equal to the number of atoms of metal, but such is not the case, at least in appearance, in the nitro-prussiates, as they contain $M^2\,Fe^2\,Cy^5 + NO$. I say in appearance, because, as we shall see immediately, the nitro-prussiates may really be cyanides of the same character as the ferro-cyanides, and particularly as the ferro-cyanide of uranyle.

If we establish the following parallel:

$$\begin{aligned} H^4\,Fe^2\,Cy^6 \quad &+ 2\,Uy^2\,O = Uy^4\,Fe^2\,Cy^6 \quad + 2\,H^2\,O \\ H^2\,K^4\,Fe^4\,Cy^{10} &+ \quad Ny^2\,O = Ny^2\,K^4\,Fe^4\,Cy^{10} + \quad H^2\,O, \end{aligned}$$

it will be impossible for us not to acknowledge, that in this case at least, Ny fulfils the functions, and is the equivalent of Uy. But Uy^2 or U^4O^2 is here the equivalent of H^2, M^2, &c., and consequently Ny^2 or N^2O^2 is also the equivalent of H^2, M^2, &c.

Thus the nitro-prussiates are triple cyanides of iron, another metal and nitryle, just as the prussiate of uranyle is a cyanide of iron and uranyle.

Substitutions then demonstrate to us, that the molecules of hydrogen, chlorhydric acid, and the compounds of nitrogen are respectively H^2, $H\,Cl$, N^2O^2, and N^2O^4.

If we adopt the preceding conclusions, the law of even numbers will not present any exception. But then these two oxides of nitrogen will become exceptional to Gerhardt's rule. That this rule may not be liable to any exception, it must receive a further modification, and be expressed as follows:

To determine the weight of the molecule of a compound body, we must take two volumes of it, excepting when the formula thus deduced would present fractional numbers, or an uneven number of dyads, in which two cases we must take four volumes.

VARIOUS ANOMALIES.

There exists a small number of bodies which can lose or gain a single atom of hydrogen, these are:

Benzoine	$C^7\,H^6\,O$	which forms benzile	$C^7\,H^5\,O$
Kinone	$C^6\,H^4\,O^2$	which forms green hydrokinone	$C^6\,H^5\,O^2$
Indigo	$C^8\,H^5\,N\,O$	which forms white indigo	$C^8\,H^6\,N\,O$
Isatine	$C^8\,H^5\,N\,O^2$	which forms isathyde	$C^8\,H^6\,N\,O^2$
Alloxan	$C^4\,H^4\,N^2O^5$	which forms alloxantine	$C^4\,H^5\,N^2O^5$.

---

* Only by making use of ferricum and its analogues ; thus the ferridcyanides

If the bodies of the second column be correctly formulated, they will be contrary to the law of even numbers. We may remark in the first place, that we are unacquainted with the atomic weights and vapour-densities of these substances, and that we do not know whether their formulæ should not be doubled or tripled. Nevertheless I propose to show, that we do possess sufficient data to decide upon the propriety of conserving or rejecting the preceding formulæ.

Benzile submitted to the action of potash, gives rise to a salt which contains $C^{14} H^{11} K O^3$, and of which the acid is $C^{14} H^{12} O^3$, this last, which is benzilic acid, represents benzile *plus* 1 atom of water. This acid bears the same relation then to benzile that formic and campholic acids respectively bear to carbonic oxide and camphor.

Benzile .... $C^{14}H^{10}O^2 + H^2 O =$ benzilic acid
Carbonic oxide.... $C O + H^2 O =$ formic acid
Camphor .... $C^{12}H^{16}O + H^2 O =$ campholic acid.

Benzile then contains C^{14}, and not C^7. Here also are other proofs which leave no doubt whatever on the subject.

Benzile submitted to the action of ammonia produces

$$\text{Benziline} = C^{14} H^{10} O^2 + H^3 N - H^2 O$$
$$\text{Benzilam} = C^{14} H^{10} O^2 + H^3 N - 2H^2 O.$$

Benzile is moreover obtained from benzoine, which ought also to contain C^{14}, and not C^7. Indeed this last is isomeric with hydruret of benzoyle, and we know well that the aldehydes frequently give rise to isomerides by doubling or tripling themselves (metaldehyde, el-aldehyde). The hydruret of benzoyle, or benzoic aldehyde, can comport itself in the same manner: thus it transforms itself into benzoine without altering its composition. Thus we can have

Benzoine, or benzilic aldehyde	$C^{14}H^{12}O^2$
Benzilic acid	$C^{14}H^{12}O^3$
Benzile (carbonic oxide)....	$C^{14}H^{10}O^2$
Benziline (benzilic nitryle)	$C^{14}H^{11}NO$
Benzilam....	$C^{14}H^9 N.$

Green hydrokinone is obtained by treating kinone with hydrogen in the nascent state. We have formed successively:

$=M^3fe^3Cy^6$. Gerhardt represents the nitro-prussiates as containing ferricum, and not ferrosum.—(W. O.)

Kinone	$C^6 H^4 O^2$
Green hydrokinone	$C^6 H^4 O^2.H$
White hydrokinone	$C^6 H^4 O^2.H^2$.

But the green hydrokinone may also be obtained by mixing kinone with white hydrokinone. If we knew no other than this last mode of preparation, we should certainly represent green hydrokinone by this formula:

$$C^6 H^4 O^2 + C^6 H^6 O^2 = C^{12} H^{10} O^4,$$

which despite the even numbers, we should not divide, any more than we divide the formula of acetic ether $C^4 H^8 O^2$.

As regard the first mode of preparation, it comes exactly to the same thing as the second; for when hydrogen is made to react upon kinone, it first of all produces white hydrokinone, and as this last substance is forming, it combines with an equivalent portion of kinone, to give rise to the green hydrokinone.

There exist moreover, other kinonic combinations, which formulated with C^{12} are indivisible, and have the same colour as the green hydrokinone.

White indigo and *isathyde* belong to a series, the terms of which very frequently become doubled. Thus indine, chlorindine, isamic acid, chlorisamic acid, isamide, imasatine, and sulpho-purpuric acid contain $2C^8$, whilst isatine and blue indigo contain but C^8.

As white indigo and isathyde do not form salts, either with acids or bases, and as they cannot be obtained in the state of vapour, we do not know whether their atomic weight is C^8 or $2\ C^8$.

Isathyde probably contains C^{16}, since by the action of potash it gives rise to an indinate containing this number of carbon atoms.

Alloxantine and alloxan have not the respective formulæ, which I have given above, and which are generally accorded to them. These two bodies contain water of crystallization, and I shall show further on (*vide* Table of Alloxanic Combinations) that their real atomic weights differ from those usually given, and that in any case the formula of alloxantine must be doubled with respect to that of alloxan.

ANOMALIES OF CERTAIN ORGANIC ALKALIES AND BIACID ALKALIES.

Among the alkalies, there are some which do not appear to accord with the law of even numbers.

The atoms of the following substances are usually represented thus.

According to the ordinary notation, but with Gerhardt's (*i.e.* Berzelius's) equivalents.

$$\left.\begin{array}{ll}\text{Flavine} & C^{13}\,H^{12}\,N^{2}\,O\\ \text{Benzidine} & C^{12}\,H^{12}\,N^{2}\\ \text{Cyaniline} & C^{14}\,H^{14}\,N^{4}\\ \text{Semibenzidam} & C^{6}\,H^{8}\,N^{2}\end{array}\right\}\text{which saturate } H^{2}\,Cl^{2},$$

but in each of which the sum of the dyads is not a multiple of 4.

According to the unitary notation.

$$\left.\begin{array}{ll}\text{Flavine} & C^{7\frac{1}{2}}\,H^{6}\,N\,O\tfrac{1}{2}\\ \text{Benzidine} & C^{6}\,H^{6}\,N\\ \text{Cyaniline} & C^{7}\,H^{7}\,N^{2}\\ \text{Semibenzidam} & C^{3}\,H^{4}\,N\end{array}\right\}\text{which saturate } H\,Cl,$$

but in each of which the sum of the dyads is not an even number.

In the presence of these formulæ we are compelled to draw one of the following conclusions, namely, that the law of even numbers is not true; or that the above formulæ are inexact; or that the salts of these alkalies, though heretofore considered as neutral salts, are in reality acid salts, (in other words, that the atom of flavine for instance, ought to be doubled, and its hydrochlorate represented as consisting, on the unitary system, of one atom of flavine $C^{13}\,H^{12}\,N^{2}\,O$ *plus* two atoms of hydrochloric acid 2 H Cl.—Ed.)

The mode of preparation, and the reactions of the above alkalies, do not allow us to doubt, even for a moment, the correctness of their analyses.

Gerhardt and I have felt no hesitation in adopting the last mentioned conclusion, and here are the proofs we have offered in support of our opinion.

Flavine.

Urea may be considered as carbamide or as neutral carbonate of ammonia, *minus* 2 atoms of water. Flavine, also an urea, is the anilic carbamide or the neutral carbonate of aniline, *minus* 2 atoms of water.

We have for urea

$$\begin{array}{l} 2\ H^3N + H^2CO^3 \\ -\ H^4 \qquad\quad O^2 \\ \hline = 2\ HN + H^2CO = \text{urea.} \end{array}$$

and for flavine,

$$\begin{array}{l} 2\ C^6H^7N + H^2CO^3 \\ -\quad H^4 \qquad\quad O^2 \\ \hline 2\ C^6H^5N + H^2CO = \text{flavine.} \end{array}$$

Thus, as upon the unitary system the molecule of urea is CH^4N^2O,—that of flavine must be $C^{13}H^{12}N^2O$. But in this form it combines with 2 equivalents of bichloride of platinum,

$$C^{13}H^{12}N^2O.\ 2\ HPtCl^3.$$

This, however, is not more astonishing than for urea to combine with two proportions of nitric acid and of nitrate of silver. Thus we have

$$\begin{array}{l} U.\ HNO^3 \\ U.2\ HNO^3 \\ U.\ AgNO^3 \\ U.\ 2AgNO^3. \end{array}$$

The atomic weight of flavine is moreover confirmed by the composition of the ammonio-anilic carbamide, which is formed as the result of the following equation:

$$\begin{array}{l} H^3N + C^6H^7N + H^2CO^3 \\ -\ H^2 \qquad\quad H^2 \qquad\quad O^2 \\ \hline = HN \ + C^6H^5N + H^2CO, \end{array}$$

corresponding to those of urea and flavine.*

Here then is a primary fact added to science. There are alkalies whose salts ordinarily considered as neutral, are in reality biacid.

---

* The above three equations are represented more simply as follows :

$$\begin{array}{lcccl} 2\ N\ H^4\ .CO^3 & - & H^4O^2 & = & N^2.\quad H^2\ H^2\ CO'' \\ 2\ N(C^6H^5)H^3\ .CO^3 & - & H^4O^2 & = & N^2.\ (C^6H^5)^2H^2\ CO'' \\ \left.\begin{array}{r} N\ H^4 \\ N(C^6H^5)H^3 \end{array}\right\}.CO^3 & - & H^4O^2 & = & N^2.H(C^6H^5)\ H^2\ CO''. \end{array}$$

—(W. O.)

Nicotine.

Nicotine, paranicine, quinine, and cinchonine, present us with similar salts; that is to say, with acid salts which are erroneously considered to be neutral.

Previously to the late researches of Schlœsing and Barral, the following were considered as neutral salts:

Chlorhydrate	....	$C^5H^7N. HCl$
Chloroplatinate	....	$C^5H^7N. HPt Cl^3$.

But Barral, who determined the density of the vapour of nicotine, found numbers which assigned to this alkali the 2 volume equivalent $C^{10}H^{14}N^2$, so that the preceding salts must be in reality acid salts, thus:

Bichlorhydrate	....	$C^{10}H^{14}N^2. 2 HCl$
Bichloroplatinate	....	$C^{10}H^{14}N^2. 2 HPtCl^3$.

On the other hand, Schlœsing has determined the quantity of sulphuric acid saturated by nicotine, and has found for the formula of the

Neutral sulphate .... $2 C^{10}H^{14}N^2. H^2SO^4$.

Chloronicine.

Saint-Evre has described two alkalies obtained respectively by the action of sulphydrate of ammonia upon a nitro- and upon a nitro-chloro-substitution product of the same hydrocarbon.

The hydrocarbon in question is:

Paranicene = $C^{10}H^{12}$.

The chloro-hydro-carbon:

Chloronicine = $C^{10}H^{10}Cl^2$.

The nitro-hydro-carbon, (X = NO^2)

Nitronicene = $C^{10}H^{11}X$.

The nitro-chloro-hydro-carbon:

Dinitro-chloro-nicene = $C^{10}H^8Cl^2X^2$.

The nitro compounds by the action of sulphydrate of ammonia produce respectively:

Paranicine	....	$C^{10}H^{13}N$
Chloronicine	....	$C^{10}H^{12}Cl^2N^2$.

of which the chlorhydrates and chloroplatinates are, for

aranicine .... $\left\{\begin{array}{l} C^{10}H^{13}N.\ HCl \\ C^{10}H^{13}N.\ H\,Pt\,Cl^{3} \end{array}\right.$

Chloronicine .... $\left\{\begin{array}{l} C^{10}H^{12}Cl^{2}N^{2}.\ 2\,HCl \\ C^{10}H^{12}Cl^{2}N^{2}.\ 2\,HPt\,Cl^{3}. \end{array}\right.$

It is true that Saint-Evre halves the formula of chloronicine, and considers as neutral, the salts which according to us are acid; thus he writes:

Hydrochlorate of paranicine	....	$C^{10}H^{13}\,N.HCl$
Hydrochlorate of chloronicine	....	$C^{5}H^{6}ClN.HCl$.

Independently of the above formula for chloronicine presenting an uneven number of dyads, we are also warranted in rejecting it from considerations connected with the origin and formation of the alkali it represents. We cannot consent to give to chloronicine, a number of carbon atoms differing from that given to paranicine.

On the other hand, we perceive that chloronicine is no other than *bichloro-nicotine*; and we have already shown that the corresponding salts obtained with normal nicotine are likewise acid.

Lastly, we may add that according to Saint-Evre's experiments, the above salts, which he considers as neutral, have an acid reaction to test paper.

Quinine and Cinchonine.

These alkalies also give rise to acid salts. Thus the salts of quinine are:

Neutral chlorhydrate	....	$C^{19}H^{22}N^{2}O^{2}.\ \ HCl$
Bichlorhydrate	....	$C^{19}H^{22}N^{2}O^{2}.\ 2\,HCl$
Bichloroplatinate	....	$C^{19}H^{22}N^{2}O^{2}.\ 2\,HPt\,Cl^{3}$.

And with cinchonine, we have

Bichlorhydrate	....	$C^{19}H^{22}N^{2}O.\ 2\,HCl$
Bichloroplatinate	....	$C^{19}H^{22}N^{2}O.\ 2\,HPt\,Cl^{3}$;

cinchonine also forms neutral salts.

The neutral salts of these two alkalies have been considered, we do not know why, as basic, and their acid salts as neutral, although these last are produced in the presence of a great excess of acid.

Semi-naphthalidam and Semi-benzidam.

These two alkalies likewise give rise to acid salts which have hitherto been considered as neutral. This is how these bodies are ordinarily formulated with respect to aniline and naphthalidam.

Aniline	C^6H^7N
Semi-benzidam	C^3H^4N
Naphthalidam	$C^{10}H^9N$
Semi-naphthalidam	C^5H^5N.

Semi-benzidam would thus present us with an uneven number of dyads. But to prove that these relations are not exact, it is sufficient to revert to the origin and formation of the above alkalies.

Thus we have, by treating benzine and naphthaline with nitric acid and sulphydrate of ammonia successively, (H^2N being represented by Ad, and NO^2 by X.)

	2 volumes.
Benzine	C^6H^6
Nitrobenzine	C^6H^5X
Amidobenzine	C^6H^5Ad.
(Aniline.)	
Binitrobenzine	$C^6H^4X^2$
Biamidobenzine	$C^6H^4Ad^2$
(Semi-benzidam.)	
Naphthaline	$C^{10}H^8$
Nitronaphthaline	$C^{10}H^7X$
Amidonaphthaline	$C^{10}H^7Ad$.
(Naphthalidam.)	
Binitronapthaline	$C^{10}H^6X^2$
Biamidonaphthaline	$C^{10}H^6Ad^2$
(Semi-naphthalidam.)	

We may add, that among the numerous derivatives of benzine and naphthaline, we have not a single example of the halving the number of carbon atoms into C^3 or C^5 respectively.

The formula of semi-benzidam has been reduced to C^3H^2Ad, because in this last form it combines with H Cl, to produce a salt which has usually been considered as neutral, but which, from what we have just seen, must be in reality acid.

The salts of semi-naphthalidam have not been studied, but have been represented with C^5, to maintain the analogy with those of semi-benzidam.

Benzidine.

Benzidine is represented in the ordinary notation (G. & B. Eqs) by $C^{12}H^{12}N^{2}$, and it combines with 2 HCl and 2 $HPtCl^{3}$, &c. If we halve this alkali, to reduce it to the unitary system, we shall have an uneven number for the dyads. If, however, we retain the 12 atoms of carbon, then the salts of benzidine will become bisalts. Are we justified in considering them as such?

Let us consider the formation of this alkali: it is obtained by treating either azobenzide or azoxibenzide by sulphydrate of ammonia. The series is usually represented,

	On the ordinary notation (G. & B. Eqs.),	and consequently would be on the unitary system,
Benzine	.... $C^{12}H^{12}$	.... $C^{6}H^{6}$
Nitrobenzide	.... $C^{12}H^{10}(N^{2}O^{4})$	.... $C^{6}H^{5}(NO^{2})$
Azoxibenzide	.... $C^{12}H^{10}N^{2}O$	.... $C^{6}H^{5}NO\frac{1}{2}$
Azobenzide	.... $C^{12}H^{10}N^{2}$	.... $C^{6}H^{5}N$
Benzidine	.... $C^{12}H^{12}N^{2}$	.... $C^{6}H^{6}N$
Ditto, hydrochlorate of	.... $C^{12}H^{12}N^{2}.\ H^{2}Cl^{2}$	.... $C^{6}H^{6}N.\ H\,Cl.$

This series seems indeed, to be correctly arranged; but according to our experiments, azoxi-benzide treated by nitric acid, yields a nitro derivative, which consists of—

Ordinary notation (G. & B. Eqs),

$$C^{12}H^{9}(NO^{2})N^{2}O^{2},$$

and would be on the unitary notation,

$$C^{6}H^{4\frac{1}{2}}(N\tfrac{1}{2}O)NO,$$

which is impossible, in consequence of the fractional equivalents for H and N.

We must then, represent this compound on the ordinary notation by

$$C^{24}H^{18}(N^{2}O^{4})N^{4}O^{4},$$

and on the unitary notation

$$C^{12}H^{9}(NO^{2})N^{2}O^{2}.$$

Azobenzide and benzidine being obtained from azoxibenzide, ought to contain the same amount of carbon as the last, that is to say, C^{24} on the ordinary, or C^{12} on the unitary notation, since these are the numbers of carbon atoms contained in nitro-azoxibenzide.*

The preceding series then ought to be written thus :—

	Ordinary (G. & B. Eqs.)	Unitary.
Benzine	$C^{12}H^{12} = 4$ vol.	$C^6 H^6 = 2$ vol.
Nitrobenzine	$C^{12}H^{10}(N^2O^4)$	$C^6 H^5 (NO^2)$
Azoxibenzide	$C^{24}H^{20}N^4O^2$	$C^{12}H^{10}N^2O$
Nitro-azoxibenzide	$C^{24}H^{18}N^4O^2(N^2O^4)$	$C^{12}H^9N^2O(NO^2)$
Azobenzide	$C^{24}H^{20}N^4$	$C^{12}H^{10}N^2$
Benzidine	$C^{24}H^{24}N^4$	$C^{12}H^{12}N^2$
Ditto, hydrochlorate of,	$C^{24}H^{24}N^4 . 2\,H^2Cl^2$	$C^{12}H^{12}N^2 . 2\,H\,Cl.$

In this way the salts of benzidine are bisalts.

Cyaniline.

According to us, all the cyaniline salts hitherto obtained are acid salts.

The alkali is obtained by treating aniline with cyanogen. The two bodies simply unite with one another, and produce cyaniline: thus—

$$2\,CN + 2\,C^6H^7N = C^{14}H^{14}N^4.$$

But cyaniline thus written, combines with $2\,HCl$, $2\,HNO^3$, &c., or in other words gives origin to acid salts only. True it is, that we can convert them into neutral salts by halving their formulæ thus,

$$C^7H^7N^2 . \,H\,Cl;$$

but then the sum of the dyads would be uneven. Let us consult analogy.

Not only does normal aniline combine with cyanogen, but so also does *melaniline*, a compound representing two equivalents of aniline, in which one equivalent of H is replaced by Cy.

If we apply the name *dianiline* to the result of the condensation of two equivalents of aniline into one integral molecule, we shall have

$$\text{Normal dianiline} \;\ldots.\; \begin{Bmatrix} C^6H^7N \\ C^6H^7N \end{Bmatrix} = C^{12}H^{14}N^2, \text{ unknown;}$$

$$\text{Cyanated dianiline} \; \begin{Bmatrix} C^6H^7N \\ C^6H^6CyN \end{Bmatrix} = C^{13}H^{13}N^3, \text{ melaniline.}$$

---

* Moreover azobenzide itself gives rise to a nitro-derivative, which, formulated with C^6, would present fractional numbers for the H and N; thus $C^6 \; ^{4\frac{1}{2}} (N\tfrac{1}{2}O)\,N$.—(W. O.)

Each of these two varieties can combine directly with cyanogen, and we then have

$$\text{Normal cyanodianiline....} \left\{ \begin{matrix} C^6H^7N \\ C^6H^7N \end{matrix} \right\} + Cy^2 = C^{14}H^{14}N^4, \text{ cyaniline.}$$

$$\text{Cyanated cyanodianiline} \left\{ \begin{matrix} C^6H^7N \\ C^6H^6CyN \end{matrix} \right\} + Cy^2 = C^{15}H^{13}N^5, \text{ cyamelaniline.}$$

This analogy between the mode of formation of cyaniline and cyamelaniline is so complete, and the connexion of the formulæ is so evident, that the separation of these two bodies appears to us impossible. But the formula of cyamelaniline cannot be halved: (in accordance with our law of divisibility): and consequently cyaniline, although possessing a divisible formula, ought not to be halved.

Stibethine demonstrates to us still more clearly that there are alkalies which give rise to bi-salts only.

Stibethyl, which has been compared to a metal, combines directly with chlorine, bromine, iodine, oxygen, &c., to form chloride, bromide, &c., of stibethyle.

These salts are thus written:

	Ordinary notation (G. Eqs.) 4 volumes.	Unitary notation. 2 volumes.
Stibethyl	$C^{12}H^{30}\,Sb^2$	$C^6H^{15}Sb$
Bichloride of	$C^{12}H^{30}\,Sb^2.\,Cl^4$	$C^6H^{15}Sb.\,Cl^2$
Bibromide of	$C^{12}H^{30}\,Sb^2.\,Br^4$	$C^6H^{15}Sb.\,Br^2$
Biniodide of	$C^{12}H^{30}\,Sb^2.\,I^4$	$C^6H^{15}Sb.\,I^2$
Binoxide of	$C^{12}H^{30}\,Sb^2.\,O^2$	$C^6H^{15}Sb.\,O$
Bisulphide of	$C^{12}H^{30}\,Sb^2.\,S^2$	$C^6H^{15}Sb.\,S$
Binitrate of	$C^{12}H^{30}\,Sb^2.(NO^3)^4$	$C^6H^{15}Sb.(NO^3)^2$.

Further division would give $\frac{1}{2}$ equivalents.

As the question we are now considering is independent of any theories concerning the arrangement of atoms, we may compare the preceding salts with the salts of ammonium, and also with the salts of ammonia. In which latter case we shall say, that the preceding salts are salts of an alkali, which we will call *stibethine,* and which we will represent by

$$C^{12}H^{26}Sb^2, \text{ or by } C^6H^{13}Sb \text{ (unitary notation.)}$$

Of this body stibethyle will be the hydruret,

$$C^{12}H^{26}Sb^2.\,H^4, \text{ or by } C^{12}H^{13}Sb.H^2, \text{ (on the unitary notation.)}$$

Chlorine, bromine, &c., when presented to this hydruret, unite with the hydrogen to form chlorhydric and bromhydric acids, which acids remain in combination with stibethine. We shall then have

	Ordinary notation.	Unitary notation.	
Stibethine	$C^{12}H^{26}Sb^2$	$C^6H^{13}Sb$	analogous to NH^3
Bihydruret	$C^{12}H^{26}Sb^2.H^4$	$C^6H^{13}Sb.H^2$	„ $NH^3.H$
Bichlorhydrate	$C^{12}H^{26}Sb^2.4\,H\,Cl$	$C^6H^{13}Sb.2\,H\,Cl$	„ $NH^3.HCl$, &c.
Bibromhydrate	$C^{12}H^{26}Sb^2.4\,H\,Br$	$C^6H^{13}Sb.2\,H\,Br$	
Biniodhydrate	$C^{12}H^{26}Sb^2.4\,HI$	$C^6H^{13}Sb.2\,HI$	
Bihydrate	$C^{12}H^{26}Sb^2.2\,H^2O$	$C^6H^{13}Sb.H^2O$	
Bisulphydrate	$C^{12}H^{26}Sb^2.2\,H^2S$	$C^6H^{13}Sb.H^2S$	

In the ordinary notation then, the salts of stibethyle or stibethine are bisalts, and such they remain when reduced to the unitary system.

A new question here presents itself: can alkalies, such as semi-benzidam, cyaniline, and stibethine, which combine with two equivalents of acid, also give rise to salts with only one equivalent of acid? In this case these alkaloids would only differ from the rest, in having a greater tendency to form acid, than to form neutral salts. But if the contrary, we shall then have biacid bases, in the same manner as we have bibasic acids. That is to say, we shall have bases, the neutral salts of which contain two equivalents of monobasic acids.

The facts we have just now adduced, prove clearly, that in order to determine the equivalent, or rather the molecule of an alkali, it is not in every case sufficient to obtain a salt thereof; for if there be but a single series of salts, we shall not always know, whether this series ought to be compared with a neutral or with an acid group.

ANOMALIES OF THE SALTS OF THE OXIDES (R^4O^3).

In the ordinary notation, but with the atoms of the metals halved (G. Eqs.) we represent:

Ferrous oxide	$F^2\,O$
Manganous oxide	$Mn^2\,O$
Ferric oxide	$F^4\,O^3$
Manganic oxide	$Mn^4\,O^3$
Chromic oxide	$Cr^4\,O^3$
Ferric chloride	$F^4\,Cl^6$

Ferric nitrate	$Fe^4(NO^3)^6$
Chromic nitrate	$Cr^4(NO^3)^6$
Ferric acetate	$Fe^4(C^2H^3O^2)^6$
Chromic acetate	$Cr^4(C^2H^3O^2)^6$.

To apply the unitary notation to the above compounds, we must halve the formulæ of such of them as are, so to speak, monobasic; or, in other words, we must retain the preceding formulæ for the oxides, but represent the

Ferric chloride by	Fe^2Cl^3
Ferric nitrate by	$Fe^2(NO^3)^3$
Chromic nitrate by	$Cr^2(NO^3)^3$
Ferric acetate by	$Fe^2(C^2H^3O^2)^3$
Chromic acetate by	$Cr^2(C^2H^3O^2)^3$.

But then the formulæ of these salts will not be in accordance with the law of even numbers.

We might proceed no further than this point, and show, that if the law of even numbers was not absolutely exact, it could easily be modified as follows: [Ferric oxide and ferric sulphate being bibasic in respect to the oxygen and the acid, and ferric chloride and ferric nitrate being monobasic in respect to the chlorine and the acid, we may say that (Ed.)]:

I°. *Monobasic sesqui combinations contain an uneven number of dyads.*

II°. *All other combinations in chemistry contain an even number.*

This law would be without any exception, and would serve precisely as well as the other, to judge within certain limits, as to the correctness or incorrectness of a formula.

But the first law seems to me to be preferable in consequence of its simplicity, and I now proceed to point out the method, by which the apparent exceptions presented by the sesqui-salts may be made to disappear.

How do we determine the equivalent of an oxide? By weighing that quantity of the oxide which displaces K^2O from its combinations, or which is displaced by K^2O, taken as the term of comparison: or what comes to the same thing, by weighing that quantity of the oxide which combines with SO^3 to form a normal salt.

But K^2O, Na^2O, Ba^2O, Fe^2O, Mn^2O, $Fe_{\frac{4}{3}}O$, $Mn_{\frac{4}{3}}O$, $Al_{\frac{4}{3}}O$, &c., form neutral salts with SO^3: consequently, if Fe^2O is the equivalent of protoxide of iron, $Fe_{\frac{4}{3}}O$ ought to be the equivalent of the peroxide, and not $\mathrm{Fe}^4\mathrm{O}^3$, which represents three equivalents.

How do we determine the equivalent of a metal? By weighing that quantity of the metal which displaces from a sulphate H^2 or K^2 or Pb^2 or Ag^2, &c; or on the other hand is displaced from its sulphate by H^2, K^2, Pb^2, Ag^2, &c.

But K^2, Na^2, Ba^2, Fe^2, Mn^2, Cr^2, $\mathrm{Fe}_{\frac{4}{3}}$, $\mathrm{Mn}_{\frac{4}{3}}$, $\mathrm{Cr}_{\frac{4}{3}}$, &c., displace one another mutually from their normal combinations, to reproduce other normal combinations, so that if Fe^2 is the equivalent of iron, $\mathrm{Fe}_{\frac{4}{3}}$ is also its equivalent.

I have already said (*vide* EQUIVALENTS) that a body can have as many equivalents as it fulfils functions. Iron then, has two basic equivalents, $\mathrm{Fe}^2 = 350$ and $\mathrm{Fe}_{\frac{4}{3}} = \frac{2}{3}\,350$.

When Fe^2 enters into a combination, it impresses upon that combination certain characters, which cause it to be recognised immediately, even without an analysis, for a *ferrous* salt. And when $\mathrm{Fe}_{\frac{4}{3}}$ enters into a similar combination, it likewise impresses on the body characteristic properties, which cause it to be recognised as a *ferric* salt.

Fe^2 and $\mathrm{Fe}_{\frac{4}{3}}$ comport themselves as two metals, whose combinations manifest a greater degree of difference, than that which exists between protosalts of iron and salts of nickel.

Instead then of saying, that Fe^2 represents that equivalent of iron which *corresponds to the ferrous salts*, and $\mathrm{Fe}_{\frac{4}{3}}$ that equivalent which *corresponds to the ferric salts*, let us simply say, that Fe^2 is the ferrous equivalent and $\mathrm{Fe}_{\frac{4}{3}}$ the ferric equivalent—or even let us say, that Fe^2 is the equivalent of ferrosum, and $\mathrm{Fe}_{\frac{4}{3}}$ the equivalent of ferricum.

Since we represent the equivalents of simple bodies by entire letters, let us do as much for ferricum, and agree to represent $\mathrm{Fe}_{\frac{4}{3}}$ by $\overset{\mathrm{v}}{\mathrm{F}}\mathrm{e}^2$: then let us see how, without any hypothesis, and resting entirely upon the basis of proportional numbers, we may write the formulæ of ferrous, ferric, chromic, aluminic salts, &c.

Ferrous oxide, or oxide of ferrosum	$\mathrm{Fe}^2\mathrm{O}$
Ferric oxide, or oxide of ferricum	$\overset{\mathrm{v}}{\mathrm{F}}\mathrm{e}^2\mathrm{O}$
Ferroso-ferric oxide	$\mathrm{Fe}\,\overset{\mathrm{v}}{\mathrm{F}}\mathrm{e}\,\mathrm{O}$
Ferrous acetate	$\mathrm{Fe}\,\mathrm{C}^2\mathrm{O}^2\mathrm{H}^3$
Ferric acetate	$\overset{\mathrm{v}}{\mathrm{F}}\mathrm{e}\,\mathrm{C}^2\mathrm{O}^2\mathrm{H}^3$
Aluminic acetate	$\overset{\mathrm{v}}{\mathrm{A}}\mathrm{l}\,\mathrm{C}^2\mathrm{O}^2\mathrm{H}^3$.

Thus the sum of the dyads always forms an even number.

I shall henceforth represent all protoxides by R^2O. I will admit a protoxide of aluminum, of antimony, and of bismuth, which in the notation of Berzelius would be $Al\,O$, $Sb\,O$, and $Bi\,O$ respectively; consequently all protoxides will be written thus:—

Potash	$K^2\,O$	
Oxide of aluminosum	$Al^2\,O$	unknown
Oxide of ferrosum	$Fe^2\,O$	
Oxide of antimonosum	$Sb^2\,O$	unknown
Oxide of bismuthosum	$Bi^2\,O$	
Oxide of cupricum	$Cu^2\,O$	
Oxide of mercuricum	$Hg^2\,O$	
Oxide of platinosum	$Pt^2\,O$.	

All sesquioxides and teroxides thus:—

$(\mathrm{v} = \frac{2}{3};\ \mathrm{u} = \frac{1}{3})$.

Oxide of alumunicum	$\overset{v}{Al}{}^2\,O = al^2\,O$
Oxide of cericum	$\overset{v}{Ce}{}^2\,O = ce^2\,O$
Oxide of manganicum	$\overset{v}{Mn}{}^2\,O = mn^2\,O$
Oxide of ferricum	$\overset{v}{Fe}{}^2\,O = fe^2\,O$
Oxide of cobalticum....	$\overset{v}{Co}{}^2\,O = co^2\,O$
Oxide of nickelicum	$\overset{v}{Ni}{}^2\,O = ni^2\,O$
Oxde of antimonicum	$\overset{u}{Sb}{}^2\,O = sb^2\,O$
Oxide of bismuthicum	$\overset{u}{Bi}{}^2\,O = bi^2\,O$
Oxide of iridoicum	$\overset{v}{Ir}{}^2\,O = ir^2\,O$
Oxide of rhodicum	$\overset{v}{Rh}{}^2\,O = rh^2\,O$
Oxide of ruthenoicum	$\overset{v}{Ru}{}^2\,O = ru^2\,O$.

The binoxides and suboxides thus:—

(— $= \frac{1}{2}$. Italic letter with — $= 2$.)

Oxide of cuprosum	$\overline{\mathit{Cu}}{}^2\,O = \mathit{cu}^2\,O$
Oxide of mercurosum	$\overline{\mathit{Hg}}{}^2\,O = \mathit{hg}^2\,O$
Oxide of platinicum	$\overline{Pt}{}^2\,O = pt^2\,O$
Oxide of palladicum	$\overline{Pd}{}^2\,O = pd^2\,O$
Oxide of iridicum	$\overline{Ir}{}^2\,O = ir^2\,O$
Oxide of osmicum	$\overline{Os}{}^2\,O = os^2\,O$
Oxide of ruthenicum	$\overline{Ru}{}^2\,O = ru^2\,O$
Oxide of stannicum	$\overline{Sn}{}^2\,O = sn^2\,O$
Oxide of titanicum	$\overline{Ti}{}^2\,O = ti^2\,O$.

SECTION SECOND.

Divisibility of Atoms.

Formulæ of Neutral, Acid, Basic, Anhydrous, and Hydrated Salts.

The result to which I have just arrived, is exactly the same as that to which I was led some years back, as a deduction from certain atomic speculations.

I said that I would found my system upon facts, and not upon hypotheses: if then I return for an instant to the question of atoms, I do so, in order that I may explain my ideas more clearly by expressing them in two different ways; and also, because if I neglected to show that my system is not in contradiction with the atomic theory, I should risk its rejection by the majority of chemists.

When I endeavoured to arrange the salts of the sesquioxides, in the classification of which I gave the first sketch fifteen years ago, I met with a difficulty which arrested me for a long time. I sought to include all salts of the same acid in the same formula. The majority of salts yielded pretty well to my notions, with the exception of the salts of sesquioxides and certain double salts. For instance I wished to obtain with the sulphates an unique series of the following description:

$$\begin{array}{lll} H^2 & SO^4 & \\ K^2 & SO^4 & \\ KH & SO^4 & \\ K\,Mg & SO^4 & \\ R^2 & SO^4 & + \text{n}\,H^2\;O \\ & & + \text{n}\,R^2\;O \\ & & + \text{n}\,HR\;O. \end{array}$$

But ferric, aluminic, &c., salts, stood out of this series, for we have for the

Ferric sulphate .... $Fe^4.S^3O^{12}$,

and for the

Alumino potassic sulphate .... $K^2\,Al^4.S^4O^{16}$.

I then replaced the ordinary equivalents of the sesquioxides by the following:

$$\mathrm{Fe}\tfrac{4}{3}\mathrm{O} \qquad \mathrm{Al}\tfrac{4}{3}\mathrm{O} \qquad \mathrm{Cr}\tfrac{4}{3}\mathrm{O},$$

or by

$$\overset{v}{\mathrm{F}}\mathrm{e}^2\,\mathrm{O} \qquad \overset{v}{\mathrm{A}}\mathrm{l}^2\,\mathrm{O} \qquad \overset{v}{\mathrm{C}}\mathrm{r}\,\mathrm{O};$$

in other words, I arrived at the same result as that to which I have been more recently led, in following out the law of even numbers; I could then arrange the preceding sulphates according to the simple sulphate *type*.

Ferric sulphate .... $\overset{v}{\mathrm{F}}\mathrm{e}^2\ \mathrm{SO}^4$

Alumino potassic sulphate .... $\overset{v}{\mathrm{A}}\mathrm{l}\tfrac{3}{2}\,\mathrm{K}\tfrac{1}{2}\mathrm{SO}^4$.

But in making use of this expression *type*, I must direct attention to a difficulty which exists in the system I am now describing. The idea of a type calls forth the idea of arrangement, and consequently, the idea of atoms. But the preceding formulæ, which in a proportional number point of view are irreproachable, are in the atomic system absurd, since we see fractions of atoms introduced. Nevertheless in the establishment of my classification, I find myself countenanced by the atomic theory, to this effect,—that in analogous bodies the same disposition of the atoms will obtain.

But seeing the formulæ of ferrous sulphate and ferric sulphate thus written—

$$\mathrm{Fe}^2\ \mathrm{SO}^4 \text{ and } \mathrm{Fe}^4\ \mathrm{S}^3\mathrm{O}^{12},$$

I could not conceive how the two salts could both be sulphates, for containing such different numbers of atoms, they ought not to have the same atomic arrangement. It was then that I asked myself, whether the atoms of chemists might not be divisible.

We know how much metaphysicians disagree concerning the divisibility of matter. Is it, or is it not divisible to infinity? The affirmative and the negative are equally incomprehensible. However, the law of combination in definite proportions seems to have given great support, to the cause of those who maintain, that matter is composed of indivisible atoms. Indeed the existence of such atoms is admitted by nearly all chemists.

But even if we admit that there is a limit to the divisibility of matter, we are not obliged to consider the atoms of chemists as constituting this limit, and we might very well comprehend the cause of the law of definite proportions, by supposing that the chemical atoms are but molecular groups, composed of a certain number of minuter atoms. Some physicists have even gone further, and while admitting the existence of these molecular groupings, have supposed them to be infinitely divisible.

Berzelius, to whom the atomic theory owes so much of its completeness, is strongly opposed to the idea of the divisibility of atoms. Nevertheless he has admitted that gaseous bodies contain the same number of atoms in the same volume, and consequently, that if Cl (= 1 vol.) and H (= 1 vol.) respectively represent an atom of hydrogen, and an atom of chlorine,—$Cl_{\frac{1}{2}}H_{\frac{1}{2}}$ (= 1 vol.) must also represent an atom of chlorhydric acid. The atoms of chlorine and hydrogen are then upon this hypothesis, divisible at least into halves. That of chlorine is even divisible into quarters, since in one volume (*i. e.* one atom) of perchloride of phosphorus there are contained 1¼ volumes of chlorine. Certainly it is absurd to say on the one hand, that atoms are indivisible, and on the other hand, to consider them in certain cases as susceptible of division. But such is not the case with us; we say, that the *minute mass* of oxygen which invariably enters into all combinations with the same weight (100), the minute mass which chemists call an atom, is still divisible.

The contradiction is in the expressions of Berzelius, who admits the existence of an indivisible atom of sulphur, and of an equally indivisible atom of phosphorus, and at the same time admits that sulphur and phosphorus can give rise to modifications *a*, *b*, and *c*, modifications which, according to Berzelius, exist in the atoms themselves. Thus he represents the three phosphoric acids by P^aO^5, P^bO^5, and P^cO^5. But is not the supposition of the susceptibility of an atom to modifications, the same thing as an admission of its divisibility?

What do we say in our system?

That the chemical atom of *a* phosphorus is not indivisible, but that it is a group of twelve small atoms, for example, arranged in a certain manner. That the chemical atom of *b* phosphorus is a group of eight small atoms; and the chemical atom of *c* phosphorus is a group of six small atoms; and that if the first is represented by P, the second must be represented by $P_{\frac{2}{3}}$, and the last by $P_{\frac{1}{2}}$. The numbers 12, 8, and 6, have of course been taken at random, for we do not even know whether the *c* phosphorus may not contain more minute atoms than the *a* phosphorus contains.

Is not this hypothesis in perfect harmony with the atomic theory? Is it not, moreover, confirmed by experiment? We know that 2, 3, 4, 5, &c., molecules of methyline in uniting with one another give origin to several different bodies: etherine C^2H^4, propyline C^3H^6, butyrine C^4H^8, amyline C^5H^{10}, &c. We know also, that methyl and hydruret of ethyl each contain the same number of atoms within the same volume, and that consequently, *a* phosphorus need not differ from *b* phosphorus in the number of the minute atoms, but only in their arrangement.

The divisibility of the ordinary atoms and of our molecules being admitted, let us suppose that a molecule of iron weighing 350, is composed of 24 minute atoms $= f^{24}$,—or better $(f^{12})^2$, representing it as a dyad molecule, corresponding to H^2; let us call this grouping *ferrosum* $= Fe^2$.

From what we have just said, if 16 of these minute atoms unite to form a second binary group, we should have a body differing from the preceding; this body we will call *ferricum*, and we will represent it by $(f^8)^2 = \overset{v}{F}e^2$.

Now let us see how the formulæ of ferrous and ferric oxides may be written:

Ferrous oxide	$(f^{12})(f^{12})O = Fe^2\ O$
Ferric oxide	$(f^8)(f^8)O = \overset{v}{F}e^2\ O$
Ferroso ferric oxide	$(f^{12})(f^8)O = Fe\overset{v}{F}eO.$

This notation is similar to the following, by which we may represent the methylic, ethylic, and propylic ethers, &c., M = methyline.

Hydrate of methyline	$(M)\ (M)\ H^2O = Me^2\ O$
Hydrate of etherine	$(M^2)(M^2)\ H^2O = Et^2\ O$
Hydrate of meth. and eth....	$(M)\ (M^2)\ H^2O = MeEtO$
Hydrate of propyline	$(M^3)(M^3)\ H^2O = Pp^2\ O$
Hydrate of eth. and propyl.	$(M^2)(M^3)\ H^2O = EtPp\,O$
Hydrate of valerine	$(M^5)(M^5)\ H^2O = Vl^2\ O$
Hydrate of eth. and valer....	$(M^2)(M^5)\ H^2O = Et\ VlO.$

The molecule f^{24}, in entering into a salt, impresses upon it, certain properties different from those which the molecule f^{16} gives. We might then, in one sense affirm, that a ferrous salt does not contain the same metal that is contained in a ferric salt, and with quite as much reason as we say, that a salt of methyline does not contain the same hydrocarbon that is contained in a salt of etherine.

It is to the presence of one or other of these metals, that we ought to attribute the respective colours of ferrous and ferric salts. It is generally admitted that the green colour of the first, is due to the protoxide they contain, and the red colour of the second, to the presence of the peroxide.

But the existence of these oxides in the salts, is nowhere demonstrated, and is indeed impossible if we admit Gerhardt's notation. Moreover, the perchloride of iron is red, and does not contain any oxygen whatever.

I ought not to omit noticing a case, which may be presented by the ferric, mercuric and platinic salts, and which, at first sight, is somewhat embarrassing.

Suppose that we cause the bichloride of platinum to react upon an organic compound, say for example, upon aniline, and that an atom of hydrogen carries away an atom of chlorine from the bichloride so as to form chlorhydric acid, and that a new compound containing protochloride of platinum and the residue of the aniline results,

$$\bar{P}t^2Cl^2 + C^6H^7N = PtCl.C^6H^6N + HCl,$$

we perceive from this equation, that the new compound contains an uneven number of dyads, namely, 9. First, let us do away with all hypothetical arrangement, and removing the point, write simply C^6H^6ClNPt. We do not know, whether the chlorine in this compound is or is not in combination with the platinum, and consequently are unable to say, whether the metal is in the state of platinosum or platinicum.

Since, by supposing the presence of platinosum, we have an uneven number of dyads, let us do away with the discrepancy by admitting that the platinum is in the state of platinicum $C^6H^6ClNpt^2 = A$, and now let us prove that such a supposition is not gratuitous. For this purpose, let us cause this new body to undergo divers metamorphoses, by treating it with ammonia, water, chlorhydric acid, potash, &c. I affirm that in all the compounds thus obtained, the platinum will always be in the state of platinicum, and definitively, that it will always be able to reappear in the form of an admitted platinic compound, such as the platinic oxide and platinic chloride, and not in the form of a platinous compound.

Let us at first combine it with ammonia, we shall then have

$$C^6H^6ClNpt^2 + H^3N = C^6H^9ClN^2pt^2 = B.$$

Let us now heat B so as to drive off an atom of chloride of ammonium,

$$C^6H^9ClN^2pt^2 - H^4NCl = C^6H^5Npt^2 = C.$$

Let us decompose C by water (under the influence of caustic potash), we shall then have

$$\mathrm{C^6H^5Npt^2 + H^2O = C^6H^7N + pt^2\,O};$$

that is to say, we shall have regenerated aniline and a platinic combination.

Let us also treat A and B by water and potash, and we shall have:

A. $\mathrm{C^6H^6ClN\,pt^2 + H^2O = C^6H^7N + H\,Cl + pt^2O}$,
B. $\mathrm{C^6H^9ClN^2pt^2 + H^2O = C^6H^7N + NH^4Cl + pt^2O}$.

It should be remarked, that in the first reaction, we did not take away chlorine but chlorhydric acid; and that if from the hydrochlorate of platinic chloride $\mathrm{Hpt^2Cl^3}$, we were to abstract chlorine in the form of chlorhydric acid, we should not alter the state of the salt, which would still remain platinic.

Supposing that the platinic chloride, in acting upon aniline, lost all its chlorine in the state of chlorhydric acid, the platinum of the new compound would still exist in the form of platinicum,

$$\mathrm{\bar{P}t^2Cl^2 + C^6H^7N = C^6H^5pt^2N + H^2Cl^2},$$

for we have just seen that $\mathrm{C^6H^5pt^2N}$, by the action of water would regenerate platinic oxide.

To obtain a combination of platinosum, we should be obliged to remove Cl and not HCl.

In treating with chlorine, any one of the salts of Reiset having as a base $\mathrm{PtH^5N^2}$, we should obtain a salt of Gros, having as its base, $\mathrm{ClPtH^5N^2}$. In this last base the sum of the dyads is uneven (9); but though the compound contains but one equivalent of chlorine for one equivalent of platinum, still the metal is in the state of platinicum $\mathrm{Clpt^2H^5N^2}$. That this is the case is proved by all the reactions of the salts of Gros.

The divisibility of atoms will moreover, enable us to account for the difficulty and even the contradiction which chemists encounter, when they endeavour to determine the equivalents of certain substances, such for example as manganese.

We know that in following out the isomorphism of the permanganates with the perchlorates, we are led to adopt the number 700 for the equivalent of the metal, whilst by the same method of reasoning, deduced from the isomorphism of the manganates with the sulphates, and of the manganous salts with the calcic and magnesic salts, we have to adopt the number 350.

By admitting the divisibility of atoms, the above difficulty would disappear, for we could then represent the equivalent

of hydrogen by .... H^2
of manganosum by .... $(m^{12})^2 = Mn^2$
and of manganicum by .... $(m^8)^2 = \overset{v}{M}n^2$.
That of the sulphates by .... $R^2. SO^4$;

and consequently that

of the manganates by $R^2(m^{24})O^4 = R^2\overset{\div}{M}nO^4$.
That of the perchlorates by .... $RCl\ O^4$;

and consequently that

of the permanganates by $R\ (m^{24})O,^4 = R, \overset{\div}{M}\ O^4$;
that is to say, that

Manganosum .... $(m^{12})^2 = M^2$ is the equivalent of calcium and magnesium Ca^2 and Mg^2, and is isomorphous with them.

Manganicum .... $(m^8)^2 = \overset{v}{M}n^2$ is the equivalent of calcium and *ferricum* f, and is isomorphous with the latter.

Mangan .... $(m^{24}) = \overset{\div}{M}n$ is the equivalent of sulphur S, and is isomorphous with it.

Manganorine .... $(m^{24})^2 = \overset{\div}{M}n^2$ is the equivalent of chlorine Cl^2, and is isomorphous therewith.

Manganese then, has several equivalents depending upon the functions which it fulfils, as we have already seen elsewhere.

The divisibility of atoms, will also enable us to understand how it is, that carbonate of lime being isomorphous with carbonate of magnesia, these two salts are isomorphous with dolomite and other carbonates of the two bases, a circumstance which in the ordinary atomic system, appears incomprehensible.

Carbonate of lime crystallises in rhombohedrons of about 107 degrees, that of magnesia in rhombohedrons of about 105 degrees, whilst the crystal of dolomite is the mean of the two preceding, or of about 106 degrees. For the sake of simplicity let us take plane figures or rhombs of 107, and of 105 degrees. Then according to the ordinary ideas, a molecule of the double salt will be constituted of two rhombs, of 107 and 105 degrees respectively, and the union of these two rhombs will still give rise to a rhomb, which moreover, will be of 106 degrees. This is as incomprehensible as the formation of a cube by the superposition of two cubes. But the difficulty will be still greater if we take a multiple carbonate, equal to $4\,Ca^2CO^3.3\,Mg^2CO^3.2\,Mn^2CO^3.Fe^2CO^3$. How could the juxtaposition of these 10 rhombs give rise to a rhomb, of which the angle would be nearly one-tenth part of the 10 angles that served to form it?

By making use of our system this difficulty will easily disappear. Let us admit in every case that each molecule of metal contains (m^{24}), and let us represent the arrangement of the molecules of a carbonate, by a rhomb, of which the four angles are occupied by C and O^3, and of which the centre is occupied by the molecule (ca^{24}), or the molecules (mg^{24}) (mn^{24}) (fe^{24}).

Experiment proves to us, that these molecules, in taking the places of one another, will not seriously disturb the arrangement of the rhomb. Let us take away from the molecule or group (ca^{24}), 1. 2. 3. 4. . . . . . 23 *minute atoms* of calcium, and replace them by 1. 2. 3. 4. . . . . . 23 *minute atoms* of magnesium, manganese, or iron, the number of these minute atoms in the central group being always the same, the figure of the rhomb will be sensibly unaltered.

We should thus be able to have a series of carbonates, of which the formulæ would be

$$CO^3\,(ca^{24})$$
$$CO^3\,(mg^{24})$$
$$CO^3\,(ca^{12}.\,mg^{12})$$
$$CO^3\,(ca^{12}.\,mg^{6}.\,mn^{6})$$
$$CO^3\,(ca.\,mg^{2}.\,mn^{4}.\,fe^{17}),$$

and which moreover would be isomorphous.

Concerning the divisibility of atoms, it may be remarked that:

1°. The dyads H^2, Cl^2, M^2, N^2, &c., cannot be divided in two by the monads. Thus when we act upon them, either directly or indirectly, with oxygen, sulphur, carbon, &c., we only obtain combinations containing entire dyads: H^2O, H^2S, CH^2, Cl^2O, Cl^2S, CCl^2, &c.

2°. A dyad can divide itself in two, by the action of another dyad, but solely on the condition, that the demidyad set free be replaced by some other demidyad, whether analogous or not. Thus we have HCl, HBr, MCl, MBr, H^3N, Cl^3N, &c.

3°. The demidyads or atoms, H, Cl, M, N, &c., can in their turn, when presented to analogous dyads, divide themselves into $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, $\frac{2}{3}$, $\frac{2}{5}$, &c., that is to say, into any simple fractional part, on condition that the part set free be replaced by its equivalent. Thus we have

$$H^2O, \quad Fe_{\frac{3}{2}}H_{\frac{1}{2}}O, \qquad H^2SO^4, \quad K_{\frac{4}{3}}H_{\frac{2}{3}}SO^4, \text{ \&c.}$$

4°. The demidyads can divide themselves in all proportions, under the influence of dyads which have a great analogy with them, always upon the condition of equivalent substitution. It is thus that we have $CO^3(Ca\ Mg)^2$, $CO^3(Mg,\ Zn,\ Fe\ \ldots\ldots)^2$, &c., &c.

Double Salts.

Let us now take leave of hypotheses, and return to proportional numbers, or to molecules.

I have endeavoured to prove by the aid of the preceding hypotheses, and by the law of even numbers, that if the molecule of sulphuric acid is H^2SO^4, each molecule of the alumino-potassic, cobalto-magnesic, or other double or triple sulphate, ought to contain the same quantity of sulphur and of oxygen; in a word, ought to be moulded upon the molecule of sulphuric acid.

If we considered proportional numbers, simply as a means of representing the composition of bodies, it would be a matter of indifference whether we formulated the double sulphates in this manner:

$$\begin{array}{l} K^2\ SO^4.\ H^2\ SO^4 \\ K^2\ SO^4.\ 3al^2\ SO^4 \\ 2K^2\ SO^4.\ H^2\ SO^4 \\ 6Fe^2SO^4.\ 3fe^2\ SO^4; \end{array}$$

or in this:

$$\begin{array}{l} K\ H\ SO^4 \\ K_{\frac{1}{2}}\ al_{\frac{3}{2}}\ SO^4 \\ K_{\frac{4}{3}}\ H_{\frac{2}{3}}\ SO^4 \\ Fe_{\frac{4}{3}}\ f_{\frac{2}{3}}\ SO^4; \end{array}$$

although the second plan would be the most simple.

But if by proportional numbers, we seek to represent masses or molecules, comparable to one another in their physical and chemical properties, then our choice between the two notations will no longer be indifferent, for accordingly as we adopt one or the other, we shall arrive at different conclusions,—which can however, be experimentally tested or controlled.

We have seen that the determination of the weight of a molecule by means of its volume, leads us in more than ninety-nine cases out of a hundred to a correct result.

Consequently, if the molecule of water be $H^{2}O$, and that of hydrate of potash (double oxide of hydrogen and potassium) $H^{2}O.K^{2}O$, there is more than ninety-nine to one against the likelihood of these two molecules occupying the same volume in the state of vapour, whilst if $H^{2}O$ be the molecule of water, and KHO the molecule of hydrate of potash, there will be an equal improbability of the two molecules occupying different volumes. Unfortunately there is no double oxide whose vapour density we are capable of ascertaining. But in default of any such compound, we can argue from the vapour densities of certain bodies which may be compared to double oxides, namely, certain etheramides and mixed ethers.

For the sake of simplicity let us adopt the ethyl theory, according to which we must formulate in the following manner:

Water .... $H^{2}\,O$
Ether .... $Et^{2}\,O$
Alcohol .... $H^{2}\,O.\,Et^{2}O$
and Methylovinic ether $Me^{2}O.\,Et^{2}O$.

These formulæ if they respectively represent the *molecules* of the above oxides, should correspond to one and the same volume; but such is not the case, for we find the formulæ of water and ether correspond to two,—while those of alcohol and methylovinic ether correspond to four volumes.

To render these bodies comparable with one another, we must take an equal volume of each, thus:

Water .... $H^{2}\,O = 2$ volumes
Ether .... $Et^{2}\,O = 2$,,
Alcohol .... $H\,Et\,O = 2$,,
Methylovinic ether $Me\,Et\,O = 2$,,

Oxide of ethyl in combining with oxide of methyl divides itself into two, and does not form a simple combination by the addition of the two oxides, but a true double decomposition with the formation of two other oxides.

$$\begin{aligned} &Et^2O + Me^2O \\ &= Me\,Et\,O + Me\,Et\,O. \end{aligned}$$

Consequently, we must represent

Carbonic acid, by	H^2CO^3
Carbonate of ethyl, by	Et^2CO^3
Carbonate of ethyl and methyl, by	$Me\,Et\,CO^3$
Carbonate of potassium and hydrogen, by	$KH\ CO^3$,

and not by

$$K^2CO^3.\ H^2CO^3.$$

This argument is of course intended only for those who consider water and carbonic acid as bibasic compounds.

The density of bodies in the liquid or solid state leads us to a similar conclusion. Dumas has remarked that the atomic volumes of

Sulphuric acid	H^2SO^4	$+ 6$ Aq
Alum	$K^2Al^4S^4O^{16}$	$+24$ Aq
Sulphate of Magnesia	$Mg^2\ SO^4$	$+ 6$ Aq

have no relation to one another, when we employ the above formulæ, but that when we give the same type to these three bodies, their atomic volumes become sensibly equal,

$$\begin{aligned} &H^2SO^4 + 6\ Aq \\ &Mg^2SO^4 + 6\ Aq \\ &al\tfrac{3}{2}K\tfrac{1}{2} + 6\ Aq. \end{aligned}$$

Gerhardt has arrived at a similar result with regard to double and triple oxides, as seen in the following table arranged by him.

*Atomic volume = $\frac{P}{D}$

Type oxide	$O\,R^2$	mean	11·0
Oligistic iron	$O\,fe^2$	„	11·4
Braunite	$O\,mn^2$	„	11·2
Magnetic iron oxide	$O\,Fe\frac{1}{2}\ fe\frac{3}{2}$	„	11·4
Gahnite	$O\,Zn\frac{1}{2}\ al\frac{3}{2}$	„	10·9
Spinelle	$O\,Mg\frac{1}{2}\ al\frac{3}{2}$	„	10·6
Ceylanite	$O\,(al\ Fe\ Mg)^2$	„	10·6
Chlorospinelle	$O\,(al\ fe\ Mg)^2$	„	10·6
Chromic iron	$O\,(al\ fe\ Fe\ cr\ Mg)^2$	„	11·2
Titanic iron	$O\,(ti\ fe\ Fe)^2$	„	10·9
Franklinite	$O\,(fe\ mn\ Z\ Fe)^2$	„	11·1
Periclase	$O\,(fe\ Mg)^2$	„	10·9.

---

* P = the atomic weight according to the hydrogen scale.

Let us conceive sulphuric acid to be in the gaseous state, then with regard to the formation of its simple acid and double salts, we may suppose that the volume of the acid continues invariable; but that certain portions of its hydrogen are removed, and are replaced by exactly the same volume of one or more metals.

Moreover, what I am endeavouring to prove, is even now admitted by all chemists, in certain instances, and they cannot with consistency, reject the sum of my conclusions.

Thus they admit, that if to the molecule of phosphoric acid we add successively K, K^2 and K^3, we form successively the three simple salts, PO^4H^2K, PO^4HK^2 and PO^4K^3. Let us suppose that instead of three, six different salts existed, which differed from one another by a half atom of potassium. Then would these chemists adopt the following formulæ:

6 $PO^4H^3 + K^3$ forming a *double* salt = 5 $PO^4H^3 . PO^4K^3$
3 $PO^4H^3 + K^3$ forming a simple salt = 3 PO^4H^2K
2 $PO^4H^3 + K^3$ forming a *double* salt = $PO^4H^3 . PO^4K^3$
3 $PO^4H^3 + K^6$ forming a simple salt = 3 PO^4HK^2
6 $PO^4H^3 + K^{15}$ forming a *double* salt = $PO^4H^3 . 5PO^4K^3$
$PO^4H^3 + K^3$ forming a simple salt = PO^4K^3.

They would suppose then, that during the successive additions of potassium, there was an alternate formation of double and simple salts, thus alternately rejecting and admitting our views upon the subject. In addition to the caprice of these alternate halvings and doublings, we should have another incomprehensible circumstance. By the addition of K^2 to 2 PO^4H^3, we should obtain a salt which might be considered as monopotassic phosphoric acid 2 PO^4H^2K. By adding an additional quantity of potassium, one-half of the acid would lose its potassium and would reunite with hydrogen, so as to form the double salt $PO^4H^3 . PO^4K^3$. This metallisation and demetallisation of phosphoric acid appears to us extremely improbable.

Avoiding the above anomalies, we maintain that, by the addition of potassium, the process is continuous and not alternative, or in other words, that we have formed successively from

$PO^4H^3 + K_{\frac{1}{2}}$ a simple salt $= PO^4H_{\frac{5}{2}}K_{\frac{1}{2}}$
$PO^4H^3 + K$ a simple salt $= PO^4H^2 K$
$PO^4H^3 + K_{\frac{3}{2}}$ a simple salt $= PO^4H_{\frac{3}{2}}K_{\frac{3}{2}}$
$PO^4H^3 + K^2$ a simple salt $= PO^4H\ K^2$
$PO^4H^3 + K_{\frac{5}{2}}$ a simple salt $= PO^4H_{\frac{1}{2}}K_{\frac{5}{2}}$
$PO^4H^3 + K^3$ a simple salt $= PO^4\ \ K^3$.

That the salts containing $K_{\frac{1}{2}}K_{\frac{3}{2}}K_{\frac{5}{2}}$ are unknown to us, does not detract at all from our reasoning, since we are acquainted with combinations of a precisely analogous character.

Hureaulite	$P\,O^4Mg_{\frac{5}{2}}H_{\frac{1}{2}}+2\,Aq$
Berzelite	$AsO^4Mg_{\frac{3}{2}}Ca_{\frac{3}{2}}$
An acid sulphate of potash	$S\,O^4K_{\frac{4}{3}}H_{\frac{2}{3}}$.

Basic and hydrated salts.

From what we have just said, and recollecting that we have considered hydrogen as a metal, or at least as fulfilling the functions of a metal, it follows that we must represent

Simple sulphates by	$M^2\,SO^4$
Acid sulphates by	$(MH)^2\,SO^4$
Double sulphates by	$(MM')^2SO^4$.

It now remains for us to point out the manner in which we ought to formulate basic and hydrated salts, and also a particular class of salts analogous to the anhydrous bisulphate and bichromate of potash. Basic and hydrated salts may obviously be included in the same class, since we admit that the oxide of hydrogen plays the part of a metallic oxide. Then nothing is more easy than to formulate the composition of basic, hydrated, and hydrobasic salts. It suffices in fact, to write the formula of the normal salt separately, and then to add the water or oxides which render it hydratic or basic. Thus we should write:

Neutral sulphate	M^2SO^4
Hydrated sulphate	$M^2SO^4.\ \ H^2O$
Basic sulphate	$M^2SO^4.\ \ M^2O$
Hydrobasic sulphate	$M^2SO^4.\ HM\,O$.

Now it remains to be seen, whether or not all the hydrated or basic sulphates can be reduced to these simple formulæ.

We learn from experiment, that whenever a molecule (whether of a salt, acid, alkaloid, amide, &c.,) becomes hydrated, it takes up 1, 2, 3, 4, 5, ..., 12, or 13 atoms of water of crystallisation, and that, representing the molecule by M, we very rarely have such combinations as $2\,M+Aq$, $2\,M+3\,Aq$, and $2\,M+5\,Aq$, while there is not perhaps a single authentic instance of a body containing $3\,M+5\,Aq$, or $4\,M+5\,Aq$, &c.

Nevertheless, there exist certain double salts, especially among the silicates, phosphates, and arseniates, also certain sub-salts, principally those of the sesquioxides, which appear to have more complicated formulæ, such as 1, 2, 3, 4, 5, 6, 7, 10, 20, ... M + 10, 20, 43, 47, 52, 63, 100, and 200 Aq.

For the present let us set aside these last bodies, and examine pure and well crystallised substances only, and we shall then see, that in nineteen out of every twenty cases, the series of hydration is M + 1, 2, 3, 4, ... Aq, and occasionally, 2 M + 1, 3, and 5 Aq.

In following out this idea, we require to know whether ther can possibly exist:—

1°. A basic sulphate with this formula:

$$4\ SO^3 + 5\ M^2O.$$

2°. A hydrated sulphate with this:

$$4\ SO^3 + 3\ M^2O + 5\ H^2O.$$

3°. A hydrobasic sulphate with this:

$$4\ SO^3 + 6\ M^2O + 9\ H^2O.$$

4°. Whether the molecule of alum contains 4 SO^3, or only 1 SO^3.

In a word, whether all the sulphates do really enter into the simple series I have above given.

If, as I contend, the molecule of alum contains but 1 SO^3, this molecule will be capable of combining with 1, 2, 3, 4 . . . . Aq, that is to say, that alum, if we quadruple its formula so as to transform it in $S^4\,O^{16}\,al^6\,K^2$, should be able only to combine with 4, 8, 12, 16 . . . . . Aq,—whilst if the real molecule of alum contains 4 SO^3, it should be able to combine with 1, 2, 3, 4, 5, ... Aq. We learn from experiment that the octohedric alums (with 4 SO^3) contain 24 Aq,—that the ferric hexagonal alum contains 12 Aq,—that the ferric alum precipitated by absolute alcohol retains 8 Aq,—that the sulphate of chrome and soda retains 8 Aq at 100° C,—and lastly that dried common alum retains 4 Aq.

If octohedric alum, instead of a multiple of 4, contained for example 25 Aq, then, in reducing its formula to 1 SO^3, we should have $SO^4\,Al\frac{3}{2}\,K\frac{1}{2} + \frac{25}{4}$ Aq, which is impossible.

(Such not being the case, however, we contend that the molecule of alum should be represented with 1 SO^3, as with that formula only, does it correspond with the ordinary 1, 2, 3, 4 series of hydration.—ED.)

The double carbonate of potash and soda contains

$$3\ CO^2 + K^2O + 2\ Na^2O.$$

If such be the weight of one simple molecule, then the body having the above formula, ought to combine with 1, 2, 3, 4, ... Aq. But if, on the contrary, experiment shows us that with the above formula it combines only with 1 × 3, 2 × 3, 3 × 3 . . . . . X × 3 Aq, we should conclude therefrom that the above formula represented the weight of three molecules. Now this is really the case, for the salt as above represented combines with 18 Aq, and on dividing the whole by three, we arrive at the real molecule

$$CO^3\ K_{\frac{2}{3}}N_{\frac{4}{3}} + 6\ Aq.$$

I have just now inquired whether or not certain sulphates could possibly exist. To answer this question, let us effect the necessary reductions, by dividing each formula by the multiplier of SO^3, and we perceive that

$$1^\circ.\ \frac{4\ SO^3 + 5\ M^2O}{4} \text{ becomes } M^2SO^4 + \tfrac{1}{4}\ M^2O\,;$$

$$2^\circ.\ \frac{4\ SO^3 + 3\ M^2O + 5\ H^2O}{4} \text{ becomes } M_{\frac{3}{2}}H_{\frac{1}{2}}SO^4 + H^2O\,;$$

$$3^\circ.\ \frac{5\ SO^3 + 8\ M^2O + 3\ H^2O}{5} \text{ becomes } M^2SO^4 + \tfrac{1}{5}MHO\,;$$

$$4^\circ.\ \frac{4\ SO^3 + Fe^2O + Zn^2O + 2\ Am^2O + 12\ H^2O}{4}$$

$$\text{becomes } Fe_{\frac{1}{2}}\ Zn_{\frac{1}{2}}\ Am\ SO^4 + 3\ H^2O.$$

I conclude, in consequence of the fractions ($\frac{1}{4}$ and $\frac{1}{5}$ Aq) that the first and third salts cannot possibly exist, whilst the existence of the other two is not impossible.

The following formula is attributed to a ferroso-ferric sulphate:

$$9\ SO^3 + 6\ Fe^2O + 3\ fe^2O + 60\,Aq,$$

which formula is indivisible if we represent ferric oxide by F^2O^3. I believe that the 60 Aq has been taken, simply because 60 is a *convenient number*, and that we should have had this same number made use of, even though the analysis had indicated 59 or 61 Aq.

I reject the number 60, and am persuaded that a more exact analysis performed upon a perfectly pure body would give 63 Aq, that is to say that in dividing by 9 we should have

$$SO^4\,F\tfrac{4}{3}\,fe\tfrac{2}{3} + 7\,Aq.$$

Instances taken at hazard cannot prove anything. We must prepare a table of all the salts (as I have done at the end of this work), and must put aside those of which the analyses are at all questionable, either in consequence of the substances operated upon being impure or uncrystallisable, or because the analyses are of too ancient a date.

We must in fact make a selection, similar to the one I employed with regard to organic combinations, when I wished to see whether the law of even numbers was or was not correct. For the present I rest satisfied with giving a table of the double and basic sulphates, dividing this table into two parts, including in the one such salts as accord with my views, and including in the other such salts as are contrary thereto.

Acid sulphate of potash	$2\ SO^3 + K^2\ O + H^2O$	$= SO^4\ KH$	
	$3\ SO^3 + 2\ K^2\ O + H^2O$	$SO^4\ K_{\frac{4}{3}}H_{\frac{2}{3}}$	
	$7\ SO^3 + 5\ K^2\ O + 2\ H^2O$*	$SO^4\ K_{\frac{10}{7}}H_{\frac{4}{7}}$	
Acid sulphate of ammonia	$4\ SO^3 + 3\ Am^2O + H^2O$	$SO^4\ Am_{\frac{3}{2}}H_{\frac{1}{2}}$	
Sulphate of soda and ammonia	$2\ SO^3 + Na^2\ O + Am^2O + 4\ H^2O$	$SO^4\ AmNa$	$+2\ Aq$
Sulphate of soda and magnesia	$2\ SO^3 + Na^2\ O + Mg^2O + 4\ H^2O$	$SO^4\ NaMg$	$+2\ Aq$
Glauberite sulphate	$2\ SO^3 + Na^2\ O + Ca^2O$	$SO^4\ NaCa$	
Dréelite sulphate	$3\ SO^3 + 2\ Ba^2\ O + Ca^2O$	$SO^4\ Ba_{\frac{4}{3}}Ca_{\frac{2}{3}}$	
Sulphate of potash and glucina	$2\ SO^3 + K^2\ O + Gl^2O + 2\ H^2O$	$SO^4\ KG$	$+Aq$
Acid sulphate of alumina	$4\ SO^3 + Al^4\ O^3 + 9\ H^2O$ †	$SO^4\ \overset{v}{A}l_{\frac{3}{2}}H_{\frac{1}{2}}$	$+2\ Aq$
Alum sulphate	$4\ SO^3 + K^2\ O + Al^4O^3 + 24\ H^2O$	$SO^4\ \overset{v}{A}l_{\frac{3}{2}}K_{\frac{1}{2}}$	$+6\ Aq$
Alum dried	$4\ SO^3 + K^2\ O + Al^4O^3 + 4\ H^2O$	$SO^4\ \overset{v}{A}l_{\frac{3}{2}}K_{\frac{1}{2}}$	$+Aq$
Hexahedral ferric alum	$4\ SO^3 + K^2\ O + Fe^4O^3 + 12\ H^2O$	$SO^4\ fe_{\frac{3}{2}}K_{\frac{1}{2}}$	$+3\ Aq$
Hex. ferric alum precep. by alcohol	$4\ SO^3 + K^2\ O + Fe^4O^3 + 8\ H^2O$	$SO^4\ fe_{\frac{3}{2}}K_{\frac{1}{2}}$	$+2\ Aq$
Sulphate of alumina and magnesia	$6\ SO^3 + 3\ Mg^2O + Al^4O^3 + 36\ H^2O$	$SO^4\ Al\,Mg$	$+6\ Aq$

---

* According to analyses communicated to me by Is. Pierre; from them I have deduced the following formula.

		Found.	
$7\ SO^3$	52·4	51·6	52 2
$5\ K^2O$	44·3	42·8	43·5
$2\ H^2O$	3·3		
	100·0		

† According to my unpublished analyses.

Urano-uranylic sulphate	$2\,SO^3 + U^2\,O + U^4O^3$*	$= SO^4\,U\,Uy$	
Uranylo-ammonia sulphate	$2\,SO^3 + U^4\,O^3 + Am^2O + 2\,H^2O$	$SO^4\,AmUy$	$+Aq$
Uranylo-potassic sulphate	$2\,SO^3 + U^4\,O^3 + K^2O + 2\,H^2O$	$SO^4\,K\,Uy$	$+Aq$
Mangano-potassic sulphate	$2\,SO^3 + K^2\,O + Mn^2O + 6\,H^2O$	$SO^4\,K\,Mn$	$+3\,Aq$
Mangano-sodic sulphate	$2\,SO^3 + Na^2\,O + Mn^2O + 6\,H^2O$	$SO^4\,NaMn$	$+3\,Aq$
	$2\,SO^3 + Na^2\,O + Mn^2O + 2\,H^2O$	$SO^4\,NaMn$	$+Aq$
Acid bismuthylic sulphate	$2\,SO^3 + Bi^4\,O^3 + 3\,H^2O$*	$SO^4\,ByH$	$+Aq$
Acid zincic sulphate	$2\,SO^3 + Zn^2\,O + 9\,H^2O$	$SO^4\,ZnH$	$+4\,Aq$?
	$4\,SO^3 + 3\,Zn^2\,O + 5\,Aq$	$SO^4\,Zn_{\frac{3}{2}}H_{\frac{1}{2}}$	$+Aq$
Ammonio-zincic sulphate	$2\,SO^3 + Am^2O + Zn^2O + 6\,H^2O$	$SO^4\,AmZn$	$+3\,Aq$
Sodio-zincic sulphate	$2\,SO^3 + Na^2\,O + Zn^2O + 4\,H^2O$	$SO^4\,NaZn$	$+2\,Aq$
Magnesio-zincic sulphate	$2\,SO^3 + Mg^2\,O + Zn^2O + 14\,H^2O$	$SO^4\,MgZn$	$+7\,Aq$
	$2\,SO^3 + Mg^2O + Zn^2O + 10\,H^2O$	$SO^4\,MgZn$	$+5\,Aq$
Alumino-zincic sulphate	$4\,SO^3 + Z^2\,O + Al^4O^3 + 24\,H^2O$	$SO^4\,\check{A}l_{\frac{3}{2}}Zn_{\frac{1}{2}}$	$+6\,Aq$
Potassio-cadmic sulphate	$2\,SO^3 + K^2\,O + Cd^2O + 6\,H^2O$	$SO^4\,K\,Cd$	$+3\,Aq$
Acid ferrous sulphate	$3\,SO^3 + 2\,Fe^2\,O + 7\,H^2O$	$SO^4\,Fe_{\frac{4}{3}}H_{\frac{2}{3}}$	$+2\,Aq$
Potassio-chromous sulphate	$2\,SO^3 + K^2\,O + Cr^2O + 6\,H^2O$	$SO^4\,K\,Cr$	$+3\,Aq$
Potassio-chromic sulphate	$4\,SO^3 + K^2\,O + Cr^4O^3 + 24\,H^2O$	$SO^4\,K_{\frac{1}{2}}\check{C}r_{\frac{3}{2}}$	$+6\,Aq$
Sodio-chromic sulphate	$4\,SO^3 + Na^2\,O + Cr^4O^3 + 24\,H^2O$	$SO^4\,Na_{\frac{1}{2}}\check{C}r_{\frac{3}{2}}$	$+6\,Aq$
Sodio-chromic sulphate (at 100°)	$4\,SO^3 + Na^2\,O + Cr^4O^3 + 8\,H^2O$	$SO^4\,Na_{\frac{1}{2}}\check{C}r_{\frac{3}{2}}$	$+2\,Aq$

---

* Further on I shall allude to the salts of uranyl, bismuthyl, &c.

Ammonio-chromic sulphate	$4SO^3 + Am^2O + Cr^4O^3 + 24\,Aq$	$= SO^4\,Am\frac{1}{2}\overset{\blacktriangledown}{Cr}\frac{3}{2}$	$+ 6\,Aq$
Ferroso-ferric sulphate	$18SO^3 + 6\,Fe^2\,O + 4\,Fe^4O^3 + 9\,H^2O$	$SO^4\,Fe\frac{2}{3}fe\frac{4}{3}$	$+ \frac{1}{2}Aq$
	$4\,SO^3 + 3\,Fe^2\,O + H^2O$	$SO^4\,Fe\frac{3}{2}H\frac{1}{2}$	
	$9\,SO^3 + 6\,Fe^2\,O + Fe^4O^3 + 63\,H^2O$ *	$SO^4\,Fe\frac{4}{3}fe\frac{2}{3}$	$+ 7\,Aq$
Ferroso-ammonia sulphate	$2\,SO^3 + Am^2O + Fe^2O + 6\,H^2O$	$SO^4\,AmFe$	$+ 3\,Aq$
Ferroso-soda sulphate	$2\,SO^3 + Na^2\,O + Fe^2O + 4\,Aq$	$SO^4\,NaFe$	$+ 2\,Aq$
Ferroso-zinco-ammonia sulphate	$4\,SO^3 + 2\,Am^2O + Fe^2O + Zn^2\,O + 12\,H^2O$	$SO^4\,AmZ\frac{1}{2}Fe\frac{1}{2}$	$+ 3\,Aq$
Cobalto-magnesia sulphate	$4\,SO^3 + Mg^2O + 3\,Co^2O + 28\,H^2O$	$SO^4\,Mg\frac{1}{2}Co\frac{3}{2}$	$+ 7\,Aq$
Cobalto-potassic sulphate	$2\,SO^3 + K^2\,O + Co^2O + 6\,H^2O$	$SO^4\,K\,Co$	$+ 3\,Aq$
Cobalto-ammonia sulphate	$2\,SO^3 + Am^2O + Co^2O + 6\,H^2O$	$SO^4\,AmCo$	$+ 3\,Aq$
Nickelo-potassic sulphate	$2\,SO^3 + K^2\,O + Ni^2O + 6\,H^2O$	$SO^4\,K\,Ni$	$+ 3\,Aq$
Nickelo-ammonia sulphate	$2\,SO^3 + Am^2O + Ni^2O + 6\,H^2O$	$SO^4\,AmNi$	$+ 3\,Aq$
Mercuroso-mercuric sulphate	$SO^3 + Hg^4\,O + 2Hg^2O$	$SO^4\,hg^2$	$+ 2\,Hg^2O$
Mercurico-sulphoxi-basic sulphate	$SO^3 + 2\,Hg^2\,O + Hg^2S$	$SO^4\,Hg^2$	$+ \left\{\begin{matrix} Hg^2O \\ Hg^2S \end{matrix}\right.$
Acid cupric sulphate	$5\,SO^3 + 4\,Cu^2\,O + H^2O$	$SO^4\,Cu\frac{8}{5}H\frac{2}{5}$	
	$5\,SO^3 + 4\,Cu^2\,O + 6\,H^2O$	$SO^4\,Cu\frac{8}{5}H\frac{2}{5}$	$+ Aq$
	$5\,SO^3 + 4\,Cu^2\,O + 16\,H^2O$	$SO^4\,Cu\frac{8}{5}H\frac{2}{5}$	$+ 3\,Aq$
Cuprico-ammonia sulphate	$2\,SO^3 + Am^2O + Cu^2O + 6\,H^2O$	$SO^4\,AmCu$	$+ 3\,Aq$
Cuprico-potassic sulphate	$2\,SO^3 + K^2\,O + Cu^2O + 6\,H^2O$	$SO^4\,K\,Cu$	$+ 3\,Aq$
Cuprico-sodic sulphate	$2\,SO^3 + Na^2\,O + Cu^2O + 2\,Aq$	$SO^4\,CuNa$	$+ Aq$

---

* *Vide* my preceding observations.

Basic cuprico-potassic sulphate	$4\,SO^3 + K^2\,O + 4\,Cu^2O + 3\,H^2O$	$= SO^4\,K\tfrac{1}{2}Cu\tfrac{3}{2}$	$+ Cu\tfrac{1}{2}H\tfrac{3}{2}O^2$
Brochantite sulphate	$SO^3 + 4\,Cu^2\,O + 3\,H^2\,O$	$SO^4\,Cu^2$	$+ 6\,CuHO$
Cuprico-magnesio-ammonia sulph.	$4\,SO^3 + 2\,Am^2O + Mg^2O + Cu^2\,O + 12\,H^2O$	$SO^4\,AmMg\tfrac{1}{2}Cu\tfrac{1}{2}$	$+ 3\,Aq$
Cuprico-nickelo-potassic sulphate	$4\,SO^3 + 2\,K^2\,O + Ni^2O + Cu^2\,O + 12\,H^2O$	$SO^4\,K\,Ni\tfrac{1}{2}Cu\tfrac{1}{2}$	$+ 3\,Aq$
Acid sulphate of quinine	$2\,SO^3 + Q^2\,O + 15\,H^2O$	$SO^4\,Q\,H$	$+ 7\,Aq$
Acid sulphate of strychnine	$2\,SO^3 + St^2\,O + H^2O$	$SO^4\,StH$	
Acid sulphate of biplatinamine	$2\,SO^3 + P^2\,O + H^2O$	$SO^4\,P\,H.$	

Thus we perceive that despite the reduction, all the best known and best analysed sulphates, whether double, acid, or basic, present us with whole numbers for the atoms of water or of base, which numbers vary from 1 up to 7, or in other words, are the same as those of the simple salts.

Let us now glance over those double salts which do not accord with the preceding table.

Blœdite	$2\,SO^3 + Na^2O + Mg^2O + 5\,H^2O$
Ceroso-ceric sulphate	$4\,SO^3 + 2\,Ce^2O + 2\,Ce^4O^3 + 7\,H^2O$
Basic sulphate of alumina	$4\,SO^3 + 2\,Al^4O^3 + 30H^2O$
Basic potash alum	$4\,SO^3 + 3\,Al^4O^3 + K^2O + 9\,H^2O$
Thorico-potassic sulphate	$2\,SO^3 + K^2O + Th^2O + H^2O$
Basic sulphate of chrome	$2\,SO^3 + 3\,Cr^4O^3 + 14\,H^2O$.

I have omitted several other chromic, ferric, and aluminic sulphates, both double and basic, which, like the preceding, cannot be reduced to the type $SO^4R^2 + n\,H^2O$ without giving a fractional value for n.

We may remark, that all the salts of the second table are but impure precipitates, or earthy, or barely fibrous matters, or the salts of comparatively unknown metals, such as cerium (which is at present admitted to be a mixture of several metals).

We may add moreover, that when we endeavour to repeat or confirm the analysis of any of these salts, we never arrive at concordant results. I have myself repeated the analysis of two extremely well crystallised basic iron alums, and have obtained results altogether different from those which have hitherto been given; I shall advert to them again further on.

It would even be possible for us to remove from the second table blœdite and the thorico-potassic sulphate, which by reduction produce $SO^4\,NaMg + \frac{1}{2}\,Aq$, and $SO^4KTh + \frac{1}{2}\,Aq$, as I have said that we may occasionally have $\frac{1}{2}$, $\frac{3}{2}$, and $\frac{5}{3}$ Aq. In every case, however, these fractions are to be suspected.

Hydrated salts of the sesquioxides.

Let us continue our examination of the consequences deducible from the law of even numbers, and from the divisibility of atoms.

If the formula for the sesquioxides is r^2O, and not R^4O^3, then the usual formulæ of *all* their salts must necessarily be divisible by 3, as also must the number of their atoms of water of crystallisation.

Double, or acid salts, may unquestionably be capable of having other divisors; but as regards the formulæ of the monobasic salts of these oxides, we may go still further, and say, that they must necessarily be divisible by 6; as also must the number of atoms of crystallisation water which they contain.

Let us resort to experiment.

Monobasic salts.

Aluminic chloride	$\mathrm{Cl^6\,Al^4 + 12\,H^2\,O = Cl\ al + 2\,Aq}$
Ferric chloride	$\mathrm{Cl^6\,Fe^4 + 12\,H^2\,O = Cl\ fe + 2\,Aq}$
	$\mathrm{Cl^6\,Fe^4 + 6\,H^2\,O = Cl\ fe + Aq}$ *
Chromic chloride	$\mathrm{Cl^6\,Cr^4 + 6\,Aq = Cl\ cr + Aq}$
	$\mathrm{C^6\,Cr^4 + 12\,Aq = Cl\ cr + 2\,Aq}$
Aluminic nitrate	$\mathrm{3\,N^2\,O^5 + Al^4\,O^3 + 18\,H^2\,O = NO^3\,al + 3\,Aq}$
Ferric nitrate	$\mathrm{3\,N^2\,O^5 + Fe^4\,O^3 + 18\,H^2\,O = NO^3\,fe + 3\,Aq}$
Chromic nitrate	$\mathrm{3\,N^2\,O^5 + Cr^4\,O^3 + 18\,H^2\,O = NO^3\,cr + 3\,Aq}$.

Polybasic salts.

Aluminic sulphate	$\mathrm{3\,SO^3 + Al^4\,O^3 + 18\,H^2\,O = SO^4\,al^2 + 6\,Aq}$
Acid aluminic sulphate	$\mathrm{4\,SO^3 + Al^4\,O^3 + 9\,H^2\,O = SO^4\,al\tfrac{3}{2}\,H\tfrac{1}{2} + 2\,Aq}$
Alum sulphate	$\mathrm{4\,SO^3 + K^2\,O + Al^4\,O^3 + 24\,H^2\,O = SO^4\,al\tfrac{3}{2}\,M\tfrac{1}{2} + 6\,Aq}$
Crystallised ceric sulphate	$\mathrm{3\,SO^3 + Ce^4\,O^3 + Al^4\,O^3 + 9\,H^2\,O = SO^4\,ce^2 + 3\,Aq}$
Ferric sulphate	$\mathrm{3\,SO^3 + Fe^4\,O^3 + 9\,H^2\,O = SO^4\,fe^2 + 3\,Aq}$ †

---

* Formerly written + 5 Aq, but the salt was not then crystallised. Wittstein, by operating upon a crystallised salt, found 6 Aq.

† Usually formulated with + 10 Aq; but I have recalculated all the analyses, and the mean gives 9 Aq.

Polybasic salts—(continued).

Acid ferric sulphate	$4\,SO^3 + Fe^4O^3 + 9\,H^2\,O = SO^4\,fe_{\frac{3}{2}}H_{\frac{1}{2}} + 2\,Aq$ *
Octohedral chromic sulphate	$3\,SO^3 + Cr^4O^3 + 15\,H^2\,O = SO^4\,cr^2 + 5\,Aq$
Prismatic chromic sulphate	$3\,SO^3 + Cr^4O^3 + 18\,H^2\,O = SO^4\,cr^2 + 6\,Aq$ *
Acid uranylic phosphate	$P^2\,O^5 + 2\,U^4O^3 + 11\,H^2\,O = PO^4\,Uy^2\,H + 5\,Aq$ $P^2\,O^5 + 2\,U^4\,O^3 + 9\,H^2\,O = PO^4\,Uy^2\,H + 4\,Aq$
Chalkolite phosphate	$P^2\,O^5 + 2\,U^4\,O^3 + Cu^2\,O + 8\,H^2\,O = PO^4\,Uy^2\,Cu + 4\,Aq$
Uranite phosphate	$P^2\,O^5 + 2\,U^4\,O^3 + Ca\,^2O + 8\,H^2\,O = PO^4\,Uy^2\,Ca + 4\,Aq$
Lazulite phosphate	$P^2\,O^5 + Al^4O^3 + Mg^2O + H^2\,O = PO^4\,Al^3 + Mg\,HO$
Crystallised ferric phosphate	$2\,P^2\,O^5 + Fe^4O^3 + 7\,H^2\,O = PO^4\,fe_{\frac{3}{2}}H_{\frac{3}{2}} + Aq$
Neutral ferric phosphate	$P^2\,O^5 + Fe^4O^3 + 4\,H^2\,O = PO^4\,fe^3 + 2\,Aq$
Scorodite	$As^2O^5 + Fe^4O^3 + 4\,H^2\,O = As\,O^4\,fe^3 + 2\,Aq$
Mellite	$3\,C^8\,O^6 + 2\,Al^4O^3 + 36\,H^2\,O = C^4\,al^2\,O^4 + 6\,Aq.$

---

* According to my unpublished analyses.

These then, with one or two exceptions, are all the known crystallised salts of the sesquioxides.

As a sequel to this table we might put down the exceptional combinations, such as pissophane $2\,SO^3 + 5\,Al^2O^3 + 30\,Aq$; but such a proceeding would be useless, for it is sufficient to observe that all these combinations are impure, or uncrystallisable, or earthy, &c., and that consequently, we cannot accord any confidence to the formulæ which have been attributed to them.

Para-salts and silicates.

There exist certain salts, such as the anhydrous bisulphate and the bichromate of potash, also several titanates, stannates, arsenites, silicates, borates, &c., of which the composition does not accord with the ideas we have just announced. The majority of these salts may be represented by a normal salt, *plus* an excess of anhydrous acid. We have seen that the acid sulphate of potash $2\,SO^3 + K^2O + H^2O = 2\,KHSO^4$, accords very readily with our views; but such is not the case with the anhydrous sulphate $2\,SO^3 + K^2O$, or $K^2SO^4 + SO^3$.

We may remark at starting, that we are unacquainted with any combination of this kind among monobasic salts. We have previously remarked that the monobasic acids very rarely give rise to acid salts; but that when such a case does occur, the excess of acid is always in the state of a salt of hydrogen, that is to say, in the state of a hydrate. Thus the binacetate of potash contains $C^4H^6O^3.K^2O + C^4H^6O^3.H^2O$, but not $C^4H^6O^3.K^2O + C^4H^6O^3$. If indeed, one or two monobasic salts of this kind (such as the biniodate of potash.—Ed.) may be adduced, their formulæ are more than questionable.

Among the salts with excess of anhydrous acid, there are some of which we need not take any account whatever, namely, those of which the anhydrous acids are fixed, and which are obtained by fusing together the base and the acid in atomic or other proportions.

In these cases there is nothing whatever to prove to us, that the results are rather combinations than mixtures.

Moreover, when the crystallised acid salts (of a fixed acid) produce by calcination, salts with an excess of anhydrous acid, as does borax for example $B^2O^3.Na^2O + B^2O^3.H^2O$ which by fusion leaves $2\,B^2O^3 + Na^2O$; in these latter, as in the preceding cases, we do not know whether mixtures or combinations result.

We must also subtract from the anomalies the *para-salts*. This is a name I have given to all such salts as the meta-, para-, pyro-, iso-, ... phosphates, stannates, titanates, tartrates, &c.

There would remain then only the tungstates, silicates, some borates, tellurates, arsenites, chromates. and the anhydrous bisulphate of potash. From this list we may yet remove the tungstates, for I am persuaded that certain anomalous salts of this acid are only mixtures, and that others belong to various types of tungstates, meaning that tungstic acid gives rise to several *soi-disant* isomeric acids, of the same character as the different phosphoric acids.

The same condition very probably holds good with regard to the anhydrous bi- and quadritellurates. We know moreover, that telluric acid presents itself under two different modifications, and that the hydrated bitellurates, when made to yield up their water, do not form anhydrous bitellurates, but instead mixtures of neutral tellurates and anhydrous quadritellurates. With regard to these last, they are far from possessing the properties of acid tellurates, but undoubtedly constitute a particular class of salts analogous to the metaphosphates, paratungstates, &c.

Let us put the silicates on one side for the present, and there will only remain certain arsenites, certain bichromates, and the anhydrous bisulphates of potash and soda.

Since we have seen that nearly all the salts which appeared to be exceptional, are in reality para-salts, we are naturally induced to put the following question. May not the anhydrous bisulphate of potash be a para-salt; may there not exist two sulphuric acids, just as we know there are two stannic acids?

The stability of the modifications of phosphoric, tartaric, and tungstic acids, &c., is very variable. For instance, some acids undergo modifications by the action of a red heat, and others at 100° C., or even lower; some of the modifications suffer a spontaneous change in the space of several months, the others require but a few hours. May there not then be some of them, in which the modifications are effected in a much shorter,—even in an inappreciable time?

I have noticed that when a little chlorhydric acid is dropped into a neutral tungstate, the free tungstic acid passes immediately into the state of paratungstic acid, or of a paratungstate. If we pour upon this scarcely soluble crystallised paratungstate, slightly moistened with water, a few drops of dilute chlorhydric acid, it dissolves in an instant, without leaving the slightest turbidity in the liquor; but in a few seconds' time, the soluble paratungstate undergoes a modification, and the liquid suddenly becomes turbid. May it not be the same with the anhydrous bisulphate of potash, which will then be a *parasulphate* $K^2S^2O^7$, and of which the acid will be that of Nordhausen, $H^2S^2O^7$?

This supposition is countenanced by a very interesting fact, pointed out by Jacquelain. When the anhydrous and the hydrated sulphates are dissolved in lukewarm water, the two salts are deposited on cooling, each conserving its primitive constitution. If we considered these two salts as ordinary sulphates $2\,SO^3.K^2O$, and $2\,SO^3.K^2O + Aq$, it would be difficult for us to comprehend so singular a result. If we admit, on the contrary, that the first is a parasulphate $K^2S^2O^7$, and the second a sulphate $KH\,SO^4$; then this fact of the separate crystallisations ought not to astonish us, any more than the similar one offered by the neutral pyrophosphate of soda $Na^4P^2O^7$, and the common tribasic phosphate $Na^4P^2O^7.H^2\,O = Na^2\,H\,PO^4$. The only difference which exists between these bodies is, that the parasulphate of potash has a very feeble stability, and in the presence of water readily becomes metamorphosed into the normal acid sulphate, whilst the pyrophosphate requires either a longer time, or a brisker ebullition, in order to undergo an analogous metamorphosis.*

In a similar manner, may not the bichromate and terchromate of potash be in reality parachromates, and certain arsenites pararsenites? do we not know that arsenious acid occurs in variously modified conditions? May not the silicates appertain to several types, such as para-, meta-, iso- . . . . silicic, &c.?

Even admitting that my hypothesis with regard to the bisulphate of potash is not well founded, it will nevertheless be necessary to distinguish this salt and its analogues by some particular appellation, and we may designate them by the name of *anhydro-salts;* we should then speak of them as anhydrosulphates, anhydrochromates, &c.

Now let us direct our attention to the silicates. The formulæ, by which mineralogists represent the composition of these salts, are so complicated and so little comparable to the formulæ of any other salts, that for my part I find it impossible to admit them. Not only do I reject formulæ similar to this, which is attributed to cordierite,

---

* The analogy of the pyro- and meta-phosphates to the anhydrous bisulphates and bichromates, was pointed out by the Translator in a paper published in the seventh volume of the Quarterly Journal of the Chemical Society.—(W. O.)

$$2\,(\mathrm{Si\,O^3 + 3\,Fe^2\,O}) + 2\,(\mathrm{Si\,O^3 + Al^4O^3})$$
$$+ 2\,(2\,\mathrm{Si\,O^3 + 3\,Mg^2O}) + 3\,(\mathrm{Si\,O^3 + Al^4O^3}),$$

inasmuch as they do not represent the arrangement of the atoms, but also the empiric formulæ, as not representing even the centesimal composition of the bodies.

To ascertain the actual composition of the silicates there are many difficulties to be resolved, some of which appear to me insurmountable in the present state of science. I proceed to notice some few of them.

Equivalent of silicon.—According to Berzelius, the equivalent of silicon should be 92, or three times that number. According to the experiments of Pelouze it should be reduced to 87·5, which is a multiple of the equivalent of hydrogen. Even if so great a difference does not affect the formulæ of the more simple silicates, it must certainly throw some degree of uncertainty upon the formulæ of silicates having several bases.

Formula of silica.—Three formulæ have been proposed, namely: SiO, $\mathrm{SiO^2}$, $\mathrm{SiO^3}$. How then can we determine the weight of the molecules of the silicates, when we are ignorant of the number of atoms of oxygen and silicon which are contained in silica?

Neutral silicates.—Supposing that the formula of silica were known to us, we should still be ignorant of the composition of a neutral silicate. Adopting $\mathrm{SiO^3}$ for silica, would a neutral salt contain $\mathrm{SiO^3.M^2O}$ or $\mathrm{SiO^3.2\,M^2O}$ or $\mathrm{SiO^3.3M^2O}$? We have no means of replying.

Hydrated silicates.—Hitherto chemists have constantly considered the water of silicates as water of crystallisation; but seeing the important part which water fulfils in the acid salts, we cannot doubt that very many silicates contain basic water. I have observed that several tungstates retain a certain quantity of basic water, which they lose on the attainment of a red heat, at the same time losing their characteristic properties; four or five thousandths of water, more or less, are sufficient to alter their properties, and to transfer them from one type to another; that is to say, to effect a change in their formulæ. Must it not be the same with the silicates, especially when we remember the recent discovery, that some of these salts do not give up all their water, even at a white heat?

Divers types of silicates.—I have already remarked that polybasic salts, salts yielding anhydrous acids, and salts of which the acids are fixed, are capable of transforming themselves into para-salts. The silicates ought then to fall into this class; and in support of such an opinion, we may adduce the existence of silicic acid, soluble and insoluble in water, also soluble and insoluble in potash, and particularly the nature of the three silicic ethers. One and the same acid may readily give rise to three ethers—as does the phosphoric acid; but among these three combinations, one only is neutral, the other two are acid, and all three can in accordance with the ethyl theory, be represented on the same type, as Et^3PO^4, Et^2HPO^4, EtH^2PO^4. But such is not the case with the silicic ethers, which contain respectively $SiO.Et^2O$, $2\,SiO.Et^2O$, and $4\,SiO.Et^2O$. If we suppose that the same silicic acid is contained in each of these three ethers, then they will present a composition, of which no other example exists, throughout the whole of chemistry. Certainly if parasilicates do exist, it must at present be very difficult to establish the fact; but who knows, if in studying the silicates from this point of view, in comparing their chemical and physical properties, in determining carefully the different temperatures at which they successively lose their water, in ascertaining the change of chemical and physical properties which accompanies this loss of water, who knows I repeat, that we shall not succeed in grouping these salts into several genera, as we have already grouped the phosphates into *common*, *pyro-*, *meta-*, *iso* . . . . . phosphates?

Uncertainty of the analyses.—To the number of causes which oppose our obtaining a correct knowledge of the empiric formulæ of the silicates, we must add the difficulty which surrounds their analyses. Do we wish to analyse a simple salt, such as the chloride of copper, we make two determinations; in the one we estimate the chlorine, in the other the copper. One precipitation, one filtration, one calcination suffice for each element. But if we wish to estimate the magnesia or the soda of a silicate, what a series of operations have we to perform! Fusion in a crucible with potash, baryta, or oxide of lead; treatment by acids; evaporation to dryness; solution and filtration; precipitation of alumina and oxide of iron; filtration; precipitation of the lime; filtration; evaporation to dryness; transformation into sulphate; transformation into acetate; filtration; transformation into carbonate by calcination; solution and filtration; solution of the carbonate of magnesia; precipitation; filtration; calcination; without reckoning a hundred precautions.

We may refer also to the impurities of the salts, which cannot possibly be recrystallised; moreover we know that in very many silicates, there have been found some thousandths, and even one or two hundredths of water, of which no account has been taken in the analysis, and which have been considered as accidental, whilst we know that three or four thousandths of water suffice to change both the properties and formulæ of the tungstates.

Uncertainty of the functions of the elements.—I have already said that we are ignorant as to whether the water of such or such a silicate is basic, crystallisation, or accidental water. I would add that we are equally ignorant concerning the part played by fluorine, boric acid, and even by the oxides R^2O and R^3O^4. I shall presently advert more fully to this question. How, in the presence of so much uncertainty, can the composition of the silicates be set in opposition to our views of the nature of salts?

SECTION THIRD.

ON THE RELATIONS WHICH EXIST BETWEEN THE FORM AND THE COMPOSITION OF CERTAIN BODIES.

IF the law of even numbers is correct, if atoms are divisible, and consequently if the molecules of ferrous and ferric oxides respectively contain Fe^2O and fe^2O, may it not be possible for these two oxides to be isomorphous, and may they not entirely, or at any rate in part, mutually replace one another in their combinations, without producing any alteration in the form of the compound? May it not be the same with the other oxides R^4O, R^2O, and R^4O^3?

It has been ascertained that very many R^2O oxides are isomorphous with one another, and likewise that the R^4O^3 oxides are isomorphous with one another, but hitherto not a single example has been adduced of isomorphism between these two kinds of oxides, or between their respective combinations. I am disposed to think, that chemists perceiving the atomic difference, which exists between the R^2O, the R^4O^3, and the R^4O oxides, have *à priori* supposed, that these three kinds of oxides could not possibly have the same form, and that it is this supposition which has hindered them from recognising the facts of daily occurrence, that prove the contrary.

But before examining this question, I must make some remarks on the subject of isomorphism.

Hitherto, bodies have been considered as isomorphous, when their crystals have the same, or very nearly the same, axes and angles, *and belong to the same crystalline system.* I propose to modify this definition, and to say, that two substances are isomorphous when their crystals have the same, or very nearly the same axes and angles; *no matter to what crystalline system each of the comparable crystals belongs.*

It is admitted that a rhombohedron of 103 degrees can be isomorphous with a rhombohedron of 104, 105 and even of 107 degrees (as allowed in the cases of the different calcic and ferrous carbonates, &c.).

I admit in addition, that a rhombohedron of 89° 30′ or of 90° 30′, can be isomorphous with a rhombohedron of 90°, that is to say, with a cube, the limit of acute and obtuse rhombohedra. I admit that a right prism with a rhombic base of 119° can be isomorphous with a right prism of 120°, and consequently with the regular hexagonal prism, or with a rhombohedron. In a word, I admit that isomorphism can overstep all crystalline types, which are indeed only limiting or intermediate forms, occurring at intervals between the infinite varieties of the genus parallelopipedon.

We know that the angles of one and the same substance are not invariable even at the same temperature. Thus according to Baudrimont, Iceland spar does not always present the same angles, but variations of several minutes may be noticed. According to Nicklés, the bimalate of ammonia sometimes occurs with an angle of 108° 30′, sometimes with an angle of 110°.

It might then happen, that a single substance should in its oscillations transgress the limits of its own crystalline system, and enter into the confines of another. That is to say, that one and the same substance might crystallise sometimes in a cube, and sometimes in a rhombohedron, or in a square prism very nearly approaching to a cube.

Crystallographers, who recognize an absolute difference between the different crystalline systems, would reply, that the difference between a cube and a rhombohedron has reference, not so much to their angles as to their kind of figure, and that to each kind there corresponds a law of modification, which law differs from that of another kind. Then I would ask, whether it has been clearly demonstrated, that a rhombohedron of 90° 1′ may not be submitted to the same laws of cleavage as a cube, and whether the laws of Haüy may not be modified in the following manner:

1°. When two edges, or two solid angles, are equal, if one of them becomes modified, the other will become modified also, and in precisely the same manner.

2°. If the two edges, or the two solid angles are unequal, the one may be modified, and the other not; or if each of them undergoes a modification, the modification of the one will be different from that of the other.

3°. If the two edges, or the two solid angles, are sensibly equal, they may each undergo a modification, and this modification will be sensibly the same for the two angles in question. That is to say, that the greater the resemblance of the two angles, the greater the probability of their undergoing cotemporary and similar modifications.

In support of these opinions, I will first of all allude to the forms of the mesotypes. Under the names of scolezite, mesolite, mesole, and mesolysse, there have been designated certain minerals formerly considered as forming but one single kind.

$$\begin{array}{l}
{}^{*}S^6Al^3Ca + 3\ Aq \\
S^6Al^3Na + 2\ Aq \\
S^6O^6 \\
\quad \underline{O^4\ Ca^2Al^6 + 2.\ 3.\ Aq} \\
\hline
S^6O^{10}Ca^2Al^6 + \\
S^3O^5\ Ca\ Al^3 + \ Aq \\
S^3.
\end{array}$$

They are hydrated silicates of alumina, soda, and lime, in which the soda and the lime replace one another mutually in all proportions. Representing silica by SiO their formula would appear to be

$$Si^3O^5\overset{v}{Al}{}^3 \left.\begin{matrix} Na \\ Ca \end{matrix}\right\} + Aq.$$

Haüy, who included them all under the name of mesolysse, considered them to have for their fundamental form a right prism on a square base.

Since then, it has been ascertained that scolezite appertains to

---

* This table is incomplete in the original.—(W. O.)

the *right* prism with a *square* base, whilst mesotype presents itself in the form of a *right* prism with a *rhombic* base of 91° 40′.

Lastly, Rose has just examined afresh the crystals of this last substance, and he considers them as non-symmetrical *oblique* prisms, but approaching very nearly to a right prism with a square base.

This singular variation, in the measurement of the angles, and in the types assigned to these substances, made me think that I might find in them, a confirmation of the views which I have just propounded.

I have been able to procure but one specimen of scolezite, and that without summits. I have examined four specimens of mesotype from Auvergne, and one from Faroë. The planes of the prisms were not sufficiently intact to allow of my determining their inclination. But by cleavage perfectly exact faces were obtained parallel to the planes of the prisms.

The base being replaced by a four-sided prism, I shall designate by a and b, two opposite faces, and a' and b' the two others. These are my measurements:

Mesotype from Auvergne, No. 1.

		Angle of cleavage of prism.	Type.
$aa'=142^\circ$	$a'b=143^\circ0'$	$90^\circ45'$	Right prism on rhombic base.
$bb'=142^\circ$	$ab'=143^\circ0'$		

Mesotype from Auvergne, No. 2.

$aa'=141^\circ45'$	$a'b=144^\circ30'$	?	Right prism on rhombic base.
$bb'=141^\circ45'$	$ab'=144^\circ30'$		

Mesotype from Faroë.

$aa'=142^\circ15'$	$a'b=143^\circ10'$	$91^\circ00'$	Right prism on rhombic base.
$bb'=142^\circ15'$	$ab'=143^\circ10'$		

Mesotype from Auvergne, No. 3.

$aa'=141^\circ45'$	$a'b=146^\circ40'$	$91^\circ00'$	Oblique prism on rhombic base.
$bb'=141^\circ45'$	$ab'=142^\circ40'$		

Mesotype from Auvergne, No. 4.

$aa'=142^\circ30'$	$a'b=142^\circ30'$	?	Oblique prism on rhombic base.
$bb'=142^\circ30'$	$ab'=141^\circ30'$		

Scolezite from Faroë.

92°45′

Scolezite (Beudant's Mineralogy)

90° Right prism on square base.

	Type.
Mesotype (H. Rose)	
closely bordering upon a right prism on a square base	Oblique non-symmetrical prism.
Mesole and Mesolite.	
	Prism of scolezite or mesotype.

We know that these minerals resemble one another in the highest degree, that they have the same density, the same cleavage, and the same modifications; that they are met with in the same countries, and even in the same rocks.

Thus the same mineral, mesotype, crystallises in three different systems. Will mineralogists consequently recognise three distinct species? Will they moreover, divide scolezite into two species?

But then, by having regard at the same time to the chemical composition, the crystalline type, and the measurement of the angles, there would be no reason why we should not make twenty or thirty new species.

Are these different crystals, which belong to four different systems, subjected to four different laws of modification? No: in all, or nearly all, we meet with the same modifications; the similar and the dissimilar angles are nearly always modified together, and obviously in the same manner.

Haüy himself was led into error by the cleavage and symmetry of the modifications. The reason of this is simple: all these crystals, no matter to what type each individual of them belongs, differ but very slightly from a right prism with a square base; their axes are sensibly of the same length, and sensibly inclined to one another at the same angle; and they are in consequence sensibly modified like crystals of the square prismatic system.

Another example is furnished by nitrate of potash. This salt crystallises in a right prism with a rhombic base of 119°, whilst nitrate of soda crystallises in a rhombohedron of 106°, that is to say, in a regular hexagonal prism of 120°.

But according to Beudant, when nitrate of potash is made to crystallise out of a solution of nitrate of soda, it is deposited in crystals, which pass from the prism of 119° to the prism of 120°, or rather, which are rhombohedra of 106° 36′.

Another example occurs in the case of sulphate of nickel. This salt crystallises in right rhombic prisms, isomorphous with sulphate of zinc, and very nearly approaching to a prism with a square base. According to Nicklés, by the acidification of the liquor from which the salt is deposited, the crystals are formed in right prisms with a square base. To imagine that the angles of these prisms are not right angles, but only close approximations to right angles, would be an error, for these latter prisms possess but one axis of double refraction, whilst the ordinary sulphate of nickel prisms possess two. Thus, there is a real change in the crystalline system.

Results still more striking are afforded by the tartrates. According to Pasteur, the neutral tartrates of potash, of soda, and of ammonia; the double tartrates of potash and ammonia, of potash and soda, and of soda and ammonia; also the bitartrates of potash and of ammonia, belong to two different crystalline systems, being met with in the form of right rhombic and oblique rhombic prisms: nevertheless they are isomorphous; for on the one hand, the two prisms approach very nearly indeed to one another (there being, even at the farthest, not more than two degrees of difference between them), and on the other hand, the salts crystallise together in all proportions.

The bichloride of chloronaphthaline $C^{10}H^{7}Cl.Cl^{4}$ crystallises from alcohol as an oblique prism with a rhombic base, and from ether as a right prism with a rhombic base. The angles of the two prisms are sensibly equal.

The bichloride of naphthaline $C^{10}H^{8}.\ Cl^{4}$ is isomorphous with the two varieties of the preceding compound, as it presents the same values for the angles; nevertheless its crystals belong to the oblique non-symmetrical prism, but then this last approaches very nearly to the symmetrical prisms both right and oblique.

Some years ago I wrote upon this subject as follows:

" The singular relations which exist between the two forms of the chloride of chloronaphthaline, have induced me to compare the forms of the two varieties of carbonate of lime with the carbonates of baryta and of strontia, &c.; the work I have in my hands gives the angles of the planes only. These are the measurements:

Carbonate of lime,	six-sided	prism of	120°
Carbonate of baryta,	,,	,,	118° 57′
Carbonate of strontia,	,,	,,	117° 30′
Carbonate of lead,	,,	,,	117°
Arragonite	,,	,,	116° 5′.

"Thus, although the carbonates of lime and baryta are not isomorphous, they approach very nearly to one another in the angles of the prisms; and the two forms of carbonate of lime which, at the first glance, seem to differ very much from one another, do not appear to be so widely separated when we consider the intermediate steps. I fancy that this crude conception of mine deserves to be pushed further."

Since that period, Pasteur has been engaged in confirming my anticipations by fresh observations. He has discovered the remarkable fact, that dimorphous substances, such as the two sulphurs, the two carbonates of lime, the two arsenious acids, the two oxides of antimony, the red and yellow iodides of mercury, are, so to say, isomorphous,—in other words, that the angles of any one of the varieties approach very nearly to those of the other. Dimorphous bodies have consequently forms bordering upon the limits of the systems, and under the influence of certain determining conditions, can pass easily out of the one into the other system.

There frequently exist very singular relations between the crystals of different substances, whether having analogous formulæ or non-analogous, or at any rate, not manifesting any analogy at the first glance.

Sometimes there is complete isomorphism between these different substances, sometimes the isomorphism can only be recognised by passing out of one system into another; and, lastly, the isomorphism may have respect to certain angles only, whilst the remaining angles of the two bodies may be altogether unlike.

These different relations then, must be classified as much from a crystallo-graphic as from a chemical point of view. The following table is an attempt in this direction; hereafter it will certainly have to be modified and extended.

	ISOMORPHOUS BODIES.		HEMIMORPHOUS BODIES.
	ISOMORPHOUS IN THE SAME SYSTEM.	PARAMORPHOUS IN DIFFERENT SYSTEMS.	
A. Identical composition.	1. Icono-ideomorphous. Image of one another.	4. Isodimorphous.	
	2. Isomero-morphous. Alternative composition.	5. Isotrimorphous.	
B. Different composition.	3. Isomorphous Plessiomorphous Constitution. A. Similar. B. Comparable. C. Different.	6. Paramorphous Constitution. A. Similar. B. Comparable. C. Different.	7. Hemimorphous Constitution. A. Similar. B. Comparable. C. Different.

I. *Icono-ideomorphous bodies.*

Under this name we may designate the lævo and dextro tartaric acids, and other analogous bodies, of which, according to the excellent researches of Pasteur, the non-superposable forms are, when received in a mirror, the images one of the other.

II. *Isomero-morphous bodies.*

Chlorine and bromine being isomorphous with hydrogen, I endeavoured by substitution to make them enter *alternatively* into the place of the hydrogen. I hoped by this means to obtain different bodies, which should have the same composition and the same crystalline form.

Let us take for example the hydro-carbon $C^{10}H^{10}$. Treated firstly by chlorine it would give $C^{10}H^{9}Cl$; and this, treated by bromine, would subsequently give $C^{10}H^{8}BrCl$. But in first attacking the carbo-hydrogen $C^{10}H^{10}$ by bromine, we should have $C^{10}H^{9}Br$, and this treated by chlorine would subsequently give $C^{10}H^{8}ClBr$.

It would then remain to be seen whether the two compounds $C^{10}H^{8}BrCl$ and $C^{10}H^{8}ClBr$ were or were not identical. If they were not identical, the two different bodies would probably be isomorphous with one another.

The attempts of this description that I have made with naphthaline, have given me but very questionable results. But we may readily employ the following process, which will allow us to obtain *different* bodies, but isomeric and isomorphous with one another, as often as we please.

Chlorine and bromine can enter by substitution into the constitution of certain organic bases without destroying their alkaline properties; such for instance, is the case with aniline, which gives rise to chloraniline and bromaniline. If we combine chloraniline with hydrobromic acid, and bromaniline with hydrochloric acid, we shall obtain two isomeric bodies:

$$C^{6}H^{6}ClN.\ HBr$$
$$C^{6}H^{6}BrN.\ HCl,$$

which ought to be isomorphous.

I have obtained two combinations of this description with bichlorocinchonine and bibromocinchonine respectively. Each of these two bases combines with two equivalents of the hydracid, so as to produce the two following salts:

Bichlorhydrate of bibromo-cinchonine.
Bibromhydrate of bichloro-cinchonine.

which are not only isomeric, but also isomorphous.*

III. *Isomorphous bodies.*

A. *Of similar constitution.*—In this class are arranged isomorphous bodies having similar formulæ, such as the salts of calcium and magnesium, the salts of barium and strontium, the sulphates and the seleniates, the chlorides and the bromides, &c.

I would only add, that according to my experiments, hydrogen is isomorphous with potassium.

B. *Of comparable constitution,* or *similar by hypothesis.* *a. Ammonium salts.*—We have known for a long time past that the ammoniacal salts are isomorphous with those of potassium, although the composition of the former differs so much from that of the latter class. We are aware also of the hypothesis that has been conceived for the explanation of this isomorphism, which hypothesis consists in admitting that ammonia, *plus* one atom of hydrogen or NH^4, plays in the salts of *ammonium* the part of a simple body; I merely recall the fact to our memories.

β. Nitro compounds.—Many organic substances under the action of nitric acid, lose their hydrogen, and acquire in its stead an equivalent quantity of peroxide of nitrogen. I have remarked that in some cases the primitive compound and the nitro compound are isomorphous. We may account for the isomorphism by supposing that the atom of hydrogen set free, has ceded the place which it occupied to the peroxide of nitrogen, which, to a certain extent, plays the part of hydrogen. Let us represent the molecule of peroxide of nitrogen by $N^2O^4 = X^2$, we shall then formulate phenic acid and its derivatives in the following manner:

Phenic acid	C^6H^6O
Binitro-phenic acid	$C^6H^4X^2O$
Trinitro-phenic acid	$C^6H^3X^3O$.

---

* We might also ask, whether the ferrous manganate $FeO.MnO^3$ would be identical with, or different from, the manganous ferrate $MnO.FeO^3$. In the latter case they would be isomorphous. But though it is not very likely that these two compounds can exist, we can conceive nevertheless that mineral chemistry may be able to furnish us with analogous instances. When the mercuric iodide combines with the chloride of potassium, does it under all circumstances give rise to the same body as that produced by the combination of mercuric chloride with the iodide of potassium?

With regard to the isomorphism of phenic acid with its two derivatives, the crystals are not sufficiently well defined for us to determine the question.

γ. *Homologous bodies.*—The bodies designated by the term homologous, fulfil the same chemical functions, and differ one from the other by *n* times CH^2. Thus the formic, acetic, and propionic acids $CH^2.O^2$, $C^2H^4.O^2$, $C^3H^6.O^2$ are homologous bodies.

It would appear from observations I have made upon the acetate and butyrate of copper, that certain homologous bodies may be isomorphous. Moreover Nicklés has noticed that the oxalates of methylamine and ethylamine have the same form. We might attribute this isomorphism to the presence of the groups CH^2, C^2H^4, C^3H^6, &c., which in the free and gaseous state occupy the same volume, and which in mutually replacing one another in their combinations, do not alter the gaseous volumes of the compounds. The isomorphism of these homologous bodies does not by any means prove that the bodies really contain, ready formed, the groups CH^2, C^2H^4, C^3H^6, &c., since we might as easily account for the isomorphism, by the aid of other hypotheses. Thus, according to the ordinary notation, we might say that:

Formic acid is a combination of formyl	$(C^2\cancel{H})O^3.\ \cancel{H}O$
Acetic acid, a combination of acetyl	$(C^4\cancel{H}^3)O^3.\ \cancel{H}O$
Propionic acid, a combination of propionyl	$(C^6\cancel{H}^5)O^3.\ \cancel{H}O$

$C^2\cancel{H}$, $C^4\cancel{H}^3$, $C^6\cancel{H}^5$, fulfilling the functions of simple bodies, and mutually replacing one another from their combinations, without change of form.

But in the end, all these hypotheses come to the same thing; they all tend to manifest the analogy which exists in the composition of homologous bodies, which analogy extends likewise to their form.

δ. *Various bodies*—We have known for a long time, that nitrate of soda and calcareous spar are isomorphous. I have shown that the bichloride of naphthaline, and the chloride of bromo-naphthaline, are isomorphous.

Latterly Rose has taught us, that nitrate of soda and red silver are isomorphous with calcareous spar, whilst nitrate of potash and bournonite are isomorphous with arragonite.

We know, moreover, that the argentic and plumbic sulphides have the same form as the cupr*eous* sulphide.

By employing the ordinary notation, we do not seize upon any relation in the composition of the bodies forming these different groups: thus we have—

Plumbic sulphide	$Pb^2 S$
Argentic sulphide	Ag^2S
Cupreous sulphide	$Cu^4 S$

Bichloride of naphthaline	$C^{20}H^{16}Cl^8$
Chloride of bromo-naphthaline	$C^{20}H^{14}Br^2Cl^4$

Nitrate of soda	$Na^2N^2O^6$
Calcareous spar	$Ca^2C\,O^3$
Red silver	$Ag^6Sb^2S^6$

Nitrate of potash	$K^2N^2O^6$
Arragonite	$Ca^2C\,O^3$
Bournonite	$Pb^4Cu^4Sb^2S^6$.

Although we have already alluded to the subject, let us again instance the acetate, propionate, and butyrate of copper, or for greater simplicity, the acids of these salts.

Acetic acid	$C^4H^8\,O^4$
Propionic acid	$C^6H^{12}O^4$
Butyric acid	$C^8H^{16}O^4$.

Here, also, we do not recognise any obvious analogy of composition in isomorphous bodies.

Let us now make use of the unitary notation with *synoptic formulæ*;* we shall have—

Plumbic sulphide	$Pb^2 S$
Argentic sulphide	$Ag^2 S$
Cupreous sulphide (cuprosum)	$cu^2\ S$

Bichloride of naphthaline	$C^{10}H^8.\ 2\ Cl^2$
Chloride of bromo-naphthaline	$C^{10}H^7Br.\ Cl^2$

Acetic acid	$O^2.\ 2\ CH^2$
Propionic acid	$O^2.\ 3\ CH^2$
Butyric acid	$O^2.\ 4\ CH^2$

---

* I shall advert further on to synoptic formulæ; for the present I rest satisfied with observing, that by synoptic formulæ I propose to indicate, not what the arrangement of the atoms really is, but that in such or such a body it is the same as in such or such other body.

Nitrate of soda	$Na.NO^3$
Calcareous spar	$2\ Ca.CO^3$
Red silver	$3Ag.Sb\,S^3$

Nitrate of potash	$K.NO^3$
Arragonite	$2\ Ca.CO^3$
Bournonite (cuprosum)	$2\ Pb.cu.Sb\,S^3$.

Already these formulæ manifest certain approximations, and the introduction of *cuprosum* assists us in penetrating a part of the mystery. For if, in the ordinary notation, the formulæ for the cupreous and cupric sulphide are Cu^4S and Cu^2S, with *cuprosum* and *cupricum* they will become $cu^2\,S$ and $Cu^2\,S$. Then we can conceive, how the sulphide of cuprosum may have the same form as the sulphides of lead and silver, and how it may be capable of replacing them in the grey coppers, polybasite, bournonite, and cupro-plumbite.

Thus then 2 Cu fulfils the same functions as Cu. Do we not recognise a precisely similar circumstance in the acetic, propionic, and butyric acids, where $2\ CH^2$, $3\ CH^2$, $4\ CH^2$, likewise fulfil the same functions?

May we not associate with these examples, the illustration afforded by the bichloride of naphthaline and the chloride of bromo-naphthaline, which substances only differ from one another (not considering the bromine, which is isomorphous with the hydrogen it replaces) by Cl^2 and $2\ Cl^2$?

Do not similar conditions obtain in the nitrates of soda and potash, calcareous spar, arragonite, red silver, and bournonite?

We might place here the bimalate and bitartrate of ammonia, which contain, the first—

$$C^4H^6O^5.H^3N,$$

the second—

$$C^4H^6O^5.H^3N.O.$$

I cannot terminate this subject without remarking that calcareous spar and nitrate of soda, Ca^2CO^3 and $Na\,NO^3$, when thus formulated, have sensibly the same atomic volume, for that of the first is to that of the second as 18·7 is to 19·5.

I repeat, that by the formulæ I have just given, I do not intend to explain the cause of isomorphism, but simply to indicate certain relations of composition which exist in isomorphous bodies.

C. *With a different consitution.*—Here we may arrange certain isomorphous bodies, such as the diamond and alum, quartz and chabasite, sulphur and bisulphate, *a* of potash, feldspar and bisulphate, *β* of potash, &c., in which at present we do not recognise any similarity of composition.

This isomorphism may perhaps be only accidental. Nevertheless, I cannot resist the desire to compare here the formulæ of feldspar and bisulphate of potash. In the ordinary notation, these two salts contain:

$$\begin{aligned} &KO.\ Si\,O^3 + Al^2O^3.\ 3\ Si\,O^3, \\ &KO.\ SO^3 \ + H^2O.\ SO^3. \end{aligned}$$

These two formulæ do not manifest any analogy. But if we transcribe them on the unitary notation, we shall then have the following relations:

$$\begin{aligned} &K\,H.\quad SO^4 \\ &K_{\frac{1}{2}}\overset{v}{\dot{A}}l_{\frac{3}{2}}.SiO^4 \end{aligned}$$

or, in writing silica, $= Si\,O$,

$$K_{\frac{1}{2}}\overset{v}{\dot{A}}l_{\frac{3}{2}}.Si^3O^4.$$

IV. *Isodimorphous bodies.*

In this class I arrange bodies which, having the same composition, are also isomorphous; the isomorphism, however, being manifested between forms belonging to different crystalline systems. Such are the two sulphurs, the two carbonates of lime, the two arsenious acids, the two oxides of antimony, the two bichlorides of chloronaphthaline, the red and the yellow iodide of mercury, &c.

Probably the mesotypes ought to be included in the sixth class, since the variations of the angles, and the passages from one system to the other, doubtless depend upon a greater or less replacement of the soda by lime. And moreover, the passage from one system to the other does not seem to be sudden as in the preceding instances; but there are *intermediate* angles.

V. *Isotrimorphous bodies.*

According to Ladrey, titanic acid crystallises in three different systems, and the three forms approach very nearly to one another.

VI. *Paramorphous bodies.*

I place in this class bodies, which having a different composition, are isomorphous, the isomorphism being manifested between forms belonging to different crystalline systems.

A. *With similar constitution.*—In this division will be placed certain isodimorphous bodies, those only being compared which have a different composition. Thus the octohedral arsenious acid is paramorphous with the prismatic oxide of antimony, and prismatic arsenious acid with the octohedral oxide of antimony.

There is also paramorphism:—

Between arragonite and the carbonates of magnesia, iron, and manganese.

Between calcareous spar and the carbonates of baryta and strontia.

Between nitrate of soda and nitrate of potash.

Between the bichloride of naphthaline, and the bichloride of chloronaphthaline crystallised from ether.

B. *Of comparable constitution*, or *similar by hypothesis.*—I may adduce the chloride of bromonaphthaline, crystallising in an *oblique* prism with a rhombic base, and the bichloride of chloronaphthaline crystallising in a *right* prism with a rhombic base. The formula of the first is

$$C^{10}H^7Br.\ Cl^2;$$

that of the second,

$$C^{10}H^7Cl.\ 2\ Cl^2.$$

There is also paramorphism between the nitrate of soda and arragonite, and between red silver and bournonite.

C. *Of different constitution.*—I might adduce braunite crystallising in square-based octohedra of 109° 53′ and 108° 39′, and alum crystallising in regular octohedra of 109° 30′. We could find plenty of analogous examples; but in the above illustration we do not perceive any relation between the composition of braunite and of alum, and we can only attribute the similarity of their crystals to accident.

VII. *Hemimorphous bodies.*

I give this name to bodies of which the crystals resemble one another in part only.

If we open a book on crystallography, we may in any page of it meet with substances having one or two angles sensibly equal, but the remainder perfectly different. Relations of this description however, do not offer anything of particular interest. But those

I am about to point out do not allow us to doubt but that the greater or less analogy existing in the composition of certain bodies, is not unfrequently sustained by greater or less differences in their forms.

A. *Of similar constitution.* As an example, I will notice only the bichloride of naphthaline, and the bibromo-chloro-naphthaline, both of which crystallise in non-symmetrical prisms, approaching nearly to an oblique prism with a rhombic base. In the first body the angle of the prism is 109°, and in the second 110°. The inclination of the base to the sides is in the first 108° 30′, in the second 102° only.

B. *Of comparable constitution.*—Naphthaline presents us with several curious instances of hemimorphism. This substance submitted to the action of chlorine and bromine gives rise to two classes of bodies. The first class comprises bodies, the atoms of which are equal in number to those of naphthaline; and the second, bodies containing a greater number of atoms, as seen below.

$$\textit{First class.}\ \begin{cases} C^{10}H^{8} \\ C^{10}H^{7}Cl \\ C^{10}H^{6}BrCl \\ C^{10}H^{5}BrCl^{2} \end{cases}$$

$$\textit{Second class.}\ \begin{cases} C^{10}H^{8}.\ Cl^{4} \\ C^{10}H^{7}Cl.\ Cl^{4} \\ C^{10}H^{5}Br^{3}.\ Br^{4} \\ C^{10}H^{5}Br^{2}Cl.\ Cl^{4}. \end{cases}$$

The bodies of the first class crystallise in non-symmetrical prisms, the three angles of which are nearly equal, and vary from 100° to 103°. The bodies of the second class crystallise either in non-symmetrical prisms, or in oblique prisms with a rhombic base, but of these the three angles are nearly equal, and vary from 108° to 111°, at least in the majority of them. But there are others of them, which as it were, establish a gradation from the first class to the second, as may be seen in the following examples.

	First class.		
Trichloro-naphthaline	103°	100°	101° 30′
	Second class.		
Bichloride of bibromochloro-naph.	110°	102°	102°
Bibromide of tribromo-naph.	110°	105°	
Bichloride of naphthaline	109°	108° 30′	108° 30′

I have met with another example of hemimorphism in the paratungstates of potash and of soda. The first of these salts contains 8 atoms of water, the second 9 atoms. In these two salts, two-thirds of the angles of the one, resemble very closely those of the other, whilst the remaining third is very different. Moreover the aspect, cleavage, and striæ, of these crystals present the greatest analogy.

The tartrates offer other very interesting examples. I once showed to Pasteur some crystals of tartrate of lime, the angles of which I had succeeded in determining. "I know," said he to me, "without measuring, the angle of the prism; it is of about 100°; for all the tartrates, simple or double, neutral or acid, anhydrous or hydrated, have prisms of about 100° and 80°, but the angles of the summits vary from one tartrate to another."

According to Nicklés, homologous bodies present us with similar facts. Thus we have with

		Angle of the prisms.	Angle of the summits.
Formate of baryta	— $C\,H\,Ba\,O^2$	80° to 82°	75°
Acetate of baryta	— $C^2H^3BaO^2 + \frac{3}{2}\,Aq$		116°48′
Acetate of lead	— $C^2H^3PbO^2 + \frac{3}{2}\,Aq$		116°48′
Propionate of baryta	— $C^3H^4BaO^2 + \frac{1}{2}\,Aq$		92°

We have just seen hemimorphism manifested in the salts of the same acid, and in the salts of homologous acids. Nicklés has shown that compounds of the same base may also be hemimorphous:

The sulphate and nitrate of glycocine have prisms of 123° 8′, 125° 10′, 126° 15′.

The oxalate and chlorhydrate of glycocine have each an angle of 113°.

The oxalate of methylamine has an angle of 131° 20′, the chlorhydrate of 132°.

We may add also, that the oxalates of methylamine and ethylamine, isomorphous with one another, are hemimorphous with the oxalate of ammonia.

The composition of these three bodies may be represented as follows:—

Oxalate of ammonia .... $C^2O^4H^2 + H^6N^2$
Oxalate of methylamine .... $C^2O^4H^2 + H^6N^2 + 2\,CH^2$
Oxalate of ethylamine .... $C^2O^4H^2 + H^6N^2 + 4\,CH^2$.

We might compare the atomic arrangement of hemimorphic combinations to that of gothic cathedrals. Of these some are adorned with two towers, and others have but one; some are surmounted with spires, with or without lateral galleries; but the fundamental plan of the edifice is always the same, namely, the Greek cross.

If we ventured to pursue this comparison, we should say, that it is possible to ally two edifices of different kinds, to put the cupola upon the Parthenon, and so obtain mixed edifices, such as St. Peter's at Rome, in which we recognise the influence of two kinds of architecture.

This last comparison induces us to ask, what would be the form of the crystal obtained by combining glycocine with tartaric acid? We have seen above that all the tartrates have an angle of about 100°; we have also seen that the salts of glycocine have an angle of 123° 8′ or of 113°, each of which appertains to free glycocine. Consequently the tartrate of glycocine would have one angle of 100°, and the other of 123° 8′ or of 113°.

Isomorphism of the oxides R^2O *with the oxides* R^4O *and* R^4O^3.

We have just seen that isomorphism and paramorphism lead us to the same consequences, as regards the composition of bodies. This being admitted, let us return to the isomorphism of the different oxides R^2O, R^4O, and R^4O^3.

Nearly all these oxides, and their corresponding sulphides, crystallise in cubes or in regular octohedra, or in rhombohedra approximating nearly to cubes, or in octohedra with a square base approaching nearly to regular octohedra. Thus the ferric *a*, ferroso-ferric, aluminico-magnesic, aluminico-zincic, ferro-chromic, ferro-titanic *a*, cupric, cuprous, magnesic, plumbic, and nickelic oxides, crystallise in the regular system.

The aluminic, ferric *b*, ferro-titanic *b*, and chromic oxides are paramorphous with the preceding, since they crystallise in rhombohedra, bordering upon the cube.

Braunite Mn^4O^3 is paramorphous with the oxides of the regular system, since it crystallises as an octohedron with a square base, its angle being 109° 53′, while that of the regular octohedron is 109° 30′. It is the same with hausmannite Mn^6O^4, which crystallises as an octohedron with a square base, having an angle of 105° 25′.

The manganous, zincic, plumbic, cobaltic, cobaltoso-cobaltic, nickelo-bismuthic, cuprous, cuproso-plumbic, cuproso-ferric, cuproso-ferrous, and argentic sulphides, crystallise in the regular system.

Copper pyrites crystallises as an octohedron with a square base, having an angle of 108° 40′.

Mercuric sulphide gives rise to two rhombohedra, of which one is of 92°.

All the varieties of phillipsite, the grey coppers, and tennantite belong to the regular system.

The sub-sulphuret of bismuth appears to be isomorphous with the sulphuret, which crystallises in right rhombohedral prisms of 91°.

Thus then, all the preceding compounds are isomorphous, or what comes to the same thing, paramorphous. Let us now glance at their composition, expressed in the ordinary formulæ:

Oxide magnesic	$O Mg^2$
„ plumbic	$O Pb^2$
„ cupric	$O Cu^2$
„ nickelic	$O Ni^2$
Sulphide manganous	$S Mn^2$
„ plumbic	$S Pb^2$
„ zincic	$S Zn^2$
„ argentic	$S Ag^2$
„ mercuric	$S Hg^2$
Sub-sulphide bismuthic	$S Bi^2$
Oxide cuprous	$O Cu^4$
Sulphide cuprous	$S Cu^4$
Oxide aluminic	$O^3 Al^4$
„ ferric	O^3Fe^4
„ chromic	O^3Cr^4
„ manganic	O^3Mn^4
Sulphide cobaltic	S^3Co^4
„ bismuthic	S^3Bi^4
Copper pyritic	$S^2Cu^2Fe^2$
Cupro-plumbite	$S^3Cu^4Pb^4$
Phillipsite	$S^3Cu^8 Fe^2$ $S^3Cu^6 Fe^2$ $S^4Cu^6 Fe^2$ $S^5Cu^{16}Fe^2$ $S^6Cu^{18}Fe^2$ $S^6Cu^{14}Fe^4$ $S^{10}Cu^{22}Fe^8$.

The grey coppers have a composition still more variable.

In the following minerals, the composition varies as follows:

Gahnite from	$Al^4 Zn^2 O^4$	up to	$Al^8 Zn^2 O^7$
Spinelle from	$Al^4 Mg^2 O^4$	up to	$Al^{12} Mg^2 O^{10}$
Pleonaste from	$Al^{10} Mg^3 O^4$	up to	$Al^{28} Mg^6 O^{24}$
Magnetic iron from	$Fe^6 O^4$	up to	$Fe^{22} O^{15}$

In chromic iron, the protoxide of iron varies from 18 to 36, the chromic oxide from 36 to 60, and the alumina from 6 to 20 per cent.

In titanic iron ores the variations are equally great. The octohedral and magnetic titanic iron, contains from 12 to 22 per cent. of titanic acid. The octohedral and non-magnetic titanic iron, from 48 to 58 per cent., and the rhombohedric and non-magnetic variety, 47 per cent.

Let us refer also to magnetic pyrites and subsulphide of copper. This last occurs in two forms, one of which is derived from the rhombohedron, or regular hexagonal prism. The base is inclined to certain facets at an angle of 116° 53′, and to others at an angle of 106°. Magnetic pyrites crystallise in the same form, the inclination of the base to the facets forms angles of 116° 25′ and of 105°, and yet the two minerals do not present the slightest analogy in their formulæ, that of the former being $Cu^4 S$, that of the latter $Fe^5 S^3$.

The subsulphide of copper is also isomorphous with *silber-kupfer-glanz*, which consists of $Ag^2Cu^4S^2$ or $AgCu^2S$.

In the presence of these facts, and by employing the ordinary notation, it is impossible to conceive why all these minerals should be isomorphous. If, on the contrary, we introduce ferrosum and ferricum, &c., into our formulæ, then the isomorphism of the above minerals will be readily intelligible, as they will all have similar formulæ, as we perceive in the following table:

Oxide magnesic	$R^2 O$
„ plumbic	
„ cupric	
„ nickelous	
„ ferric	$\overset{v}{R}{}^2 O$
„ aluminic	
„ chromic	
„ manganic	

Oxide cuprous	$\overline{R}^2\,\mathrm{O}$
Sulphide plumbic	$\mathrm{R}^2\,\mathrm{S}$
,, cupric	
,, manganous	
,, bismuthous	
,, zincic	
,, argentic	
,, cobaltic	$\overset{v}{\mathrm{R}}{}^2\,\mathrm{S}$
,, bismuthic	
,, mercurous	$\overline{R}^2\,\mathrm{S}$
Cupro-plumbite	$\mathrm{Pb}\,\overline{Cu}\,\mathrm{S}$
Silver-copper-glance	$\mathrm{Ag}\,\overline{Cu}\,\mathrm{S}$
Copper pyrites	$\mathrm{Cu\,Fe\,S}$
Magnetic pyrites	$\mathrm{Fe}\,\overset{v}{\mathrm{F}}\mathrm{e}\,\mathrm{S}$
Phillipsite	$\overline{Cu}_{\frac{4}{3}}\,\mathrm{Fe}_{\frac{2}{3}}\quad\mathrm{S}$ $\overline{Cu}\,\mathrm{Cu}_{\frac{1}{2}}\mathrm{Fe}_{\frac{1}{2}}\quad\mathrm{S}$ $\overline{Cu}_{\frac{8}{5}}\mathrm{Fe}_{\frac{2}{5}}\quad\mathrm{S}$ $\overline{Cu}_{\frac{4}{3}}\,\mathrm{Cu}_{\frac{1}{3}}\mathrm{Fe}_{\frac{1}{3}}\quad\mathrm{S}$ $\overline{Cu}\,\mathrm{Cu}_{\frac{1}{3}}\mathrm{Fe}_{\frac{2}{3}}\quad\mathrm{S}$ $\overline{Cu}\,\mathrm{Cu}_{\frac{1}{5}}\mathrm{Fe}_{\frac{4}{5}}\quad\mathrm{S}$
Magnet	$\overset{v}{\mathrm{F}}\mathrm{e}_{\frac{3}{2}}\mathrm{Fe}_{\frac{1}{2}}\quad\mathrm{O}$
Spinelle, gahnite, chromic iron	$\mathrm{R}\,\overset{v}{\mathrm{R}}\;.\;.\;.\;{}^2\;\mathrm{O}.$*

Cuprosum replaces lead and silver in cupro-plumbite, in bournonite, and in *silber-kupfer-glanz,* which substitution does not affect the form of the combinations. Moreover, we have shown a few paragraphs back, that all these oxides when formulated as in the preceding table, have the same atomic volume.

Should any uncertainty concerning the isomorphism of the

---

* O=16. $\overset{v}{\mathrm{R}}$ or r = $\frac{1}{3}$ the usual atomic weight of a metal forming a teroxide, and $\frac{2}{3}$ the usual atomic weight of a metal forming a sesquioxide. Thus

$\overset{v}{\mathrm{S}}\mathrm{b}^2\mathrm{O} = \mathrm{sb}^2\mathrm{O}$ = oxide of stibicum = teroxide of antimony

$\overset{v}{\mathrm{F}}\mathrm{e}^2\mathrm{O} = \mathrm{fe}^2\mathrm{O}$ = oxide of ferricum = sesquioxide of iron.

$\overline{R}$ or r = twice the ordinary atomic weight of a metal forming a suboxide. Thus

$\overline{Cu}^2\mathrm{O} = cu^2\mathrm{O}$ = oxide of cuprosum = suboxide of copper.—(W. O.)

oxides R^2O, R^4O^3, and R^4O still exist in the minds of chemists, I trust it will, by the following facts, be completely dissipated.

The epidotes have been of late years, the subject of the researches of several mineralogists, and principally of Hermann. All the specimens of which the analyses were made, were extremely well crystallised. These are the results arrived at:

	OXYGEN.			
	Of the silica.	Of the bases R^2O.	Of the bases R^4O^3.	Of all the bases.
From Suland	100	65·3	30·2	95·5
Falltigel	100	64·2	33·0	97·2
St. Marcel	100	68·0	33·0	101·0
Arendal	100	66·2	33·0	99·2
	100	66·3	33·0	99·3
Achmatowsk	100	66·2	33·0	99·2
	100	69·0	34·0	103·0
Schumnaja	100	69·0	33·0	102·0
Arendal	100	66·6	35·0	101·6
Burowa....	100	64·4	37·0	101·4
Werchneiwinsk...	100	64·6	37·0	101·6
Dauphiné	100	61·7	38·4	100·1
Achmatowsk	100	61·0	39·0	100·0
	100	59·5	39·0	98·5
Géier	100	51·0	45·8	96·8
Mean	100	64·2	35·5	99·7

I pass silently over a dozen more ancient analyses which lead to the same results, and alike with the preceding, prove to us, that the oxygen of the bases R^2O diminishes, as that of the bases R^4O^3 increases.

In the presence of analyses so discordant, Hermann divides the epidotes into three species, of which the following are the formulæ:

$$a.\ 3\,(Si\,O^2 .\,2\,R^2\,O) + 2\,(3\,Si\,O^2 .\,2\,R^4\,O^3),$$

$$\begin{aligned} b.\ & [3\,(Si\,O^2 .\,2\,R^2\,O) + 2\,(3\,Si\,O^2 .\,2\,R^4\,O^3)\,] \\ & + [2\,(Si\,O^2 .\,2\,R^2\,O) + (3\,Si\,O^2 .\,2\,R^4\,O^3)\,] \end{aligned}$$

$$\begin{aligned} c.\ & 2\,[3\,(Si\,O^2 .\,2\,R^2\,O) + 2\,(3\,Si\,O^2 .\,2\,R^4\,O^3)\,] \\ & + 3\,[2\,(Si\,O^2 .\,2\,R^2O) + (3\,Si\,O^2 .\,2\,R^4\,O^3)\,] \end{aligned}$$

Here then is a silicate, which always presents itself with the same form, the same properties, and the same atomic volume, and of which, mineralogists have made but one species: the chemist then arrives, executes his analyses, and not finding any relation in the composition of the different varieties, he immediately by the aid of his mysterious hieroglyphics, manufactures three species, as far removed from one another as feldspar is from granite.

But if, instead of putting the bases with one atom of oxygen on one side, and the bases with three atoms of oxygen on the other, we unite them in one group, and compare the oxygen which they contain with that contained by the silicic acid, we then discover the uniform ratio of 99·7 to 100. Could any one require a more evident proof of the isomorphism of the oxides R^2O and R^4O^3?

Rammelsberg and Svanberg consider this conclusion absurd, and prefer the preceding hieroglyphics to the formula $(R\,r)^2\,Si\,O^2$ which I propose.

I recollect that at one time I admired the penetration of those chemists, who were able to prescribe formulæ with numerous parentheses and numerous bracketings. I wondered how they could discover such complicated arrangements. Since then, I have taught a child of eight years old to construct similar formulæ, and even to adorn them with one or several copulæ, and I am bound to confess that in the fantasies of his constructions, he frequently surpassed the great masters of his art!

One example of a silicate will not suffice, and I now proceed to pass rapidly in review, the composition of the best known and best crystallised silicates. We shall see that in the same species, the ratio of the oxygen of the bases R^2O to that of the bases R^4O^3 is very variable, whilst the sum of the oxygen of the two kinds of bases is constant, that is to say, that within certain limits these bases can mutually replace one another, without changing the form of the compound into which they enter. I shall represent by S the ratio of the oxygen in the silica to that contained in the united bases, and by ω the ratio of the oxygen in the bases R^2O to that in the bases R^4O^3.

If the formulæ of mineralogists are correct, if the bases R^2O cannot replace the bases R^4O^3, ω ought of necessity to be constant in the same species.

I do not attach any great value to the formulæ I am about to propose, because, as I have said before, we are ignorant of the formula of silica, of the exact atomic weight of silicon, of the different para- and meta-silicic acids, and of the functions of the constituent hydrogen, &c.

In order to give to the silicates their real formulæ, I represent silica by SiO, ($= \frac{1}{3}\,SiO^3$), the metals of the bases R^2O by R, and the metal of the bases R^4O^3 or $R_{\frac{4}{3}}O$ by r, and I admit in some cases that water plays the part of a base.

Granites and idocrases $SiO^2(R\,r)^2 = SiO(R\,r)^2O$.*

These two minerals are paramorphous. In the granites ω is nearly invariable, but in the idocrases this ratio varies from $\frac{12}{12}$ to $\frac{12}{6\cdot2}$. Hence it is not astonishing that mineralogists have proposed formulæ differing thus:

$$a.\quad (SiO^3.\,3\,R^2O) + (SiO^3.\,R^4O^3)$$
$$b.\quad 2\,(SiO^3.\,3\,R^2O) + (SiO^3.\,R^4O^3),$$

In fifteen analyses, S varied only from $\frac{19}{20}$ to $\frac{21}{20}$, and the mean gave $\frac{103}{100}$.

Allanite $SiO^2(R\,r)^2 = SiO\,(R\,r)^2\,O$.

$S = \frac{16}{16}$ and $\frac{16}{16\cdot5}$, whilst ω varies from $\frac{10}{6\cdot3}$ to $\frac{10}{4\cdot8}$.

Anorthite $SiO^2(R\,r)^2 + SiO\,(R\,r)^2\,O$.

$S = \frac{24}{23}$, whilst ω varies from $\frac{3\cdot8}{16}$ to $\frac{7}{16}$. Nevertheless this mineral has received the following formulæ:

$$3\,(SiO^3.\,3\,R^2O) + 8\,(SiO^3.\,R^4O^3),$$

according to which $\omega = \frac{6}{16}$.

Harmotome $SiO^2(R\,r)^2 = SiO\,(R\,r)^2O$.

ω varying from $\frac{1}{2}$ to $\frac{1}{5}$, this single mineral has received the the following formulæ:

$Si^{11}\,R\;r^4\,Aq^6$
$Si^{13}\,R\;r^4\,Aq^7$
$Si^{7}\,R\;r^2\,Aq^4$
$Si^{15}\,R\;r^5\,Aq^7$.

---

* This and the succeeding analogous formulæ do not exist in the original work; they are introduced for the purpose of indicating more clearly the ratio of the oxygen of the acid to that of the united bases.—(W. O.)

The mean of a score of analyses gives as the value of S, $\frac{24}{23{\cdot}8}$; consequently one single formula is sufficient, namely,

$$\mathrm{SiO^2(R\,r\,H)^2},$$

or by doubling,

$$\mathrm{Si^2O^3(R\,r\,H)^2 + Aq = SiO(R\,r\,H)^2O + SiO.H^2O}.$$

Ilvaïte $\mathrm{SiO^2(Fe\,fe)^2 = SiO(Fe\,fe)^2O}$.

The protoxide and peroxide of iron exist in very variable proportions.

Prehnite $\mathrm{SiO^2(R\,r)^2 = SiO(R\,r)^2O}$.

$$\mathrm{S} = \frac{23{\cdot}2}{22{\cdot}6},\ \frac{22{\cdot}4}{23{\cdot}5},\ \frac{22{\cdot}4}{22{\cdot}6},\ \frac{22{\cdot}4}{22{\cdot}5},\ \frac{22{\cdot}2}{22{\cdot}1},\ \frac{22{\cdot}7}{23{\cdot}4},\ \frac{22{\cdot}7}{22{\cdot}5}.$$

Here then is an extremely constant ratio. The following formulæ, which have been attributed to this mineral, will give an idea of the value of ω:

$\mathrm{Si^6\,R^2\,r^3\,Aq}$
$\mathrm{Si^4\,R\,r^2}$
$\mathrm{Si^4\,R\,r^2\,Aq}$
$\mathrm{Si^3\,R\,r^2}$
$\mathrm{Si^{18}R^6\,r^9\,Aq^3}$.

If these formulæ are exact, mineralogical characters have no value whatever. I believe that owing to the despotism of dualistic chemistry, several mineralogists have preferred returning to the classification of shorls, spars, and precious stones.

Chabasite $\mathrm{Si^4O^6(R\,r)^4 + 3\,Aq = 4\,SiO.\,2(R\,r)^2O + 3\,H^2O}$.

The mean of twenty-four analyses gives the following ratio for the oxygen:

$$\mathrm{SiO : R^2O + R^4O^3 : Aq :: 24 : 11 : 17;}$$

ω varies from $\frac{1}{2{\cdot}7}$ to $\frac{1}{4{\cdot}8}$, whilst the sum of the oxygen of the bases is constant.

The ratios deduced from experiment being $\mathrm{Si^{24}(R\,r)^{2\times11}Aq^{17}}$, I venture to transform them into $\mathrm{Si^{24}(R\,r)^{2\times12}Aq^{18} = Si^4(R\,r)^4Aq^3}$. If I thus lessen somewhat the ratio of the silica, I have experimental warrant for so doing, since it has been discovered, that chabasite in its crystallisation carries down in a state of mixture, a sensible quantity of silica, with which it is isomorphous.

Thomsonite $Si^2O^4(R^3\,r) + Aq = 2\,SiO.(R^3\,r)O^2.\ H^2O.$

The mean of eight analyses gives for S. $\frac{20}{30{\cdot}2}$.

Nevertheless Berzelius has proposed the formula

$$Si^{48}Al^{36}Na^3Ca^9H^{30},$$

in which $S = \frac{20}{32{\cdot}5}$.

Rammelsberg gives $Si^{12}Al^9R^3H^7$, in which $S = \frac{20}{31{\cdot}7}$.

Mesotype $Si^3O^5(R\,r\,H)^4 + Aq = 3\,SiO.\ 2(R\,r\,H)^2O.H^2O.$

The mean of fifteen analyses gives for S $\frac{5^*}{6{\cdot}1}$; ω varies from $\frac{1}{3}$ to $\frac{1}{5{\cdot}4}$, and in the face of these facts, the following formulæ have been proposed.

Lime mesotype	$Si^{12}\,R^2\,r^6\,Aq^6$
Soda mesotype	$Si^{12}\,R^2\,r^6\,Aq^4$
Soda lime mesotype	$Si^{12}\,R^2\,r^6\,Aq^5$,

in which ω is invariable, whilst S ranges from $\frac{12}{12}$ to $\frac{12}{14}$, a conclusion precisely opposed to experiment.

Cordierite $Si^4O^7(R\,r)^6 = 4\,SiO.\ 3(R\,r)^2O.$

In ten analyses S varied only from $\frac{4}{3}$ to $\frac{4}{3{\cdot}18}$, whilst ω ranged from $\frac{4}{15}$ to $\frac{7{\cdot}3}{15}$; the following formulæ have been proposed.

a. $(SiO^3.\,3\,R^2\ O) + (2\,SiO^3.\,Al^4O^3)$

b. $3\,(2\,SiO^3.\,3\,R^2\ O) + 8\,(SiO^3.\,Al^4O^3)$

c. $[(2\,SiO^3.\,3\,Fe^2\,O) + 2\,(SiO^3.\,Al^4O^3)]$
$+ 2\,[(2\,SiO^3.\,3\,Mg^2O) + 3\,(SiO^3.\,Al^4O^3)].$

Achmite $Si^5O^7\,(R\,r)^4 = 5\ SiO.\ 2\,(R\,r)^2\,O$

$S = \frac{5}{2{\cdot}1}$ and $\frac{5}{2{\cdot}2}$, whilst ω varies from $\frac{1{\cdot}7}{10}$ to $\frac{3}{10}$.

Albite $Si^3O^4\,(R\,r)^2 = 3\ SiO.\,(R\,r)^2\,O$

ω varies from $\frac{2}{9}$ to $\frac{3{\cdot}6}{9}$, whilst S but from $\frac{36}{12}$ to $\frac{36}{12{\cdot}5}$.

Apophyllite $Si^5\,O^7\,(R\,H)^4 + 2\,Aq$
$= 5\ SiO.\ 2\,(R\,H)^2\,O + 2\,H^2O.$

In five analyses, S varied only from $\frac{5}{3{\cdot}9}$ to $\frac{5}{4{\cdot}2}$.

The mineral has been represented thus:

$$(2\,SiO^3.\,K^2O) + 8\,(SiO^3.\,Ca^2O) + 16\,Aq.$$

---

[*] $\frac{5}{6{\cdot}1}$ is probably a misprint for $\frac{6}{6{\cdot}1}$.—(W. O.)

Axinite.

The latest analyses lead to the formula

$$3\,(\mathrm{Si^3\,O^5\,R^4}) + \mathrm{B\,O^2\,R},$$

By doubling the borate, we obtain

$$\mathrm{B^2O^3.\,R^2O} = 2\,\mathrm{B\,O^2\,R}.$$

Brewsterite $\mathrm{Si^5\,O^7\,(R\,r)^4} + 2\,\mathrm{Aq} = 5\,\mathrm{Si\,O}.\,2\,\mathrm{(R\,r)^2\,O} + 2\,\mathrm{H^2\,O}.$

$S = \frac{5}{4}$, and there have been proposed

$a.$ $\mathrm{Si^{45}\,Al^{12}\,R^3\,Aq^{13}}.$
$b.$ $\mathrm{Si^{60}\,Al^{18}\,R^5\,Aq^{25}}.$

Couzeranite $\mathrm{Si^3\,O^5\,R^4} = 3\,\mathrm{Si\,O}.\,2\mathrm{R^2O}.$

$S = \frac{3{\cdot}1}{2}$; nevertheless, the mineral has been supposed to consist of $\mathrm{Si^6\,K^3} + 6\,\mathrm{Si^3\,Ca} + 6\,\mathrm{Si^3\,Al^3}$, in which $S = \frac{2{\cdot}55}{2}$.

Datholite $\mathrm{Si^2\,O^3\,Ca\,H} + \mathrm{B\,O^2\,Ca}.$

Botryolite $\mathrm{Si^2\,O^3\,Ca\,H} + \mathrm{B\,O^2\,Ca} + \frac{1}{2}\,\mathrm{Aq^2}.$

Feldspar $\mathrm{Si^3\,O^4\,(R\,r)^2} = 3\,\mathrm{Si\,O}.\,\mathrm{(R\,r)^2O}.$

S ranges from $\frac{33}{10}$ to $\frac{33}{11}$, whilst ω from $\frac{9{\cdot}3}{2}$ to $\frac{9}{5{\cdot}2}$.

Topaz $\mathrm{Si^5\,O^9\,al^8} + 4\,\mathrm{Fl\,al}.$

Piknite $\mathrm{Si^5\,O^{10}\,al^{10}} + 4\,\mathrm{Fl\,al}.$

Chondrodite $\mathrm{Si^3\,O^6\,Mg^6} + \mathrm{Fl\,Mg}.$

Helvine $\mathrm{Si^4\,O^6\,R^4} + \mathrm{R^2}\genfrac{}{}{0pt}{}{\mathrm{O}_{\frac{1}{2}}}{\mathrm{S}_{\frac{1}{2}}}.$

This sulphuretted silicate gives $\frac{4}{3{\cdot}07}$ as the value of S, and is nevertheless represented as—

$$3\,(\mathrm{Mn^2S.\,Mn^2O}) + (2\,\mathrm{Si\,O^3}.\,3\,\mathrm{Mn^2O})$$
$$+ 2\,(\mathrm{Si\,O^3.\,Bi^4\,O^3}) + 2\,(\mathrm{Si\,O^3.\,Al^4\,O^3}).$$

Heulandite $\mathrm{Si^3\,O^4\,R^2} + \frac{3}{2}\,\mathrm{Aq}.$

$S = \frac{6}{5}$; yet the formula $\mathrm{Si^3\,Ca^4\,H^{21}}$, in which $S = \frac{6}{5{\cdot}4}$.

Nepheline $\mathrm{Si^3\,O^4\,(R\,r)^2} + \frac{3}{2}\,\mathrm{(R\,r)^2\,O}.$

According to the mean of twenty closely agreeing analyses, $S = \frac{24}{20}$, and the proposed formulæ give $\frac{20}{20}$ and $\frac{22}{20}$

Scapolite $\mathrm{Si^3\,O^5\,(R\,r)^4} = 3\mathrm{SiO}.\,2\mathrm{(R\,r)O}.$

Five analyses give as the value of $S\,\frac{3}{2}$, in the proposed formula $S = \frac{3}{2{\cdot}2}$.

Murchisonite $Si^4O^5R^2. = 4\,SiO.(R\,r)^2O.$

$S = \frac{4}{1 \cdot 1}$, and in the proposed formula.

$$(4\,SiO^3.\,3\,K^2O) + 3\,(SiO^3.\,Al^4O^3).$$

$S = \frac{2 \cdot 1}{1 \cdot 2}.$

Copper silicates $Si^2O^3Cu^2 + Aq + 2\,Aq + 3\,Aq.$

Cimolite, dermatine, dioptase, chlorophaite, fowlerite, gokumite, indianite, manganese silicate, zinc silicate, kirwanite, knebelite, lepidomelan, ottrelite, phenakite, phonolite, polyadelphite, rhodalite, saussurite, seybertite, xenolite, smelite, muromontite, liebenerite, vermiculite, appertain to the formula

$$SiO^2(R\,r)^2.$$

From these examples we perceive, that the formulæ usually attributed to the silicates are far from according with experiment, and that in general S is constant, while ω is very variable. I do not intend to maintain that the formulæ I have proposed are free from objection, but this much is certain, they are infinitely more simple than the ordinary formulæ, and agree better with the results of experiment.

SECTION FOURTH.

BASYLES OR BASYLIDES.

UPON THE BASYLES OR BASYLIDES.

I apply the term *basyles* to compounds, real or hypothetical, analogous to uranyle, which in certain combinations may be conceived to have a distinct existence.

I have previously* given a short table containing several compounds of this class, as for instance, the borylic, arsenylic, antimonylic, uranylic tartrates, and the nitrylic ferrocyanide.

The composition of these salts embarrasses us somewhat, when we endeavour to apply to them, the notation that we have just made use of for the ferric, chromic, and aluminic salts.

But before entering upon this subject, we must glance for a moment at the salts of uranyle, so as to ascertain whether they

---

* Anomalies of nitric oxide and peroxide of nitrogen.

are neutral or basic. We must moreover, examine into the question, what constitutes a neutral salt? What, for instance, constitutes a neutral nitrate?

We know well that there are two answers to this question.

1°. A neutral nitrate is a salt which contains 5 proportions of oxygen in the acid, for 1 proportion in the base.

2°. A neutral nitrate is a salt which has no action upon the colours of blue and red litmus.

We may choose which we please of these definitions, but that is obviously the best one, which best associates with each other, bodies partaking to a certain extent of common properties.

Now in adopting the first definition, we find, not only that all *neutral nitrates* have the same composition (for that is the definition itself), but that nearly all of them have similar properties. Thus the majority of them are without action upon the colour of litmus paper; they may be prepared easily, not only by employing one equivalent of base for one equivalent of acid, but even in a great excess of the latter; they are soluble salts, and can be obtained in the crystallised condition, whereby we are enabled to determine their composition with exactitude. By double decomposition with other neutral salts, they give rise to two new salts, which continue neutral (as regards their composition*), and are devoid of action upon litmus paper.

The *basic nitrates* contain more than one proportion of oxygen in the base. They are usually insoluble and uncrystallisable. It is with difficulty that they can be obtained in a state sufficiently pure for analysis, and consequently their formulæ are very questionable. Such of them as are crystallisable alter in their composition when we attempt to purify them by a second crystallisation. When added to neutral salts, they undergo an irregular double decomposition, sometimes producing neutral salts mixed with an excess of base, sometimes neutral salts with basic salts of variable composition. The addition of nitric acid immediately alters the basity of these salts.

By adopting the second definition, we find that the neutral nitrates include soluble and crystallisable salts, that is to say, some of the salts that we have already arranged among neutral salts according to the first definition, and also many other salts but slightly soluble or insoluble, uncrystallisable, and of irregular double decomposition. *These* neutral nitrates have a very variable

---

* Mr. Watts and others make use of the term normal salts to indicate salts which are neutral as regards their composition.—(W. O.)

composition, some of them containing but 1 proportion of oxygen in the base, others $\frac{3}{2}$, 2 and 3 proportions. From this class the nitrates of copper, bismuth, and peroxide of iron are excluded in consequence of their reddening the colour of litmus.

The first definition is consequently preferable to the second, and has moreover been adopted by all chemists.

Let us now direct our attention to the uranic nitrate $U^2O^3.N^2O^5$. Is this a neutral or a basic salt? Since we adopt the first definition, there can be no doubt but that it is a basic nitrate. But observe the singular anomaly—the salt in question does not manifest a single property characterizing basic salts, insomuch that previously to their becoming acquainted with its composition, all chemists considered it as a neutral salt.

What we have just remarked concerning the nitrate, must be applied to the other uranic salts, since all of them, as regards their properties, are neutral, and as regards their composition, basic, and that to the same degree.

May not this anomaly of the uranic salts depend simply upon the definition we give to neutral salts, and to the manner in which we regard their constitution? A neutral sulphate we say, is a salt of which the base contains 1, and the acid 3 proportions of oxygen. But chemists who admit this definition take good care not to apply it to the neutral sulphates of quinine, and of ethylonitraniline; and I believe that not one of them would consider as basic salts, the arsenious and boric sulphates obtained in the presence of an excess of boiling concentrated sulphuric acid. Ought we not then to say, that a neutral sulphate is a salt of which the composition may be represented by one proportion of sulphate of hydrogen, plus one proportion of oxidised matter, minus one proportion of water? Let us represent the composition of the oxidised matter by the symbols Z^2O, we may then establish the following parallel:

$$\left\{\begin{array}{l} H^2\,SO^4 + K^2\,O = \\ K^2\,SO^4 + H^2\,O \end{array}\right.$$

$$\left\{\begin{array}{l} H^2\,SO^4 + Z^2\ O \\ Z^2\ SO^4 + H^2\,O \end{array}\right.$$

Here we see that a neutral sulphate is simply sulphuric acid, of which the hydrogen has been set free, and has ceded its place to the previously oxidised substances K^2 or Z^2, which in this manner fulfil its functions. Now whether Z^2 represents sodium, or iron, or copper, or ethylonitranilium, or partially deoxidised uranic oxide, or partially deoxidised arsenious acid, is a matter of no consequence, provided that the new salt possesses all the distinguishing properties of a neutral salt. The oxides which can in this manner remove the hydrogen from sulphuric acid, are not necessarily bodies *containing but one* proportion of oxygen, but bodies capable of *ceding but one* proportion, to the hydrogen set free.

In this way U^4O^3, As^2O^3, Sb^2O^3, B^2O^3, N^2O^3, &c., may each represent one equivalent of an oxide equivalent to K^2O, but then we shall be led into other consequences, from which fresh embarrassments will arise.

How do we proceed to formulate the salts of uranyle? Having regard to the analogous salts of arsenyle, boryle, nitryle, &c., and representing uranic oxide by U^4O^3, uranous oxide being U^2O, we designate U^4O^2 by the name of uranyle, a body isomeric but not identical with uranous oxide, having indeed twice the atomic weight of the latter, and not possessing an equivalent substitution value, nor fulfilling similar functions. Thus far then, we do not meet with any difficulty.

But the ferric, manganic, chromic, aluminic, bismuthic, and antimonious oxides — do not they comport themselves like the uranic oxide? With the view of ascertaining whether the oxides of bismuth and antimony might not be analogous to the oxide of uranyle, Peligot has recently made some researches, and from his results has felt himself bound to reply in the negative.

Nevertheless we meet with several salts of bismuth and antimony, which, though basic as regards their composition, are yet crystallisable, which redden rather than blue the colour of litmus, and which ought to be considered as the salts of bismuthyle and antimonyle with as much reason as the uranic salts are considered to be salts of uranyle; such are the following:

Chloride of antimonyle	$Sb^2Cl^6 + 2\ Sb^2O^3$	$\doteq Sby\ Cl$*
Chloride of bismuthyle	$Bi^2Cl^6 + 2\ Bi^2O^3$	$\doteq By\ Cl$
Acid sulphate of antimonyle....	$5\ SO^3 + 2\ Sb^2O^3 + 3\ H^2O$	$\doteq (Sby_{\frac{2}{3}}\ H_{\frac{2}{3}})^2\ SO^4$†
Neutral sulphate of bismuthyle	$SO^3 + Bi^2O^3$	$\doteq By^2\ SO^4$
Acid sulphate of bismuthyle....	$2\ SO^3 + Bi^2O^3 + 3\ H^2O$	$\doteq ByH\ SO^4 + Aq$‡
Acid sulph. of arsenyle (crist) .	$4\ SO^3 + 3As^2O^3 + H^2O$	$\doteq Asy_{\frac{3}{2}}\ H_{\frac{1}{2}}\ SO^4$†
Acid oxalate of antimonyle	$2\ C^2O^3 + Sb^2O^3 + H^2O$	$\doteq Sby\ H\ C^2O^4$
Carbonate of bismuthyle	$CO^2 + Bi^2O^3$	$\doteq By^2\ CO^3$
Nitrate of bismuthyle....	$N^2O^5 + Bi^2O^3 + 2\ H^2O$	$\doteq By\ NO^3 + Aq$†.

---

* I shall make use of the sign $\doteq$ to indicate that two bodies or two formulæ correspond to one another. Thus $P^2O^5 \doteq P^2Cl^{10} \doteq PCl^5$.

† † † According to my unpublished analyses.

‡ According to the analyses of Heintz and myself.

It seems to me that the following salts, which are *soluble*, *crystallisable*, and *rather acid* than neutral, to test paper, ought to be classed not among basic, but among neutral or acid salts.

Sulphite of aluminyle	$SO^2 + Al^4O^3 + 4\ H^2O$	$\doteqdot$	$Aly^2SO^3 + 4\ Aq$
Soluble sulphate of aluminyle	$4\ SO^3 + 3\ Al^4O^3 + 29\ H^2O$	$\doteqdot$	$Aly_{\frac{3}{2}}H_{\frac{1}{2}}SO^4 + 7\ Aq$
Crystallised basic alum	$4\ SO^3 + 3\ Al^4O^3 + K^2O + 8\ H^2O$	$\doteqdot$	$Aly_{\frac{3}{2}}K_{\frac{1}{2}}SO^4 + 2\ Aq$
Plumose alum	$3\ SO^3 + Fe^2O + Mg^2O + Al^4O^3 + 15\ H^2O$	$\doteqdot$	$Mg_{\frac{2}{3}}Fe_{\frac{2}{3}}Aly_{\frac{2}{3}}SO^4 + 5\ Aq$
Sulphate of ceryle	$4\ SO^3 + 3\ Ce^4O^3 + 9\ H^2O$	$\doteqdot$	$Cey_{\frac{3}{2}}H_{\frac{1}{2}}SO^4$
Crystallised hyposulphate of chrome.	$S^2O^5 + Cr^4O^3 +$	$\doteqdot$	$Cry^2S^2O^6$
Soluble sulphate of chrome	$2\ SO^3 + Cr^4O^3 + x\ H^2O$	$\doteqdot$	$CryHSO^4 + x\ Aq$
Soluble chloride of chrome	$Cl^6Cr^4 + 2\ Cr^4O^3 + 3\ H^2O$	$\doteqdot$	$CryCl + \frac{1}{2}\ Aq$
Sulphite of ferryle	$SO^2 + Fe^4O^3 + 6\ H^2O$	$\doteqdot$	$Fy^2SO^3 + 6\ Aq$
Crystallised basic alum	$8\ SO^3 + 3\ K^2O + 2\ Fe^4O^3 + 11\ H^2O$	$\doteqdot$	$K_{\frac{3}{4}}Fy_{\frac{2}{4}}H_{\frac{3}{4}}SO^4 + \ Aq$
Basic ammoniacal alum*	$8\ SO^3 + 3Am^2O + 2\ Fe^4O^3 + 11\ H^2O$	$\doteqdot$	$Am_{\frac{3}{4}}Fy_{\frac{2}{4}}H_{\frac{3}{4}}SO^4 + \ Aq$
Another deliquescent alum, about	$8\ SO^3 + 2\ K^2O + 3\ Fe^4O^3 + 19\ H^2O$	$\doteqdot$	$K_{\frac{2}{4}}Fy_{\frac{3}{4}}H_{\frac{3}{4}}SO^4 + 2\ Aq$
Acid sulphate of ferryle	$2\ SO^3 + Fe^4O^3 + 9\ H^2O$	$\doteqdot$	$FyHSO^4 + 4\ Aq$

---

* According to my unpublished analyses.

What differences are there between the salts of chromyle, ferryle, aluminyle, antimonyle, or bismuthyle, and those of uranyle? Scarcely one can be adduced. The former salts are decomposable by water, the salts of uranyle are not so. But this difference is not of sufficient importance, to warrant us in considering the former salts as basic and the latter as neutral.

Nevertheless a difference does exist, not indeed in the properties of the above salts, but between the properties of iron, antimony, &c., on the one hand, and those of uranium on the other; for while uranium gives rise only to salts of uranyle, and not to a single salt of uranicum,—iron, antimony, &c., alike produce salts of ferryle and of antimonyle, and salts of ferricum and antimonicum.

Since salts of ferricum can exist, why may we not have basic salts of ferricum? and if basic salts of ferricum exist, in what will they differ from the salts of ferryle? Then if the salts of ferryle are but basic salts of ferricum, why should not the salts of uranyle be basic salts of uranicum?

In the midst of these difficulties I would ask, may we not have basic salts of ferricum isomeric with neutral salts of ferryle?

Basic salt of ferricum .... $fe^2SO^4 . 2\, fe^2O$
Neutral salt of ferryle .... Fy^2SO^4.

I appear here to give the question a hypothetical turn, so as to avoid its real solution; but in demanding whether there may not be a neutral sulphate of ferryle isomeric with the tribasic sulphate of ferricum, I am leaving the whole question to experiment, for if there are two isomeric sulphates, we are bound to render their different properties apparent.

The subject is a very difficult one to treat of: the bodies in question are for the most part insoluble and incrystallisable; consequently their formulæ are very uncertain.

I shall confine myself to directing attention to some few facts, without pretending that they are sufficient for the decision of the question. The first point that occurs to me is the following: we know that certain basic sulphates are insoluble, while certain other sulphates having the same composition or even a higher degree of basity, are soluble. Thus aluminite $SO^3 . Al^4O^3 . 9\, H^2O$ is an insoluble salt, but that we may obtain a similar salt in the state of solution, is shown by the following experiment. I dissolved three proportions of sulphate of alumina $3SO^3 . Al^4O^3$ in water, and added thereto, drop by drop, a solution of carbonate of soda, agitating between each addition, so as to re-dissolve the precipitate at first thrown down. As soon as a slight permanent turbidity took place, I ceased to add the carbonate, and on examination, found that I had employed two proportions thereof. The liquid still retained strongly its property of reddening the colour of litmus. This liquid ought then, to contain the tribasic sulphate of alumina, for

$$\mathrm{Al^4O^3.\ 3\ SO^3 + 2\ Na^2O = 2\ (Na^2O.\ SO^3) + Al^4O^3.\ SO^3.}$$

This acid and very soluble subsulphate has but little stability, and is precipitated or decomposed by the addition of water, and also by ebullition.

According to some chemists, the precipitate thus produced would have exactly the same composition as aluminite, but different experimentalists have not arrived at concordant results.

Be this as it may, we have here two aluminic tribasic sulphates, the one soluble, the other insoluble. May not aluminite then be a *basic* sulphate of aluminicum $\overset{v}{\mathrm{A}}\mathrm{l^2SO^4.2}\overset{v}{\mathrm{A}}\mathrm{l^2O.9Aq}$, and consequently insoluble, whilst the soluble salt is a neutral sulphate of aluminyle $\mathrm{Aly^2SO^4}$, or a double salt of aluminyle and soda $\mathrm{(Aly\ Na)^2\ SO^4}$. Then we can conceive how it is, that the neutral sulphate of aluminicum, possessing an acid reaction, retains its acidity despite the addition of carbonate of soda, for the alumina gradually set at liberty, instead of rendering the salt basic, simply transforms it into a salt of aluminyle.

There exists also a soluble salt of alumina, consisting of

$$\mathrm{3\ SO^3.\ Fe^2O.\ Mg^2O.\ Al^4O^3 + 15\ Aq,}$$

which we may consider as a combination of the three following salts

$$\begin{array}{l}\mathrm{Fe^2.\ SO^4 + 5\ Aq} \\ \mathrm{Mg^2.\ SO^4 + 5\ Aq} \\ \mathrm{Aly^2.\ SO^4 + 5\ Aq.}\end{array}$$

Ferric sulphate comports itself similarly to aluminic sulphate. If we operate upon a very concentrated solution, adding, little by little, a mixture of ammonia and carbonate of ammonia, the liquid, from being but faintly yellow, becomes of a very deep reddish-brown colour; left to itself for twenty-four hours, it remains translucid, but assumes a gelatinous consistency. On the application of a gentle heat, the liquid gradually coagulates, in a manner resembling that of the white of an egg.

The coagulum is translucid; water poured upon it does not receive any coloration. If we precipitate the solution by alcohol, we obtain a syrupy matter, which by desiccation becomes hard, brilliant, and translucid. The salt thus dried has not lost its solubility; exposed to the air it attracts moisture and dissolves; but on diluting its solution with water, or on the application of a gentle heat, the salt becomes insoluble or decomposed.

An analogous precipitate, obtained by the action of potash and alcohol, yielded to Soubeiran

$$8\ SO^3 + 2\ K^2O + 3\ Fe^4O^3 + 22\ H^2O$$

or $$2\,(K^2O.\ SO^3) + 3\,(Fe^4O^3.\ 2\ SO^3) + 22\ Aq,$$

or in admitting but 19 Aq (?), and supposing it to be an acid salt of ferryle,

$$(K_{\frac{2}{4}}\,Fy_{\frac{3}{4}}\,H_{\frac{3}{4}})\,SO^4 + 2\ Aq.$$

Then the soluble salt of ferryle would be coagulated by heat, and become insoluble, in consequence of its being converted into a basic salt of ferricum.

Chromic sulphate presents analogous phenomena. This salt, in common with all other chromic salts, sometimes occurs with a blue or violet, sometimes with a green colour. May not these variations in colour depend upon the presence of chromicum in some cases, and of chromyle in others?

Chemists are not agreed concerning the solubility of sulphate of bismuth. This is due, as I shall proceed to demonstrate, to the existence of two sulphates, of which the one is soluble, the other insoluble.

When we have dissolved bismuth in boiling nitric acid, and to the liquid have added sulphuric acid, there sometimes is no precipitate whatever produced, and at other times a very abundant one. If upon this precipitate we pour a few drops of water, sometimes it dissolves suddenly and at other times remains perfectly insoluble, however great the quantity of water we may add. Now then, for the explanation of these phenomena. If we add sulphuric acid to the cold solution of the nitrate, taking care not to operate upon too large a quantity, so that the mixture may not become heated, there will be no precipitate produced. If we add too much sulphuric acid, there will be deposited a sulphate of bismuth, crystallised in needles, scarcely soluble in sulphuric acid, but extremely soluble in water.

If upon this crystallised sulphate we pour a few drops of water, or even a very large quantity, it will dissolve immediately; but if we heat the solution, whether the quantity of water be great or small, little by little the sulphate of bismuth will be precipitated, and will no longer dissolve in water either hot or cold, nor even on the addition of a considerable quantity of sulphuric acid. May we not then have in one case a sulphate of bismuthyle, in the other a sulphate of bismuthicum?

We know that one variety of arsenious acid reddens litmus paper, while the other turns it blue. May not this latter be the oxide of arsenyle $\mathrm{(As^2O^2)\,O}$?

The natural and artificial varieties of hydrate of alumina are soluble in sulphuric acid. Diaspore however, is insoluble therein, but curiously enough, becomes soluble after the loss, of its water. May there not be then an oxide of aluminicum $\overset{\mathrm{v}}{\mathrm{Al}}{}^2\mathrm{O}$, and a hydrated or anhydrous aluminic acid, $\mathrm{Al^4O^3}$?

Soluble Prussian blue results from the oxidation of the precipitate, produced by the addition of prussiate of potash to a ferrous salt. We can scarcely conceive how an insoluble salt of iron can acquire solubility by becoming basic. Let us however admit, that oxygen, in oxidising ferrosum, transforms it into the state of ferryle, and then, the blanco-ferric precipitate and the soluble Prussian blue will be represented in the following manner:

Ferrocyanide of hydrogen	$\mathrm{C^6N^6Fe^2.\,H^4}$
Ferrocyanide of ferrosum and potassium, or the white precipitate	$\mathrm{C^6N^6Fe^2.\,K^2Fe^2}$
Ferrocyanide of potassium, ferryle, and hydrogen, or soluble Prussian blue	$\mathrm{C^6N^6Fe^2.\,K^2FyH} + x\,\mathrm{Aq.}$

And this latter, instead of being a basic, will be an acid soluble salt.

The chromic, aluminic, and ferric sulphates, present us with another extremely interesting fact. Jacquelain's experiments show, that accordingly as the solutions of these salts have been made in the hot or cold, accordingly as they are hot or cold, accordingly as they have been left to cool for a longer or shorter time, so are we able by the aid of barytic salts, to precipitate the whole of the sulphuric acid, or only a part thereof. The liquid which is precipitated completely and the liquid which is precipitated incompletely being isomeric, may not the one contain a salt of ferryle or of chromyle, and the other a salt of ferricum or chromicum?

The chlorides undoubtedly present us with similar facts. Phillips had given the analysis of a ferric chloride fourteen times basic and yet soluble. This great degree of basity for a soluble salt appeared to me extraordinary, and I endeavoured to repeat the analysis myself; but in adding nitrate of silver to the solution of the salt, the whole became milky, and yielded but a slight precipitate, quite devoid of any clottiness in its appearance. In attempting to filter off the liquid, even when employing four or five filters placed one within another, the filtrate continued milky; by ebullition with nitric acid however, the precipitate gradually increased. It is possible then, that Phillips had not precipitated all the chlorine, from the salt which yielded him so high a degree of basity.

For the reception of my hypothesis concerning the salts of ferryle and ferricum, exact analyses will be necessary; we must classify the salts according to their properties, and must see whether or not salts having common properties correspond to analyses which accord with the ferryle theory. The simplicity of the formulæ would also serve as a guide in these cases. I will adduce as an example, a basic alum crystallising in regular hexagonal prisms, and of which the formula is

$$4\,\mathrm{SO}^3 + 2\,\mathrm{K}^2\mathrm{O} + \mathrm{Fe}^4\mathrm{O}^3 + 6\,\mathrm{Aq}.$$

If we represent it with ferricum, we shall have

$$\left\{ 4\,\mathrm{SO}^3 + \begin{matrix} 2\,\mathrm{K}^2\mathrm{O} \\ 2\,\mathrm{fe}^2\mathrm{O} \end{matrix} \right\} + \mathrm{fe}^2\mathrm{O} + 6\,\mathrm{Aq},$$

which is not reducible; and adopting the ferryle theory we shall have

$$\left\{ 4\,\mathrm{SO}^3 + \begin{matrix} 2\,\mathrm{K}^2\mathrm{O} \\ \mathrm{Fy}^2\ \mathrm{O} \\ \mathrm{H}^2\ \mathrm{O} \end{matrix} \right\} + 5\,\mathrm{Aq},$$

which is equally irreducible. In consequence of this complexity I repeated the analysis, and found the following composition

$$8\,\mathrm{SO}^3 + 3\,\mathrm{K}^2\mathrm{O} + 2\,\mathrm{Fe}^4\mathrm{O}^3 + 11\,\mathrm{Aq},$$

which with ferricum gives the formula

$$\left\{ 8\,\mathrm{SO}^3 + \begin{matrix} 3\,\mathrm{K}^2\mathrm{O} \\ 5\,\mathrm{fe}^2\mathrm{O} \end{matrix} \right\} + \mathrm{fe}^2\mathrm{O} + 11\,\mathrm{Aq},$$

which is irreducible. But with ferryle we have

$$\left\{ 8\ \mathrm{SO}^3 + \begin{matrix} 3\ \mathrm{K}^2\ \mathrm{O} \\ 2\ \mathrm{Fy}^2\mathrm{O} \\ 3\ \mathrm{H}^2\ \mathrm{O} \end{matrix} \right\} + 8\ \mathrm{Aq},$$

which, divided by 8, gives us

$$(\mathrm{K}_{\frac{3}{4}}\,\mathrm{Fy}_{\frac{2}{4}}\,\mathrm{H}_{\frac{3}{4}})\ \mathrm{SO}^4 + \mathrm{Aq},$$

an acid and soluble salt.

But as I have before said, these analyses are encompassed with difficulties, and ought to be controlled by numerous chemists, the greatest attention being at the same time devoted to the preparation of pure products.

PART THIRD.

METAMORPHOSES.

SECTION FIRST.

Symmetrical Reactions—Classification of Reactions—Substitutions.

SYMMETRICAL REACTIONS.

The study of chemical reactions is indispensable for the classification of organic substances, since a good classification ought to be, as it were, the resultant of all the reactions.

Some of these reactions are extremely exact, and may be explained by means of very simple equations; such for example is the decomposition of oxamide by potash; others, on the contrary, are very complex, and cannot be reduced to an equation in consequence of the numerous products which are formed; such for instance, is the case, when sugar is distilled with lime. We say that in the first instance there is *metamorphosis*, in the second, *destruction*. Not that we make an absolute distinction between these two kinds of reactions, for the second variety probably depends upon a numerous succession of metamorphoses. Thus the action of potash upon indigo, might equally well be considered as a destruction or as a metamorphosis, since a very great number of products are formed, the simultaneous appearance of which would be difficult to explain, but the successive formation of which may be represented by very simple equations. We know that in this way there are produced, white indigo—isatinate, carbanilate, and carbonate of potash—hydrogen—oxide of carbon, —and aniline. Thus:

1°. $3\,C^8H^5NO + KHO + H^2O = C^8H^6KNO^3 + C^{16}H^{12}N^2O^2$

Isatinate of potash. White indigo.

2°. $C^{16}H^{12}N^2O^2 + 2\,KHO + 2\,H^2O = 2\,C^8H^6KNO^3 + H^6$

3°. $C^8H^6KNO^3 = C^7H^6KNO^2 + CO$

Carbanilate of potash.

4°. $C^7H^6KNO^2 + KHO = C^6H^7N + K^2CO^3$

Aniline.

We acknowledge willingly that this series of metamorphoses produces a destruction of the indigo.

Leaving aside destructive reactions, let us direct our attention solely to metamorphoses; and let us moreover disregard, as not conducing to our object, those reactions in which the substance experimented upon becomes divided into two parts, each of which contains carbon as a constituent, at any rate in those cases, in which we do not allow that the substance in question is a combination of the two parts, as is the case with carbanilide, which may be decomposed into carbonic acid and aniline.

We perceive then, that bodies undergoing metamorphoses, limited as above, may disappear, change their state, pass successively from one form to another, and re-appear with their primitive properties. These bodies, in the phases which they pass through, give origin to a multitude of new bodies, constituting as it were a sort of family, all the members of which may be metamorphosed one into another. Such, for example, is the case with etherene, which may be transformed into Dutch liquid, chloretherine, perchloride of carbon, chloracetic acid, acetic acid, acetate of potash or soda, aldehyde, acetic ether, &c., and may re-appear in the state of perchloride of carbon, or even in its primitive form.

Despite their apparent diversity, we perceive that nearly all these metamorphoses may be included in two principal cases: 1, *Addition* or *subtraction* of a simple or compound body; 2, *Substitution*, or what comes to much the same thing, *double decomposition*.

Metamorphosis by substitution, is without doubt the most frequent mode of reaction, and if chemists have not heretofore been struck with this fact, such omission is due on the one hand to the employment of dualistic formulæ, and on the other hand to secondary reactions, which disguise the *symmetry* of the primitive reactions.

I make use of this word *symmetry*, because when these substitutional reactions are represented in the form of an equation, the second member of the equation being written underneath the first, we perceive that to each term of the superior member, there is a corresponding term in the inferior one, as in this example

$$\begin{aligned} &H^2SO^4 + Z^2 \\ &= Z^2SO^4 + H^2. \end{aligned}$$

Thus there is a symmetrical reaction, when we treat a salt by a metal, or by an oxide, a hydrate, a binoxide, an acid, an anhydride, another salt, &c.; for there is always a tendency to displace or give origin to another metal, another oxide, hydrate, binoxide, anhydride, or other salt. If the symmetry does not hold good in every case, it is in consequence of its being destroyed by a secondary reaction, or in consequence of the body which ought to be formed or displaced, being unable to exist in the circumstances under which the experiment was performed. Thus when sulphuric acid is added to a carbonate, we ought to have the following symmetrical reaction

$$\begin{aligned} &H^2SO^4 + K^2CO^3 \\ &= K^2SO^4 + H^2CO^3. \end{aligned}$$

But H^2CO^3 being, under ordinary circumstances, incapable of existing, becomes decomposed immediately into H^2O and CO^2; and as a consequence, the symmetry of the reaction is destroyed. There is one very remarkable point connected with symmetrical reactions, namely, that almost always the gaseous volume of the bodies employed, is equal to the gaseous volume of the bodies produced. Since experiment manifests to us that in ninety-nine out of a hundred cases the molecules correspond to two volumes, we may make use of these volumes, even for bodies which have never been reduced to the vaporous state.

Thus in the manufacture of chlorate of potash, we employ 18 volumes of chlorine and hydrate of potash, and we obtain 18 volumes of water, chlorate of potash, and chloride of potassium

$$\underset{\text{6 vol.}}{3\,Cl^2} + \underset{\text{12 vol.}}{6\,KHO} = \underset{\text{2 vol.}}{KClO^3} + \underset{\text{10 vol.}}{5\,KCl} + \underset{\text{6 vol.}}{3\,H^2O}.$$

It would be useless to cite such examples of symmetrical reactions as are afforded by the decomposition of sulphate of potash with nitrate of baryta, &c. I prefer to select examples in which this symmetry is not apparent, either from the interference of secondary products, or from the employment of dualistic formulæ. As in the following instances:

1°. Action of chlorine upon hydrogen	Cl^2+H^2	$=H^2Cl^2$
2°. Chlorine upon hydrate of potash	$2\,Cl^2+2\,(K^2O.\ H^2O)$	$=K^2Cl^2+(K^2O.\ Cl^2O)+2\,H^2O$
3°. Chlorine upon hydrate of potash	$6\,Cl^2+6\,(K^2O.\ H^2O)$	$=5\,K^2Cl^2+(K^2O.\ Cl^2O^5)+6\,H^2O$
4°. Chlorine and iodine upon water	$5\,Cl^2+I^2+6\,H^2O$	$=5\,H^2Cl^2+(H^2O.\ I^2O^5)$
5°. Iodine and sulphurous acid upon water	$SO^2+I^2+H^2O$	$=SO^3+H^2I^2$
6°. Chlorine upon ammonia	$6\,Cl^2+4\,H^6N^2$	$=Cl^6N^2+3\,(H^6N^2.\ H^2Cl^2)$
7°. Iodine upon ammonia	$12\,I+6\,H^6N^2$	$=(2\,I^6N^2.\ H^6N^2)+6\,(H^6N^2.\ H^2I^2)$
8°. Sulphuric acid upon peroxide of manganese	$SO^3+Mn^2O^2$	$=Mn^2O.SO^3+O$
9°. Solid chloride of cyanogen upon ammonia	$C^6N^6.\ Cl^6\ +4\,H^6N^2$	$=C^6H^8Cl^2N^4+2\,(H^6N^2.\ H^2Cl^2)$
10°. Chloride of benzoyl upon water	$2\,C^{14}H^{10}O^3.C^{14}H^{10}Cl^6+3H^2O$	$=3\,C^{14}H^{10}O^3+3\,H^2Cl^2.$

There does not appear to be any symmetry between the corresponding terms of the above equations.

Let us now write these same reactions according to the unitary notation; then we shall have

$$1^\circ.\ \ldots\ldots\ \left\{\begin{array}{lll} \mathrm{Cl\,Cl} & +\mathrm{HH}= & \\ \mathrm{H\,Cl} & +\mathrm{H\,Cl} & \end{array}\right.$$

$$2^\circ.\ \ldots\ldots\ \left\{\begin{array}{lll} \mathrm{Cl\,Cl} & +\mathrm{KHO} & +\mathrm{KHO}\ = \\ \mathrm{K\,Cl} & +\mathrm{K\,Cl\,O} & \mathrm{HHO} \end{array}\right.$$

$$3^\circ.\ \ldots\ldots\ \left\{\begin{array}{llll} 3\ \mathrm{Cl\,Cl} & +2\ \mathrm{KHO} & +\mathrm{KHO} & +3\ \mathrm{KHO}= \\ 3\ \mathrm{K\,Cl} & +2\ \mathrm{K\,Cl} & +\mathrm{KClO^3} & +3\ \mathrm{HHO} \end{array}\right.$$

$$4^\circ.\ \ldots\ldots\ \left\{\begin{array}{llll} 5\ \mathrm{Cl\,Cl} & +5\ \mathrm{HHO} & +\mathrm{HHO} & +\mathrm{II}\quad = \\ 5\ \mathrm{H\,Cl} & +5\ \mathrm{H\,Cl} & +\mathrm{HIO^3} & +\mathrm{HIO^3} \end{array}\right.$$

$$5^\circ.\ \ldots\ldots\ \left\{\begin{array}{lll} \mathrm{H^2SO^3} & +\mathrm{II} & +\mathrm{HHO}\ = \\ \mathrm{H^2SO^4} & +\mathrm{HI} & +\mathrm{HI} \end{array}\right.$$

$$6^\circ.\ \ldots\ldots\ \left\{\begin{array}{ll} 3\ \mathrm{Cl\,Cl} & +\mathrm{H^3N}\quad = \\ 3\ \mathrm{H\,Cl} & +\mathrm{Cl^3N} \end{array}\right.$$

$$7^\circ.\ \ldots\ldots\ \left\{\begin{array}{ll} 2\ \mathrm{II} & +\mathrm{H^3N}\quad = \\ 2\ \mathrm{HI} & +\mathrm{HI^2N} \end{array}\right.$$

$$8^\circ.\ \ldots\ldots\ \left\{\begin{array}{lll} \mathrm{H^2SO^4} & +\mathrm{Mn^2O^2}\ = & \\ \mathrm{Mn^2SO^4} & +\mathrm{H^2O} & +\mathrm{O} \end{array}\right.$$

$$9^\circ.\ \ldots\ldots\ \left\{\begin{array}{lll} \mathrm{C^3N^3Cl.\ Cl^2} & +\mathrm{H^2.} & \mathrm{H^4N^2}\ = \\ \mathrm{H^2.\ Cl^2} & +\mathrm{C^3N^3Cl.} & \mathrm{H^4N^2} \\ & & \text{chlorocyanamide.} \end{array}\right.$$

$$10^\circ.\ \ldots\ldots\ \left\{\begin{array}{ll} \mathrm{C^7H^5ClO} & +\mathrm{H^2O}\quad = \\ \mathrm{C^7H^6\ O^2} & +\mathrm{H\,Cl.} \end{array}\right.$$

In the sixth and seventh reactions I have not taken into consideration the hydrochlorate and hydriodate of ammonia which occur as secondary products.

In the eighth reaction peroxide of hydrogen ought to be formed, but this body not being capable of existing in the presence of binoxide of manganese, undergoes decomposition, and sets free its oxygen, whence the interference with the symmetry of the reaction.

The ninth reaction is at present symmetrical, but if we operate at too high a temperature, the chlorocyanamide decomposes and gives origin to mellon, the symmetry thus becoming destroyed.

Chlorine, bromine, and iodine, in acting upon organic substances, nearly always give rise to symmetrical equations, as for instance, when chlorine acts upon ether:

$$C^4 H^{10} O + 10 \, Cl \, Cl$$
$$= C^4 Cl^{10} O + 10 \, H \, Cl.$$

It is the same with nitric acid, as in this example

$$C^6H^6 \quad O + 3 \, XHO$$
$$= C^6X^3H^3O + 3 \, HHO,$$

Picric acid.

and also with the acids, alkalies, chlorides, &c., when they act upon alcohols, ethers, amides, &c.

Lastly it may be remarked, that the majority of the reactions in which we make use of compound radicals, such as amide, imide, ethyl, acetyl, &c., singularly resemble the double decomposition of two salts by one another. It would be useless to adduce ordinary well known instances. I content myself with showing, that if we admit peroxide of hydrogen to be a radical analogous to chlorine, a hypothesis which in thousands of cases is as plausible as that of ethyl or amide, then the tenth reaction will perfectly resemble a saline double decomposition, from which it at present appears to be so far removed. Let us represent peroxide of hydrogen by E^2, analogous to Cl^2, then water, the acid of this new radical, will become HE, and will give with the chloride of benzoyl

$$Bz \, Cl + HE$$
$$= Bz \, E + H \, Cl;$$

and with ter-chloride of phosphorus,

$$P \, Cl^3 + 3 \, HE$$
$$= P \, E \quad + 3 \, H \, Cl,$$

and so on.

I will adduce moreover, the action of chloride of benzoyl upon benzoic acid. Making benzoyl a radical, and benzoic acid a body analogous to chlorhydric acid, we shall have

$$C^7H^5O. \, Cl \qquad + H. \, C^7H^5O^2$$
$$= C^7H^5O. C^7H^5O^2 + H \, Cl,$$

that is to say, we shall have anhydrous benzoic acid represented as a benzoate of benzoyl. We may say then, that nearly all the metamorphoses of organic chemistry, *when viewed in this manner*, are but substitutions, or double decompositions, or symmetrical reactions.

CLASSIFICATION OF REACTIONS.

We have said that reactions ought to serve as the basis of a chemical classification, but for this purpose the reactions themselves must be capable of being classified. Now the difficulty of distinguishing the reactions from one another, and consequently of classifying them, is apparent from what we have just seen concerning symmetrical reactions, and particularly such of them as resemble saline double decompositions.

This difficulty is manifested, when we examine, for instance, the action of chlorine upon hydrogen, chlorine upon hydruret of benzoyl, chloride of benzoyl upon water, and that of chloride of potassium upon iodide of sodium, for we have but to express the reactions in a similar manner, to see that they resemble one another in the highest degree

$$\left.\begin{array}{l}\mathrm{Cl\,Cl+HH}\\ \mathrm{=H\,Cl+HCl}\end{array}\right\}\quad \left.\begin{array}{l}\mathrm{Cl\,Cl+Bz\,H}\\ \mathrm{=H\,Cl+Bz\,Cl}\end{array}\right\}\quad \left.\begin{array}{l}\mathrm{BzCl+HE}\\ \mathrm{=Bz\,E+HCl}\end{array}\right\}\quad \left.\begin{array}{l}\mathrm{K\,Cl+Na\,I}\\ \mathrm{=K\,I+Na\,Cl}\end{array}\right\}$$

yet they are never confounded with one another. For to do as we have just now done, to express two reactions in the form of equations, and observe whether they correspond with one another, term for term, is not sufficient for the purposes of comparison; we must show in addition that the terms have some analogies between them.

We are brought then, to this consequence, that to classify reactions we must first have a classification of substances. But as this latter is only to be obtained by the aid of equations, we fall inevitably into a vicious circle. It cannot indeed be otherwise; or in other words, the classification of substances and the study of reactions ought to lend one another mutual support, and become progressively ameliorated.

Even the classification of reactions however, would afford us but a secondary interest, if we were unable to deduce therefrom, the laws which preside over the reactions themselves.

For a long time past chemists have observed, that the majority of analogous mineral substances, when submitted to similar reactions, give rise to new bodies which are likewise analogous with one another. They have also recognised a similar state of things with regard to certain organic substances; that similar ethers, for instance, are formed by virtue of similar equations; that the reaction which gives rise to benzamide is similar to that which furnishes oxamide; that the same equation is applicable to the decomposition by potash of sulphovinic, and of sulpho-methylic acid, &c. But they have never imagined that these equations might one day lead them to a general law. Indeed the principal bodies they examined, were far from invariably giving rise to analogous bodies by similar reactions. Thus camphoric acid, in losing an atom of water, produces an anhydride, whilst citric and malic acids, under similar circumstances, produce new acids. Oxalate of ammonia, in losing two atoms of water, gives rise to a neutral amide, whilst the carbonate becomes transformed into an alkali. This same oxalate, in losing four atoms of water, gives origin to cyanogen, whilst the formiate is metamorphosed into cyanhydric acid. Moreover, the employment of dualistic formulæ has often hindered chemists from perceiving the similitude, which really existed between different reactions, and has given them dissimilar equations where similar ones ought to have resulted. Thus when they would express the action which chlorhydric and nitric acids exert upon alcohol, they write the equations in the following manner

$$N^2O^5 + C^4H^{10}O.\ H^2O = N^2O^5.\ C^4H^{10}O + H^2O$$
$$H^2Cl^2 + C^4H^{10}O.\ H^2O = Cl^2.\ C^4H^{10} + 2\ H^2O,$$

as if one equivalent of water were set free in the first case, and two in the second, whilst in reality, the quantity of water eliminated in both instances is the same.

In studying the action which chlorine and nitric acid exert upon organic substances, I speedily perceived, that with analogous bodies, similar equations invariably gave origin to fresh analogous bodies. We shall see further on, that the reactions of the acids upon organic substances lead to a similar conclusion. We also catch glimpses of other not less important generalities, to formulate which at the present time, however, would be premature.

My object being, not to write a treatise upon metamorphoses, but simply to examine such of them as lead to certain generalities, which may aid me in my classification, I proceed to indicate briefly, the manner in which I conceive these may be arranged, only entering into details upon some of the most important of them.

Supposing that we wish to classify the reactions of chlorine upon organic substances, the substances must first of all be divided into several groups, as the hydrocarbons, the simple acids, the complex acids, the aldehydes, the alcohols, the alkaloids, &c. We should then have to establish certain sub-divisions, as the normal hydro-carbons, the hyper-hydro-carbons, &c.

We should place together the equations which afford the same number of terms, and then classify them in the following manner.

These equations are only proceeded with through three or four terms. A represents the substance employed, $C=Cl^2$ the chlorine, B the new substance produced, and y the chlorhydric acid.

I. ACTION OF CHLORINE UPON ORGANIC SUBSTANCES.

A.—*Action of chlorine upon the hydro-carbons.*

a. 1° .... $B=A+C$
2° .... $B=A+C^2$
3° .... $B=A+C^3$

b. 4° .... $B=A+C-y$

c. 5° .... $B=A+C^2-y$
6° .... $B=A+C^2-y^2$

d. 7° .... $B=A+C^3-y$
8° .... $B=A+C^3-y^2$
9° .... $B=A+C^3-y^3$

e. 10° .... $B=A+C^4-y$
11° .... $B=A+C^4-y^2$
12° .... $B=A+C^4-y^3$
13° .... $B=A+C^4-y^4$;

and so on.

B.—*Action of chlorine upon the hyper-hydro-carbons.*

1° .... $B=A+C-y$
2° .... $B=A+C^2-y^2$
3° .... $B=A+C^3-y^3$;

and so on.

C.—*Action of chlorine upon the aldehydes.*

1° .... $B=A+C-y$
2° .... $B=A+C^2-y^2$
3° .... $B=A+C^3-y^3$;

and so on.

D.—*Action of chlorine upon the alcohols.*

1° .... $B=A+C-y^2$?
2° .... $B=A+C^2-y^3$?
3° .... $B=A+C^3-y^4$?

and so on.

E.—*Action of chlorine upon the alkaloids.*

$$a.\begin{cases} 1^\circ \quad \dots\dots \quad B=A+C \\ 2^\circ \quad \dots\dots \quad B=A+C^2 \end{cases}$$

$$b.\begin{cases} 3^\circ \quad \dots\dots \quad B=A+C-y \\ 4^\circ \quad \dots\dots \quad B=A+C^2-y \\ 5^\circ \quad \dots\dots \quad B=A+C^3-y^2; \end{cases}$$

and so on.

F.—*Action of chlorine upon the acids homologous with formic acid, and upon the analogues of benzoic acid.*

1° .... $B=A+C-y$
2° .... $B=A+C^2-y^2$
3° .... $B=A+C^3-y^3$
4° .... $B=A+C^4-y^4$.

I have in the above table indicated some of the principal reactions. We might, *à priori,* arrange a much more complete table, and afterwards ascertain by experiment, whether such and such a reaction is or is not possible. We should then compare the properties of all the compounds produced, in order to see which are the equations that give rise to analogous bodies. At the present time we know that with the same hydro-carbon A, the equations

$$\begin{aligned} B &= A+C \\ B' &= A+C^2-y \\ B'' &= A+C^3-y^2 \\ B''' &= A+C^4-y^3, \end{aligned}$$

yield the analogous bodies $B\ B'\ B''\ B'''$.

We know also that with the same hydro-carbon, the equations

$$\begin{aligned} B &= A+C-y \\ B' &= A+C^2-y^2 \\ B'' &= A+C^3-y^3 \\ B''' &= A+C^4-y^4, \text{ \&c.,} \end{aligned}$$

yield for $B\ B'\ B''\ B'''$ compounds which are analogous with one another, but which are altogether different from those resulting from the preceding equations.

We may also remark that in chloro-substitutions, the saturating capacities of the acids, do not change.

II.—ACTION OF NITRIC ACID.

There appear to be only two principal kinds of reactions, produced by nitric acid.

A. *Action of nitric acid upon the alkaloids and certain neutral bodies.*

(A=the acid, B=the body submitted to its action, C=the new product, and Aq=the water set free.)

1° .... $C=B+A$
2° .... $C=B+A^2-Aq$
3° .... $C=B+A^3-Aq^2$.

B. *Action of nitric acid upon other substances.*

4° .... $C=B+A-Aq$
5° .... $C=B+A^2-Aq^2$
6° .... $C=B+A^3-Aq^3$, &c.

In all these reactions, the saturating capacity of $C, C', C''\ldots$, continues invariable.

III.—ACTION OF THE ACIDS.

I shall confine myself to a glance at those reactions, in which but a single product is formed, with or without elimination of water.

I divide the acids into four classes, comprising respectively the mono-, bi-, tri-, and quadribasic acids=A', A'', A''', A''''. The bodies upon which they re-act, ought also to be distributed into several divisions, as into the acids, mono-, bi-, tri-, and quadribasic, the alkaloids, alcohols, hydro-carbons, &c.

Then we should be able to arrange the following table:

A. *Action of monobasic acids upon the alkaloids.*

1° .... $C=A'+B$
2° .... $C=A'+B-Aq$
3° .... $C=A'+B-Aq^2$.

B. *Action of monobasic acids upon neutral bodies.*

4° .... $C=A'+B-Aq$
5° .... $C=A'+B-Aq^2$.

C. *Action of bibasic acids upon the alkaloids.*

$$a.\left\{\begin{array}{ll}1^\circ \quad \ldots \quad \ldots \quad \ldots & C = A'' + B \\ 2^\circ \quad \ldots \quad \ldots \quad \ldots & C = A'' + B^2\end{array}\right.$$

$$b.\left\{\begin{array}{ll}3^\circ \quad \ldots \quad \ldots \quad \ldots & C = A'' + B - Aq \\ 4^\circ \quad \ldots \quad \ldots \quad \ldots & C = A'' + B - Aq^2\end{array}\right.$$

$$c.\left\{\begin{array}{ll}5^\circ \quad \ldots \quad \ldots \quad \ldots & C = A'' + B^2 - Aq \\ 6^\circ \quad \ldots \quad \ldots \quad \ldots & C = A'' + B^2 - Aq^2 \\ 7^\circ \quad \ldots \quad \ldots \quad \ldots & C = A'' + B^2 - Aq^3 \\ 8^\circ \quad \ldots \quad \ldots \quad \ldots & C = A'' + B^2 - Aq^4.\end{array}\right.$$

D. *Action of bibasic acids upon the acids.*

$$\begin{array}{ll}1^\circ \quad \ldots \quad \ldots \quad \ldots & C = A'' + A' - Aq \\ 2^\circ \quad \ldots \quad \ldots \quad \ldots & C = A'' + A'' - Aq \\ 3^\circ \quad \ldots \quad \ldots \quad \ldots & C = A'' + A'' - Aq^2 \\ 4^\circ \quad \ldots \quad \ldots \quad \ldots & C = A'' + A''' - Aq, \text{ \&c.}\end{array}$$

I shall not pursue this classification further. Experiment proves that the bodies corresponding to each of these equations are altogether analogous. The equation A 1°, originates neutral salts; A 2°, amides; A 3°, imides or nitryles; C 3°, amidic acids; C 6°, di-amides; D 1°, bibasic acids; D 2°, tribasic acids, &c.

IV.—ACTION OF CHLORIDES, BROMIDES, &C.

A. *Action upon the alkaloids.*

(M represents the alkaloidic chlorhydrate produced.)

$$a.\left\{\begin{array}{ll}1^\circ \quad \ldots \quad \ldots \quad \ldots & C = A + B \\ 2^\circ \quad \ldots \quad \ldots \quad \ldots & C = A + B^2 \\ 3^\circ \quad \ldots \quad \ldots \quad \ldots & C = A^2 + B\end{array}\right\}?$$

It is not certain that the chlorides can in this manner combine with the alkaloids.

$$b.\left\{\begin{array}{ll}4^\circ \quad \ldots \quad \ldots \quad \ldots & C = A + B^2 - M \\ 5^\circ \quad \ldots \quad \ldots \quad \ldots & C = A + B^3 - M^2 \\ 6^\circ \quad \ldots \quad \ldots \quad \ldots & C = A + B^4 - M^3 \\ 7^\circ \quad \ldots \quad \ldots \quad \ldots & C = A + B^5 - M^4\end{array}\right.$$

$$c.\left\{\begin{array}{ll}8^\circ \quad \ldots \quad \ldots \quad \ldots & C = A^2 + B^2 - M \\ 9^\circ \quad \ldots \quad \ldots \quad \ldots & C = A^2 + B^3 - M^2 \\ 10^\circ \quad \ldots \quad \ldots \quad \ldots & C = A^2 + B^4 - M^3 \\ 11^\circ \quad \ldots \quad \ldots \quad \ldots & C = A^2 + B^5 - M^4, \text{ \&c.}\end{array}\right.$$

This table would not lead to important results, unless we first of all established divisions among the chlorides, classifying them into mono-, bi-, and tribasic chlorides, or at least as corresponding to mono-, bi-, and tri-basic acids.

I proceed now to examine certain of the most important of these reactions, particularly those, which like substitutions, will serve as a basis for my classification of organic substances.

SUBSTITUTIONS.

On the functions fulfilled by simple bodies in organic substances.

We maintain for our part, that an organic substance is simply a substance containing carbon; thus marble, cyanogen, carbonic oxide, sulphide of carbon, chloro-carbonic acid, &c., are organic substances.*

As on the one hand, cyanogen, carbonic acid, and acetic acid, can combine with all the metals, and on the other hand, we have carbon compounds, containing sulphur, selenium, chlorine, nitrogen, &c., it is clear that organic chemistry comprises, not only the combinations of carbon with hydrogen, oxygen, and nitrogen, as is ordinarily stated, but also the combinations of carbon with all simple bodies whatever. Organic chemistry thus defined, or the chemistry of carbon, differs from mineral chemistry, by the

* When I announced my first classification, I hesitated about associating carbonic oxide, carbonic acid, and marble, among the compounds of organic chemistry. I wished at first to separate the products obtained by the reactions of the simple elements upon one another, such for instance as carbonic acid, sulphide of carbon, &c., but then cyanhydric acid must be likewise separated, and consequently cyanuric acid, melamine, &c. The products of the action of chlorine upon sulphide of carbon, and consequently hyposulphomethylic acid, per-chloride of carbon, chloracetic acid, acetic acid, would also have to be abstracted. But from the last mentioned substance we obtain acetone, and subsequently mesitylene, and we are at once in the midst of organic chemistry by the side of cumene and cinnamic acid. I was forced then to replace the sulphide of carbon among organic chemical substances, or what comes to the same thing, among the combinations of carbon.

---

* In connexion with the subject of the above note, see Dr. Hoffman's introductory lecture on organic chemistry, delivered at the Royal Institution, and published in the Medical Times and Gazette, 1853.—(W. O.)

unlimited number of combinations which may be produced, when but two or three simple substances are associated with carbon.

Oxygen, sulphur, and a metal, may perhaps give rise to a dozen combinations; oxygen, phosphorus, and hydrogen, to an equal number; whilst, at the present day, we are already acquainted with two or three hundred combinations consisting of carbon and hydrogen alone,— thousands containing carbon, hydrogen, and chlorine alone,—and hundreds of thousands containing carbon, hydrogen, and oxygen alone. If to these we add the nitro-, phospho-, and metallic combinations, &c., organic chemistry will appear to us inaccessible, from the infinite number of substances which it embraces, the catalogue of which will shortly exceed that elaborated by astronomers for the stars themselves.

But fortunately, the majority of the simple bodies play reciprocally the parts one of another, so that it suffices (for example) to know the preparation, properties, and composition of the benzoate of hydrogen, in order to know the preparation, properties, and composition of the other benzoates. By this single fact, organic chemistry becomes at once remarkably simplified. Let us now see, which of the simple bodies may be substituted for one another, without altering the principal properties of the combinations into which they enter. We will then ascertain whether or not compound bodies may be substituted for simple bodies, whether or not organic chemistry may in consequence be susceptible of still further simplification.

Carbon substitutions.

Carbon is perhaps the only elementary body which is without an analogue. To prove this assertion, we shall not refer to the important parts played by it and its compounds in the constitution of the earth, to its indispensable existence in all organised matters, vegetable and animal, nor to the important functions which, under the form of carbonic acid, it fulfils in the air and water; but we will, from a strictly chemical point of view, show that it is unparalleled by any other body.

In all treatises on chemistry, we find it compared, sometimes to hydrogen, sometimes to boron and silicon, but these associations are forced, and have reference but to one particular, the affinities of these bodies for oxygen; in other respects there is not the slightest analogy.

If we examine even the most simple combinations of carbon, its oxides, niturets, hydrurets, and chlorides,—among all other compound bodies, we shall not find any at all resembling them.

Lastly, we are not acquainted with any compound, which can have its carbon replaced by some other simple body, and which, despite the permutation, will retain its principal properties. We might indeed compare the sulphites with the carbonates, or rather consider them as carbonates in which the carbon had been replaced by sulphur; but, on the one hand, this would be the only case in which the hypothesis would be admissible; and on the other hand, the sulphites do not bear any greater resemblance to the carbonates, than to the chlorites, to the sulphates, or to the majority of other salts.

Carbon substitutions, therefore, have no existence.

Metallic and hydrogen substitutions.

We need not inquire, whether or not certain metals, as zinc and potassium, can displace the hydrogen from certain acids, or in acting upon certain chloro- and iodo- combinations, can unite with the chlorine or iodine, and set at liberty bodies which are designated by the term compound radicals; we need only remember, that the majority of the metals play the parts one of another to a greater or less degree,—that we have placed hydrogen among the metals,—and that in our view, hydrogen is the representative of all the metals, that it is, so to say, *the* metal of organic chemistry; and we shall have occasion to bestow but a very secondary consideration upon the numerous metallic combinations.

Oxygen substitutions.

Let us recall to our recollections, a primary fact, recognized in science for a long time past, namely, that oxygen, sulphur, selenium, and tellurium form a group of *equivalent* bodies;—of bodies which may replace one another mutually in their combinations, without altering the principal properties of the compounds into which they enter.

But can the above bodies likewise replace other bodies?—Are they the *equivalents* of chlorine, bromine, hydrogen, &c.? All chemists, admit this equivalence, at least for chlorine and its analogues. Let us see if this opinion is conformable to experience.

In comparing the phosphorous, phosphoric, silicic, benzoic, &c.,

chlorides, with the phosphorous, phosphoric, silicic, benzoic, &c., anhydrides, the comparison has had reference simply to the numerical composition of each of the terms. According to the equivalent system of notation, the chlorides are represented as containing as many equivalents of chlorine, as the anhydrides contain equivalents of oxygen.

Chlorides. . . .	$\cancel{P}\cancel{Cl}^3$,	$\cancel{P}\cancel{Cl}^5$,	$Si\cancel{Cl}$,	$C^{14}\cancel{H}^5O^2\cancel{Cl}$;
Anhydrides . .	$\cancel{P}O^3$,	$\cancel{P}O^5$,	SiO,	$C^{14}\cancel{H}^5O^3$.

It has been observed also, that under the influence of water, the chlorides transform themselves into anhydrides, by an equivalent interchange of chlorine for oxygen, and from this metamorphosis, and from the above pointed out numerical correspondence, the analogy of the chlorides and anhydrides has been deduced.

We may remark in the first place, that there is an error in the numbers that have been compared, and that if we desire to be logical, we must write the formulæ of the chlorides and anhydrides in the following manner:

Chlorides. . . .	$P\,Cl^3$,	$P\,Cl^5$,	$SiCl^2$,	$C^7\,H^5\,O\,Cl$,
Anhydrides . .	P^2O^3,	P^2O^5,	SiO,	$C^{14}H^{10}O^3$;

We see that in this point of view the equality of the numbers no longer exists, and hence the transformation of the chlorides into anhydrides is but a hypothesis, springing naturally from the manner in which chemists have been accustomed to regard the combinations in question. Even if this transformation did take place, we should have no reason to conclude therefrom, that the chlorides and anhydrides resemble one another. But, in reality, the products of the transformation of the chlorides by water, are as follows:

Chlorides	PCl^3,	PCl^5,	$SiCl^2$,	C^7H^5OCl,
Products formed . .	PH^3O^3,	PHO^4,	$(SiO.xH^2O)$,	$C^7H^6O^2$;

which experimental results, are very different from the hypothetical ones.

But let us still further compare the chlorides with the anhydrides, let us see in what points they resemble one another. When put in the presence of the same reagent, I do not know of any case in which they comport themselves similarly. When placed in contact with oxides, or with salts, they behave in very different manners. When acted upon by ammonia, the chlorides decompose the alkali, the anhydrides unite with it, producing bodies analogous to sulphammon.

Moreover, Dutch liquid has no resemblance to aldehyde. Chloride of carbon, by the action of water, is not transformed into carbonic oxide; in one word, bibasic water does not resemble monobasic hydrochloric acid:

Let us now see, if oxygen may not in some cases be substituted for, or play the part of, hydrogen.

We have but few bodies, to which, even in a proportional number point of view, such a supposition would be applicable. The transformation of the alcohols into their corresponding acids, might however be adduced.

Wood spirit	$C\,H^4O$
Formic acid	$C\,H^2O^2$
Alcohol	C^2H^6O
Acetic acid.	$C^2H^4O^2$, &c.

but as there is no analogy of properties between these acids and their alcohols, we cannot, from their analogy of composition, conclude that oxygen is the *equivalent* of hydrogen.

Oxygen being then the representative of sulphur, selenium, and tellurium, up to this time we have only carbon, hydrogen, and oxygen, as constituents of organic substances.

Let us say a few words concerning the action of oxygen upon organic substances. About fifteen years ago Dumas, in a law known as the *theory of substitutions,* endeavoured to define the action, which oxygen and chlorine exert upon organic substances.

Dividing all of them into two classes only, comprising the alcohols and hydrates in one division, and all the remaining organic substances in the other, he remarked, that these latter bodies when submitted to the action of chlorine or oxygen, always gained as many equivalents of chlorine and oxygen, as they lost equivalents of hydrogen.

This law, written under the influence of dualistic ideas, and at a period when but a very crude classification of bodies had been established, cannot be sustained at the present day. Even the examples then adduced by Dumas for the support of his law, now bear witness against it. Thus the transformations of the hydrides of benzoyl and cinnamyl into benzoic and cinnamic acids, being formulated thus:

$$C^{14}H^{12}O^{2}+O^{2}=C^{14}H^{10}O^{3}+H^{2}O$$
$$C^{18}H^{16}O^{2}+O^{2}=C^{18}H^{14}O^{3}+H^{2}O,$$

were considered by him as cases of substitution, but are in reality cases of addition, as seen below.

$$C^{7}H^{6}O+O=C^{9}H^{6}O^{2}$$
$$C^{9}H^{8}O+O=C^{7}H^{8}O^{2},$$

whilst the alcohols, which he considered as hydrates, may, according to circumstances, exchange an equivalent of hydrogen for an equivalent of oxygen, or lose an equivalent of hydrogen without substitution. In chlorine substitutions however, we observe the frequent and remarkable fact, that the atoms of hydrogen set free, are exactly replaced by the same number of atoms of chlorine; such for example is the case with ether, which in losing 10 atoms of hydrogen, gains precisely 10 atoms of chlorine.

Even at the present day, it is impossible to define the action of oxygen upon organic substances. Some few remarks may nevertheless be made upon the subject.

Oxygen appears to be capable of combining directly or indirectly with certain hydro-carbons, which it transforms into aldehydes, and with certain aldehydes which it transforms into acids. The most general circumstance to be noted is, that oxygen, in oxidising bodies, tends to acidify them, and in superoxidising them, tends to convert them into polybasic acids.

Thus alcohols and aldehydes become changed into acids, the former by losing hydrogen with substitution, the latter by a simple absorption of oxygen. Camphor, in uniting with three equivalents of oxygen, gives rise to bibasic camphoric acid; butyric acid, in exchanging one equivalent of hydrogen for two equivalents of oxygen, becomes bibasic; dialuric acid, by the absorption of an equivalent of oxygen, also becomes bibasic; it is the same with opianic acid, which, in taking up an equivalent of oxygen, is transformed into bibasic hemipinic acid. Lastly there are some substances which can lose hydrogen without substitutions; such are white indigo, hydrokinone, quinhydrone, Borneo camphor, &c.

Chlorine substitutions.

We have seen that fluorine, chlorine, bromine, and iodine, are the equivalents one of another, and we have refused to admit an equivalence between these bodies and oxygen. We now proceed to inquire, whether among the other simple bodies, there are any which should be associated with them.

When we cast a general glance at the metamorphosis produced by chlorine, in its action upon organic substances, we perceive the greatest variety.

Here, for example, are bodies which absorb 2, 4, or 6 atoms of chlorine without any loss; there, on the other hand, are bodies which lose hydrogen without any absorption of chlorine. Here are substances which lose successively 1, 2, 3, 4 . . . . . atoms of hydrogen, and acquire precisely the same number of atoms of chlorine; there are substances which having lost hydrogen, acquire sometimes more, sometimes less, than an equivalent proportion of chlorine.

But if, instead of examining organic substances in the mass, we divide them into several classes according to the functions which they fulfil, then we discover for some of these classes, a remarkable regularity in the manner in which chlorine comports itself with them.

Let us first of all examine the action of chlorine upon hydro-carbons, which I shall divide into hydro-carbons properly so called, and into hyperhydro-carbons.

Action of chlorine upon the hydrocarbons.

From the experiments I have made upon this subject, I have deduced the following conclusions:

1°. *There are hydro-carbons which can absorb* 2, 4, *or* 6 *atoms of chlorine, without any loss of hydrogen.*

2°. *The hydrogen eliminated is always replaced, sometimes by its equivalent of chlorine, sometimes by more than its equivalent.*

Let us therefore divide the products of the action of chlorine upon the hydro-carbons, into two classes; the first containing the bodies in which the hydrogen lost, has been exactly replaced by its equivalent of chlorine; the second containing the bodies, which have simply absorbed chlorine, or which have absorbed a greater proportion thereof, than they have lost, of hydrogen.

To the first class let us give the name of *halydes*; to the second, that of *hyperhalydes*. If we take naphthaline as an example, the composition of the products obtained, will be as follows.

First class.

$$\text{Naphthaline}\ldots\ldots\ldots\ldots\ C^{10}H^8$$

$$\text{Halydes}\ldots\ldots\ldots\ldots\left\{\begin{array}{l} C^{10}H^7Cl \\ C^{10}H^6Cl^2 \\ C^{10}H^5Cl^3 \\ C^{10}H^4Cl^4 \\ C^{10}H^3Cl^5 \\ C^{10}H^2Cl^6 \\ C^{10}H\ Cl^7 \\ C^{10}\quad Cl^8 \end{array}\right.$$

Second class.

$$\text{Hyperhalydes}\ldots\ldots\left\{\begin{array}{l} C^{10}H^8.\quad Cl^2 \\ C^{10}H^8.\quad Cl^4 \\ C^{10}H^7\ Cl.\ Cl^4 \\ C^{10}H^6\ Cl^2.Cl^4 \\ C^{10}H^5\ Cl^3.Cl^4. \end{array}\right.$$

Let us now compare the properties of the halydes, with those of the hyperhalydes.

1°. All the halydes, however great the quantity of chlorine they contain, can be distilled without alteration.

2°. All the hyperhalydes, however small the quantity of chlorine they contain, are decomposed by distillation.

3°. All the halydes are undecomposable by potash.

4°. All the hyperhalydes are decomposable by potash.

5°. The hyperhalydes, either by distillation or by potash, invariably *lose* in the state of *chlorhydric acid, one half* of the chlorine absorbed, over and above the amount substituted for hydrogen. Thus the new product is invariably a halyde.

However, the hyperhalydes of the other hydro-carbons, are not always decomposed by distillation, especially when they are very volatile as is Dutch liquid; but in all cases, they are decomposed by potash.

It is clear that those hyperhalydes which no longer contain hydrogen, cannot lose the half of their chlorine in the state of chlorhydric acid; such for instance is the case with the perchloride of carbon $C^2Cl^4.\ Cl^2$; but this body when treated by sulphide of potassium, loses all its excess of chlorine, and consequently gives rise to the halyde C^2Cl^4.

Lastly, it may be remarked, that the bromine compounds do not behave exactly as do their chlorine analogues.

Thus, there are bromhyperhalydes, which, by distillation, lose bromine instead of bromhydric acid, but curiously enough, a halyde is nevertheless produced.

Let us adduce some examples of these different reactions.

	Hyperhalydes.				Halydes.
Naphthaline .	$C^{10}H^8.\ Cl^2$	loses	$H\ Cl$	and produces	$C^{10}H^7Cl$
	$C^{10}H^8.\ Cl^4$		H^2Cl^2		$C^{10}H^6Cl^2$
	$C^{10}H^6Cl^2.\ Br^4$		H^2Br^2		$C^{10}H^4Cl^2Br^2$
	$C^{10}H^6Cl^2.\ Br^4$		Br^2Br^2		$C^{10}H^6Cl^2.$
Benzine	$C^6\ H^6.\ Cl^6$		H^3Cl^3		$C^6\ H^3Cl^3$
Etherine	$C^2\ H^4.\ Cl^2$		$H\ Cl$		$C^2\ H^3Cl$
	$C^2\ H^3Cl.\ Cl^2$		$H\ Cl$		$C^2\ H^2Cl^2$
	$C^2\ H^2Cl^2.\ Cl^2$		$H\ Cl$		$C^2\ H\ Cl^3$
	$C^2\ H\ Cl^3.\ Cl^2$		$H\ Cl$		$C^2\ \ Cl^4$
	$C^2\ \ Cl^4.\ Cl^2$		$Cl\ Cl$		$C^2\ \ Cl^4.$

We may remark, that by treating the halydes with chlorine, the majority of them become transformed into hyperhalydes. But as these latter, by the influence of potash, become reconverted into halydes, it is clear that we can obtain the two series of halydes and hyperhalydes, from the same hydrocarbon, by treating it successively with chlorine and potash.

I take as an example etherine, the reactions of which, when submitted to this alternate treatment, I had pre-indicated. It is to Regnault that we owe the experimental confirmation of what I had advanced.*

---

* Immediately after my researches upon naphthaline, Regnault published a memoir upon Dutch liquid. He shewed that this compound, by the action of an alkali, loses the half of its chlorine, and he thence concluded, as I had done with regard to the chlorides of naphthaline, that the formula of Dutch liquid, ought to be represented thus: $C^4H^6Cl^2 + H^2Cl^2$. Nevertheless an essential difference separated Regnault's manner of viewing the subject, from mine. According to him, the first term is not (or was not) a representative or derivative of bihydrocarbon C^4H^8, but on the contrary, a chloride of aldehydene $C^4H^6 + Cl^2$. Liebig having asserted that I obtained my notions concerning the naphthalic chlorides from this first memoir of Regnault, although my researches were published before those of this distinguished chemist, and the majority of chemists having in their turns copied the assertion of Liebig, without in the least troubling themselves as to its correctness, I feel myself warranted in transcribing in this place, the note I published in the *Annales de Chemie et de Physique* immediately after the appearance of the memoir on the chloride of aldehydene.

"In a memoir upon the combinations of bihydro-carbon with chlorine and bromine, Regnault adduces the following experiment."

"*Condensed bromide of aldehydene* ($C^4H^6 + Br^2$) *was mixed with bromine in a*

treated by chlorine			which treated by KHO
C^2H^4	produces	$C^2H^4.\ Cl^2$	produces
C^2H^3Cl	”	$C^2H^3Cl.\ Cl^2$	”
$C^2H^2Cl^2$	”	$C^2H^2Cl^2.Cl^2$	”
$C^2H\ Cl^3$	”	$C^2H\ Cl^3.Cl^2$	”
$C^2\ \ Cl^4$	”	$C^2\ \ Cl^4.Cl^2$	”

flask,......; after exposure to the sun it contained a liquid having a perfect resemblance to the bromo-hydrocarbon ($C^4H^8+Br^4$) *; submitted to analysis it gave,*

Carbon	9·38
Hydrogen	1·3
Bromine.	89·32.

We must then admit, that bromine, by its action upon the bromide of aldehydene, produces bromo-hydrocarbon ($C^4H^8+Br^4$) *and bromhydric acid.*

“It is impossible to conceive how bromine, by abstracting hydrogen from bromide of aldehydene, should produce a bromo-hydrocarbon, containing more hydrogen than the bromide itself.” (I recalled here my views concerning the chloro-hydrocarbons and added):

“We can have then four possible combinations, as results of the action of bromine upon the bromide of aldehydene; $C^4H^4Br^4$, or $C^4H^4Br^4+H^2Br^2$, or $C^4H^2Br^6$, or $C^4H^2Br^6+H^2Br^2$. By translating Regnault’s analysis into formulæ we have:

$$C^4H^4Br^4 + H^2Br^2.$$

	Calculated.	Found.
C^4	9·28	9·38
H^6	1·13	1·30
Br^6	89·59	89·32

“Some day we shall realize the following table:

No. 1	C^4H^8
2	$C^4H^6Cl^2+H^2Cl^2$
3	$C^4H^6Cl^2$
4	$C^4H^4Cl^4+H^2Cl^2$
5	$C^4H^4Cl^4$
6	$C^4H^2Cl^6+H^2Cl^2$
7	$C^4H^2Cl^6$
8	$C^4\ \ Cl^8+H^2Cl^2$
9	$C^4\ \ Cl^8$.

No. 4 will be obtained by treating No 3 with chlorine; No. 5, by treating No. 4 with potash; No. 6, from No. 5 by chlorine; No. 7, from No. 6 by potash; and No. 8, from No. 7 by chlorine.

After that, I myself discovered numbers 6 and 7, and three or four years afterwards, Regnault completed the series.

It is in opposition to such glaring facts, that Liebig and his copyists have denied me all my rights, and have passed silently over all that I have done upon this subject. Some persons have said, that the merit in this case consists, not in the prevision of the facts, but in their experimental realization. Be it so, I will not argue upon such a subject. But, gentlemen, before distributing your rewards, you should first render justice; I ask for nothing more.

All hydrocarbons do not give rise to hyperhalydes. Turpentine and some others, lose hydrogen only by an equivalent substitution. The halydes formed in this manner, are equally unattackable by potash.

Action of chlorine upon the hyperhydrides.

The hyperhydrides are to the normal hydrocarbons, what the hyperhalydes are to the halydes. Thus there exists a compound of hydrogen and carbon, which may be represented as etherine *plus* hydrogen, $C^2H^4.\,H^2$, precisely as Dutch liquid is represented by this same etherine *plus* chlorine, $C^2H^4.\,Cl^2$.

Let us see in what manner chlorine comports itself with the hyperhydrides; for example, with the hydruret of etherine.

$C^2H^6 + Cl^2$ gives rise to $C^2H^5Cl + HCl$ which is set free.
$C^2H^5Cl + Cl^2$ „ $C^2H^4Cl^2 + HCl$ „
$C^2H^4Cl^2 + Cl^2$ „ $C^2H^3Cl^3 + HCl$ „
$C^2H^3Cl^3 + Cl^2$ „ $C^2H^2Cl^4 + HCl$ „
$C^2H^2Cl^4 + Cl^2$ „ $C^2H\,Cl^5 + HCl$ „
$C^2H\,Cl^5 + Cl^2$ „ $C^2\,Cl^6 + HCl$ „

Thus, from the first to the last term, there is an equivalent substitution. We have compared the hyperhydrides to the hyperhalydes; this comparison is warranted by the action of potash upon their *derivatives*, which are thereby converted into halydes.

I call a chloro-compound a *derivative* of some other body, when its composition may be represented by that of the other body, *minus* hydrogen, *plus* an *equivalent* quantity of chlorine. Thus C^2H^5Cl is a derivative of C^2H^6,—C^2Cl^4 is a derivative of C^2H^4, and chloride of benzoyl, C^7H^5ClO, is a derivative of oil of bitter almonds, C^7H^6O. Since I first made use of this term, other chemists have employed it, but in another and very loose signification. Thus, according to them, Dutch liquid is a derivative of etherine, picric acid a derivative of indigo, &c. I retain the signification which I originally gave to the term, and thus when I say, that trichloracetic acid is a derivative of acetic acid, I mean, that this latter has lost three equivalents of hydrogen, and gained three equivalents of chlorine.

I ought not to close this subject without remarking, that marsh gas $CH^2.H^2$, the most simple of all the hyperhydrides, appears to comport itself differently from the rest of them. By the action of chlorine, it gives rise to the following derivatives CH^3Cl, CH^2Cl^2, $CHCl^3$, CCl^4; these, like the ordinary hyperhalydes, are decomposed by potash, but, in a different manner. Thus the compound $CHCl^3$ would be chloroform, and would consequently yield, by the action of potash, formic acid, CH^2O^2, instead of chloride of carbon, CCl^2; the compound CH^3Cl would be the chloride of methyl, and when acted upon by potash would give rise to methylic alcohol. Nevertheless I ought to remark, that the experiments made upon this subject require to be repeated.

I may observe generally, that the bodies of the most simple series, that which contains but one atom of carbon, not unfrequently comport themselves differently from the corresponding terms of the superior series, as we shall presently see exemplified in the case of formic acid.

Action of chlorine upon the aldehydes.

Aldehydes homologous with ordinary aldehyde, as well as those analogous to hydruret of benzoyl, when submitted to the action of chlorine, lose hydrogen, with equivalent substitution only. Thus ordinary aldehyde produces successively

$$\begin{array}{llll}
C^2H^4\;O + Cl^2 & = & C^2H^3Cl\;O + HCl & \text{set free} \\
C^2H^3Cl\;O + Cl^2 & = & C^2H^2Cl^2O + HCl & \text{,,} \\
C^2H^2Cl^2O + Cl^2 & = & C^2H\;Cl^3O + HCl & \text{,,} \\
C^2H\;Cl^3O + Cl^2 & = & C^2\;Cl^4O + HCl & \text{,,}
\end{array}$$

The chlor-aldehydes are attackable by potash, but this reagent does not simply remove chlorhydric acid from them, as from the hyperhalydes, but by virtue of an equation similar to the following, converts them into the state of acids:

$$C^7H^5ClO + H^2O = C^7H^6O^2 + H\,Cl.^*$$

Action of chlorine upon the acids, respectively homologous with acetic, and analogous to benzoic acid.

All these acids, when they lose hydrogen, invariably acquire equivalent proportions of chlorine. Thus acetic acid gives rise to chloracetic acid,

$$C^2H^4O^2 + 3\,Cl^2 = C^2Cl^3HO^2 + 3\,H\,Cl.$$

---

* After the example of Gerhardt, I nearly always replace potash by water in my equations, by which means, acids instead of (what comes to much the same thing) potash salts, appear to be produced. To avoid confusion, it is sufficient to be warned of the convention.

It is worthy of remark, that despite the greater or less substitution of chlorine, the saturating capacities of the acids, continue unaltered.

Formic acid, the most simple of all, comports itself differently from the rest, being decomposed into chlorhydric and carbonic acids,

$$CH^2O^2 + Cl^2 = CO^2 + 2\,H\,Cl.$$

Up to this time, we have not succeeded in complétely dehydrogenising an acid, by substitution; thus trichloracetic acid still retains one atom of hydrogen, as does likewise the pentachlorophenic acid. It would seem from this, that in the formation of a salt, it is this last atom which is exchanged for the metal: nevertheless, the impossibility of removing this last atom of hydrogen by a substitution of chlorine, is not anywhere proved, and we know well, that the more hydrogen a body has lost, the more difficult is it to remove the remainder.

It would be interesting to study the action of chlorine upon the trichloracetate of silver, to see if we should have, as with the benzoate of silver,

$$C^2Cl^3AgO^2 + Cl^2 = C^2Cl^4O^2 + Ag\,Cl.$$

In this case we might inquire, whether the quadrichloracetic acid could be an acid. The reply would depend upon our definition of an acid. If an acid is a body containing hydrogen, and by an ordinary double decomposition capable of exchanging its hydrogen for a metal, it is clear that quadrichloracetic acid could no longer be considered as an acid.

But if an acid is a body which can exchange one of its elements for a metal, so as to form a salt of the metal, then quadrichloracetic acid might well be an acid. If when put in the presence of hydrate of potash, it gave rise to trichloracetate of potash,

$$\begin{aligned} &C^2Cl^4\;O^2 + KHO \\ &= C^2Cl^3KO^2 + ClHO \end{aligned}$$

the reaction would be similar to that afforded by trichloracetic acid, with the same alkali,

$$\begin{aligned} &C^2Cl^3HO^2 + KHO \\ &= C^2Cl^3KO^2 + HHO, \end{aligned}$$

and no one could refuse to consider it as an acid.

Nevertheless the two reactions would not correspond so closely as the two equations seem to indicate, because the hypochlorous acid, ClHO, or mono-chloruretted water, produced in the one instance, would give rise to a secondary reaction.

Action of chlorine upon the other acids.

We have no exact knowledge upon this subject. Nevertheless we might foresee, that complex acids, such as the sulphanilic, sulphonaphthalic, camphovinic, &c., would undergo equivalent substitutions, or would give rise to products, procurable by acting separately upon sulphuric acid, camphoric acid, aniline, naphthaline, and alcohol, by chlorine.

Action of chlorine upon the alkaloids.

Two principal cases may present themselves, accordingly as the product of the action of chlorine is an alkaloid or a neutral body.

In the latter case we have a simple equivalent substitution, as is the case with ammonia and aniline.

$$\begin{aligned} H^3N + 3\,Cl^2 &= Cl^3\,N && + 3\,H\,Cl \\ H^3N + 2\,I^2 &= HI^2N && + 2\,HI \\ C^6H^7N + 3\,Cl^2 &= C^6H^4Cl^3N && + 3\,H\,Cl. \end{aligned}$$

In the former case, the chlorine might at first sight appear to combine simply with the alkaloid; as, for instance, when chlorine acts upon codeine, we obtain

$$C^{18}H^{21}NO^3 + Cl^2 = C^{18}H^{21}NO^3Cl^2,$$

and with cinchonine,

$$C^{19}H^{22}N^2O + Cl^4 = C^{19}H^{22}N^2OCl^4.$$

But what really takes place in these instances is this: the codeine undergoes a chlorine substitution, and gives rise to a basic chlorocodeine, with which the hydrochloric acid continues combined.

$$C^{18}H^{21}NO^3 + Cl^2 = C^{18}H^{20}ClNO^3.\ HCl.$$

so that when potash is added to the salt, monochloro-codeine is precipitated.

With cinchonine the reaction is analogous, bichloro-cinchonine is formed, and the two equivalents of chlorhydric acid remain in combination with the new base.

$$C^{19}H^{22}N^2O + Cl^4 = C^{19}H^{20}Cl^2N^2O.\ H^2Cl^2.$$

Nevertheless codeine would appear to comport itself differently with iodine: according to Anderson it produces simply an iodide of codeine containing $C^{18}H^{21}NO^{3}.I^{3}$, from which, codeine is regenerated by the action of potash. I cannot admit such a formula, firstly on account of the uneven number of its dyads, secondly, because the reactions of the substance are inconceivable.

Action of chlorine upon the alcohols.

According to Dumas, these bodies lose at first two atoms of hydrogen without substitution; and then, for every subsequent displacement of an atom of hydrogen, acquire an equivalent of chlorine. This is the same as saying, that the alcohols are firstly transformed into aldehydes, upon which the chlorine then acts by substitution. Despite the researches that have been made upon this subject, we are far from knowing exactly what takes place, when we treat with chlorine, I do not say the alcohols, but even ordinary vinic alcohol.

For if aldehyde is formed, chlorhydric acid must be disengaged, and this latter in the presence of alcohol, should produce chlorhydric ether and water. Under the influence of this water, the chlorine might transform a part of the alcohol into acetic acid, and consequently give rise to acetic ether. Chlorine in acting upon all these products, ought to convert them into chlorhydric ether, more or less chlorinated, and even into perchloride of carbon, —into aldehyde, acetic acid, and acetic ether, more or less chlorinated.

Wood spirit gives products, of which the formation is far from being explained. Thus, according to Kane, Weidman, Schweizer and Bouis, we may have formed; $C^{6}H^{4}Cl^{2}O^{2}$, $C^{12}H^{16}Cl^{8}O^{3}$, $C^{12}H^{16}Cl^{10}O^{5}$, $C^{3}H^{3}Cl^{3}O$, $C^{5}H^{10}Cl^{2}O^{2}$, $C^{3}H^{2}Cl^{4}O + 4Aq$, &c., &c.

Action of chlorine upon the ethers.

Having had occasion to examine the action of chlorine upon the acetate of methyl, and having seen that for each atom of hydrogen set free, an equivalent of chlorine was absorbed, I concluded that the acetate of methyl, despite its change of composition, retained its primary constitution. Since this first experiment, Malaguti has examined the subject with much care, and has shown, that nearly all the ethers undergo equivalent substitutions; although, according to him, pyromucic ether absorbed four atoms of chlorine without loss of hydrogen. We can conceive, that some of these complex combinations may occasionally divide themselves, and thus disturb the substitutions. Acetic ether for instance, when its saturation by chlorine is nearly arrived at, splits up into two molecules, and becomes metamorphosed into per-chloride of carbon, which is not a derivative of acetic ether.

With formate of methyl on the other hand, the combination rises in the scale, for the two carbon groups which form this ether, unite into one, so as to produce here likewise, per-chloride of carbon.

Action of chlorine upon various compounds.

Among other compounds, there exist a great many which, like isatine, undergo equivalent substitutions; there are also others, such as white indigo, benzoine, hydro-kinone, &c., which may lose hydrogen without substitution, or else gain less of chlorine than they have lost of hydrogen. At present we are unable to formulate any law upon the subject.

Theory of chlorine substitutions.

The first fact which struck me in these substitutions, was the stable condition of equilibrium of the halydes: I perceived these molecular groups reappear incessantly, from the midst of the successive transformations of the first term; I perceived these groups, however great the quantity of chlorine they contained, resist, contrarily to all previous experience, the action of alkalies.

The instability of the hyperhalydes was not less striking, for all these bodies, however minute the quantity of chlorine they contained, were, on the contrary, attackable by alkalies.

The next circumstance which astonished me still more, was to see the halydes, hyperhalydes, acids, ethers, alkaloids, and numerous other bodies, conserve their fundamental properties throughout the transformations effected by the action of chlorine,—to see certain bodies lose but 1 or 2 per cent. of hydrogen, and gain fifty or sixty per cent. of chlorine or bromine, and yet bear to the bodies from which they were derived, a greater resemblance than is borne by sulphate of iron to sulphate of potash.

Formerly I expressed these facts by saying, that chlorine, a body so different from hydrogen, might, under certain circumstances, take its *place* and fulfil its functions, without changing the arrangement of the atoms of the compounds into which it entered.

To render my idea more intelligible, I made the following comparison.

"Let us imagine a four-sided prism, of which the eight angles are occupied by eight atoms of carbon, and the centres of the twelve edges by twelve atoms of hydrogen. Let us call this prism the *form* or *fundamental nucleus*, and let us represent it by

$$C^8H^{12}.$$

"If to the bases of the prism, we apply pyramids or atoms of hydrogen, we shall have a hyperhydride,—if of chlorine, a hyperhalyde,—and if of oxygen, an aldehyde or acid. We will represent the form and composition of these pyramidal prisms thus:

$$C^8H^{12}+H^2$$
$$C^8H^{12}+Cl^2$$
$$C^8H^{12}+O$$
$$C^8H^{12}+O^2.$$

"By certain reactions, we shall be able to slice away the pyramidal portions of the crystal, that is to say, take away its chlorine, oxygen, or excess of hydrogen, and re-obtain the fundamental prism.

"Let us suppose that chlorine, put in presence of this simple prism, removes one of the edges or hydrogen atoms; the prism deprived of this edge would be destroyed, unless it were supplied with some other edge, whether of chlorine, bromine, zinc, &c.; no matter what the nature of the edge, provided it succeeds in maintaining the equilibrium of the other edges and angles. Thus will be formed a new or *derived nucleus* similar to the preceding, and of which the form may be represented by

$$C^8(H^{11}Cl).$$

"If we put this new prism in the presence of chlorine, we may pyramidise it, that is to say, transform it into a hyperhalyde,

$$C^8(H^{11}Cl)+Cl^2;$$

or we may remove from it, another edge of hydrogen. But this, must be still replaced by an edge of chlorine, and we shall obtain a new derived prism of which the formula will be

$$C^8(H^{10}Cl^2).$$

"With this prism and chlorine, bromine or iodine, we may construct, either other derivatives, or other hyperhalydes; and with oxygen, aldehydes, and acids. The formulæ of all these new prisms derivative and pyramidal, will be represented in the following manner:

Halydes.	Hyperhalydes.	Aldehydes.	Acids.
$C^8H^{10}Cl^2$	$C^8H^{10}Cl^2 + Cl^2$	$C^8H^{10}Cl^2 + O$	$C^8H^{10}Cl^2 + O^2$
$C^8H^6 Cl^6$	$C^8H^6 Cl^6 + Cl^2$	$C^8H^6 Cl^6 + O$	$C^8H^6 Cl^6 + O^2$
$C^8H^4 Cl^4 Br^4$	$C^8H^4 Cl^4 Br^4 + Cl^2$	$C^8H^4 Cl^4 Br^4 + O$	$C^8H^4 Cl^4 Br^4 + O^2$
$C^8 Cl^{12}$	$C^8 Cl^{12} + Cl^2$	$C^8 Cl^{12} + O$	$C^8H Cl^{11} + O^2$

"Chlorine, bromine, oxygen, &c., in excess, completely alter the properties of the fundamental nucleus and its derivatives, whilst the chlorine, bromine, and iodine, which enter into the various nuclei, do not destroy the principal properties of the original substance. Each nucleus, however little or much chlorinated, is capable of forming a hyperhalyde by the absorption of chlorine, an aldehyde or an acid by the absorption of oxygen. It is then to the position occupied by, and not to the nature of, the chlorine, that we must attribute the resistance it offers to the action of alkalies. Thus the chlorine of the nuclei, resists the action of heat and alkalies; whilst the chlorine in excess, under the influence of one or other of these agents, seizes upon one of the hydrogen edges of the nucleus, to become disengaged in the form of chlorhydric acid, at the same time that another portion of the excess of chlorine, takes the place of the hydrogen that has been set free. Thus it is necessary, that in the hyperhalydes, the excess of chlorine should always present an even number."

Whether or not the halydes exist as such in the hyperhalydes, aldehydes, and chloracids, is a matter of but little consequence. Whatever atomic arrangement we may please to imagine, we cannot destroy the fact, that certain substances may experience chlorine substitutions without losing their fundamental properties.

Such are the ideas enunciated by me some time since, upon the subject of substitutions, by which ideas chemists were so greatly scandalized.

To have compared nitrogen with antimony, with boron, or even with chlorine, might up to a certain point have been conceivable, but to imagine that chlorine, the most negative of all bodies, could fulfil the functions of the highly positive hydrogen, was to misunderstand the most elementary notions of chemistry.

The first attack started from Giessen. Liebig criticised not only the ideas I had made known, but also the analyses on which they were founded. He therefore proposed other formulæ, and thought fit to accompany them with cutting personalities.

Unfortunately for Liebig, it was shown that all the corrections he had made, were themselves incorrect. This was the first check to dualism.

Malaguti then made known his excellent researches upon the chloro-ethers. I seized this occasion to return to the question of substitutions, and I maintained, that the ethers in becoming chlorinated, still continued ethers. I do not know, said I, what the arrangement of the atoms of acetic ether really is; whether $(C^4H^6O^3+C^4H^{10}.O)$ or $(C^4H^6O^3+C^4H^8+H^2O)$ or $(C^4H^8O^4+C^4H^8)$ &c., I cannot tell; but I maintain, that be the arrangement what it may, it continues the same in the chlorine derivatives.

In reply to the question, what is meant by the words: "The chloro-ether continues an ether?" I might repeat, what I have just said, namely, that the arrangement of its atoms is the same as that of the normal ether. But I prefer to leave hypotheses aside, and say simply, that an ether is a body obtained by the reaction of an acid upon an alcohol, with an elimination of water, and that under certain circumstances the ether can be divided, either by regenerating the alcohol and acid which gave it birth, or by forming products which belong to the families of the alcohol and of the acid; as if indeed the ether were formed of two groups, the one containing a part of the elements of the alcohol, the other a part of the elements of the acid.

Well then, certain chlor-ethers can he obtained by the reaction of chloracids upon alcohols, with a similar elimination of water; and nearly all these chlor-ethers when submitted to the action of anhydrous ammonia, of an alcohol, of potash, and even of heat, divide themselves into products belonging to the families of the acid and of the alcohol which served to produce them. Thus acetic ether for example, gives origin to acetamide; chloracetic ether to chloracetamide, &c. Numerous examples of these changes may be seen in a very lucid résumé, that has been published upon this subject by Gerhardt.

The labours of Malaguti excited Berzelius to undertake the defence of dualism. Relying upon pure hypothesis indeed, and treating from the summit of his grandeur, the ideas which had been emitted upon the subject, he showed, that the notion of substitutions was contrary to common sense. In his hands, the mono-, bi-, and tri-, chloro-naphthalines were transformed into the chloride of icodecatesseryle, chloride of decahexyle, and chloride of decapentyle. Chloride of benzoyl C^7H^5ClO became a benzoic oxy-chloride $2\,(C^{14}H^{10}O^3)+(C^{14}H^{10}Cl^3)$.

The whole of chemistry was simplified in the same fashion.

Berzelius having confounded the *law of substitutions*, with the remarks, the generalities, and the theory that I had published, Dumas took advantage of the opportunity, to reject all consistency between his opinions and mine, by saying, *that his theory was no theory at all* (which is the truth), *but only an empirical law, expressive of a simple relation between the hydrogen eliminated, and the chlorine absorbed—nothing more.*

Nevertheless some years after, Dumas made the discovery of trichloracetic acid. Astonished at seeing, that acetic acid and its derivative had the same capacity of saturation, the same volume, were decomposed in an analogous manner under the influence of baryta, yielded each of them an ether, &c., he adopted my opinion, saying, that in the two acids the arrangement of the atoms must be the same, that the acids in fact, belonged to the same type.*

---

* I perceive in several works on chemistry, that many persons do not understand the difference that exists, between Dumas's ideas and mine concerning substitutions, notwithstanding that they are altogether dissimilar.

The notion of substitutions, if we understand thereby, as we ought to understand, the replacement of chlorine, by bromine, iodine, and fluorine, or the replacement of silver, by copper, iron, or potassium, is as ancient as are the ideas of Richter and Wenzel upon the decomposition of salts. We have known for a long time that the simple bodies displace one another mutually from their combinations, most generally by exchanging equivalent for equivalent, but not unfrequently in a different manner.

We have known that chlorine, by its action upon certain organic substances, as cyanhydric acid, essence of bitter almonds, wax, &c., expels a certain number of atoms of hydrogen, which are replaced by an equal number of atoms of chlorine. We have known that oxygen sometimes comports itself in a similar manner, and also, that in some bodies the hydrogen set free is not replaced by its equivalent of chlorine.

Two questions present themselves: 1°. Can we know *à priori*, whether the hydrogen set free, will or will not be replaced by its equivalent of chlorine, and how much of it may be liberated without substitution? 2°. What becomes of the chlorine in the new chloro-compounds; what function does it fulfil; of what nature are the compounds into which it enters, either by an equivalent, or a non-equivalent substitution?

These two questions are, we perceive, altogether independent of each other. We might discover the law presiding over substitutions, without knowing what takes place within the chloro-compounds, and *vice versâ*.

Dumas confined himself to the first question, and under the name of the theory of substitutions (he himself remarked that he ought to have said *law* of substitutions) he announced the two following propositions.

1°. *When we treat an organic substance by chlorine, bromine, iodine, or oxygen, these bodies generally set free hydrogen, and for one equivalent of hydrogen liberated, there is retained in the compound one equivalent of chlorine, bromine, iodine, or oxygen.*

Then Berzelius, placing the question upon its real footing, though but for a moment, examined if the properties of the chloro derivative, really did resemble those of acetic acid; he pro-

2°. *If a part of the hydrogen of the organic substance, exists in the state of water (as in alcohol), it will be set free by the chlorine or oxygen, without substitution.*

The law is precise, and void of ambiguity: I do not purpose to inquire whether or not it is correct (*vide*, what I have said concerning chlorine and oxygen substitutions in this and the preceding chapter respectively). All that I have to say is, that I have not adopted this law, and that I have myself formulated certain propositions which are altogether different, and are applicable, almost solely to the hydro-carbons. I then have nothing whatever to claim in the above *law* of substitutions. It belongs entirely to Dumas.

With regard to the second question, Dumas never concerned himself with it, unless indeed, after I had done so. It is this subject that I have for a long time had in view in my researches (*vide* my opinion thereon in this chapter); it is in reference to it, that I have advanced the following proposition: *when there is* EQUIVALENT *substitution of chlorine or bromine for hydrogen, the chlorine actually takes the* PLACE *that was occupied by the hydrogen, and to a certain degree, fulfils the functions thereof, consequently the chloro-compound must be analogous with the compound from which it was derived.*

Thus there is but little analogy betwen my opinion, my propositions—and the law of Dumas. Here is the reply of this illustrious chemist to Berzelius, by whom he had been rendered somewhat responsible for my extravagances. "Berzelius attributes to me, an opinion precisely contrary to that which I have always maintained, namely, that the chlorine in this case* takes THE PLACE of the hydrogen. I have never said anything of the kind, neither can anything of the kind be deduced from the opinions I have put forward with regard to this order of facts. To represent me as saying, that hydrogen is replaced by chlorine, which fulfils the same functions, is to attribute to me an opinion against which I protest most strongly, as it is opposed to all that I have written upon these matters. The law of substitutions is an empiric law and nothing more; it expresses a relation between the hydrogen expelled, and the chlorine retained. I am not responsible for the gross exaggeration with which Laurent has invested my theory; his analyses moreover do not merit any confidence."

Dumas and I made use of the same word substitution, from which circumstance arose much of the confusion that prevails on this subject. This confusion was still further augmented, by our employment of special terminations in *ase*, *ese*, and *ise*, &c., terminations *conceived by Dumas* as expressive of the relation between the number of hydrogen atoms liberated, and the number of other atoms retained, but *employed by me* to indicate that the chloro-compound *in the case of an equivalent substitution*, must still preserve the constitution of the original substance.

Thus Dumas represented the constitution of essence of canella by this formula: $C^{18}H^{14}O^2+H^2$; that of chloride of cinnamyl by this: $C^{18}H^{14}O^2+Cl^2$;

---

* I had just made the chlorhydrate of chloretherise, and an acetate of chloromethylene. I maintained that the first body had the same constitution as Dutch liquid, and that in the second, the atoms were disposed exactly as in the acetate of methylene. It was in reference to this opinion, that Berzelius chose to render Dumas responsible for my errors.

nounced for the negative, and in consequence, attributed to each of the acids a different atomic arrangement, and represented their composition thus:

$$\begin{array}{ll} \text{Normal acetic acid ....} & C^4H^6.\,O^3+H^2O \\ \text{Trichloracetic acid ....} & C^2O^3+H^2O+C^2Cl^6, \end{array}$$

which latter body was in his opinion, a combination of oxalic acid with an unknown oxalic chloride.

In reply to Berzelius, the resemblance of the halydes to each other, and of the hyperhalydes to each other, was pointed out. It was shown that the chlorethers divided themselves into

and the *composition* of chlorocinnose (=the hydride $-4H^2+4Cl^2$) by $C^{18}H^8Cl^8O^2$, observing that he called the body *chlorocinnose provisionally*, inasmuch as he did not know how to represent its molecular constitution, nor with what body to compare it.

My opinion was very different. If I had considered essence of canella as forming a unique molecule $C^{18}H^{16}O^2$, and had named it cinnamyl, I should have called the chloro-compound, *chlorocinnose*. If I had regarded the essence as a hydride $C^{18}H^{14}O^2+H^2$, I should have named the chloro-compound *chloride of chlorocinnise* $C^{18}H^8Cl^6O^2+Cl^2$: If I had considered the essence as a hydrate of cinnamyl $C^{18}H^{14}O+H^2O$, I should have called the chloro-compound *hydrate of chlorocinnose* &c., &c.

Thus despite the similitude of the terminations, despite the same values ascribed to the same vowels by Dumas and myself, there is not any analogy between the ideas which these two nomenclatures represent, excepting, that they both express the quantity of hydrogen set free, and the quantity of chlorine fixed.

I will adduce the following examples, to show the absolute difference that exists between my opinion and that of Dumas.

Dumas represented alcohol by $C^4H^8+H^4O^2$, and acetic acid by $C^4H^6O^3+H^2O$ and nevertheless saw a case of substitution in the conversion of the first into the second:

$$\text{Alcohol}-2H^2+2O=\text{acetic acid.}$$

Since at that time, Dumas maintained that alcohol contained 2 atoms of water, while acetic acid contained only one, it is clear that in his law of substitutions, he considered only the ratio between the hydrogen liberated, and the chlorine or oxygen fixed, without pretending that the primitive and the derived body, belonged to the *same type*.

This is rendered still more evident by the following examples, which Dumas brought forward in support of his law.

$$\begin{array}{ll} \text{Alcohol} & -4\,H^2+4O=\text{formic acid,} \\ \text{Acetic acid} & -2\,H^2+2O=\ \text{“}\quad\text{“} \end{array}$$

It is certain that Dumas, notwithstanding the equivalent substitution, did not consider alcohol, acetic acid, and formic acid, as belonging to the same type.

It was some considerable time after this, when he had discovered the chloracetic acid, that he adopted my opinion concerning the functions of chlorine in substitution compounds, which view he extended so as to include oxygen, although I had myself ceased to apply it to this last body.

products appertaining to the families of the acids and the alcohols from which they had been formed, that the two acetic acids have the same capacity of saturation, &c.; and lastly, that in all compounds, the chloro-derivatives retain the same volume as the normal substances from which they were derived. But Berzelius rejected all these ties of community, and persisted in arranging normal substances, in positions most opposite to those of their chloro-derivatives.

About this time, Wœhler entered the lists; but, more courteous than his brethren in arms, contented himself with lancing jocularities against the theory of substitutions.

He said, that by treating sulphate of manganese with chlorine, he had succeeded in replacing successively, the manganese, sulphur, and even the oxygen, by chlorine, and had thus obtained a chloro-sulphate of manganese, which contained neither manganese, nor oxygen, nor sulphur, and which was nevertheless a sulphate.

Though less skilful than Wœhler, I endeavoured to imitate his marvellous discovery, and proceeded as follows: I treated isatine by chlorine and by bromine; I procured derivatives which contained from 25 to 50 per cent. of chlorine and bromine, in the place of 1 and 2 per cent. of hydrogen. And in despite of this enormous difference in the centesimal composition, despite the loss of the highly positive hydrogen, and the substitution of the highly negative chlorine, here are the changes which the isatine had undergone:

Isatine.	Chlorisatine. Bichlorisatine.
Orange red	idem.
Prisms of 113°	id. of 114°.
Sublimes in part without decomposition	id.
Very slightly soluble in water	id.
Moderately soluble in alcohol and ether	id.
Yellow solutions	id.
With potash, at first exchanges H for K	id.
The potassic salt is of a reddish black	id.
With silver salts, it gives a precipitate like the dregs of wine	id.
It is very unstable, and quickly absorbs H^2O to form isatinate of potash	id. chloro.
This new salt is yellow	id.
By the action of acids, it regenerates isatine	id. chloro.
Isatine decomposed by sulphide of ammonium, absorbs hydrogen, forming isathyde	id. chloro.

Isatine.	Chlorisatine.	Bichlorisatine.
This last body occurs in whitish scales	idem.	
It is transformed according to circumstances .... into crimson indine .	id. chloro.	
or into isatine	id. chloro.	
Ammonia forms with isatine .... a grey amide	id. chloro.	
a yellow amide	id. chloro.	
a scarlet amidic acid.	id. chloro.	
The isatinate of ammonia is transformed by evaporation into a yellow isamate....	id. chloro.	
This isamate by desiccation, forms a yellow isamide	id. chloro.	
The isamate and isamide, by the action of acids, produce either isamic acid or isatine	id. chloro.	
Isatine combines with the bisulphite of potash to form an isato-sulphite	id. chloro.	
Etc., etc.		

What thinks Wœhler of all this? if not quite so marvellous as his chloro-sulphate of manganese, it is very nearly so.

Let us see what was the reply of Berzelius to my memoir on isatine.

I should first remark, that the discovery of chlorisatine and bichlorisatine was made by Erdmann, who was unacquainted with isatine.

Berzelius in noticing Erdmann's publication, took great pains to show, that the facts therein related, far from according with substitutional ideas, lent a new support to dualism. Then with his usual ability, he pointed out the real arrangement of the atoms in chlorisatine and bichlorisatine.

Dualism was for the third or fourth time unfortunate, for at the same moment that Erdmann published his memoir, I discovered isatine, and from it procured directly its chloro and bromo derivatives. I found their composition different from that which had been attributed to them by Erdmann, and this new composition confirmed in an astonishing manner the ideas I had put forth concerning substitutions.

On receiving my memoir, Berzelius took up the ironic vein, he pitied the state of my head, and endeavoured to show, that the chloro-derivatives of isatine, isathyde, &c., were, the one a *sus-porrindinous sub-hypochlorite,* the other a *fulvidinous hypochlorite,* and a third an *acid of rubindene,* &c. One must be blind said he, not to see this immediately, from simple inspection of the empiric formulæ.

A sub-hypochlorite volatile without decomposition! A sub-hypochlorite undecomposable by sulphuric acid! A sub-hypochlorite without action upon vegetable colouring matters! A sub-hypochlorite of an unknown oxide of an unknown porrindene! and all the compounds of isatine treated in the same manner! It is almost incredible.

Worse treated than ever, I published fresh papers on naphthaline and phenyl, and showed, that chloro and bromo compounds have frequently the same form as the substances from which they were derived.

Hofmann in distilling isatine, chlorisatine, and bichlorisatine, obtained aniline, chloraniline and bichloraniline. He announced that these last, as I had foreseen, possessed the alkaline properties of aniline.

In treating cinchonine with chlorine, I obtained chloro- and bichloro-cinchonine, both of them basic and isomorphous with the primitive alkaloid, and I found that the normal and chloralkaloids deviated the polarised ray in a similar manner. Lastly, I prepared from the sulphate of strichnine, a sulphate of chloro-strichnine, and to two dogs of the same size, I administered respectively an equal dose of each of the two salts. The animals succumbed in the same time, and with the same symptoms of poisoning.

What more could be done to convince the partisans of dualism? Colour, solubility, volatility, vapour density, crystalline form, metamorphoses, action upon polarised light, action upon the animal economy, all testified in favour of the theory of substitutions.

But experiments went for nothing,—dualism had sworn to uphold its position.

Then I associated myself with Gerhardt, for the purpose of defending and propagating our common ideas. Dualism, ashamed of its late defeat, seized upon this occasion to revenge itself. Having at its disposal numerous journals, Scandinavian, German, and French, it let slip no opportunity for attacking me. It aspersed my researches, skilfully avoided the facts that were favorable to my ideas, bantered my style, and ridiculed my person. I was an impostor, the worthy associate of a brigand, &c., &c., and all this for an atom of chlorine put in the place of an atom of hydrogen, for the simple correction of a chemical formula!

I forgive dualism its abuse, but never its dishonesty. Listen to the edifying history thereof.

What reply was made to my last researches? for surely abuse does not constitute argument. To persist in denying the analogy of certain compounds with their chloro-derivatives was no longer possible; so they even seized upon this analogy, which they had all along denied, and used it as a weapon against me. For the third or fourth time they altered the formulæ of isatine and chlorisatine, and then exclaimed, in the tone of victors, "If Laurent's ideas had not been twisted and falsified by his absurd theories, he would have perceived, that the analogy of isatine with chlorisatine, depends upon the *copulæ* which the two bodies contain."

A word let fall from the pen of Gerhardt, was thus transformed into a luminous idea for dualism. From this time everything was copulated. Acetic, formic, butyric, margaric, &c., acids,—alkaloids, ethers, amides, anilides, all became copulated bodies. So that to make acetanilide, for example, they no longer employed acetic acid and aniline, but they re-copulated a copulated oxalic acid with a copulated ammonia. I am inventing nothing—altering nothing. Is it my fault if, while writing history, I appear to be composing a romance?

What then is a copula?

A copula is an imaginary body, the presence of which disguises all the chemical properties of the compounds with which it is united. Thus margaric acid contains oxalic acid united to the copula $C^{32}H^{66}$; and butyric acid, oxalic acid united to the copula $C^{6}H^{14}$.

But, it may be asked, what proof is there that margaric and butyric acids contain oxalic acid? It is precisely because there is no proof, that they do contain it. We have just said that copulæ disguise the properties of the bodies to which they are united. If, by any reaction, we could render probable the existence of oxalic acid in margaric acid, this reaction would prove that margaric acid was not a copulated body. Reactions are quite incapable of unravelling the mystery, nought but the penetrating spirit of dualism will suffice.

But admitting that acetic acid is a copulated body, what has that to do with the analogy subsisting between certain bodies and their chloro-derivatives? Let us see. Acetic acid, say these gentlemen, contains oxalic acid, copulated with $C^{2}H^{6}$; trichloracetic acid also contains oxalic acid, but its copula is $C^{2}Cl^{6}$. But by paying regard to the composition of the two acids, we perceive, that the atoms are arranged in the same manner, and that consequently they ought to have analogous properties.

$$(C^2H^6)\,C^2O^3.\,H^2O$$
$$(C^2Cl^6)C^2O^3.H^2O$$

The dishonesty is flagrant. What have I to do with your copulæ, your radicals, and your castles of cards? Have I not said over and over again, that I was unacquainted with the arrangement of the atoms in acetic acid? Have I not everywhere repeated, that the chloro-acid must have the same arrangement as the normal acid? Have I not said that the analogy between these two acids was due to this similarity of arrangement? And do you now say otherwise? Only to disguise your defeat, you clothe your formulæ with copulæ, and affect to understand the real arrangement of the atoms. You may possibly be correct in your opinion, but your penetration in this respect appears to me as questionable as your honesty. You have too often varied in your manner of viewing this subject, for me to accept your notions until they are supported by proofs.

Come what may, however, the substitution of chlorine for hydrogen is henceforth an admitted fact.

We shall presently see, that this simple fact materially alters the aspect of science, and enables us with ease, to classify, name, and formulate, one half of all organic substances.

Nitrogen Substitutions.

Nitrogen, phosphorus, arsenic, and antimony, form a group of equivalent elements, and do not appear to have any analogy with other bodies. We may say, that they do not exercise any action upon organic substances,—that they do not combine directly with them,—and that they do not even displace one another mutually from their combinations. Lastly, they all possess the remarkable property of originating alkaloids.

Nitrogen being the representative of phosphorus, arsenic, and antimony, we may say, that organic chemistry comprehends only the combinations of carbon with oxygen, hydrogen, and nitrogen.

But it must be remarked, that nitrogen does not enter into the constitution of organic substances, on the same footing so to speak, as do the other bodies. Organic compounds seem to consist of carbon, oxygen, and hydrogen only; whilst nitrogen exists therein, but as the representative of ammonia on the one hand, and of nitrous, or of nitric acid on the other.

We affirm unhesitatingly, that the non-oxygenated orange azobenzide, contains a residue of nitric acid, which only awaits a favouring influence to be regenerated ; and that the non-hydrogenated cyanogen, contains a residue of ammonia, which is also ready to redevelop itself. I shall presently return to this subject, which enables us to establish a very important division in organic substances.

ACTION OF COMPOUND BODIES UPON ORGANIC SUBSTANCES.

Nitro Substitutions.

Nitric acid frequently acts upon organic substances as a simple oxygenant. It is by its oxygen that it transforms camphor into camphoric acid,—the fats into suberic, pimelic, and butyric acid, &c. I do not propose to examine into these cases of oxidation, of which I have said a few words while on the subject of oxygen substitutions, but to confine myself to certain remarkable reactions produced by nitric acid, which reactions offer the greatest analogy with chlorine substitutions.

To bring out this analogy, I shall take examples from compounds belonging to classes the most different. I shall place the chloro and nitro reactions under one another, and shall then demonstrate the resemblance of the chloro and nitro-products. Let us represent nitric acid, NO^3H by $NO^2.HO = XHO$, and observe the products obtained, as well with it as with chlorine.

$$\text{Naphthaline} \ldots\ldots \left\{ \begin{array}{lllll} C^{10}H^8 & + & Cl^2 & = C^{10}H^7Cl & + \; H\,Cl \\ C^{10}H^8 & + & XHO & = C^{10}H^7X & + \; H^2O \\ C^{10}H^8 & +2 & Cl^2 & = C^{10}H^6Cl^2 & +2 \; H\,Cl \\ C^{10}H^8 & +2 & XHO & = C^{10}H^6X^2 & +2 \; H^2O \\ C^{10}H^8 & +3 & Cl^2 & = C^{10}H^5Cl^3 & +3 \; H\,Cl \\ C^{10}H^8 & +3 & XHO & = C^{10}H^5X^3 & +3 \; H^2O \end{array} \right.$$

$$\text{Phenic acid} \ldots\ldots \left\{ \begin{array}{lllll} C^6H^6O & +3 & Cl^2 & = C^6H^3Cl^3 & +3 \; HCl \\ C^6H^6O & +3 & XHO & = C^6H^3X^3 & +3 \; H^2O \end{array} \right.$$

$$\text{Benzoic acid} \ldots\ldots \left\{ \begin{array}{lllll} C^7H^6O^2 & + & Cl^2 & = C^6H^5ClO^2 & + \; H\,Cl \\ C^7H^6O^2 & + & XHO & = C^6H^5XO^2 & + \; H^2O \end{array} \right.$$

$$\text{Hydride of benzoyl} \left\{ \begin{array}{lllll} C^7H^6O & + & Cl^2 & = C^6H^5ClO & + \; H\,Cl \\ C^7H^6O & + & XHO & = C^6H^5XO & + \; H^2O \end{array} \right.$$

$$\begin{array}{l}\text{Sulpho-naphthalic} \\ \quad \text{acid} \ldots\ldots \end{array} \left\{ \begin{array}{lllll} SO^3C^{10}H^8 & + & Cl^2 & = SO^3C^{10}H^7Cl & + \; H\,Cl \\ SO^3C^{10}H^8 & + & XHO & = SO^3C^{10}H^7X & + \; H^2O \end{array} \right.$$

$$\text{Aniline} \ldots\ldots \left\{ \begin{array}{lllll} C^6H^7N & + & Cl^2 & = C^6H^6ClN & + \; H\,Cl \\ C^6H^7N & + & XHO & = C^6H^6XN & + \; H^2O \end{array} \right.$$

$$\text{Salicylate of ethyl} \ldots \left\{ \begin{array}{lllll} C^7H^{10}O^3 & + & Cl^2 & = C^7H^9ClO^3 & + \; H\,Cl \\ C^7H^{10}O^3 & + & XHO & = C^7H^9XO^3 & + \; H^2O \\ C^7H^{10}O^3 & +2 & Cl^2 & = C^7H^8Cl^2O^3 & +2 \; H\,Cl \\ C^7H^{10}O^3 & +2 & XHO & = C^7H^8X^2O^3 & +2 \; H^2O. \end{array} \right.$$

In general, substances which undergo chloro, can also experience nitro-substitutions; nevertheless, the homologues of etherine, and of all the compounds associated therewith, such as aldehyde, acetic acid, Dutch liquid, &c., do not give rise to nitro substitutions, although the number of their chloro-substitutions is very great; possibly nitro-propionic acid might be adduced as an exception.

I make use of the term *nitro-substitution*, as if the peroxide of nitrogen or X took, like chlorine, the place of the hydrogen set free, and fulfilled its functions. That experience corresponds exactly with this opinion, is shown by the following facts:—

1° That the mono-, bi-, and tri-nitro naphthalines are neutral, like the normal, mono, bi- and tri-chloro naphthalines.

2° That naphthaline produces with sulphuric acid, a sulpho-naphthalic acid; and that the chloro and nitro-naphthalines produce chloro and nitro-sulpho-naphthalic acids.

3° That there exists a basic nitraniline, analogous to normal aniline and to chlor-aniline.

4° That there exists a nitro benzoic acid, having the same capacity of saturation as the normal, and chloro-acid.

5° That if the hydruret of benzoyl, when acted upon by ammonia, gives rise to a neutral hydrobenzamide, and an alkaline amarine, the hydruret of nitro benzoyl, when acted upon by ammonia, gives rise to a neutral nitro-hydrobenzamide, and an alkaline nitramarine.

6° That certain nitro compounds are isomorphous with the corresponding normal and chloro compounds.

7° That in the animal economy, benzoic and nitro-benzoic acids are transformed; the one into hippuric acid, the other into nitro-hippuric acid.

8° That if salicylic ether behaves as an acid, so also do the chloro and bichloro, nitro and binitro, salicylic ethers.

Whether in all cases the nitrogen be in the state of NO^2, replacing H, or in the state of NHO^2, replacing H^2, or in the state of nitrogen separated from oxygen, (which appears to me to be occasionally possible for reasons I shall advert to further on) the fact is not the less established in science, that certain substances in losing H, and gaining NO^2, retain their fundamental properties, in a similar manner, as do those which lose H, and gain Cl.

Nitro substitutions met with the same treatment as chloro substitutions. It would be useless for me to return to the subject, or to adduce the wonderful formulæ that were attributed to picric acid, *the nitrate of the oxide of icodecatesseryle,* and to the other nitro compounds.

Nitroso Substitutions.

Nitrous acid would appear to comport itself similarly to nitric acid, at least if we may judge from the three or four known examples.

Let us represent nitrous acid. NO^2H by
$(NO)\,HO = YHO$, and we shall have with

$$\text{Alcohol} \;\ldots\ldots\ldots\ldots \left\{\begin{array}{l} C^2H^6\ O + XHO = C^2H^5\ XO + HHO \\ C^2H^6\ O + YHO = C^2H^5\ YO + HHO \end{array}\right.$$

$$\text{Amylic Alcohol} \left\{\begin{array}{l} C^5H^{12}\ O + XHO = C^5H^{11}XO + HHO \\ C^5H^{12}\ O + YHO = C^5H^{11}\ YO + HHO \end{array}\right.$$

We may also obtain nitroso substitutions, by partial reduction of certain nitro-compounds. Thus, for example, when we boil an alcoholic solution of potash with nitro-benzide, two molecules of this latter substance unite into one; and if the action of the alcoholic potash is too energetic, the reduction is complete, and we obtain azobenzide.

$$\left\{\begin{matrix} C^6H^5N \\ C^6H^5N \end{matrix}\right\} = 2\ C^6H^5\ (NO^2) - O^4$$

But by putting a stop to the operation, before this result is arrived at, we obtain another body, azoxibenzide,

$$\left\{\begin{matrix} C^6H^5\ N \\ C^6H^5(NO) \end{matrix}\right\}$$

the composition of which manifests, that of the two molecules of nitro-benzide; one has been reduced completely, whilst the other has lost but the half of its oxygen.

We have already seen in the nitro-prussiates, the nitrous residue, or nitric oxide, replace an equivalent of hydrogen, or of a metal.

Inverse Substitutions.

The observations I have just made concerning the action exercised upon organic substances, by chlorine, bromine, nitric acid, &c., enable us in many instances, to ascertain the otherwise unknown origin of certain substances.

By treating with bromine, the crude oil obtained from the distillation of benzoate of lime, I obtained a substance, bromeine, which contained $C^{10}H^6Br^4$. From what source was it derived? As it was unattackable by potash, I concluded that it was a halyde, and that in the crude oil, there existed a hyrdocarbon, $C^{10}H^{10}$, from which the bromeine was produced by the substitution of Br^4 for H^4.

If the bromeine had been attackable by potash, it would have been a hyperhalyde. We should have discovered its fundamental nucleus, by noticing how many atoms of bromine it ceded to the potash, doubling this number, and subtracting the product from the bromeine.

The residue, whether or not brominated, would have contained as many atoms of hydrogen, or of hydrogen and bromine, as the fundamental nucleus contained atoms of hydrogen. Thus, if bromeine had given

$$C^{10}H^6Br^4 = C^{10}H^5Br^3 + HBr,$$

its fundamental nucleus would have been $C^{10}H^8$; but if

$$C^{10}H^6Br^4 = C^{10}H^4Br^2 + H^2Br^2$$

it would have been $C^{10}H^6$, and so on.

By treating coal tar oil with chlorine and nitric acid, Delbos and I obtained an acid containing $C^6H^3N^2O^5Cl$. From its mode of preparation, we concluded that its nitrogen was in the state of peroxide of nitrogen. Replacing then N^2O^4 by its equivalent H^2, and Cl by H, we obtained C^6H^6O, or phenic acid,—the body from which, consequently, our nitro-chloro acid was derived.

It is evident, that in seeking thus to ascend from a derivative to its original, we need not necessarily arrive at the body from which it *was produced*, but only at a body from which it *might have been produced*. Thus, bromine, in acting upon citraconic acid, forms an acid that contains $C^3H^4Br^2O^2$. Replacing Br^2 by H^2, I conclude that this acid originated from $C^3H^6O^2$, or propionic acid; that is to say, that it could be obtained from propionic acid and bromine.

SECTION SECOND.

ACTION OF ACIDS UPON ORGANIC SUBSTANCES.—LAW OF COPULATED BODIES.—ACTION OF AMMONIA.

ACTION OF ACIDS UPON ORGANIC SUBSTANCES.

THE manner in which the acids comport themselves with organic substances is extremely variable. We have just seen how nitric acid acts upon them. Sulphuric acid disengages, sometimes carbonic acid or carbonic oxide, sometimes sulphurous acid; frequently it unites with the organic compounds, with or without elimination of water. Chloric acid gives rise to complex reactions. Chlorhydric, bromhydric, and phosphoric acids behave differently. Lastly the majority of the acids, especially those which are considered as feeble acids, exercise but an indirect action upon organic substances.

Despite the different actions of all these acids, there are two circumstances in which they all comport themselves in a very similar manner.

In the first case, the acids simply unite with certain substances, as the alkaloids, so as to form salts, and occasionally with neutral bodies to form compounds which may be considered as salts, such for instance, as the nitrates of camphor, and essence of canella, the chlorhydrates of camphene, citrene, &c.

In the second case, the acids unite with a host of different substances, such as the alcohols, hydrocarbons, alkaloids, starch, mannite, lignine, organic acids, &c., water being at the same time eliminated, probably at the expense both of the acid, and of the substance employed.

The bodies formed in the second manner, possess very various properties; some are neutral, some acid, some alkaline, but they all resemble each other in one respect, namely, that under the influence of certain reagents, they can absorb the water they had abandoned, and regenerate the acids, and the organic substances from which they had been prepared. It is to such compounds that Gerhardt has given the name of *copulated bodies.* These bodies must not be confounded with others, to which Berzelius has applied the same name. According to the Swedish chemist and his pupils, copulated bodies are not bodies that are formed and decomposed as above described, but simply, bodies containing a *copula*, the existence of which in any particular compound, depends entirely upon the manner in which each chemist may figure to himself the arrangement of the atoms. Consequently, there is no relation between the copulated bodies of Berzelius and those of Gerhardt.

I ought also to remark, that some chemists consider as copulated bodies, certain products, formed in a similar manner to the preceding, but without any elimination of water; such for example, as formobenzoilic acid.

Dumas has given the name "conjugated acid" to sulphovinic, and to tartaric acid. I believe that by this name he intends to designate, the acids which are, or which may be considered to be complex. Thus tartaric acid, which may be regarded as a combination of acetic and oxalic acids, but without elimination of water, would be a conjugated acid.

There are indeed some compounds, which though formed without elimination of water, such for example as sulphobenzidic acid $SO^3C^6H^6$, ought nevertheless to be classified among copulated bodies, and for the following reason: For the purpose of generalising the facts, I never employ in my equations the anhydrides, but always the normal acids. Thus, when I wish to compare the formation of sulphovinic and carbovinic acids, I write the equations in this manner:

$$H^2SO^4 + C^2H^6O - Aq = \text{sulphovinic acid},$$
$$H^2CO^3 + C^2H^6O - Aq = \text{carbovinic acid},$$

and consequently,

$$H^2SO^4 + C^6H^6 \quad - Aq = \text{sulphobenzidic acid},$$

although the carbonate of hydrogen has no existence, and the sulphobenzidic acid is prepared with anhydrous or fuming sulphuric acid. This last is then a copulated body, although in reality obtained without any elimination of water.

LAW OF COPULATED BODIES.

All these distinctions being well understood, we perceive that the formation of copulated bodies may be represented by the following formula:

$$x\,A + yB = C + zAq,$$

in which A represents the acid, B the organic substance acted upon, whether neutral acid or alkaline, and C the new product.

X, y, and z vary, generally from 1 to 2, occasionally from 3 to 4. Nevertheless, we may adduce one example, in which both x and z have the value 6, namely, the equation for sexnitro mannite. Most usually, x, y, and z, represent unity, as in the formation of the amides and monobasic ethers.

Let us now proceed to a generality pointed out by Gerhardt, under the title of the *law of the saturating capacity of copulated bodies,* which law may be thus expressed.

The capacity of saturation of a copulated body is equal to the sum of the capacities of saturation of the bodies employed, diminished by a single unit.

Let us adduce a few examples (the saturating capacity of neutral bodies and alkaloids being nought, is represented by a cypher =0):

1 + 0 − 1 = 0
Acid Alcohol Acetic ether (neutral).

1 + 0 − 1 = 0
Acid Aniline Formanilide (neutral).

1 + 0 − 1 = 0
Acid Benzine Nitrobenzide (neutral).

2 + 0 − 1 = 1
Bibasic acid Alcohol Sulphovinic acid (monobasic).

1 + 1 − 1 = 1
Acid Benzoic acid Nitrobenzoic acid (monobasic).

2 + 1 − 1 = 2
Bibasic acid Acetic acid Sulphacetic acid (bibasic).

2 + 2 − 1 = 3
Bibasic acid Succinic acid Sulphosuccinic acid (tribasic).

3 + 0 − 1 = 2
Tribasic acid Alcohol Phosphovinic acid (bibasic).

There is one point to which we must pay attention. We are asked, what is the saturating capacity of trinitro-phenic acid. Were we to proceed according to Gerhardt's formula,

$$\begin{array}{c} 3 \quad + \quad 1 \quad - \quad 1 \quad = 3, \\ 3HNO^3+C^6H^6O-3Aq=\text{trinitrophenic acid,} \end{array}$$

we should thence deduce that the acid was tribasic, which would be erroneous, it being in reality monobasic.

The error however has arisen, from our having as it were, taken a leap in the equation: Gerhardt admits that trinitro-phenic acid is formed successively, that it undergoes three copulations, and that at each copulation we must diminish its saturating capacity by a unit; we ought then to write successively

$$\begin{array}{c} 1 \quad + \quad 1 \qquad - \quad 1 \quad = 1 \\ HNO^3+C^6H^6O \quad -Aq=\text{nitrophenic acid} \end{array}$$

$$\begin{array}{c} 1 \quad + \quad 1 \qquad - \quad 1 \quad = 1 \\ HNO^3+C^6H^5XO-Aq=\text{binitrophenic acid} \end{array}$$

$$\begin{array}{c} 1 \quad + \quad 1 \qquad - \quad 1 \quad = 1 \\ HNO^3+C^6H^4X^2O-Aq=\text{trinitrophenic acid.} \end{array}$$

Hence the trinitro acid is monobasic.

Strecker, seeing that at each copulation, Gerhardt lessened the capacity of saturation by unity, and that at each copulation one atom of water was eliminated, proposed another expression, by which these successive operations were dispensed with. He showed, that we must diminish the saturating capacities of the bodies employed, by as many units as there are units of water abstracted; thus he arrived at the same conclusion as Gerhardt;

$$\begin{array}{lclcl} 1 & + & 0 & - & 1 = 0 \\ HNO^3 & + & C^6H^6 & - & Aq = \text{nitrobenzide} \end{array}$$

$$\begin{array}{lclcl} 3 & + & 0 & - & 3 = 0 \\ 3HNO^3 & + & C^{10}H^8 & - & 3\,Aq = \text{trinitronaphthaline} \end{array}$$

$$\begin{array}{lclcl} 2 & + & 1 & - & 2 = 1 \\ 2HNO^3 & + & C^7H^6O^2 & - & 2\,Aq = \text{binitrobenzoic acid} \end{array}$$

$$\begin{array}{lclcl} 2 & + & 0 & - & 1 = 1 \\ H^2SO^4 & + & C^6H^7N & - & Aq = \text{sulphanilic acid} \end{array}$$

$$\begin{array}{lclcl} 2 & + & 0 & - & 2 = 0 \\ H^2SO^4 & + & 2C^6H^7N & - & 2\,Aq = \text{sulphanilide} \end{array}$$

$$\begin{array}{lclcl} 4 & + & 0 & - & 2 = 2 \\ 2H^2SO^4 & + & C^{10}H^8 & - & 2\,Aq = \text{thionaphthic acid.} \end{array}$$

Gerhardt has justly remarked, that as we are unable to establish in an absolute manner, the boundaries which separate acid from non acid compounds, his law will be sometimes found at fault in those cases, where the bodies employed are situated close upon this boundary. Thus, ought phenic acid to be considered as an acid? Yes and no. We are aware that it has received the name of phenol or hydrate of phenyl, in addition to the acid appellation we have made use of.

In the presence of sulphuric acid, it must be considered as a neutral body, for we have:

$$\begin{array}{lclcl} 2 & + & 0 & - & 1 = 1 \\ H^2SO^4 & + & C^6H^6O & - & Aq = \text{sulphophenic acid (monobasic).} \end{array}$$

but with nitric acid it behaves as an acid, for we have

$$\begin{array}{lclcl} 2 & + & 1 & - & 2 = 1 \\ 2HNO^3 & + & C^6H^6O & - & 2\,Aq = \text{binitrophenic acid (monobasic).} \end{array}$$

There are also other cases in which this law may fail, or at least be inapplicable, except by the aid of certain interpretations, which consequently, render it more or less uncertain. I will cite, for instance, allophanic ether, which considered as a cyanic ether, does not accord with the law, but which considered as a combination of carbureic acid (allophanic acid), or even as a combination of carbonic acid, urea, and alcohol, tends, on the contrary, to confirm it. Thus we have—

$$\begin{array}{ccccccccc} 2 & + & 0 & + & 0 & - & 2 & = & 0 \\ H^2CO^3 & + & CH^4N^2O & + & C^2H^6O & - & 2\,Aq & = & \text{Allophanic ether.} \end{array}$$

We might also put the equation in this form, representing urea itself, as a copulated body—

$$\begin{array}{ccccccccc} 4 & + & 0 & + & 0 & - & 4 & = & 0 \\ 2\,H^2CO^3 & + & 2\,H^3N & + & C^2H^6O & — & 4\,Aq & = & \text{Allophanic ether.} \end{array}$$

Notwithstanding the existence of intermediate or limiting bodies; notwithstanding the impossibility of always determining the exact function of a body ; notwithstanding the theoretical interpretations necessary, in certain cases, to render the rule applicable ; notwithstanding moreover that in some instances the formula is absolutely faulty, still the *law of saturating capacity* must be considered as very generally true, and as a very useful means for the appreciation of certain facts.

I shall presently attempt to show the relations which subsist, between the values of x, y, and z, and the properties of the copulated bodies, but we must first examine the ammoniacal combinations.

ACTION OF AMMONIA UPON OXIDES, ACIDS, SALTS, CHLORIDES, AND ORGANIC SUBSTANCES.

Ammonia forms with very different bodies, combinations which, by the singularity of their properties, and the variety of their metamorphoses, have constantly attracted the attention of chemists, who, however, when they attempt to study these compounds, are surprised at the confusion in which they find them, and are forced to register the facts without order and without method.

But from these various combinations, they have eventually separated a considerable number, which they have, moreover, succeeded in dividing into three classes, containing respectively the salts of ammonium, the salts of ammonia, and the amides.

The last class comprises such heterogeneous combinations as oxamide and sulphammon; and the second is composed of bodies which have no existence, or, at least, can only be regarded as mixtures.

Lastly, for the multitude of compounds excluded from these classes, particular theories have been conceived, which have never received a place in general classifications.

I have endeavoured on several occasions to define and group the whole of these ammoniacal compounds, and I now proceed to give a summary of the observations I have made upon the subject.

Ammonia and its derivatives.[*]

When ammonia is submitted to the action of certain metals, as potassium for instance, a part of the hydrogen is liberated, and is replaced by its equivalent of metal.

This metallic substitution for hydrogen may also be effected, by causing ammonia to act upon certain oxides, hydrates, and chlorides.[†] Thus we have—

$$\text{Platinous oxide} \ldots\ldots \left\{\begin{array}{l} \mathrm{Pt^2O + 2\,H^3N =} \\ \mathrm{H^2\,O + 2\,PtH^2N} \end{array}\right.$$

$$\text{Platinic oxide} \,.\, \ldots\ldots \left\{\begin{array}{l} \mathrm{pt^2\,O + H^3N =} \\ \mathrm{H^2\,O + pt^2\,HN} \end{array}\right.$$

$$\text{Mercurous chloride} \left\{\begin{array}{l} hg\mathrm{Cl + H^3N =} \\ \mathrm{H\,Cl +} hg\mathrm{H^2N} \ddagger \end{array}\right.$$

$$\text{Mercuric chloride} \left\{\begin{array}{l} \mathrm{3\,HgCl + H^3N =} \\ \mathrm{3\,H\,Cl + Hg^3N.} \ddagger \end{array}\right.$$

We obtain other derivatives in replacing the nitrogen by phosphorus, arsenic, and antimony. And lastly, we may have derivatives procured by the substitution of chlorine, bromine, or iodine for the hydrogen.

---

[*] It must not be forgotten, that *derivatives* are bodies obtained by equivalent substitution, and that consequently chloride of ammonium is not a derivative of ammonia.

[†] I have already remarked, that for the purpose of generalizing the facts, I do not always represent in my equations, the bodies which were really employed in the experiments.

[‡] These two examples have been slightly altered. $hg\mathrm{H^2N}$ may be supposed to exist in the two compounds produced by the action of ammonia upon calomel, thus, $hg\mathrm{H^2N.HCl}$, and $hg\mathrm{H^2N.}hg\mathrm{Cl}$. The compound $\mathrm{Hg^3N}$ is represented in the original as containing the mercury in the state of mercurosum, which is I believe incorrect.—(W.O.)

What is the nature of all these compounds? Some of them have been considered as metallic amidides, analogous to metallic oxides and chlorides, thus:

$$\left.\begin{array}{ll}\text{Amidide of potassium} & K^2\ Ad\\ \text{Amidide of mercury} & Hg^2Ad\end{array}\right\}\begin{array}{c}\text{corresponding}\\ \text{to}\end{array}\left\{\begin{array}{l}K^2\ O \text{ or } K^2\ Cl^2\\ Hg^2O \text{ or } Hg^2Cl^2\end{array}\right.$$

Iodide of nitrogen was said to be an iodo nitride of ammonia,

$$2\ I^6N^2 + H^6N^2.$$

Chloride of nitrogen was compared to anhydrous nitrous acid, to chloride of phosphorous, and to anhydrous phosphorous acid, &c.

Those ammoniacal compounds which contained more than one atom of metal, have been represented in very different manners, which it would be useless to refer to here, especially as in some instances I do not admit even the proportional composition assigned to the bodies.

I consider all these compounds as ammonias, some of them active, others passive. We know that there exists an aniline which saturates chlorhydric acid completely, a chloraniline which saturates it less completely, a bichloraniline which retains it but very feebly, and a trichloraniline which is quite incapable of combining with it.

On this account, I do not the less consider the last mentioned body as an aniline, inactive it is true, but having the same atomic arrangement as normal aniline. In the same manner I consider the ammonias, one, two, or three times, platinicised, platinosed, or mercurosed, as alkaloids capable of combining with acids,—and the chloro- and iodo-ammonias as inactive alkaloids, but, nevertheless, having the same atomic arrangement as ammonia. We know, moreover, that the iodide of nitrogen dissolves in chlorhydric acid, and is reprecipitated by ammonia.*

From these considerations, I classify the ammonias as follows:—

---

* When we pass a current of chlorine gas through a solution of chloride of ammonium, the chloride of nitrogen is not immediately deposited; but if no intermediate products are formed, this immediate deposition ought necessarily to take place. It would be interesting to see whether, at the moment when the chloride of nitrogen is deposited, the supernatant liquid contains a chloride of a more or less chlorinated ammonium. For this purpose, it would be sufficient to abstract a portion of the liquid, to add to it at intervals bichloride of platinum, to collect the precipitates separately, and to ascertain whether or not they contained a constant proportion of chlorine.

A. Genus ammonia or ammine $=H^3N$.

1°. Derivatives of ammonia by the replacement of its hydrogen.

a. varieties produced by metallic substitution.[*]

Ammonia	potassic .	KH^2N
	platinous .	PtH^2N
	biplatinic .	pt^2HN
	trimercuric	Hg^3N

b. Varieties produced by non-metallic substitution.

Ammonia	iodo . .	IH^2N
	biniodo .	I^2HN
	trichloro .	Cl^3N

2°. Derivatives of ammonia by the replacement of its nitrogen:

c.	Phosphamine	H^3P
	Phosphamine trimercuric .	Hg^3P
	Phosphamine trichloro .	Cl^3P.
d.	Arsamine	H^3As
	Arsamine trimercuric . .	Hg^3As
	Arsamine trichloro . .	Cl^3As
e.	Stibamine	H^3Sb
	Stibamine trichloro . .	Cl^3Sb.

B. Genus diammine $=H^6N^2$.

f.	Platinous	PtH^5N^2
	Biplatinic	$pt^2H^4N^2$.

We might adduce in addition, a great number of alkaloids, such as methylamine, ethylamine, phenylamine, &c.

I have, up to this time, considered copulated compounds as formed of two residues,[†] the one appertaining to the acid, the other to the organic matter.

Thus I conceived that nitrobenzide contained a residue NO^2, and a residue C^6H^5; aniline, an ammoniacal and a phenic residue, benzanilide in like manner two others; so that this last substance might be placed indifferently by the side of benzoic acid, or of

---

[*] Some of these ammonias cannot exist free; this is of no consequence, provided we are acquainted with their oxides, hydrates, or chlorides.

[†] These residues must not be confounded with those of Gerhardt, to which I shall refer further on.

aniline. Nevertheles, to facilitate the study of my series, I gave the preference to one place rather than the other. Thus I placed the nitro-naphthalines by the side of naphthaline,—and nitro-alcohol not by the side of alcohol, but along with the formic and carbonic ethers. I placed aniline by the side of phenic acid and benzine, although my formula $C^6H^5. H^2N$ indicated, that it might equally well be placed by the side of ammonia; indeed it represents either benzine, in which H has been replaced by an ammoniacal residue, or ammonia in which H has been replaced by a phenic residue.

Seeing that aniline remained basic like the ammonia from which it sprung, I ought, in accordance with the principles I had enounced in reference to substitutions, to have regarded it as an ammonia with a phenic residue. This last mode of considering the subject is the one adopted by Hofmann, who, viewing it in a particular aspect, has drawn from it one of the most ingenious ideas ever promulgated in chemical science. He has represented the phenic residue C^6H^5 as a radical analogous to ethyl, or to a metal, and, consequently, capable of replacing an atom of hydrogen, without affecting the basic properties of the ammonia into which it enters.

In consequence of my having pointed out the existence of ammonias containing 1, 2, and 3, atoms of metal, Hofmann conceived the possibility of preparing ammonias containing 1, 2, and 3, phenylic, methylic, or ethylic residues; and he succeeded in obtaining such compounds, by processes analogous to those which had yielded me the metallic ammonias. Thus we may have,—

Mercuric hydrate . $\left\{\begin{array}{l} \mathrm{Hg\,H\,O} + \mathrm{H^3N} = \\ \mathrm{H^2O} + \mathrm{HgH^2N.} \end{array}\right.$

Alcohol . . . . . $\left\{\begin{array}{l} \mathrm{Et\ H\,O} + \mathrm{H^3N} = \\ \mathrm{H^2O} + \mathrm{Et\ H^2N} \end{array}\right.$

Mercuric oxide . . $\left\{\begin{array}{l} \mathrm{Hg^2O} + \mathrm{H^3N} = \\ \mathrm{H^2O} + \mathrm{Hg^2H\ N.} \end{array}\right.$

Ether . . . . . . $\left\{\begin{array}{l} \mathrm{Et^2O} + \mathrm{H^3N} = \\ \mathrm{H^2O} + \mathrm{Et^2H\ N.} \end{array}\right.$

Mercuric iodide . . $\left\{\begin{array}{l} 3\ \mathrm{Hg\ I} + \mathrm{H^3N} = \\ 3\ \mathrm{H\ I} + \mathrm{Hg^3N.} \end{array}\right.$

Ethylic iodide . . $\left\{\begin{array}{l} 3\ \mathrm{Et\ I} + \mathrm{H^3N} = \\ 3\ \mathrm{H\ I} + \mathrm{Et^3N.} \end{array}\right.$

Thus, in replacing 1, 2, and 3 atoms of the hydrogen of ammonia, by 1, 2, and 3 atoms of methyl, or of ethyl, or of phenyl, or by 1, 2, and 3 atoms of methyl and ethyl, or of methyl and phenyl, or of ethyl and phenyl, or by 1, 2, or 3 atoms of methyl, and ethyl and phenyl; also by replacing the nitrogen by phosphorus, arsenic, and antimony, we obtain a new division of ammonical derivatives, which may be arranged in continuation of the preceding.

3° Compound radical derivatives of ammonia:

g. Ammonia....	Ethylic	EtH^2N
	Biethylic	Et^2HN
	Triethylic	Et^3N
	Phenyl-ethylic	$PhEtHN$
	Phenyl-methyl-ethylic	$PhMeEtN$
h. Phosphamine....	Trimethylic	Me^3P
i. Stibamine	Triethylic	Et^3Sb.

The point of interest in connexion with Hofmann's views, is the manner in which he generalises his ammonias, and not the theory by which he represents them as containing ethyl, methyl, phenyl, &c. At present this theory concerns us but little, for we might here also make use of that of etherine, and say, that ammonia can take up as many atoms of etherine, methyline, or benzine, as it contains atoms of H; or even that ammonia, like a tribasic acid, may combine with one, two, or three atoms of etherine, or methyline, &c. If I had to make choice, I should give the preference to the first theory, as being more elegant, though not more correct than the other. In a word, whether these ammonias *contain*, or have such a composition that they "*may be considered to contain*," ethyl in the place of hydrogen, is, in my view, the same thing.

Salts of Ammonium and their derivatives.

Ammonia, when put in the presence of acids, unites with them, forming salts, which are ordinarily designated by the term "*salts of ammonium*" to distinguish them from the compounds which are obtained by means of the anhydrides, and which are called *salts of ammonia*. Since the acids are only salts of hydrogen, we should conclude that salts of other metals ought also to unite directly with ammonia, giving rise to combinations, which might be considered as salts of ammonium, in which one atom of hydrogen was replaced by one atom of cupricum, mercurosum, mercuricum, platinosum, platinicum, palladicum, &c.; and since, according to my views, ammonias, 1, 2, and 3 times mercuricised or platinicised, are still alkaloids, they also ought to be able to unite not only with the salts of hydrogen, but likewise with those of copper, mercury, platinum, &c., to form salts of ammonium, 1, 2, 3, and 4 times platinicised, mercuricised, &c.

Now there exist numerous combinations, which obviously are only salts of 1, 2, 3, and 4 times metallicised ammoniums, but which have hitherto been considered as complex salts, having no relation with those of ammonium.

Thus, the hydrate $(Hg^4N)HO+2Aq.$ is considered as a combination of $H^6N^2+4\,Hg^2O+2\,H^2O$; the sulphate $(Hg^4N)^2SO^4+2Aq.$ is considered as a mercuric subsulphate combined with the amidide of mercury.

$$3Hg^2O.SO^3+Hg^2Ad.$$

The nitrate of bimercuroso-ammonium $(hg^2H^2N)\,NO^3+Aq$, is represented as a combination of nitrate of ammonium and mercurous oxide,

$$N^2H^8O.N^2O^5+3hg^2O.$$

The iodate of mercuric ammonium, $NHgH^3.IO^3$, is represented as

$$3\,Hg^2O.I^2O^5+Hg^2Ad+N^2H^8O.I^2O^5.$$

The salts of Gros and Reiset contain the three radicals,

$$NPtH^3, \qquad N^2H^6Pt, \qquad N^2H^6PtCl,$$

and their chlorides are

$$NPtH^3.Cl, \qquad N^2H^6Pt.Cl, \qquad N^2H^6PtCl.Cl.$$

I ought not to omit noticing, that Graham was the first to consider the ammoniacal salts of copper as salts of ammonium, in which one atom of hydrogen had been replaced by one atom of copper. Thus he represented the ammoniacal sulphate and chloride of copper, by these formulæ,

$$(N^2H^6Cu^2)\,O.SO^3$$
$$(N^2H^6Cu^2)\,Cl^2;$$

But Graham did not proceed beyond this point; he did not endeavour to ascertain, whether or not his idea was applicable to combinations containing several atoms of metal, such as the salts of Gros and of Reiset. Moreover, for certain of these combinations, he has given formulæ altogether at variance with the preceding. Thus according to Graham, the atoms of the succeeding compounds would be disposed as follows:—

Wœhler's white precipitate .... $\frac{\mathrm{Cl\ N}}{\mathrm{Hg\ H^3}}$ $\frac{\text{negative elements}}{\text{positive elements.}}$

Black precipitate .... $\frac{\mathrm{Cl\ N}}{\mathrm{Hg^2\ H^2\ Hg^2}}$ or $\frac{\mathrm{Cl\ N\ \ Hg}}{\mathrm{Hg^2\ H^2\ Hg}}$

What relation, I ask, is there between these formulæ, and that of chloride of ammonium, even when represented as $\frac{\mathrm{ClN}}{\mathrm{H^4}}$.

But it is in the presence of such formulæ, that Hofmann, who has read my papers, attributes to Graham the ideas which I have just developed, concerning some of the most obscure combinations in Chemistry. Among these combinations, there were some that did not accord with any of the theories of metallic ammoniums, be they what they might, not even with that of Graham. Did this distinguished chemist suspect, as I did, that such formulæ were incorrect? Did he, as I did, propose to replace them by others? To attribute to Graham, my manner of viewing these compounds, is to commit a more serious error than that of attributing to me, Hofmann's ideas on the ammonias, on account of my having represented aniline by

$$C^6H^5(H^2N),$$

and amarine by

$$\begin{array}{l} C^7H^5.H^2N, \\ C^7H^5.N, \\ C^7H^6, \end{array}$$

analogous to triethylamine; and would place me in a false position, by referring to me ideas which, though approaching very nearly, I never arrived at.

It would be useless for me to show, that the classification adopted for the ammonias is equally applicable to the salts of ammonium.

Amides, diamides, amidic acids, &c.

Ammonia, after the fashion of organic compounds, may, by its reaction upon acids, eliminate one or several atoms of water. It may also combine with the anhydrides, in some instances with, in others without, a simultaneous elimination of water.

The compounds formed by the above methods, possess very different properties: some of them are neutral bodies, others constitute acids; some of them are real salts of ammonium, others are simply alkaloids; and lastly, we meet with some of them which, although neutral, can combine indifferently with acids or alkalies.

What then is the nature of these combinations?

Some of them receive the name of *amides*, a name which was first given to them by Dumas, because he supposed them to contain a certain particular radical, amide$=$Ad$=$ N^2H^4. Thus, according to him, oxamide was a compound of oxide of carbon and amide, and was thus represented, $C^2O^2.N^2H^4$ or, C^2O^2Ad.

But we should entertain a false idea of the amide theory, if we imagined it to have an exclusive reference to the presence of amide, imide, or some other radical. Dumas's theory has a very different bearing. Neglecting all hypotheses, it signifies: 1°, that the amides are combinations formed by an acid and an ammonia, with an elimination of water; 2°, that the amides are not salts, and that reagents do not reveal the characters of the acids, or of the alkaloids from which they were produced. 3°, That nevertheless, under certain influences, they are capable of regenerating the ammonia and the acid. 4°, That they have compositions which may be represented by that of the anhydrous acid, minus one equivalent of oxygen, plus one equivalent of amide.

Examples—

Oxamide	$C^2O^2Ad.$
Acetamide	$C^4H^6O^2Ad.$
Benzamide	$C^{14}H^{10}O^2Ad.$

But it is necsssary to distinguish several species of amides, accordingly as they are produced by mono-, bi-, tri-, or quadribasic acids. I shall distinguish them as

1°. Amides	$A' + NH^3 - Aq.$
2°. Diamides	$A'' + 2\,NH^3 - 2\,Aq.$
3°. Triamides . . .	$A''' + 3\,NH^3 - 3\,Aq.$
4°. Tetramides . .	$A'''' + 4\,NH^3 - 4\,Aq.$

There exist a great number of other compounds, which cannot be represented by the preceding equations; such are for instance, the *imides* or *nitryles*. These are generally considered as cyanides, thus:—

Formimide = hydric cyanide = $H.CN$.
Acetimide = methylic cyanide = $CH^3.CN$.
Propionimide = ethylic cyanide = $C^2H^5.CN$.

But as the imides can be obtained from ammonia and the acids, as they can regenerate both the one and the other, and as they cannot regenerate either cyanhydric acid, or the methylic, ethylic, &c. alcohols, I consider them simply as monbasic salts of ammonium, minus two equivalents of water.

Among the combinations by which chemists have been most embarrassed, we must mention those proceeding from the union of the anhydrides with ammonia, without any elimination of water; such for example are sulphammon, carbammon, chloranilam, chloranilammon, &c.

Sulphammon has been considered by some chemists, as hydrated sulphamide, $N^2H^4SO^2.H^2O$; and by others, as sulphuric acid, in which one atom of oxygen is replaced by its equivalent of amide, H^2SO^3Ad. Lastly, it is very generally considered as an anhydrous sulphate of ammonia. This last method of considering it is quite illogical, for according to all definitions, a sulphate is a body containing SO^4, or SO^3 *plus* O. Sulphammon might indeed be a combination of the anhydride with ammonia, but then it would not be a sulphate.

I reject altogether the above different opinions; for I have shown beyond question, that in all combinations of this description, a part only of the ammonia is dissimulated as in the amides, whilst the other part is precipitated by the bichloride of platinum, and fulfils the same function as it does in the salts of ammonium. These bodies then are salts of ammonium, and we ought consequently to be able to extract the acid, with which the ammonium is combined.

Thus, according to me,

Sulphammon would be a combination of

	Sulphamic acid	NH^3SO^3, and NH^3.
Carbammon of............	Carbamic acid	NH^3CO^2, and NH^3.
Sulpho-carbammon....	Sulpho-carbamic acid	NH^3CS^2, and NH^3.
Oxammon	Oxamic acid............	$NH^3C^2O^3$, and NH^3.
Phthalammon	Phthalamic acid	$NH^3C^8H^4O^3$, and NH^3.[*]

which opinions have been completely confirmed by experiment.

---

[*] Oxamic acid was first discovered by Balard; but in consequence of its not having been obtained by the action of oxalic anhydride upon ammonia, he did not think of generalizing the remarkable fact he had just observed.

Thus to oxamic acid, discovered by Balard, I have added the phthalamic, camphoramic, &c., acids. It is to these bodies that I have given the name of *amidic acids.* We may give an exact idea of their composition, by saying, that they are bibasic acid salts of ammonium, minus one atom of water.

Sulphamic acid . $(NH^4H)SO^4 - H^2O = NH^3SO^3$.
Oxamic acid . . $(NH^4H)C^2O^4 - H^2O = NH^3C^2O^3$.

There exist, or may exist, other amidic acids having the following formulæ,—

Tri-amidic acids . . . $A''' + 3\,NH^3 - H^2O$.
Tetramidic acids . . $''A'' + 4\,NH^3 - H^2O$.

and other varieties.

Thus, in my opinion, Jacquelain's sulphammon would be a disulphamate of ammonium, $= S^2O^6NHAm^2$ (empirical formula, $N^3H^9S^2O^6 = H.NH^2SO^3 + NH^4.NH^2SO^3$), and the deliquescent sulphammon of Rose, the same salt in a state of hydration,

$$S^2O^6NHAm^2 + Aq(\text{or } 2\ Aq?).$$

The ammons may be considered as neutral salts of ammonium, minus one atom of water:

Sulphammon . . . . . $Am^2SO^4 - Aq$.
Carbammon . . . . . $Am^2CO^3 - Aq$.

It is unnecessary to say, that amidic acids can give rise to metallic salts: thus

Oxamic acid . . . $H.NH^2C^2O^3$
Oxamates . . . $M.NH^2C^2O^3$
Sulphocarbamic acid $H.NH^2C\,S^2$
Sulphocarbamates . $M.NH^2C\,S^2$

To the preceding divisions, I have added that of the di-imides, which may be considered as amidic acids, minus one equivalent of water, or as bibasic acid salts, minus two atoms of water;

Pthalimide .... $AmH{\cdot}C^8H^4O^4 - 2\,H^2O$.
Camphorimide .... $AmH{\cdot}C^{10}H^{14}O^4 - 2\,H^2O$.

I omit for the present, several other compounds of this description, and in concluding this chapter, would only remark,

1°. That the composition of all these bodies may be represented by a salt of ammonium, minus water.

2°. That in all cases, the properties of the acid employed are dissimulated, and likewise the properties of the ammonium, excepting in the ammons, where a portion of the alkaloid *is* recognisable.

3°. That all these bodies, like the simple amides, can, by the absorption of water, regenerate the acids and the ammonia from which they were prepared; consequently all of them belong to the class of copulated bodies.

It is needless to observe, that aniline and the other alkaloids comport themselves similarly to ammonia, and by analogous reactions give rise to analogous products. Thus,

Form-anilide	$F + An - Aq$,
Ox-anilide	$Ox + 2\,An - 2Aq$,
Oxanilic acid	$Ox + An - Aq$,
Camphoranil (di-imide)	$C + An - 2Aq$.

It is from the existence of these new compounds, that I have been lead to reject the rational formulæ, containing amide, imide, and such other radicals; for we should necessarily have to imagine two or three new radicals, for each amide, imide, &c., of aniline, methylamine, and the other alkaloids.

ACTION OF AMMONIA UPON NEUTRAL ORGANIC SUBSTANCES.

Ammonia exerts its action, not only upon acids, but also upon certain neutral organic substances. In these cases, water is eliminated, with a consequent production of new compounds, which are, to a certain extent, analogous to copulated bodies. Thus, for instance, the majority of them are able, by an absorption of water, to regenerate the bodies from which they took their origin.

The reason why some of them cannot undergo this dedoubling, when acted upon by acids and bases, is simple. I have stated above, that in my opinion, aniline is a copulated body, is in fact, phenolamide. Acids, instead of dedoubling it, to unite with its ammonia, simply combine with it; and alkalies have not any tendency to effect its decomposition, in consequence of phenol being a neutral substance.

Monobasic acids, as we shall presently see, re-act upon one equivalent of ammonia only, to produce amides, imides, &c., for the existence of such amides as the following is very questionable:

$$2\,A' + NH^3 - x\,Aq$$

$$A' + 2\,NH^3 - x\,Aq.$$

We shall also find, that bibasic acids do not produce amides of the form

$$A'' + 3\,NH^3 - x\,Aq$$
$$A'' + 4\,NH^3 - x\,Aq, \&c.$$

Now, on the other hand, neutral bodies, bodies which have no saturating capacity, or in which we can scarcely conceive a capacity equal to unity, are capable of copulating themselves with ammonia in very various proportions. Thus the essence of bitter almonds gives rise to the following combinations:—

Benzolanilide . . . . $= Ess + NH^3 - Aq$ *
Dibenzolimide . . . $= 2\,Ess + NH^3 - Aq$
Thiobenzaldine . . $= 3\,Ess + NH^3 - Aq$ †
Hydrobenzamide . . $= 3\,Ess + 2\,NH^3 - 3\,Aq$
Urea-hydrobenzamide $= 3\,Ess + 4\,Urea - 3\,Aq.$

Benzile, benzoine, isatine, and other neutral bodies, likewise give rise to very various amides.

It is probably among these compounds, that the majority of the alkaloids are to be found. Thus ammonia, by its action upon

Hydruret of benzoyl	produces	Amarine
Hydruret of nitrobenzoyl	,,	Nitramarine
Furfurol	,,	Furfurine
Sulphaldehyde	,,	Thialdine.

I believe that amides of the form $A + B - Aq$, when obtained from either alcohols, or aldehydes, will be alkaline. Thus we should have directly or indirectly

Aniline . . . . $= C^6H^6O + NH^3 - H^2O$
Phenol.
Base of the kakodyle salts $= C^2H^4O + AsH^3 - H^2O$
Aldehyde.
Methylamine . . . . . $= C\,H^4O + NH^3 - H^2O$
Methol.
Ethylamine . . . . . $= C^2H^6O + NH^3 - H^2O$
Alcohol.

---

* This compound is produced not from ammonia, but from aniline; this is of no consequence as regards the result I wish to establish.

† In this equation, the oxygen of the different terms should be replaced by sulphur.

Amarine, furfurine, thialdine, and stibethine,* appear to be alkaloids of different aldehydes and compound radicals: thus,—

$$\text{Amarine} = \underset{\text{Benzoic aldehyde.}}{3\,C^7H^6O} + 2\,NH^3 - 3\,H^2O$$

$$\text{Furfurine} = \underset{\text{Furfuric aldehyde.}}{3\,C^5H^4O^2} + 2\,NH^3 - 3\,H^2O$$

$$\text{Thialdine} = \underset{\text{Sulphaldehyde.}}{3\,C^2H^4S} + NH^3 - H^2S$$

$$\text{Stibethine} = \left\{ \begin{matrix} C^2H^4O \\ 2\,C^2H^4 \end{matrix} \right\} + Sb\,H^3 - H^2O$$

ACTION OF AMMONIA UPON CHLORIDES, CYANIDES, ETC.

Chlorine, bromine, iodine, fluorine, and cyanogen, have usually been considered as functionally equivalent to oxygen. Thus, chloride of potassium has been compared with oxide of potassium; perchloride of iron with peroxide of iron; phosphoric chloride with phosphoric anhydride, &c.

It is in consequence of this supposed equivalence, that chloro-salts have been considered to correspond with oxy-salts and sulpho-salts, and that the ammoniacal combinations of the chlorides and of the anhydrides have been placed in the same category.

In a preceding chapter, I have pointed out the nature of the ammoniacal combinations of the anhydrides, and I now proceed to show, that the ammoniacal combinations of the chlorides are of an entirely different character; whence we deduce a new proof, that oxygen and sulphur are not the equivalents of chlorine and bromine.

At one time I considered the combinations of the chlorides with ammonia, as chloramic salts. Thus titanic chloride for instance, formed, with one atom of ammonia, a chloro-titanamic acid $= TiCl^2NH^3$, which, with another atom of ammonia, formed a chlorotitanamate of ammonium. Experiment seemed to confirm my opinion, as the bichloride of platinum can precipitate from these compounds, a part only of the ammonia.

Nevertheless, I speedily abandoned this view; and, in accounting for the preceding and other properties, was led to consider all similar ammoniacal combinations, to the number of forty or fifty,

---

* I give the name of stibethine to the base, or ammonia, of the salts of stibethyl. *Vide* pages 95 and 96.

as mixtures of chloride, bromide, iodide, fluoride, and cyanide of ammonium, with new chloro, bromo, &c., amides.

We should have, for example, with the chloride RCl^3 and ammonia,

$$\begin{aligned}
&R\,Cl^3 + NH^3 - H\,Cl = NH^2R\,Cl^2\\
&R\,Cl^3 + NH^3 - 2\,H\,Cl = NH\,R\,Cl\\
&R\,Cl^3 + NH^3 - 3\,H\,Cl = N\,R\\
&R\,Cl^3 + 2\,NH^3 - 2\,H\,Cl = N^2H^4RCl, \text{ \&c.}
\end{aligned}$$

The chlorhydric acid, instead of being set free, would combine with the excess of ammonia, so that a mixture of sal ammoniac and the chloramide, having the appearance of a simple combination of the chloride with ammonia, would result.

Experiment has most completely confirmed my mode of viewing the subject. Thus we have with

Arsenious chloride .... $AsCl^3 + NH^3 - 2\,H\,Cl = NH\,AsCl$
Or for the mixed product $AsCl^3 + 3\,NH^3 - 2\,NH^4Cl = NH\,AsCl$
Chloride of cyanogen.... $CyCl + NH^3 - H\,Cl = NH^2Cy$
Phosphoric chloride .... $P\,Cl^5 + NH^3 - 3\,H\,Cl = NP\,Cl^2$.

The chloramides $NH\,AsCl$, $NPCl^2$, &c., would thus be considered as copulated bodies, from which, not water, but hydrochloric acid had been eliminated, and which, by the absorption of water, would regenerate, not the original chloride and ammonia, but a compound corresponding to the chloride and to ammonia. Thus, the ammonical phosphorous chloride by the action of water, eliminates HCl, and produces phosphorous acid.

The ammoniacal phosphoric chloride by the action of water, eliminates HCl, and produces phosphoric acid.

By the action of ammonia, several chlorides transform themselves into non-chlorinated amides, identical with those which are obtained from the oxisalts of ammonium by the elimination of water. Thus chloride of benzoyl gives rise to benzamide, and the phosphoric chloride to phosphamide.

At present, it would be impossible to indicate the relations which exist between the properties of the chloramides and the equations representing their formation. To attain to this knowledge, the chlorides would have to be divided into the mono-, bi-, and tri-basic varieties; and then, according to the amount of ammonia absorbed, and chlorhydric acid eliminated, we might establish the following category:

Monobasic chlorides.

$$\text{Chlorides}\ldots\; + \; NH^3-1,\,2,\,3\ldots HCl.$$

Bibasic chlorides.

$$\text{Chlorides}\ldots\left\{\begin{array}{l} +\;\; NH^3-1,\,2,\,3\ldots HCl \\ +2\,NH^3-1,\,2,\,3\ldots HCl. \end{array}\right.$$

Tribasic chlorides.

$$\text{Chlorides}\ldots\left\{\begin{array}{l} +\;\; NH^3-1,\,2,\,3\ldots HCl \\ +2\,NH^3-1,\,2,\,3\ldots HCl \\ +3\,NH^3-1,\,2,\,3\ldots HCl. \end{array}\right.$$

All these chloramides, when acted upon by water, bases, alcohol, ammonia, heat, &c., would probably give rise to a host of interesting compounds and of unexpected reactions.

Thus chlorocyanilide, by the agency of heat alone, yields new compounds. Chlorophosphamide, by the action of bases, is transformed into pyrophosphamic and pyrophosphodiamic acids. Chlorarsenimide, by the action of water, forms at first a chlorarsenite of ammonium,—and then, arsenious acid. Chloride of sulphur re-acts differently from the other chlorides, for the simple reason, that it has no corresponding oxygen acid. It ought to give rise to the following equation, $3SCl^2+N^2H^6=3H^2Cl^2+N^2S^3$. But N^2S^3 decomposes itself into sulphide of nitrogen N^2S^2 and sulphur: so that the ammoniacal chloride of sulphur is at least, a triple mixture of chloride of ammonium, sulphur, and sulphide of nitrogen.

According to Rose, stannic chloride and ammonia produce, not a mixture but a real combination, soluble in water, and capable of being sublimed without decomposition. It would be important to verify this fact; it appears to me somewhat questionable. Rose found in the primitive product 10·9, and in the sublimed product 13·3 per cent of ammonia. Nevertheless, he attributes to both of them the same formula,

$$Sn^2Cl^4.N^2H^6,$$

whilst, acording to Persoz and Grouvelle, the non-sublimed product contains,

$$Sn^2Cl^4.\,2N^2H^6.$$

Seeing however, that stannic chloride is equally a chloride of stannicum, $snCl=\frac{1}{2}SnCl^2$, we may regard the above compounds as metallised ammoniacal chlorides. Thus, Persoz and Grouvelle's combination would be a chloride of stannicised ammonium NH^3snCl, and Rose's compound, a double chloride of stannicum and stannicised ammonium, $=\mathrm{snCl}+\mathrm{NH^3snCl}$. Moreover, we know, that stannic chloride unites with chloride of ammonium, to form the following combination:

$$2\,\mathrm{snCl}.+\mathrm{NH^4Cl}.$$

SECTION THIRD.

ON THE RELATIONS EXISTING BETWEEN THE EQUATIONS AND PROPERTIES OF THE DIAMERIDES.

HAVING thus examined the products obtained by the action of acids, chlorides, ammonia, &c., upon organic substances, we will now refer to them in a general manner, for the purpose of ascertaining what relations exist between their properties, and the equations representing their formation.

One and the same body may be obtained by several different processes: consequently, if we do not make some systematic choice of reactions, we may readily overlook all the analogies existing between the properties and the modes of preparation of the products under comparison. Thus, for instance, the benzoic and acetic nitryles might be obtained in the following ways:—

$$\mathrm{C^7H^6O^2+NH^3-2\,H^2O}=\text{Benzoic nitryle},$$
$$\mathrm{C\,N\,H+CH^4O-H^2O}=\text{Acetic nitryle};$$

and then, despite the analogy of their properties, we should not recognise any relation between their modes of preparation. Very different would it be, however, if for the latter of the preceding equations, we were to substitute the following:

$$\mathrm{C^2H^4O^2+NH^3-2\,H^2O}=\text{Acetic nitryle}.$$

Thus we see the necessity of making some choice in our reactions. For the amides, anilides, &c., I always adopt equations having reference to the acids, and to ammonia, or aniline; for the ethers, equations having reference to the acids, and to the alcohols. When possible, I remove sulphuretted hydrogen, and chlorhydric acid, as terms of an equation, and replace them by water. If, for instance, I wished to compare the formation of benzamide with that of benzoic ether, I should not write the equations in this manner,

Chloride of benzoyl, $C^7H^5ClO + NH^3 - HCl =$ benzamide.
Benzoic acid .... $C^7H^6O^2 + C^2H^6O - H^2O =$ benzoic ether.

but should transform the former into

Benzoic acid, $C^7H^6O^2 + NH^3 - H^2O$ Benzamide,

even although the amide in question could not be obtained by the process last represented.

If I wished to compare some other body with thialdine, I should not write the equation of this latter compound in the usual way

$$3\ C^2H^4O + 2\ H^2S + NH^3 - 3\ H^2O = \text{thialdine};$$

on the contrary, I should at first effect the substitution of sulphur for oxygen, and should write

$$C^2H^4O + H^2S = C^2H^4S + H^2O;$$

then I should give the reaction

$$3\ C^2H^4S + NH^3 - H^2S = \text{thialdine},$$

which I should then transform into

$$3\ C^2H^4O + NH^3 - H^2O = \text{aldine (unknown)}.$$

I could then, in comparing aldine with amarine and benzolimide for example, see in what points their equations resembled, or differed from, one another.

$$\begin{aligned} 3\ C^7H^6O &+ 2\ NH^3 - 3\ H^2O = \text{amarine},\\ 2\ C^7H^6O &+ NH^3 - H^2O = \text{benzolimide},\\ 3\ C^2H^4O &+ NH^3 - H^2O = \text{aldine}. \end{aligned}$$

This being understood, we will now endeavour to establish a classification of all the products we have to examine. We might divide all compound bodies, as well of mineral as of organic chemistry, into two great classes, comprising;—*The first,* all simple combinations. *The second,* all copulated bodies, and those produced by a disengagement of chlorhydric acid.

In the first class, would be arranged, acids, salts, even those of ammonium, formobenzoilic acid, &c. This last acid however, has some analogy with the bodies of the second class: for indeed, the most striking characteristics of bodies of the second class,—of the ethers for example—are, the dissimulation of the properties of the bodies from which they were produced; their incapability of undergoing an ordinary saline double decomposition; and their capability of splitting up into two or more products, which are precisely the bodies that were employed to produce them. In these respects then, formobenzoilic acid is a genuine copulated body.

But to avoid confusion of names and definitions, I shall at first consider all metallic, ammoniacal, anilic, &c., salts, as varieties of their acid, with which I shall accordingly arrange them; then I shall divide all compound bodies, into two classes, namely,

Aplones, or simple combinations. *Diamerones,* or complex or *divisible** combinations.

The aplones include carbonic oxide, ammonia, acids (nitric, chlorhydric, formic, acetic, &c.,) and their salts, the majority of the hydrocarbons, the halydes, and aldehydes, &c.

The diamerones include all products formed by the action of the aplones upon one another, *with* or *without* elimination of water, or chlorhydric acid; which products do not undergo ordinary saline double decomposition, and behave as if formed of two or more groups, susceptible of being separated from one another.

I divide the diamerones into *diamerones A,* which are formed with elimination of water, sulphydric, chlorhydric acids, &c., and *diamerones B,* which are obtained without elimination.

I shall pay no further attention to the last division, which contains such compounds as

Formobenzoilic acid $CH^2O^2.C^7H^6O$,

—kakodyle, compounded, as I have shown of two identical groups, Kk and Kk, which are susceptible of division under the influence of chlorine, 2KkCl being produced; also

---

* I do not deem it necessary to enter into greater detail concerning these definitions. Without doubt the aplone, sulphuric acid, is divisible; but we speak here of a relative divisibility; thus, sulphanilide is a diamerone.

† Bodies formed with simultaneous disengagement of water, sulphydric or chlorhydric acid, &c., are not necessarily copulated bodies: thus, hydruret of benzoyl gives the following reaction with sulphhydric acid: $C^7H^6O + H^2S = C^7H^6S + H^2O$. But, in this case, there is a simple substitution of sulphur for oxygen. Also when sulphuric acid acts upon common salt and sets free chlorhydric acid, there is but a simple substitution of sodium for hydrogen. But the gentle reader will allow me to pass rapidly over explanations of this description.

Stilbene, which possibly consists of 2 C^7H^6,
Metaldehyde .... $=3\ C^2H^4O$,
Green hydrokinone $=C^6H^4O^2.C^6H^6O^2$,

and others.

The diamerones A, naturally divide themselves into *hydro-diamerides* produced by the elimination of H^2O,H^2S,H^2Se, and H^2Te; and halo-diamerides produced by elimination of HCl, HBr, HI, and HFl.

I shall not enter into any further details concerning the halo-diamerides; my previous observations are sufficient for my purpose. I would only remark, that such of the halo-diamerides as may be obtained by hydrodiameridic equations, ought to be classed with this last description of bodies. Thus, phosphamide, which is obtained from phosphoric chloride and ammonia, with elimination of chlorhydric acid, ought to be considered as phosphate of ammonium, minus water, and be consequently placed among the hydro-diamerides.

The hydro-diamerides would scarcely comprise any other than copulated bodies properly so called. Nevertheless, I arrange in this division, aniline, hydrobenzamide, amarine, kinonamide, thialdine, &c., that is to say, the compounds obtained by the reactions of *neutral* or *alkaline* bodies upon each other. Moreover, I include herein, all nitrogenised combinations with the exception of the nitric and nitrous acids, and ammonia;* for in my opinion, every nitrogenised substance contains either a nitrous or nitric residue, as is the case for example with fulminic acid, nitrobenzide, azobenzide, nitrous ether, &c.,— or an ammoniacal residue, as is the case with cyanic acid, the alkaloids, and the amides.

By having regard both to the functions and to the origin of the hydrodiamerides, we may subdivide them as follows:

1. Alkaline products	B upon B A upon B †	....	*Diamerines.*
2. Neutral products,	A upon B	DIAMERIDES.	*Diameramides.*
3. Acid products,	2 A or A upon B		*Diameracids.*
4. Neutral products,	2 A or B upon B	....	*Diameraies.*

---

* Nitrous oxide, nitric oxide, and peroxide of nitrogen, also the nitrous and nitric anhydrides, are diamerones. Nitrous oxide is nitrimide, containing a nitric and an ammoniacal residue ON·N. I have shown that nitric oxide $N^2O^2=Y^2$ halves itself in substitutions, as likewise does peroxide of nitrogen $N^2O^4=X^2$. As regards the nitrous and nitric anhydrides, they are, as are all monobasic anhydrides, divisible by the action of water into two equal parts.

† A represents an acid, B a non-acid, body.

Putting aside the diameraies as being too little known, I arrange the remainder in one great table.

The table is divided into 16 compartments, and each of the compartments into 4 squares, or the whole into 64 squares. Each of these 64 squares is labelled with its typical equation. All bodies formed according to one and the same typical equation, are placed in the particular square to which that equation belongs.

16 squares are devoted to the monobasic acids .... $= A'$
16 squares are devoted to the bibasic acids.... .... $= A''$
16 squares are devoted to the tribasic acids .... $= A'''$
16 squares are devoted to the quadribasic acids .... $= {}''A''$.

I place in a supplementary compartment, the diameracids resulting from the action of two acids upon one another.

I confine myself to those diamerides, in the formation of which from 1 to 4 atoms of water are eliminated, and from 1 to 4 atoms of neutral or alkaline matter employed. We know but two or three equations in which more than 4 Aq are eliminated, or more than 4 B employed.

A glance at the following table will at once manifest the plan of its division, and render any explanation unnecessary. The isolated figures preceded by the sign −, indicate the number of atoms of water eliminated; the figures preceded by the sign =, indicate the saturating capacity of the diamerides.

We have now to assign names to the sixty-four kinds of diamerides.

Let us represent the figures 1, 2, 3, and 4, by the vowels a, e, i, and o; and for the present neglecting the acid, let us designate

The square B − Aq by aa
The square B − 2 Aq by ae
The square B − 3 Aq by ai
The square B − 4 Aq by ao
The square 2 B − Aq by ea
The square 3 B − 2 Aq by ie
The square 4 B − 3 Aq by oi
The square 4 B − 4 Aq by oo,

and so on, the first vowel having reference to the organic matter employed, and the second to the water eliminated.

For the sake of euphony, let us add to these pairs of vowels, arbitrary consonants and terminations; then we shall call:

Anams or anamides .... $A' + B - Aq$
Aleses or alesides .... $A' + B - 2\ Aq$
Aziles or azilides .... $A' + B - 3\ Aq$
Anoses or anosides .... $A' + B - 4\ Aq$,

and so on.

To distinguish from one another, the respective products of mono-, bi-, tri-, and quadri-basic acids, we shall say:

Anamides .... $A' + B - Aq$
Dianamides .... $A'' + B - Aq$
Trianamides .... $A''' + B - Aq$
Tetranamides .... $''A'' + B - Aq$
Emonides .... $A' + B^2 - Aq^4$
Diemonides .... $A'' + B^2 - Aq^4$
Triemonides .... $A''' + B^2 - Aq^4$
Tetremonides .... $''A'' + B^2 - Aq^4$

Supposing we wish to designate the varieties; let us take at first the ammoniacal combinations, which will serve us for a type. We shall say:

Acetalese .... $A' + B - Aq^2$
Sulphalese .... $A'' + B - Aq^2$
Phosphalese .... $A''' + B - Aq^2$
Pyrophosphalese $''A'' + B - Aq^2$.

Lastly, let us vary B by substituting methol, alcohol, or phene, for ammonia. We shall say:

Acetanamide etholic .... $A' + B - Aq$
Formialese metholic .... $A' + B - Aq^2$
Sulphenelide phenic .... $A'' + B^2 - Aq^2$.

Let us establish two exceptions:

1°. In order to retain a name consecrated by custom, we will give to the following compounds, the names of

Amides .... $A' + B - Aq$ = acetamide
Diamides .... $A'' + B^2 - Aq^2$ = sulphamide
Triamides .... $A''' + B^3 - Aq^3$ = phosphamide
Tetramides .... $''A'' + B^4 - Aq^4$ = silicamide.

2°. We will designate the diameracids by these names:

Sulphamic	$A'' + B - Aq$
Sulphomethólic	
Phosphamic	$A''' + B - Aq$
Phosphodiamic	$A''' + B^2 - Aq^2$
Pyrophosphamic	$''A'' + B - Aq$
Pyrophosphodiamic	$''A'' + B^2 - Aq^2$
Pyrophosphotriamic	$''A'' + B^3 - Aq^3$.

I proceed now to review all the squares *seriatim;* and as a means of controlling the results arrived at, I shall admit that in those cases where but *one* atom of water is eliminated, the saturating capacity of the diameride is equal to the sum of the saturating capacities of the bodies employed, diminished by one unit.

It may be asked, whether the above rule is a mere empirical formula, or a result of observation. This question is the more natural, inasmuch as the rule seems to indicate, that the *nature* and *quantity* of B have no influence upon the saturating capacity of the hydrodiameride.

Chemistry presents us with two orders of facts, some that are estimated by means of figures, measures, and balances; others that can neither be weighed, nor measured, but simply appreciated. Thus, if we require to determine the saturating capacity of an acid, a balance will suffice; but when we seek to ascertain whether a body is an acid, an alkali, a salt, an alcohol, or an alloy, we find ourselves beset with innumerable difficulties, and are induced to inquire, whether or not alcohols, alloys, and metals, may all of them be salts. I freely admit, that it requires a sort of instinct or gift of second sight to guide us through these difficulties; and that, even with this undefinable assistance, we frequently run the risk of falling into error.

To apply the preceding rule, let us suppose that B represents ammonia. Is this body a base or an acid? In the latter case, what is its saturating capacity? This question seems absurd; but is not ammonia, like a tribasic acid, capable of exchanging 1, 2, and 3 atoms of hydrogen for 1, 2, and 3 atoms of a metal? Moreover, does it not, like phosphoric acid, form with alcohol, mono-, bi-, and tri-, ethylic combinations?

Do not the following bodies alike constitute salts?

MONOBASIC.	BIBASIC.	TRIBASIC.	
Chlorides.	Sulphides.	Phosphides	Nitrides.
ClH	SH^2	PH^3	NH^3
ClM.	SHM	PH^2M	NH^2M
	SM^2	$PH\,M^2$	$NH\,M^2$
		$P\ \ M^3$	$N\ \ M^3$.

Are there not also corresponding ethers?

$ClEt$.	$SHEt$	PEt^3.	NH^2Et
	SEt^2.		$NH\,Et^2$
			$N\ \ Et^3$.

I will not further pursue this parallel, which leads us to consider ammonia as a tribasic acid. But if we adopt this conclusion in our rule of control, we shall have

$$A' + Am''' - Aq = 3,$$

Acetic acid. Acetamide;

that is to say, that acetamide, which is neutral, ought to be a tribasic acid.

If on the other hand, we say, with the rest of the world, that ammonia is devoid of any capacity of saturation (metallic), then by making use of this conclusion in our formula, we shall have

$$A' + Am - Aq = 0,$$

Aspartic acid. Asparamide.

and yet asparamide forms salts with potassium, calcium, copper, zinc, silver, &c.

Nevertheless, no one would consider acetamide and asparamide as forming exceptions to our rule. And why? Because while we acknowledge that ammonia possesses the most important character of an acid, namely, the capability of exchanging hydrogen for a metal, or for ethyl,—we are, at the same time, firmly persuaded that it is not an acid, but, on the contrary, a body precisely opposed to an acid, that it is to say, an alkali. But if, even in this extreme case, we were asked to define exactly, without ambiguity or subterfuge, the reasons of our persuasion, we should be more embarassed than we perhaps imagine; unless indeed, we gave a definition of this description:—" An acid is a body which reddens the colour of litmus, and an alkaloid is a body which restores the blue colour of litmus that has been reddened by an acid." But we know to what conclusions such definitions would lead us.

I have entered into this discussion simply for the purpose of showing, that our rule of control differs from a mathematical formula; inasmuch as the terms of our equations have not an absolute value, and that consequently, we shall be obliged to appreciate, without measures and without balances, the results to which they conduct us.

With regard to the origin of this rule, it is one case of the general formula of Gerhardt; it is the fruit of observations which have proved its applicability in from ninety-seven to ninety-eight instances out of every hundred.

To return to our table. We see immediately that by drawing the diagonal, or rather the staircase X Y, all that part of the table on the right of the division is empty, while that on the other side is all but completely full.

The fourth horizontal series of compartments presents us with several voids, but this is in consequence of our being acquainted with only a very few quadribasic acids, and our not having endeavoured to transform them into hydrodiamerides. The empty squares are marked with an asterisk.

In addition to the sixty-four principal squares, we perceive four horizontal bands AA, BB, CC, and DD. They contain the salts of ammonium. We perceive that the monobasic acids form but one; the bibasic two, &c.; to which we may compare the diamerides.

TABLE FIRST.*

	X						
		$A' + B - 0 = 1$					
	A					A	
			M				
		$A' + B - 1 = 0$	$A' + B^2 - 1$	$A' + B^3 - 1$	$A' + B^4 - 1$		
		$A' + B - 2$	$A' + B^2 - 2$	$A' + B^3 - 2$	$A' + B^4 - 2$		
		$A' + B - 3$	$A' + B^2 - 3$	$A' + B^3 - 3$	$A' + B^4 - 3$		
		$A' + B - 4$	$A' + B^2 - 4$	$A' + B^3 - 4$	$A' + B^4 - 4$		
		$A + B - 0 A + B - 0$	M				
	B					B	
			M				
		$A'' + B - 1 = 1$	$A'' + B^2 - 1 = 1$	$A'' + B^3 - 1$	$A'' + B^4 - 1$		
		$A'' + B - 2 = 0$	$A'' + B^2 - 2 = 0$	$A'' + B^3 - 2$	$A'' + B^4 - 2$		
		$A'' + B - 3$	$A'' + B^2 - 3$	$A'' + B^3 - 3$	$A'' + B^4 - 3$		
		$A'' + B - 4$	$A'' + B^2 - 4$	$A'' + B^3 - 4$	$A'' + B^4 - 4$		
				M			
	C					C	
				M			
Phosphetholic acid		$A''' + B\,(^9) - 1 = 2$	$A'''\,(^7) + B^2 - 1 = 2$	$A''' + B^3 - 1 = 2$	$A''' + B^4 - 1$		
„ anhydride		$A''' + B \quad - 2$	$A'''\,(^6) + B^2 - 2 = 1$	$A''' + B^3 - 2 = 1$	$A''' + B^4 - 2$		
„ dianhydride		$A''' + B \quad - 3$	$A''' \quad + B^2 - 3(^1)$	$A'''\,(^8)\,B^3 - 3 = 0$	$A''' + B^4 - 3$		
Phosphorazilide; biphosphamide		$A''' + B \quad - 4$	$A''' \quad + B^2 - 4(^2)$	$A''' + B^3 - 4$	$A''' + B^4 - 4$		
				M	M		
	D					D	
					X	Y	
Pyrophosphamic acid		$A'''' + B\,(^3) - 1 = 3$	$A'''' + B^2 - 1 = 3$	$A'''' + B^3 - 1$	$A'''' + B^4 - 1 = 3$		
		„ -2	„ $(^4) \quad - 2$	„ $- 2$	„ $- 2 = 2$		
		„ -3	„ $(^5) \quad - 3 = 1$	„ $- 3$	„ $- 3$		
		„ -4	„ $- 4$	„ $- 4$ The preceding.—Aq.	„ $- 4$		Silicamide etholic.

(¹) Phosphoreliside = phosphamide (Gerhardt). (²) Phosphoremon (phospham). (³) Pyrophosphamic acid=azophosphoric (Gladstone). (⁴) Bi-azophosphoric acid. (⁵) The anhydride of the preceding. (⁶) Phosphodivinic and cyanuro-divinic acids. (⁷ query ⁹) Ammelide and sulphydromellonic acid $C^3N^3H^3O^3 + H^3N - H^2O$. (⁸) Melam and melamine,—also tribasic ethers. (⁹) Bibasic phosphovinic, also sulphoxiphosphovinic acid $PO^2S\,(C^2H^5O)\,H^2$.—Laurent.

* The first table, which is copied exactly from the French, does not correspond with the subsequent letter-press. I have appended another, more in accordance therewith, and have introduced some of Laurent's names and examples.—W.O.

TABLE SECOND.

$2A' + B - 1$		
" $- 2$		Disulphamic, and thionaphtic acids, possibly phtalic-bisulphate of carbyle.
" $- 3$		
" $- 4$		
$2A'' + B - 1$	$2A'' + B^2 - 1$	
" $- 2$	" $- 2$	
" $- 3$	" $- 3$	Carbodiorcellic, usnic acids, etc.
" $- 4$	" $- 4$	

TABLE THIRD.

	$A' + A' - 1$	Nitric acid + acid.
	$A'' + A' - 1 = 1$	Comenic, sulphamic, sulphobenzoic acids.
Ammeline soluble in alkalis and acids	$A'' + A'' - 1 = 3$	Aconitic, sulphosuccinic acids.
Ammeline anilic	$A''' + A' - 1$	
	$2A'' + A' - 1$	
	$2A'' + A' - 2 = 3$	Meconic acid.

SUPPLEMENTARY TABLE.—(W. O.)

X					
A	$A' + B - 0$				A
	$A' + B - 1 = 0$ Anamides. *Acetic ether. Benzamide.* $A' + B - 2 = 0$ Alesides or nitryles. *Aceto-nitryle. Nitrous oxide.* * * * * * * * * * *	*	*	*	
B	$A'' + B - 0$	$A'' + B^2 - 0$			B
	$A'' + B - 1 = 1$ Dianamides or monobasic diameracids. *Sulphovinic acid. Oxamic acid. Sulphobenzidic acid.* $A'' + B - 2 = 0$ Dialesides. *Phtalimide. Cyanic acid.* * * * * * * * * * *	$A'' + B^2 - 1 = 1$ Diameracid salt. *Sulphovinate of ammonia. Oxamate of aniline.* $A'' + B^2 - 2 = 0$ Dienelides or diamides. *Sulphobenzide. Sulphate of ethyl. Carbamide. Urethane.* $A'' + B^2 - 3 = 0$ Dielisides or diezilides. *Sinamine.* $A'' + B^2 - 4 = 0$ Diemonides. *Cyanogen.*	*	*	

	[illegible]	$A''' + B^2 - 0$	$A''' + B^3 - 0$		C
	$A''' + B - 1 = 2$ Trianamides or bibasic diameracids. *Phosphovinic acid.* $A''' + B - 2 = 1$ Trialesides. $A''' + B - 3 = 0$ Triazilides. *NPO biphosphamide.* * * * * *	$A''' + B^2 - 1 = 2$ Diameracid salt. *Acid phosphovinate of ammonia.* $A''' + B^2 - 2 = 1$ Trienelide or monobasic diameracid. *Phosphodivinic acid.* $A''' + B^2 - 3 = 0$ Triezilides or trielisides. *Phosphamide.* $A''' + B^2 - 4 = 0$ Triemonides. *Phospham.*	$A''' + B^3 - 1 = 2$ Diameracid salt. *Neutral phosphovinate of aniline.* $A''' + B^3 - 2 = 1$ Diameracid salt. *Phosphodivinate of ammonia.* $A' + B^3 - 3 = 0$ Triamides. *Phosphoric ether.* * * * * *	*	
D	$''A'' + B - 0$	$''A'' + B^2 - 0$	$''A'' + B^3 - 0$	$''A'' + B^4 - 0$	Y D
	$''A'' + B - 1 = 3$ Tetranamides or tribasic diameracids. *Pyrophosphamic* (*azophosphoric*) *acid.* * * * * * * * * * * * * * * *	$''A'' + B^2 - 1 = 3$ Diameracid salt. $''A'' + B^2 - 2 = 2$ Tetrenelide or bibasic diameracid. *Pyro-phosphodiamic* (*biazophosphoric*) *acid.* * * * * * * * * * *	$''A'' + B^3 - 1 = 3$ Diameracid salt. $''A'' + B^3 - 2 = 2$ Diameracid salt. $''A'' + B^3 - 3 = 1$ * * * * *	$''A'' + B^4 - 1 = 3$ Diameracid salt. $''A'' + B^4 - 2 = 2$ Diameracid salt. * * * * * $''A'' + B^4 - 4 = 0$ Tetramides or tetromonides. *Silicic ether.*	

DIAMERIDES OF THE MONOBASIC ACIDS.

Let us now examine the first square, that of the anamides. It contains the combinations of the monobasic acids, of the form $A'+B$—Aq.; such for example, as acetamide, anilic formamide, metholic formamide (formate of methyl), etholic nitramide, (nitric ether), phenenic nitramide (nitrobenzide).

It will astonish many, to see me place by the side of one another, the nitrate of ethyl = $Et^2O.2N^2O^5$, acetamide = $N^2H^4.C^4H^6O^2$, acetanilide = $N^2H^2.C^{12}H^{10}.C^4H^6O^2$, nitrobenzide = $C^{12}H^{10}O.N^2O^3$ &c. I admit that from the inspection of these dualistic formulæ, it would be absurd to attempt any establishment of analogies between the bodies which they represent. How indeed, can a nitrate of oxyde of ethyl be analogous to a simple or copulated amide?

But the question is not well put. We ought, in the first place, to avoid all pre-conceived theories, and simply appeal to experiment; and as this would show us, that acetamide and nitrate of ethyl resemble one another in their principal properties, and have not the slightest analogy with salts, ought we not to transpose the preceding question, and say,—why have chemists,* seeing that there is no analogy between nitrate of ethyl, and the nitrates, —sulphate of ethyl, and the sulphates, established hypothetical resemblances, between ethers and salts? Why have they given similar formulæ to bodies which have not the slightest similarity?

I will not anticipate a discussion to which we shall advert further on. Nevertheless, I cannot but express my astonishment, whenever I reflect that chemists have been accustomed to consider the sulphovinate of baryta as a double salt, composed of sulphate of baryta, insoluble, and sulphuric ether, soluble in alcohol.

I shall not further allude to the general characters of the amides, but would simply observe, that by having regard to the nature of B, they may naturally be divided into 1°, ALKALAMIDES, which may be sub-divided into *amides*, properly so called, into *anilamides*, *quininamides*, *methylaminamides*, *&c.* 2°, ALCOHOLAMIDES,

---

* I need scarcely point to Gerhardt as an exception, for it was he who first compared ethers and amides with one another. Nevertheless, he seems now to have adopted another opinion, which is not very far removed from the ethyl theory.

The entire arrangement of Gerhardt's admirable Traité de Chemie, as well as that of his recent papers, is founded on the doctrine of compound radicals.—(W. O.)

which may be subdivided into *metholamides, etholamides, valerolamides, &c.* 3°, HYDROCARBURAMIDES. 4°, ALDEHYDAMIDES, &c. For the present, I shall not proceed any further with these divisions, nor with those of the other diamerides; the examples above cited, are sufficient to explain the general course to be pursued.

Let us now examine the saturating capacity of the anamides. Conformably to our rule, which in fact was deduced from observations made upon them, they are neutral. Nevertheless, out of a hundred cases, three or four exceptions may be adduced. Here it is that we have to estimate or interpret the results, so as to see whether these exceptions are real or apparent.

The essential oil of Gaultheria procumbens, is a true methylic ether: as such, it comports itself with reagents, and moreover, it may be produced artificially according to the following equation;

$$\underset{\text{Salicylic acid}}{A'} + \underset{\text{Methol}}{B} - Aq. = \text{Salicylate of methyl.}$$

according to which it should have no saturating capacity. Nevertheless, experiment shows that it combines with all bases, to form salts which bear the names of gaultherates. Ought we then to consider the essence in question as constituting a real exception? Is it, indeed, a genuine acid? In the first place, if we except its aptitude for forming salts, the salicylate of methyl possesses all the characters of the ethers; it does not combine with ammonia, neither can it, like ordinary acids, form ethers with the alcohols,* nor amides with ammonia. If then, we consider it as an acid, we shall trench upon the same kind of reasoning, that would induce us to regard ammonia itself, as a tribasic acid.

Glycocol is a neutral body, which, nevertheless, combines with acids, salts, and bases. Considered as a neutral body and destitute of any saturating capacity, it would give rise to anomalies in its amides. Thus, hippuric acid, which is glycolic benzamide, ought to be a neutral body, according to the equation

$$A' + Gl - Aq = 0.$$

If, on the contrary, we consider glycocol as a monobasic acid,

---

* According to the experiments of Gerhardt, and of Cahours, gaultheric acid does form ethers; gaultherate of methyl, for instance, which may be considered as salicylic acid $C^7H^6O^3$ in which two atoms of hydrogen are replaced by methyl, $C^7H^4(CH^3)^2O^3$. Salicylic acid appears to stand upon the border land of bibasity. (W.O.)

the exception will disappear in the case of hippuric acid, to reappear however in the case of glycocol itself, which being the amide of glycolic acid, ought to be neutral. The remarks made with regard to hippuric acid, are equally applicable to glycocholic, and glycohyocholic acids, which are respectively glycolic cholesamide, and glycolic hyocholesamide.

Phenol or *phenic acid*, gives rise to similar difficulties. Is it an acid or neutral body? Accordingly as we consider it as one or the other, so shall we meet with an anomaly in sulphophenic, or in picric acid.

From these observations we conclude, that the *nature* of B does occasionally, although but very rarely, exercise a certain influence upon the saturating capacity of the diamerides. We shall presently see whether or not the *quantity* of B exerts a similar influence.

The *alesides* (nitryles) $A' + B - 2Aq$, ought to be neutral bodies, in accordance with the general experience, which proves to us, that a neutral body never becomes acid by the loss of its water; and that an acid body never becomes neutral by the absorption of water. Now the alesides are anamides deprived of one atom of water, and consequently they ought to be neutral. By the absorption of water they reproduce anamides; so that if they were acid, we should have acids *producing* neutral bodies by an absorption of water, which is absurd.

In reality, all the alesides are neutral, with the exception of form-aleside, which is no other than cyanhydric acid. But what a remarkable acid! Put in presence of potash, it remains uncombined. United with a neutral cyanide, (ferrous or ferric) it produces an energetic acid, capable of saturating bases most completely. With alcohol, methol, &c., it gives rise to ethers, from which neither the cyanhydric acid, nor the alcohol can be regenerated,—which compounds indeed constitute our alesides. With the essence of bitter almonds it, either with ammonia or by itself, behaves as if the essence were the acid, and it the neutral body.

There is another important remark to be made upon this subject. In following out the various *series* of organic compounds, we shall meet with several anomalies in the most simple of all,—that which contain but one atom of carbon. In the superior series, the number of atoms being more or less great, the influence exerted by their arrangement, more than counteracts that exerted by their nature. But in the lowest series, the nature of the material will often overbalance the order of the arrangement, and consequently exercise a great influence upon the properties proceeding therefrom. Thus it is that we meet with cyanhydric acid, cyanic acid, and chloroform, bodies which in their properties are not analogous to the corresponding terms of the superior series, though formed by virtue of similar equations.

It will be observed that up to this present time, the alesides have been produced exclusively from ammonia, (the most remarkable of them, nitraleside or nitrous oxide, must not pass unnoticed) we do not know of any that can be obtained from the alcohols. It would be interesting to see, whether it would not be possible to procure some of them, by acting upon certain ethers with anhydrous phosphoric acid.

Out of the 16 squares devoted to the monobasic acids, two only are filled. To them we may add the term $A+B—0$, or the salt of ammonium, as represented in the horizontal band AA, precisely underneath which term the two full squares are situated. Upon what does this relation depend? Is it due to chance, or can no other combination exist? If it were allowable to express an opinion upon the matter, I should say that it is impossible to obtain diamides with $A'+B^2$, or B^3, or B^4, in consequence of the monobasic acids being incapable of combining with more than a single atom of ammonia, and in consequence of the diamerides always corresponding to ammoniacal salts, whence it happens, that where the square of the ammoniacal salts is empty, the vertically inferior squares are also empty.

It would appear, nevertheless, that there exists one diameride of the form $A'+B^2—Aq^2$, namely, the pyromucic biamide. But several observations may be made concerning this compound.

In the first place, it has not been obtained from pyromucic acid, but from the distillation of mucate of ammonia, and we do not know whether or not mucic acid, when combined with bases, is transformable thus, into pyromucic acid, and consequently, we do not know, whether or not the body in question is really a species of amide of pyromucic acid.

We might also inquire, whether this latter acid is mono, or bibasic, though the latter opinion appears indeed the less probable. At any rate we see, that pyromucic biamide ought not to be considered as an authentic exception.

There are plenty of other *possible* cases that I have altogether left out of the table; the following for example:

$$2\ A'+B-Aq-Aq^2-Aq^3-Aq^4$$
$$2\ A'+B^2-Aq-Aq^2-Aq^3-Aq^4$$
$$3\ A'+\&c.$$
$$4\ A'+\&c.$$

So that in not passing beyond the number 4, we could have another table of 64 squares. Do, however, combinations of this kind really exist?

There is one singular acid that gives rise to diamerides in which A' and Aq vary from 1 to 6, and which are nevertheless reducible to the six following extremely symmetrical instances:

$$A'+B-Aq$$
$$2\ A'+B-Aq^2$$
$$3\ A'+B-Aq^3$$
$$4\ A'+B-Aq^4$$
$$5\ A'+B-Aq^5$$
$$6\ A'+B-Aq^6.$$

The acid that gives rise to all these combinations is the nitric. But if we recollect the manner in which we have regarded the nitro and nitroso substitutions, we shall see that it is more advantageous to place the nitro, binitro, trinitro, &c., naphthalines, the sexnitro mannite, &c., by the side of naphthaline and mannite, than among the diamerides, although they may certainly be placed in the latter division without violating any analogies.

With regard to the saturating capacity of nitro compounds, we have seen that it is constantly equal to that of the body from which the compounds were derived. Thus benzine is neutral, and the nitro-benzines are likewise neutral; benzoic acid is monobasic, nitro-benzoic acid is equally so. These results agree with the rule of control.

Nevertheless, it would seem that with nitric acid, other cases than those we have just adduced may present themselves. Thus we have the following equation:

$$6\ A'+B-Aq^4,$$

for the formation of sexnitro-lignine, that is to say, the portion soluble in ether. Lignine contains $C^{12}H^{20}O^{10}$,* and we know that under various influences it can absorb H^4O^2 to give rise to glucose or its isomerides. When treated with nitric acid it produces at first the xyloidine of Pelouze $C^{12}H^{18}X^2O^{10}$, then the xyloidine of Braconnot $C^{12}H^{16}X^4O^{10}$. If we admit then, that after this point the lignine absorbs H^4O^2, then it would give by a continuance of the action of the nitric acid, sexnitro-glucose = $C^{12}H^{18}X^6O^{12}$.

In other words, the reaction is not $6A'+B-4Aq$, but $6A'+B-6Aq$, only that the sexnitro-lignine instead of allowing the six atoms of water (formed at its expense and at that of the nitric acid) to be disengaged, retains two of them, so as to transform itself into sexnitro-glucose, or a sexnitro compound of some body isomeric with glucose.

Since we associate all nitro compounds with their normal congeners, we no longer have any monobasic diameride not included in our table. Nevertheless, one compound might be cited, namely, opiammon, of which the formula would be:

$$2\,A'+B-2\,Aq.$$

I must here make a reservation, not as to the interpretation, but as to the fact. I demand whether the analysis of opiammon is exact, or rather whether the body is not a mere mixture. By the agency of heat, opianic acid undergoes on isomeric modification and becomes insoluble in water, and even in potash. Opiammon is made by heating opianate of ammonia; ammonia is disengaged, and the residuary insoluble powder receives the name of opiammon. But as a result of the liberation of ammonia, opianic acid ought to be formed, which being modified by the action of heat, would remain mixed with the real opiammon or opianamide, the formula of which ought to be:

$$A'+B-Aq.$$

This view is rendered more probable by the fact, that when opiammon is treated with alcohol, it deposits a mixture of opianic acid, and it is said, of opiammon. But this is impossible, for if opiammon were a pure combination it might indeed bedouble itself into opianic acid and opianamide, but not into opianic acid and opiammon. Probably however, it is a mixture of modified

---

* These and the succeeding formulæ ought probably to be halved, so as to accord with the other two volume formulæ.—(W. O.)

opianic acid and opianamide, and by crystallisation separates into revivified opianic acid and opianamide, which has been mistaken for opiammon. Lastly, what contributes singularly to throw a suspicion upon the formula of opiammon, is, that when treated by potash it gives rise to opianic acid, and to a non-analysed xanthopic acid.

In conclusion, with the exception of the nitro combinations, we have no authentic proof of the existence of other monobasic diamerides, than those expressed by the two formulæ:

$$A' + B - Aq \quad \text{and} \quad A' + B - Aq^2.$$

DIAMERIDES OF THE BIBASIC ACIDS.

We observe at starting that the horizontal band BB contains two salts of ammonium $A'' + B—0$ and $A'' + B^2—0$. Since the diamerides should correspond to the ammoniacal salts, we comprehend why the squares not situated underneath these salts remain empty.

Diameracids, properly so called, $A'' + B - Aq$.

In accordance with our rule, we find all these bodies to be monobasic acids. Ammonia, and the other alkaloids, the alcohols, hydrocarbons, &c., give rise to acids, which, like all the hydrodiamerides, are capable of regenerating the acid, and the organic matter from which they were produced. Nevertheless, it must be observed that the hydrocarbon diameracids, and even the other diamerides thereof, regenerate the organic matter with extreme difficulty, and with a partial destruction. Thus nitro-naphthaline, and sulpho-naphthalic acid, in order to reproduce naphthaline, require to be very strongly heated with a hydrated alkali.

There is a fact which I have already pointed out, and to which I would again call the attention of chemists, namely, that diameracids always give rise to soluble salts of baryta, lead and silver. Frequently they are so soluble, that in order to isolate them from their solutions, we are compelled to precipitate them with absolute alcohol. Thus the sulphamates, sulphocarbamates, oxamates, camphoramates, &c., the sulphovinates, sulphocarbovinates, oxalovinates, camphovinates, &c., the sulphobenzidates, sulphonaphthalates, &c., of baryta, lead, and silver, are soluble. There are indeed, cases in which this solubility is influenced by an evident cause; this however, does not at all destroy the generality of the remarks I have just made. Thus, the sulphonaphthalates are soluble, the sulphochloronaphthalates are less so, the sulphotrichloronaphthalates still less, and the sulphoquadrichloronaphthalates scarcely at all, so little so in fact, that a solution of chloride of potassium is precipitated by the sulphotri-, and sulphoquadri-chloronaphthalic acids.

The diameracids form one of the most natural groups to be found throughout chemistry, and nevertheless, by the employment of dualistic formulæ, they are separated very widely from one another; their constitution being represented in the following manner:

Sulphovinic acid	$Et^2O.SO^3 + H^2O.SO^3$
Sulphamic acid	$N^2H^4.SO^2 + H^2O.SO^3$
Sulphobenzidic acid -	$C^{12}H^{10}.S^2O^5 + H^2O.$

The first appears as a combination of sulphate of ethyl with sulphuric acid, the second as a combination of sulphamide with sulphuric acid, and the third as a *copulated* hyposulphuric acid.

How is it, then, that oxamic and sulphamic acids form soluble salts with lime? Dualism is not to be confounded by such a trifle; it is because the constituent sulphuric and oxalic acids are *copulated* bodies.

I have a few words to say concerning aspartic, or malamic acid. Aspartate of silver, from the composition of which we should be led to consider aspartic acid as bibasic, is the only known insoluble aspartate. I believe in the existence of another and soluble aspartate of silver, which will be the real neutral salt. Indeed, when we mix aspartate of ammonia with nitrate of silver, no precipitate is produced; but on the addition of alcohol, we obtain a deposit of *neutral* and monobasic aspartate of silver. I say neutral, for if to its aqueous solution we add but a slight excess of ammonia, not the biargentic aspartate, but the brown oxide of silver is produced. But by ebullition, or, in the course of time, the soluble neutral aspartate is reduced by the oxide of silver (as are the tartrates by oxide of antimony at 200° C), and we obtain a biargentic salt. This salt, however, does not indicate the real saturating capacity of aspartic acid, any more than the heated emetics indicate that of tartaric acid. It is to be observed, in addition, that the other aspartates, with two atoms of metal, have a very powerful alkaline reaction, and are reduced to the neutral state even by carbonic acid.

There exists an amidic acid, the isamic, which does not belong to the class we are now considering. It corresponds to isatinic acid, which is itself, very probably, a diameride. The complication of these bodies is too great to allow of our associating them with the preceding.

Combinations of the form $A'' + B^2 - Aq$. I propose to make some few remarks upon compounds of this description, as they will afford us an opportunity of ascertaining, what influence the *quantity* of B exercises upon the saturating capacity of the diamerides. These compounds can only be formed upon one condition, namely, that one atom of B must be an alkaloid; while the other atom may be of the same alkaloid, of a different alkaloid, of an alcohol, or a hydrocarbon, &c.

We readily perceive the reason of this. If we remove one atom of B from our formula, it will remain $A'' + B - Aq =$ an amidic, anilic, or alcoholidic acid, which, being a monobasic acid, can only combine with a second atom of B, upon the condition of this second atom of B being an alkaloid, and not an alcohol, nor a hydrocarbon, as these last bodies do not unite with acids (except with elimination). We may thus have the following salts:

Sulphamate of { ammonia	$(A'' + B - Aq) + Am$
aniline	$(A'' + B - Aq) + An$
Sulphanilate of quinine	$(A'' + B - Aq) + Q$
Sulphovinate of ammonia	$(A'' + B - Aq) + Am$
Sulphophenate of ammonia	$(A'' + B - Aq) + Am$

in each of which, while the first B is an alkaloid, or an alcohol, or a hydrocarbon, the second B is necessarily an alkaloid.

We have here rather an interesting remark to make. Taking the case where B^2 represents two different alkaloids, it is evident that, according to the mode of preparation adopted, we may obtain two different but isomeric salts. Supposing that B and B' represent respectively ammonia and aniline; in one case, with sulphamic acid and aniline, we shall obtain a sulphamate of aniline, $=(A'' + B - Aq) + B'$(anilic); in the other, with sulphanilic acid and ammonia, we shall obtain a sulphanilate of ammonia $= (A'' + B' - Aq) + B$ (ammoniacal). Nevertheless, it is certain that these two salts, by the loss of Aq, will each of them give rise to one and the same body $= A'' + BB' - Aq^2$; and by parity of reason, the diamide produced from sulphovinic acid and aniline, will be identical with that obtained from sulphanilic acid and alcohol.

We come now to consider the influence exercised by the *quantity* of B. According to our rule, the quantity of B ought not to exert any influence upon the saturating capacity of the diameride; and, nevertheless, we know that the compound $A'' + B - Aq$ is an acid, whilst the compound $A'' + B^2 - Aq$ is a neutral salt. But for all this, there is no contradiction between the experimental results, and those deduced from our rule.

When we say that the saturating capacity of acetic acid is equal to unity, we mean to affirm, that acetic acid is a salt of hydrogen, and that it can exchange one atom of hydrogen, for one atom of ammonium, potassium, copper, zinc, &c.; consequently, the acetate of ammonium has also a saturating capacity equal to unity, because it can exchange one atom of ammonium, for one atom of potassium, copper, zinc, or even of hydrogen.

Hence we ought not to say, that the saturating capacity of sulphuric acid is equal to two, but that the saturating capacity of *every sulphate* is equal to two. To insist further upon this point would be useless.

The *dialesides* $A'' + B - Aq^2$ may be considered as monobasic acids, deprived of an atom of water. Consequently, they ought to be, as indeed they are, neutral.

Nevertheless, some of them—such as succinimide, phthalimide, &c.,—are capable of exchanging hydrogen for a metal; though, with the exception of carbaleside, or cyanic acid, they are none of them considered as acids.

And this exceptional body, what a singular acid does it constitute! We remark, in the first place, that, like cyanhydric acid, it belongs to the simplest series: then, that with ammonia it does not form a cyanate of ammonium,* and that with alcohols it produces not cyanic but allophanic ethers. Moreover, the cyanates form compounds which are usually regarded as methylic, ethylic, &c. cyanates, but which, in my opinion, are rather carbimides, or carbalesides of methylamine, ethylamine, &c. Lastly, cyanic acid, by its action upon the alkaloids, produces not salts, but ureas or diamides.

Thus the anomalous compounds that from time to time pre-

---

* The white powder obtained by condensing the vapours of cyanuric acid in ammoniacal gas, is probably only a mixture of carbamide and urea, the first of which bodies is capable of an isomeric transformation into the second. *Vide* further on, some remarks on the alkaline diamides.

sent themselves, have properties of so singular a nature, that we may well doubt whether or not they form real exceptions to our rule.

We are acquainted with but one alcoholic dialeside, namely, the product formed by the action of potassium upon succinic ether.

I ought not, in this place, to omit to notice a very remarkable compound, the only one of the kind to be met with throughout organic chemistry. I allude to cholestrophane. We are aware of the existence of double salts with two different acids; such, for instance, as the nitrophosphate of lead and the silicoborates. Now cholestrophane corresponds to a double salt, of two acids; at least, I consider it as a combination of oxaleside and carbaleside:

$$\left\{\begin{array}{l} CO^2\,H^2+NH^3-Aq.^2 \\ C^2O^4H^2+NH^3-Aq.^2 \end{array}\right\}$$

hence we understand why it should be so readily decomposed into ammonia, and carbonic and oxalic acids.

The *diamides* $A''+B^2-Aq^2$ form a tolerably numerous and varied class. Bibasic acids give rise to acid, neutral, and double salts. Now the diameracids correspond to the acid salts: the diamides to the neutral salts; and we ought to have double or mixed diamides corresponding to the double salts, which is indeed the case.

These mixed diamides are of two kinds, accordingly as they have been formed from two similar bodies, such as two alkaloids, two alcohols, two hydrocarbons, &c., or of dissimilar bodies, as of an alkaloid and an alcohol, an alcohol and a hydrocarbon, &c. The following classification will give an idea of their variety.

1° Simple diamides	*a.* Alkaloid	$A''+B^2-Aq^2$,
	b. Alcohol	$A''+L^2-Aq^2$,
	c. Hydrocarbon	$A''+C^2-Aq^2$,
	d. &c.	
2° Mixed diamides	*a.* two different alkaloids	$A''+B\mathit{B}-Aq^2$,
	b. two different alcohols	$A''+L\mathit{L}-Aq^2$,
	c. an alkaloid and alcohol	$A''+B\mathit{L}-Aq^2$,
	d. &c.	

Such bodies as oxamethane, urethane, sulphamethane, &c., would be classified amongst the mixed diamides.

I believe it will be unnecessary for me to give another specimen of dualistic formulæ, or to show that by their employment, it would be impossible to associate the following diamides with one another;

Sulphanilide	$H^2SO^4+An^2 \quad -Aq^2$,
Sulphate of ethyl	$H^2SO^4+Al^2 \quad -Aq^2$,
Sulphobenzide	$H^2SO^4+Bz^2 \quad -Aq^2$,
Sulphomethylane	$H^2SO^4+Am\ Me-Aq^2$,

All the diamides are neutral, or at any rate, not acid; and should be considered as simple amides of amidic or alcoholidic acids. Some of them, however, as asparagine, are capable of combining indifferently with acids, oxides, and salts.

Three curious observations may be made upon these compounds:—

1°. That with the exception of some diamides, none of the diamerides constitute alkaloids.

2°. That these exceptional diamides are capable of existing in two isomeric conditions; in the one case they are neutral, in the other, alkaline.*

3° Hitherto the alkaline diamides have been met with among the carbamides only.

Thus we are acquainted with

Carbamide and urea;

Flavine and carbanilide;

Neutral and alkaline carbanil-ammonide.

Melam and melamine.†

The methylaminic, ethylaminic, amylaminic, methylethylaminic, &c., carbamides, are alkaline.

Sinamine (?) thiosinamine, and sinapoline, are in my opinion thecarbamides of a new alkali. (*Vide* tables.‡)

The alkalinity of the carbamides, naturally induces us to ask, whether among the natural alkaloids such as quinine, there are any which may be considered as carbamides, and which consequently may afford us a chance of preparing them artificially. With the exception of sarcosine, they have all of them compo-

---

* Other hydrodiamerides obtained independently of acids, also present themselves with two modifications, such are, for example, hydrobenzamide and amarine, hydro-nitrobenzamide and nitramarine, furfuramide and furfurine.

† These two bodies are not diamides but cyanuric triamides Nevertheless, there is this remarkable point in connection with them—that they may be considered as varieties of amides of carbonic acid $= 3\ (H^2CO^3+2NH^3-3\ Aq.)$.

‡ I have not seen the tables to which Laurent makes such frequent refer-

sitions with which the above hypothesis is incompatible, even if we take into consideration the possibility of their being mixed carbamides of two different alkaloids or of an alkaloid, and an alcohol. With regard to sarcosine, it might be considered as a mixed or double carbamide of methol and methylamine.

The *dielisides* $A'' + B^2 — Aq^3$ are but few in number, and are not well known. I may however adduce the following :—

Cyanamide	$H^2CO^3 + 2NH^3 \quad — Aq^3.$
Sinamine*	$H^2CO^3 + \left\{\begin{matrix} NH^3 \\ NC^3H^7 \end{matrix}\right. — Aq^3.$
Product of †the distillation of sulpho-cyanide of benzoyl	$H^2CO^3 + 2NC^7H^7 — Aq^3.$
Product of the action of alcohol† upon sulpohcyanide of benzoyl .	$H^2CO^3 + \left\{\begin{matrix} NC^7H^7 \\ C^2H^6O \end{matrix}\right\} — Aq.^3$
One of the combinations of cyanogen‡ with sulphuretted hydrogen . .	$H^2C^2O^4 + 2NH^3 \quad — Aq.^3$

ence, but I believe that the following equations represent his views with regard to the above-mentioned bodies—

Urea	$H^2CO^3 + \left\{\begin{matrix} H^3N \\ H^3N \end{matrix}\right\} — 2H^2O = CH^4N^2O$
Thiosinamine	$H^2CS^3 + \left\{\begin{matrix} H^3N \\ C^3H^7N \end{matrix}\right\} — 2H^2S = C^4H^8N^2S$
Sinamine	$H^2CO^3 + \left\{\begin{matrix} H^3N \\ C^3H^7N \end{matrix}\right\} — 2H^2O = C^4H^8N^2O = C^4H^6N^2 + H^2O$
Sinapoline	$H^2CO^3 + \left\{\begin{matrix} C^3H^7N \\ C^3H^7N \end{matrix}\right\} - 2H^2O = C^7H^{12}N^2O.$

On the compound radical theory these bodies will be respectively—

Urea	$N^2H^4 \quad CO''$
Thiosinamine	$N^2H^3\ (C^3H^5)\ CS''$
Sinamine	$N^2H^3\ (C^3H^5)\ CO''$
Sinapoline	$N^2H^2\ (C^3H^5)^2CO''$

Or, seeing that urea is anomalous oxicyanate of ammonia, so may the other compounds be considered as anomalous oxi- and sulpho-cyanates.

Oil of mustard will be a dialeside—

$$H^2CS^3 + C^3H^7N — 2H^2O = C^4H^5NS = N\ (C^3H^5)\ CS'' = \left.\begin{matrix} C^3H^5 \\ CN \end{matrix}\right\} O$$

(W. O.)

---

* I have already placed sinamine among the diamides. According to the composition usually accorded to it, it should be placed here with the dielisides. I have reason, however, to believe, that true sinamine is a diamide, probably susceptible of losing H^2O with facility, so as to pass into the state of a dieliside, which, in its turn, may readily become reconverted into a diamide.

† *Vide* my observations in the tables.

‡ Gay Lussac represents this combination by $4CN + 3H^2S$. It was from a synthetical determination of the volumes of cyanogen and sulphuretted hydrogen

The *diemonides* $A'' + B^2 - Aq^4$ have up to this time but one representative, namely, cyanogen, or oxalemon.

DIAMERIDES OF THE TRIBASIC ACIDS.

I shall devote but a brief consideration to these compounds, of which but very few are known to us.

The horizontal band CC has three of its squares filled respectively by an acid ammoniacal, an acid bi-ammoniacal, and a neutral tri-ammoniacal salt. To each of these compounds there are corresponding diamerides.

The *diameracids* of the form $A''' + B - Aq$, ought to be, and are, bibasic. We may adduce as examples the phosphovinic and sulphoxiphosphovinic acids; $H^3PO^4 + C^2H^6O - Aq$, and $H^3PO^3S + C^2H^6O - Aq$.

Ought we to place in this division, sulph-hydromellonic acid and ammelide? These two compounds of the same type, are formed according to the equations

$$C^3H^3N^3O^3 + NH^3 - H^2O,$$
$$C^3H^3N^3S^3 + NH^3 - H^2S,$$

and should consequently be bibasic, whilst in reality they are simply monobasic. But we should scarcely be warranted in comparing the diamerides of cyanuric acid, already a very complex amide, with the diamerides of the simple acids.

Compounds of the form $A''' + B - Aq^2$. Seeing that the preceding acids are bibasic, we should conclude, that, like all other bibasic acids, they would by the loss of H^2O entirely lose their saturating capacity. But according to the formulæ of Gerhardt and Strecker, they ought to be monobasic. We are acquainted with but one compound belonging to this class, namely, citromonanilic acid, which saturates an atom of silver, or of aniline.

Such being the case, the anilic salt of this acid $(A''' + B - Aq^2.) + B$ ought to have the same composition as citrobianilic acid, $A''' + B^2 - Aq^2$, which is at present unknown.

It seems to me, that there is one very serious objection to be

---

that he arrived at this formula; such a process, however, cannot be exact, for the reaction takes place only in the presence of water, which necessarily dissolves and destroys the cyanogen. By an analysis of the crystals I arrived at the formula I have given above; only that the oxygen must be replaced by sulphur.

made to the preceding results, an objection which, in many other cases may throw us into considerable embarrassment.

Tribasic phosphoric acid, by the loss of water gives rise to pyro-, meta- . . . . phosphoric acids.

Let us admit that the ammoniacal phosphates may, by the action of heat, give rise in a direct manner to amidic compounds. We might then obtain from the acid phosphate, a bibasic phosphamic acid, $A''' + Am—Aq$. But as phosphoric acid by the loss of H^2O, passes into the state of metaphosphoric acid, it might happen that the above acid phosphate of ammonia, should, by the loss of H^2O, become converted into a neutral metaphosphate of ammonia, isomeric with phosphamic acid,—the formation of which body would be represented by the following equation:—

$$P''' + Am—Aq = P' + Am.$$

In this case, our rule would, in appearance, though not in reality, be at fault. A similar mode of reasoning may be applied to citric acid, which is also tribasic. We know, that this acid by the loss of water gives rise to aconitic acid, which is however still tribasic.

Let us admit for an instant, that citromonanilic acid $A''' + B—Aq^2$, has been prepared by means of aconitic acid: then its formula would be A''' (aconitic) $+ B—Aq$, and it should be bibasic.

But this opinion seems to be at variance with experiment, for Pebal has obtained with this acid, a monobasic salt of silver, and a monobasic salt of aniline, and has thence concluded that citra-monanilic acid is monobasic. But this conclusion is evidently premature; for in order to decide whether phosphoric acid for example, is monobasic, or tribasic, it is not sufficient to prepare a mono-argentic or a mono-ammoniacal phosphate, but we must ascertain the possibility or impossibility of obtaining bi- and triargentic salts.

But Pebal has obtained with citromonanilic acid, another silver salt which is bibasic, but which contains an additional atom of water, so that it may be regarded as a bibasic citromonanilate, corresponding to the formula $A''' + B—Aq$. Pebal has therefore decomposed this salt by hydrochloric acid, for the purpose of obtaining the above acid $A''' + B—Aq$, but as by evaporation, the acid $A''' + B—Aq^2$, was alone deposited, he thence concluded that the biargentic salt, was a monobasic salt with excess of base.

We should then have,

Citromonanilic acid	$C^{12}H^{13}NO^6$,
Neutral silver salt	$C^{12}H^{12}AgNO^6$,
Hydrobasic salt	$C^{12}H^{12}AgNO^6+HAgO$.

But the great rarity of basic salts of silver, forbids us to accept such a result without a double or triple proof, and we are led to ask, whether the above salt may not contain an atom of water, or whether there may not be an error in the analysis. Then its formula would become,

$$C^{12}H^{11}Ag^2NO^6+H^2O\ ?^*$$

I have founded the above remarks upon the assumption, that citromonanilic acid was prepared from aconitic acid, which is not the case. But Pebal, having prepared his acid by heating the acid citrate of aniline to 150°, is it not possible, that the citric acid may have passed into the state of aconitic acid, or preferably into the state of aconito-monanilic acid? We ought therefore to ascertain, whether this last compound can regenerate, aconitic or citric acid. Be this as it may, the table I have given, will serve to control our rules, and to show whether or not they are conformable to experiment.

The *triazilides* $A'''+B-Aq^3$ have up to this time but one representative, namely, phosphorazile or biphosphamide, $=H^3PO^4+NH^3-Aq^3$, which body might also be considered as a metaphosphoric nitryle $HPO^3+NH^3-Aq^2$. With regard to the difficulties springing from this consideration, I shall say a few words further on.

The *compounds of the form* $A'''+B^2-Aq$ are acid salts of ammonia, aniline, &c., having for their acid the formula $A'''+B-Aq$. Acid phosphovinate of ammonia may be taken as an example. Of the substances represented by B^2, one must be an alkaloid.

---

* I believe that this, and the preceding formulæ, are incorrect. They should be as follows:

Citromonanilic acid (unknown).	Aconitomonanilic acid (known as citromonanilic.)
$C^{12}H^{13}NO^6$	$C^{12}H^{11}NO^5$
Acid silver salt (unknown).	Acid silver salt (known).
$C^{12}H^{12}AgNO^6$	$C^{12}H^{10}AgNO^5$
Neutral silver acid ?	Hydrated neutral silver salt ?
$C^{12}H^{11}Ag^2NO^6$	$C^{12}H^9Ag^2NO^5+H^2O$ or $C^{12}H^{10}AgNO^5+HAgO$.

The composition of Pebal's salt accords with each of the lowest three formulæ.—(W. O.)

The *compounds of the form* $A''' + B^3 - Aq$ are neutral ammoniacal, or anilic salts of the same acid as the preceding, namely, $A''' + B - Aq$. Of the substances represented by B^3, two at least must be alkaloids.

We may say then, that the three formulæ

$$A''' + B - Aq,$$
$$A''' + B^2 - Aq,$$
$$A''' + B^3 - Aq,$$

represent the acid, and the acid and neutral salt, and are, despite the contrariety of their appearances, but three varieties of the same type.

Compounds of the form $A''' + B^2 - Aq^2$ ought to be monobasic acids. We have seen that $A''' + B - Aq$ represents a bibasic acid, and we know that if to such an acid we add B, and abstract Aq, it loses an unit of its saturating capacity.

We may adduce as examples the phosphodivinic, arseniodivinic, and cyanurodivinic acids. Ammiline, which would be the cyanurodiamic acid, is it acid or alkaline? We cannot say. It forms, however, a monobasic salt of silver.

Compounds of the form $A''' + B^3 - Aq^2$, are ammoniac or anilic salts of the preceding monobasic acids.

Of the bodies represented by B^3 one at least must be an alkaloid. As an example of this class of bodies, we may cite the phosphodivinate of ammonia.

The *trielisides* $A''' + B^2 - Aq^3$ ought to be neutral, since they represent the monobasic acids $A^3 + B^2 - Aq^2$ minus one atom of water. We are acquainted with but two examples—phosphorelise or phosphamide, and anilic citronelise, or citrobianil.

The *triemonides* $A''' + B^2 - Aq^4$ have but a single representative, namely, phosphoremon or phospham.

The *triamides* $A''' + B^3 - Aq^3$ ought to be neutral, since they represent the simple amides of the monobasic acids $A''' + B^2 - Aq^2$. We may adduce the neutral phosphoric, cyanuric, and citric ethers, — the boracic ethers $H^3BO^3 + 3\,CH^4O - Aq^3$, and $H^3BO^3 + 3C^2H^6O - Aq^3$,—and melamine as examples.

The triamides ought to comprise a very great variety of compounds, for B^3 may represent three atoms of the same alkaloid, the same alcohol, or the same hydrocarbon; or three atoms of different alkaloids, or of different alcohols, or of different hydrocarbons; or of the three atoms, two may be alkaline or alcoholic,

&c., and the third atom belong to a class different from that of the other two; or of the three atoms, one may be an alkaloid, one an alcohol, and one a hydrocarbon.

I take this opportunity of showing, how liable we are to mistake apparent for real anomalies. Tribasic citric acid by the loss of an atom of water becomes changed into aconitic acid, which is also tribasic. Suppose that in attempting to make citralese, or citramic anhydride $Ci''' + Am - Aq^2$, we were to obtain a bibasic acid. This compound might be a diameride, not of citric, but of aconitic acid, in which case its saturating capacity would correspond with the rule, in accordance with the formula A'''(aconitic)$ + Am - Aq$. Similar observations are applicable to certain diamerides of phosphoric acid.

DIAMERIDES OF QUADRIBASIC ACIDS.

The horizontal band DD presents us with four ammoniac salts, to each of which correspond four classes of diamerides.

The *diamerides of the form* $''A'' + B - Aq$ ought to be tribasic. I can only adduce one example of this kind, namely, Gladstone's azophosphoric acid, or rather pyrophosphamic acid $= H^4P^2O^7 + NH^3 - Aq$. Gladstone's formula, which differs considerably from this, is inadmissible. (*Vide* my observations in the Tables.)

The *compounds of the forms*

$$''A'' + B^2 - Aq,$$
$$''A'' + B^3 - Aq,$$
$$''A'' + B^4 - Aq,$$

are the three ammoniac, anilic, &c., salts of the preceding tribasic acid. We ought to obtain with pryrophosphamic acid (= PhB)

The acid....	$H^3\ (PhB)$
Two acid salts....	$H^2B\ (PhB)$ $H\ B^2(PhB)$
The neutral salt	$B^3(PhB)$

One atom of B may be an alcohol, an alkaloid, a hydrocarbon, &c. (this is, so to speak, the dissimulated or copulated B), but the remaining three atoms must be alkaloids. We perceive that no matter what the quantity of B, these four compounds belong to the same type, and have the same saturating capacity.

The *diameracids of the form* $''\mathrm{A}'' + \mathrm{B}^2 - \mathrm{Aq}^2$ ought to be bibasic, for if to the preceding acid we add B, and at the same time abstract from it $\mathrm{H^2O}$, we shall render it bibasic. We are acquainted with one compound of this class, namely, the biazophosphoric, or rather pyrophosphodiamic acid. I cannot admit the formula attributed to this compound by Gladstone. (*Vide* Tables.)

The *compounds of the forms*

$$''\mathrm{A}'' + \mathrm{B}^3 - \mathrm{Aq}^2$$
$$''\mathrm{A}'' + \mathrm{B}^4 - \mathrm{Aq}^2,$$

are the acid and neutral salts of the preceding acid.

The *diameracids of the form* $''\mathrm{A}'' + \mathrm{B}^3 - \mathrm{Aq}^3$ ought to be monobasic, since the preceding acid, by losing Aq and gaining B, ought to lose an unit of its saturating capacity. I am not acquainted with any example.

The *tetramides* $''\mathrm{A}'' + \mathrm{B}^4 - \mathrm{Aq}^4$ may be considered as simple amides of the preceding monobasic diameracids $''\mathrm{A}'' + \mathrm{B}^3 - \mathrm{Aq}^3$, and ought to be neutral. Hitherto we do not know of any other example than that afforded by silicic ether, or etholic silicamide $= \mathrm{H^4Si^2O^4} + 4\ \mathrm{C^2H^6O} - 4\ \mathrm{Aq} = 2$ volumes.

COMBINATIONS APPERTAINING TO THE SECOND TABLE.

Of diamerides not included in the principal table, I am acquainted with but a very small number. They may be separated into two classes.

Diameracids of the form $2\ \mathrm{A}'' + \mathrm{B} - \mathrm{Aq}^2$, of which the saturating capacity ought to be equal to two, as demonstrated in the following successive equations:

$$\text{First}\quad \mathrm{A}'' + \mathrm{B} - \mathrm{Aq} = A'$$
$$\text{Second}\quad \mathrm{A}'' + A' - \mathrm{Aq} = A''.$$

I may cite Jacquelain's acid disulphamate of sulphammon, thionaphthic, and ethionic acids, possibly Magnus'* sulphate of

---

* Reguault originally accorded to this compound the formula $\mathrm{SO^3.C^2H^4}$. Subsequently, Magnus proposed $\mathrm{2SO^3.C^2H^4}$. It appears to me, that both bodies may possibly exist, the production of one or the other depending upon the mode of preparation. Thus with anhydrous sulphuric acid and ammonia, we obtain

carbyle, doppeltsulphœthyl-schwefelsæure,* and terepthalic or dicarbenzidic acid (for all the above compounds *vide* my observations in the tables).

Diameracids of the form $2\ \mathrm{A}'' + \mathrm{B}^2 — \mathrm{Aq}^3$? I believe that the erythric, gyrophoric, usnic, and evernic acids enter into this category. They may also be considered as anhydrides of the monobasic erythrilinic, everninic, &c., acids. (*Vide* Tables.)

TABLE THIRD, COMPRISING THE PRODUCTS OF THE ACTION OF THE ACIDS UPON ONE ANOTHER.

Let us first of all remove the products obtained by the action of nitric acid, as represented in the following equations:

$$\mathrm{A}' + A' — \mathrm{Aq}$$
$$2\ \mathrm{A}' + A' — \mathrm{Aq}^2$$
$$3\ \mathrm{A}' + A' — \mathrm{Aq}^3$$
$$4\ \mathrm{A}' + A' — \mathrm{Aq}^4.$$

The saturating capacity of all these products is the same, that is to say, precisely equal to that of the acid A' employed.

sometimes $\mathrm{SO^3.H^6N^2}$ (Rose), sometimes $\mathrm{2SO^3.H^6N^2}$ (Jacquelain gives a different formula); with naphthaline we have sometimes $\mathrm{SO^3.Np}$, sometimes $\mathrm{2SO^3.Np}$.

Magnus' sulphate of carbyle absorbs water, and produces ethionic acid which is bibasic, $\mathrm{2H^2SO^4.C^2H^4}$.† The rule of saturating capacity appears here to be really at fault, for $\mathrm{2H^2SO^4}$ in combining without elimination of water, with $\mathrm{C^2H^4}$, ought to retain a capacity of saturation $= 4$. Nevertheless, there is no real anomaly. A metamorphosis has, indeed, taken place, and we are no longer dealing with a combination of etherine $\mathrm{C^2H^4}$, but with a combination of alcohol $\mathrm{C^2H^4.H^2O}$. Consequently we must write the equation thus:

$$\mathrm{2H^2SO^4 + C^2H^6O — 2\ Aq.}\quad \text{Ethionic bibasic.}$$

We ought to have:

Sulphethenic acid (Regnault)	$\mathrm{H^2SO^4 + C^2H^4\ — Aq.}$	Monobasic.
Sulphovinic acid...........................	$\mathrm{H^2SO^4 + C^2H^6O — Aq.}$	„
Disulphethenic acid (Magnus)	$\mathrm{2H^2SO^4 + C^2H^4\ — 2Aq.}$	Bibasic.
Disulphovinic or ethionic acid	$\mathrm{2H^2SO^4 + C^2H^6O — 2Aq.}$	„

The acid of Magnus transforms itself into ethionic acid; will that of Regnault produce sulphovinic acid, or an isomeride? Lastly, pardon the supposition, may not one of the so-called isomerides of sulphovinic acid be no other than sulphethenic acid.

* *Vide* the series $\mathrm{C^2}$. Ethionic, disulfit-etholic acids, &c.

---

† This formula for ethionic acid is incorrect. The succeeding paragraph is consequently inapplicable, but the remainder of the note is unaffected, inasmuch as with $\mathrm{C^2H^4}$ the calculated saturating capacity of ethionic acid would equal 3.—(W. O.)

We have previously considered them (*vide* Nitro Substitutions) as nitro-, and bi-, tri-, and quadrinitro-, acids.

Let us also remove the products of the action of nitric acid upon the bibasic acids.

$$\begin{aligned} \mathrm{A} + A''&\text{—}\mathrm{Aq} \\ 2\ \mathrm{A}' + A''&\text{—}\mathrm{Aq}^2 \\ 3\ \mathrm{A}' + A''&\text{—}\mathrm{Aq}^3. \end{aligned}$$

The saturating capacity of A'' does not alter. We obtain nitro-, bi-, tri-, and quadrinitro-, bibasic acids.

Compounds of the form $\mathrm{A}' + A'$—Aq, and even of the form $\mathrm{A}' + \mathrm{A}'$—Aq. With the exception of certain nitro-compounds, I do not know of any products resulting from the action of two monobasic acids upon one another.

But there exists a tolerably large number of compounds, which are obtained by different processes, but which may be considered as originating from the action of two monobasic acids upon one another. These compounds, in the presence of water dedouble themselves, so as to produce the two acids which by hypothesis served to form them. To this class belong the products of the action of chloride of benzoyl upon the different monobasic acids, and even upon benzoic acid itself. In the last case we obtain the benzoic anhydride, a complex product, and a real diameride, of the same nature as the acetylic, butyric, &c., benzoates.

Monobasic anhydrides	$\mathrm{A}' + \mathrm{A}'$—Aq
Anhydrides of two different acids	$\mathrm{A}' + A'$—Aq.

If we could also apply the rule of control to compounds of this class, they ought to be monobasic; but we cannot say whether or not they are so, for when put in the presence of bases, they become decomposed, and regenerate the two acids which served to produce them.

Compounds of the form $\mathrm{A}'' + A'$—Aq ought to be bibasic. I may adduce the sulphacetic and sulphobenzoic acids. Possibly comenic acid might also be mentioned,

$$\mathrm{C^6H^4O^5 = H^2CO^3 + C^5H^4O^3\text{—}Aq.}$$

Pyromeconic (monobasic).

Compounds of the form $\mathrm{A}'' + A''$—Aq ought to be tribasic. I may cite the sulphosuccinic, and even the aconitic acid,

$$\mathrm{C^6H^6O^6 = H^2CO^3 + C^5H^6O^4\text{—}Aq.}$$

Citraconic (bibasic).

Compounds of the form $2\ A'' + A' - 2\ Aq$. By effecting the reactions at two operations, we shall see that the product ought to be tribasic. I scarcely dare cite meconic acid as an example.

$$C^7H^4O^2 = 2\ H^2CO^3 + \underset{\text{Pyromeconic.}}{C^5H^4O^3} - 2\ Aq.$$

We have as the first step,

$$H^2CO^3 + \ C^5H^4O^3 - Aq = \underset{\text{Comenic bibasic.}}{C^6H^4O^5}$$

$$H^2CO^3 + \ C^6H^4O^5 - Aq = \underset{\text{Meconic tribasic.}}{C^7H^6O^7}.$$

SUMMARY.

Let us now recapitulate the principal observations we have made, on the compounds comprised in our table.

1°. *To analogous equations there correspond analogous bodies.* This is the principal result we have endeavoured to arrive at, in our study of the action of bodies upon one another.

2°. *The diamerides always correspond to the ammoniacal salts placed in the horizontal bands AA, BB, CC, and DD;* hence we understand why the compartments to the right of the staircase line XY, are empty.

3°. *The "quality" of B but very rarely exerts any influence upon the saturating capacity of the diamerides.*

4°. *The "quantity" of B does not exert any influence upon this capacity.*

5°. *In every case where B exceeds Aq, the product is an ammoniacal* salt,—and the difference between B and Aq, indicates precisely the quantity of ammonia which is in the state of ammonium, in the diameridic salt.*

6°. *When B represents an alcohol, a hydrocarbon, &c., it never exceeds Aq, but is either equal or inferior thereto.*

7°. *In the diameracids B is equal to Aq, but must always be inferior to the number representing the saturating capacity of the acid employed. The difference between this number and that of the atoms of B, represents the saturating capacity of the diameracid produced.*

8°. *The diameracids and their ammoniacal salts are situated on*

---

* For the sake of greater simplicity, I have applied the chief part of the reasoning to ammonia.

the same horizontal line. There are as many salts (neutral and acid) as there are squares between the diameracid and the zigzag line X Y.

9°. *Lastly, the composition of every diameride is such, that it may be represented by one of the salts of ammonium of the horizontal bands AA, BB, &c., minus water.*

Consequently representing a

Bibasic acid by .... RHH
Its acid salt by .... RHAm
Its neutral salt by RAmAm.

We may represent

The diameracid by .... $RH\ Am^{-1}$
Its salt by .... $R\ Am\ Am^{-1}$
The dialeside by .... $RH\ Am^{-2}$
The diamide by .... $RAm^{-1}Am^{-1}$
The dieliside by .... $RAm^{-1}Am^{-2}$
The diemonide by .... $RAm^{-2}Am^{-2}$.

The signs—1 and—2 indicate the quantity of water necessary to convert the diameride into the normal, neutral, or acid salt.

PART FOURTH.

ATOMIC THEORY.

SECTION FIRST.

Arrangement of Atoms.—Compound Radicals and Types.—Theory of Residues.

ARRANGEMENT OF ATOMS.

In the first part of this work, we endeavoured to prove, that the atoms of compound bodies are not arranged in accordance with the dualistic theory, and we pointed out the incompatibility of this system, with the equivalents that we employ.

Before proposing another system, we ought, in the first place, to resolve the following question:—In compound bodies, is there any predisposition in the arrangement of the atoms, from which arrangement the chemical properties result?—and if so, are we capable of ascertaining what this predisposition really is?—or, in seeking to discover this arrangement, are we not pursuing a chimera, and may not the atoms be simply disposed in a symmetrical manner, having relation to the crystalline form of the body?

I have often sought for the reasons that have induced the majority of chemists to oppose this last system, but I have seldom found any other than the following one; namely, that we should then be obliged to represent the composition of alum by the formula of $H^{48}O^{40}S^{4}K^{2}Al^{4}$, and that the tendency of such formulæ would be to throw everything into the greatest confusion.

The point, however, that we are endeavouring to ascertain, is not whether the empiric formula of alum will lead to greater or less embarrassment, but, on the contrary, whether the atoms are really disposed in such or such a fashion: whether for the purpose of study, or for the assistance of the memory, it would be advisable to divide this formula into two or more parts is another question, and one that I propose to revert to further on.

In the meantime I shall endeavour to prove the following proposition:—

In the arrangement of atoms there is a predisposition, by which we are enabled to account for the chemical properties of certain compound bodies.

First Argument.—If we mix together saltpetre and sugar, and heat them out of contact with the air, a vivid combustion is produced, which, as we know, is due to the reaction of the elements constituting the group sugar, upon the elements constituting the group saltpetre.

When we heat out of contact with the air, certain pure and unmixed bodies, such as picric acid, nitronaphthaline, nitrobenzide, &c., a combustion similar to the preceding is produced. But how are we to explain the combustion in this case, since we have not here employed two different bodies capable of reacting upon one another?

We may at starting remark, that all these compounds are obtained by treating certain organic matters with nitric acid; that they are nearly all of a yellow or reddish colour, resembling that of nitrous vapours; that they readily yield a certain portion of their oxygen to sulphydric and sulphurous acid, exactly as do the nitrous and nitric acids; and, lastly, that they all contain nitrogen.

Is it not, then, natural to admit, that the nitrogen exists in the state of nitrous, hyponitric, or nitric acid, that these acids form a distinct group in the detonating compounds, and that during the combustion their elements re-act upon the remaining elements of the organic matter? Have we not, on the one hand, the group that corresponds to saltpetre, and on the other hand, the combustible group that corresponds to sugar?

It is impossible to attribute the combustion solely to the nature and number of the constituent atoms, for we know thousands of bodies which have an analogous composition; that is to say, which contain carbon, oxygen, hydrogen, and nitrogen, but which, *not having been obtained by the action of nitric acid*, do not detonate when heated in close vessels.

There exist, indeed, two compounds, nitrotoluol and carbanilic acid, which have exactly the same composition, but of which, only the one obtained by the action of nitric acid detonates when heated in close vessels. This simple detonation is insufficient to determine, whether the nitrogen of these compounds exists in the state of nitrous, hyponitric, or nitric acid; we may readily, however, restrict our suppositions. When HNO^3 is put in the presence of C^6H^6,—H^2O is separated. Now in this case, all the oxygen of the water is furnished by the nitric acid; one part of the hydrogen is necessarily furnished by the benzine, and it remains to be ascertained, whether or not the nitric acid has supplied the remainder. In the one case we shall have the two groups C^6H^5 and NO^2, and in the other, the two groups C^6H^4 and HNO^2. The mode of arranging the two groups in respect to one another is unimportant. We reject the latter supposition, as being opposed to reasons deduced from the isomorphism and analogy, which exist between normal bodies and their nitro-derivatives. (*Vide* article, Nitro Substitutions.) In the first case, we may ask in addition, whether one only of the two atoms of oxygen is combined with the nitrogen so as to form nitric oxide, and whether the combustible property is not due to the presence of this compound. Such a supposition is, however, inadmissible; for we find that sulphuretted hydrogen seizes upon both of the oxygen atoms of nitro compounds, while it never acts upon the oxygen of ordinary organic compounds, except in some very rare cases in which a substitution of sulphur for oxygen is effected,—a result never produced with detonating bodies. In conclusion then, we are *convinced* that these nitro compounds contain a nitric group, which *most probably* corresponds to the red peroxide of nitrogen vapours.

Second argument. We have here a list of different bodies;

1°. $C^{17}H^{20}N\,O^3Cl$
2°. $C^{17}H^{20}N^2O^6$,
3°. $C^{18}H^{21}N\,O^5$,
4°. $C^{34}H^{40}N^2O^{10}S$,
5°. $C^{19}H^{23}N\,O^5$,
6°. $C^{23}H^{22}N^4O^{10}$,

the composition of which presents us with very great differences. Nevertheless, when acted upon by the same re-agent—ammonia for example—they are all transformed into a certain particular product containing $C^{17}H^{19}NO^3$: all of them, including this last product, when treated with bichloride of platinum give rise to the same compound, $C^{17}H^{20}NO^3Cl^3Pt$: all of them act in a very special and characteristic manner upon the animal economy as violent poisons;

and all of them exert an action upon polarized light. These compounds are, I presume, already recognised as the salts of an alkaloid, which is indeed morphia. How could we conceive, that these bodies, so different in their composition, were possessed of properties in common, unless they contained one and the same group, to which these properties were due? If it were not so, why should the fifth salt, namely the acetate, when acted upon by potash, give rise to morphia, rather than to some one of a hundred other alkaloids, and to acetic rather than to formic, butyric, carbonic, or some one of a hundred other acids? The compound was indeed prepared from morphia and acetic acid; but if the atoms of the two bodies are mixed, then neither acetic acid nor morphia can exist in the salt, and consequently, potash might equally well set free ammonia, methylamine, or aniline, instead of morphia. This, however, is not the case, either with the acetate, or with any of the other salts.

If in these salts, there were not any predisposition in the arrangement of their atoms, why should the sixth, prepared with picric acid, be like the acid itself, of a yellow colour, and like it, detonate when heated in close vessels? Why, by the action of potash should the salt split itself up into a yellow detonating acid, and a colourless non-detonating alkaloid, rather than into a colourless non-detonating acid, and a yellow detonating alkaloid?

All these phenomena do not prove that the preceding salts contain morphia; that the hydrochlorate, for example, is rather $C^{17}H^{19}NO^{3}.HCl$, than $C^{17}H^{20}NO^{3}.Cl$; or, $C^{17}H^{18}NO^{3}.H.HCl$; or, $C^{17}H^{16}O^{3}(NH^{4}).Cl$, &c., but simply, that they all contain a morphic group, (whether morphia, morphinum or a morphic amide) to which they owe their properties. If it were otherwise, we could not conceive why the first salt should not be a febrifuge; the second, a very wholesome aliment; the third, a violent poison; the fourth, an indifferent body, &c.

We may treat aniline by the most various re-agents; we may prepare from it, salts, aniles, anilides, anilic acids, melaniline, cyaniline, and dicyanomelaniline; we may treat each of these compounds by ammonia, potash, heat, acids, &c., and ultimately, having metamorphosed the aniline in a thousand different ways, we may always cause it to re-appear in its original condition, as if, throughout all its metamorphoses, and *even after the loss of some of its constituent elements*, it had yet retained its individuality.

We know that aniline when, submitted to the action of chlorine, produces trichloraniline.

Now by the action of this same re-agent upon the great majority of anilic compounds, even upon those which like the anilides contain but an incomplete aniline, do we likewise find this transformation into chloraniline to obtain, as if all of the compounds in question contained, if not a perfect aniline, at least its dismembered trunk.

We combine a bibasic acid, the carbonic for example, with two equivalents of alcohol; the resulting ether can dedouble itself and regenerate the two identical compounds from which it sprang. Thence we conclude that it probably contains three groups C, C^2, and C^2. This probability becomes a certainty, when we examine the products of decomposition afforded by its chloro-derivative. This body, when submitted to the action of heat, potash, alcohol, ammonia, &c., is decomposed into various products, which belong, one to the carbonic family C, and two others to the alcoholic family C^2. Lest these results should be looked upon as the effects of chance, or of affinities, we will adduce in addition, the oxalates of methyl and chloromethyl; of ethyl and chloroethyl, which comport themselves in a similar manner. The first named bodies give rise to a product corresponding to oxalic acid C^2, and two other products corresponding to methylic alcohol C, the second to a product corresponding to oxalic acid C^2, and two others corresponding to ethylic alcohol, C^2.

The perchlorinated and nonchlorinated bibasic succinic ethers, ought, for the same reason, to contain their carbon in three groups. One C^4 group depending upon the succinic acid, and two C^2 groups depending upon the alcohol; hence these two ethers, when acted upon by heat, potash, alcohol, ammonia, &c., are decomposed into a product containing C^4, and two others containing C^2. Only it must be remarked, that the chloro C^4 products (chlorazosuccic acid, for example) are very unstable, and are readily decomposed into a C^3 product, and carbonic acid, which results, may render the reaction apparently anomalous.

I do not know what are the three groups that exist in succinic ether, what their position, &c.; but certainly the carbon exists in three forms, or, rather, once as C^4, and twice as C^2. Were it otherwise, there would be a thousand chances to one against our obtaining the known reactions of this ether.

Third Argument.—If we add a single equivalent of hydrogen to indigo, isatine, alloxan, or kinone; an equivalent of oxygen* to

---

* $H=1=$ the atom of hydrogen; $H^2=2=$ the equivalent of hydrogen; $O=16=$ the atom and equivalent of oxygen.—(W. O.)

aldehyde, hydruret of benzoyl, dialuric acid, or sulphurous acid; an equivalent of chlorine to etherine or naphthaline; or if we abstract an equivalent of hydrogen from hydrokinone, alcohol, or benzoine, on the instant all the properties of the above bodies are changed. If to any other compound body, we add or abstract a single equivalent of a simple substance or of a binary compound, we shall equally see, that the properties of the new product are very different from those of the original body.

There exists a certain substance, which may be added to, or even abstracted from, the majority of compound bodies, in 1, 2, 3, ... 10, and 20 proportions, without effecting any obvious alteration in their chemical properties: I allude to water.

Seeing, on the one hand, that it is impossible to add a few thousandths of hydrogen to indigo, without producing an entire alteration in its nature, and, on the other hand, that we may add to 100 parts of carbonate of soda, from 15 to 250 parts of water, without effecting any obvious change in its chemical properties, so little so, indeed, that chemists are compelled to resort to analysis, in order to ascertain whether the carbonate in their hands contains 1 or 15 atoms of water,—seeing, I say, the great difference of properties produced by the addition or abstraction of a single equivalent of a simple body, and the little difference produced by the addition or abstraction of from 1 to 15 atoms of water, we are naturally induced to regard the so-called hydrated salts, as containing two principal groups, the one formed by the salt, and the other by the water.

It must not be thought that this slight difference of properties depends, not upon the particular position occupied by, but rather upon some special character appertaining to, the water; for it will be seen, that on the instant that this fluid is united with certain compounds, so as not to form a separate group, it effects a complete change in their properties; as when, for instance, it combines with oxygen, chlorine, and sulphuric anhydride.

We know that cyanogen, by uniting with water, may give rise to oxalate of ammonia, a body to which it has no resemblance; and although this last substance may, by decomposition, regenerate water and cyanogen, no chemist, to my knowledge, has hitherto represented the arrangement of its atoms by the formula

$$C^2N^2 + 4\,Aq.$$

But if we add to this hydrated cyanogen, a fifth atom of water, then the properties of the quinque-hydrated compound resemble entirely those of the quadrihydrate. In these two cases, the water does not fulfil the same functions, and the fifth atom ought certainly to form a separate group $C^2N^2H^8O^4 + Aq$, no matter what the arrangement of the remaining atoms of the oxalate.

The sulphuric anhydride can combine successively with 1, 2, 3, 4 . . . . . atoms of water. The first combination, $SO^3 + Aq$, does not in the least resemble the anhydride SO^3; whilst it resembles in the highest degree the compounds $SO^3 + Aq^2$, $SO^3 + Aq^3$, $SO^3 + Aq^4$. Thus ammonia, when put in the presence of the anhydride, instantly gives rise to sulphammon; whilst with each of the hydrated terms, we constantly find, that sulphate of ammonia is produced. Hence, is it not natural to consider the first term as a nonhydrated combination H^2SO^4, capable of forming the respective hydrates $H^2SO^4 + Aq$, Aq^2, Aq^3?

Almost up to this present time, alloxan has been regarded as a perfectly neutral body, incapable of combining with bases, and not having any relation, either with the sulphuric anhydride, or with the so-called hydrated acids. Latterly it has been ascertained, that this alloxan, *an isomeride of alloxanic acid*, is no other than the anhydride of alloxanic acid, combined with one atom of water of crystallisation, that may be eliminated at a temperature of from 100° to 150°C. If this water did not form a group apart, it would be impossible to conceive, why hydrated alloxan should differ from alloxanic acid. Under certain circumstances, the hydrated alloxan $C^4H^2N^2O^4 + Aq$ absorbs, so to speak, its water of crystallisation, and becomes metamorphosed into the so-called hydrated alloxanic acid, $H^2.C^4H^2N^2O^5$.

I seize the occasion here afforded me, to again point out, that the so-called hydrated acids do not contain water; for if so, alloxanic acid would be identical with monohydrated alloxan.

Fourth Argument.—I confine myself to referring the reader to the chapter treating of chloro-substitutions, and of re-instancing to him, the chlorhydrate of bromocinchonine, which, when acted upon by potash, gives rise to chlorhydric acid; whilst its isomeride, the bromhydrate of chlorocinchonine, gives rise, under similar circumstances, to bromhydric acid. If the atoms of these two salts were arranged according to their affinities, or according to the crystalline form of the compounds, then, under the influence of potash, they ought necessarily to comport themselves in an identical manner.

The argument deducible from chloro-substitutions does not prove that there are various groups existing in compound bodies; for though there were no predisposition in the arrangement of the atoms of nitrophenic acid, we could yet admit, that in nitrochlorophenic acid, chlorine had taken the place of hydrogen, and in this manner account for the similar properties of the two acids. That the atoms of chloro-compounds, however, are not arranged in the manner indicated by dualism, is, in every instance, a legitimately deducible argument.

Fifth Argument.—We know that tartaric acid exercises a special action upon polarized light. We may abstract more or less water from the acid; we may combine it with bases, with basic acids (such as arsenious, Ed.), with aniline, &c. We may form it into an ether, and an ethylic, or methylic acid, &c., yet all of these combinations will still exert an action upon polarized light. All of them must necessarily contain something in common, a certain number of atoms arranged according to the same general plan, but modifiable in their accessories, to which arrangement we may attribute the capability manifested by each of them, of acting upon polarized light.

Indigo is of a blue colour; we may add to it a molecule of oxygen or of hydrogen, and we may substitute one or two atoms of chlorine or bromine for one or two atoms of hydrogen; we may combine all of these compounds with water, sulphurous acid, or peroxide of nitrogen, and we may produce from them numerous amides and amidic acid, &c. The hundred different compounds thus obtainable, are all of them coloured, some red, orange, or yellow, and others violet, purple, or grey. When submitted to the powerful action of fused potash, or to that of boiling nitric acid, or to prolonged treatment with chlorine or bromine, all the above substances become destroyed, and give rise to products belonging to one and the same family, namely, the phenic; thus we obtain aniline, chloraniline, bromaniline, normal, nitro-, bromo-, chloro-, and perchloro-phenic acids, and chloranil, or bromanil.

Whence then arises this persistent coloration in the products of the metamorphosis of indigo; whence this constant transformation into compounds appertaining to the phenic family?

These properties cannot be attributed to the nature of the constituent atoms of indigo and its congeners, for numerous other bodies have an analogous composition; nor to their number, for that is extremely variable. But one supposition then remains, namely, that all these bodies possess this much in common, a certain grouping of atoms, and that to this grouping they owe their uniformity of properties.

Resting on the preceding arguments, I propose to show, that we are singularly advanced in the question we are now agitating, although, perhaps, unable to adduce a single body of which the atomic arrangement is known to us.

The formula of a certain compound is expressed by $C^{23}H^{23}N^{5}O^{10}$. The compond has not hitherto been produced, though everyone will allow, that it, and a hundred other analogous bodies are instantly producible. It is a hydrated salt, formed by an acid, the nitrophtal-nitranilic, and an alkaloid, methylo-ethylo-nitrophenylamine. In accordance with our third argument, we may directly alter its formula into $C^{23}H^{21}N^{5}O^{9} + H^{2}O$.

In accordance with our second argument, we may arrange the two following groups, or two others similar to them:—1°. nitronaphthal-nitranilic acid $C^{14}H^{9}N^{3}O^{7}$:—2°. the alkaloid $C^{9}H^{12}N^{2}O^{2}$.

By referring to our observations upon ammonium salts, it will be seen, that some uncertainty may exist, as to whether our salt contains a body analogous to ammonium, amidogen, or imidogen, &c.

The nitrophthal-nitranilic acid, as deduced from our second argument, contains a group corresponding, more or less, to nitrophthalic acid, and another group corresponding with the remainder of the elements, or more or less closely to nitraniline. Each of these two bodies, in conformity with our first argument, contains two other bodies, one of each pair being a nitro compound. The alkaloid itself is constituted of at least three principal groups, namely, of methylene or of methyl, and of etherene or of ethyl, and of nitrophenyl or of nitraniline. The last group, in accordance with our first argument, certainly contains a nitric compound.

Nothing hinders us from preparing a still more complicated salt, for example, a *hydrated nitrochloropthal-nitrobromanilate of methylo-ethylo-amylo-nitroiodo-phenylium.*

We could still indicate the situation of the chlorine, bromine, and iodine in this compound, though we could not positively say which were the constituent groups, nor how they were arranged with respect to one another.

By means of two salts similar to the preceding, one of which should contain bichlorocinchonine, we might be able to prepare a double salt. Could we not say, *à priori,* that the salt would lose water by desiccation, that it would be yellow and detonating, that it would exert an action upon polarised light, that it might be separated into two salts, of which one should contain bichloro-cinchonine, and the other a nitroiodo-alkaloid, that it would be decomposable by sulphuretted hydrogen, &c.? Of a certainty, we should not in this way make more hazardous predictions, than we should by saying, that the hitherto unknown propionate of quina would be colourless, non-detonating, febrifuge, and, by means of potash, decomposable into propionic acid and quina.

Hence, were there not some predisposition in the arrangement of the atoms of our double salt, there would be a thousand to one against the realization of our predictions concerning its decompositions.

ON COMPOUND RADICALS.

Having thus seen that there is a predisposition in the arrangement of the atoms, it is but natural that we should endeavour to discover what this predisposition is, and to ascertain, whether, among our various systems, there is not one that can with more or less certainty unfold it to us.

Proceeding on the principle of exclusion, we may put dualism on one side, for the various reasons that I have exposed in different parts of this work, and on account of its incompatibility with the equivalents which we employ. Other systems approach so nearly to dualism that, for similar reasons, they also may be set aside.

There remains, then, but one theory for us to examine; one which, without being dependent upon dualism, is in perfect accordance therewith. I allude to the doctrine of compound radicals.

The term "radical" is applied to certain compound bodies, which as a rule, do not exist in the free state, but which, in organic substances, are capable of playing the parts of simple bodies. Organic chemistry would, in this way, be considered as the chemistry of compound radicals. We may remark, in passing, that compound radicals appertain as well to mineral as to organic chemistry; for ammonium, platinammonium, uranyle, ferryle, antimonyle, nitric oxide, peroxide of nitrogen, arsenyle, boryle, &c., are, as I have already observed, radicals of the same category as ethyl, methyl, acetyl, &c.

The better to examine this question, we will make a provisional division of the radicals, according to the functions they fulfil.

In the first division, we will place the *alcinyles*, or *alciniums*,* which, like ammonium and kakodyl, are capable of playing the part of metals, and of giving rise to diabasic† salts.

In the second division, we will place the *basylides*, which have a constitution analogous to that of uranyle. Some of them, as uranyle, ferryle, and antimonyle, do produce diabasic salts; others, as nitryle, nitrosyle, boryle, and arsenyle, do not. Thus, in the nitroso-ferrocyanides, the nitrosyle cannot be replaced immediately by any other radical, simple or compound.

The third class will comprise the *metoyles* (metal), or radicals which play the part of metals, but which do not give rise to diabasic salts. Such bodies, for example, as ethyl.

In the last class, we will place the *rhyzonyles*, or radicals analogous to the non-metallic simple bodies; such, for example, as cyanogen, sulphocyanogen, mellon, &c.

Dydimic and dioic radicals.	Alcinyles	diabasic	Pseudo-metals.
	Basyles		
	Metoyles	non diabasic	
	Rhyzonyles.		

Alcinyles.—I shall not enter here into the well-known arguments for or against the theory of ammonium. I shall, however, advert to the following one, for the purpose of showing, that, with reference to the arrangement of atoms, the arguments we believe to be most solid, have frequently but little foundation.

It is impossible, say some chemists, to admit the theory of ammonium; for we should then admit that ammonia, a body which so readily cedes its hydrogen to chlorine, oxygen, and even to sulphur, was, notwithstanding, capable of abstracting hydrogen from chlorhydric acid, in order to form ammonium. And we should, moreover, have to admit, that all the alkaloids, as quinine, morphine, &c., could equally remove this hydrogen, in giving rise to quinum and morphum, &c.

The argument, when presented in this manner, has an appear-

---

* Bodies analogous to ammonia receive the name of alkalies or alkaloids, although they have nothing in common with the alkalies, potash, and soda. I propose to designate them by the term *alcines*, and bodies analogous to ammonium and kakodyl, by the term *alcinyles* or *alciniums*.

† (Διαβασις *transitio*), salts which undergo ordinary double decomposition, such as those of potash and baryta.

ance of solidity; and I do not know that it has ever been replied to.

Some years back, I proposed a new manner of viewing the constitution of the salts of ammonia, kakodyl, quinine, &c.; which is, so to speak, an exact mean between the theory of ammonium and that of ammonia.

Chloride of hydrogen, said I, is analogous to, and even isomorphous with, chloride of potassium. Ammonia, when put in the presence of this chloride of hydrogen, draws near to the hydrogen, and combines with it, but does not derange its position, nor take it away from the chlorine; so that we have produced, a chloride of *ammoniacal hydrogen*, which retains the arrangement of the chloride of hydrogen, is isomorphous with it, and, consequently, also with chloride of potassium, and which ought to be formulated thus:

Chloride of potassium	$\mathrm{Cl} + \mathrm{K}$
Chloride of hydrogen	$\mathrm{Cl} + \mathrm{H}$
Chloride of copper	$\mathrm{Cl} + \mathrm{Cu}$
Chloride of ammoniacal hydrogen	$\mathrm{Cl} + \begin{matrix}\mathrm{H}\\ \mathrm{Am}\end{matrix}$
Chloride of ammoniacal copper	$\mathrm{Cl} + \begin{matrix}\mathrm{Cu}\\ \mathrm{Am.}\end{matrix}$

Thus, in order to form ammonium, ammonia has no need to abstract the hydrogen from chlorhydric acid.

In this manner of disposing the atoms, if we regard their horizontal projection, we shall perceive the two groups $\mathrm{Cl\,H}$ and $\mathrm{H^3N}$; whilst if we examine their vertical projection, we shall perceive the arrangement Cl and $\mathrm{H^4\,N}$. In this way, then, can we affirm that an ammoniacal salt is rather a salt of ammonium than a salt of ammonia?

Thus, ammonium, kakodyl, stibethyl, &c., would be considered as hydrogens modified by ammonia, kakodine, stibethine, quinine. &c. Hydrogen in combination is H, when set free it becomes H^2, Ammoniacal hydrogen is $\binom{\mathrm{H}}{\mathrm{Am}}$ in combination, $\binom{\mathrm{H}}{\mathrm{Am}}^2$ when free. Kakodylic hydrogen is $\binom{\mathrm{H}}{\mathrm{Kk}}$ in combination, $\binom{\mathrm{H}}{\mathrm{Kk}}^2$ when free. Thus, $\binom{\mathrm{H}}{\mathrm{Kk}}^2 = 2$ volumes. $\mathrm{Cl} + \binom{\mathrm{H}}{\mathrm{Kk}} = 2$ volumes.

It seems then, that all the facts agree equally well with either theory.

Nevertheless, the composition of the oxichlorides of kakodyl and tellurethyl, of kakodylic acid, of kakodylic oxyifluoride, &c., has been, up to this time, considered as discordant with the ammonium theory. But we shall presently see, (series C^2H^4, group kakodylic) that though as regards the salts of the oxide of kakodyl, the existence of kakodyl is admissible, yet, is it otherwise as regards kakodylic, and fluo- and chloro-kakodylic acids, and we then find the facts completely contrary to the theory of kakodyl.

Another very powerful argument has of late been put forward in favour of the ammonium theory. We know, that stibethyl is procurable, and that this radical decomposes chlorhydric acid, and expels the hydrogen therefrom. Let us see if it be not possible to explain this fact on the theory of ammonia.

The aldehydes and alcohols appear to be capable of forming alkaloids, which differ from one another as do the aldehydes from the alcohols, namely, by two atoms of hydrogen. Thus we have arsine, or kakodine, or arsenamide of aldehyde, $= As.C^2H^5$, whilst, ethylamine or the amide of alcohol $= N.C^2H^5 + H^2$: we find the same relation between stibethine, the ammonia of the salts of stibethyl, $= Sb.C^6H^{13}$ and stibethyl itself $= Sb.C^6H^{13} + H^2$, which last, instead of being a radical, may be only a very unstable alkaloid of triethylostibamine, $3\ C^2H^4 + H^3Sb$. It would be scarcely allowable for us to consider triethylamine both as a radical, and as an alkali; yet this is the result to which we should be driven, were we to consider triethylostibamine as a radical; or what would be equally contradictory, we should have to admit, that triethylamine was an alkaloid, whilst the same triethylamine with a substitution of antimony for nitrogen, was a radical. Hence, let us consider triethylostibamine as an unstable alkaloid, capable under the influence of chlorhydric acid of losing two atoms of hydrogen, and being converted into stibethine, which remains united with the chlorhydric acid. In this manner, the hydrogen would be disengaged, not from the acid, but from the triethylo-stibamine. Besides, stibethyl considered as a radical, would by its constitution be altogether separated from ammonium and kakadoyl. We have already shown, that if ammonia is H^3N, ammonium ought to be twice H^3N, together with H^2; that if kakodine is C^2H^5As, kakodyl ought to be twice C^2H^5As, together with H^2. But stibethine being $C^6H^{13}Sb$, its radical or stibethyl ought to be twice $C^6H^{13}Sb$, together with H^2, whilst the stibethyl known to us, is but once $C^6H^{13}Sb$, together with H^2.

The difference between the composition of its salts, and those of ammonium and kakodyl, is seen below. Making use of the ordinary (4 volume) notation, we have

	Ammonium and kakodyl.	Stibethyl.
Chloride	$Cl^2 + R$	$Cl^4 + St$,
Oxide	$O + R$	$O^2 + St$,
Sulphide	$S + R$	$S^2 + St$,
Nitrate	$N^2O^6 + R$	$2\ N^2O^6 + St$.

To explain this singular difference, it is possible to consider the constitution of stibethyl in a yet different manner.

Since the radicals are dyadic, that is to say, consist of H^2,Cu^2, $\left(\begin{matrix}H\\Am\end{matrix}\right)^2$, $\left(\begin{matrix}H\\Kk\end{matrix}\right)^2$ &c., we may arrange the following tables.

Simple Radicals	H^2,	Cu^2,	Pt^2,	dydimic.*
Complex radicals	$\left(\begin{matrix}H\\Am\end{matrix}\right)^2$,	$\left(\begin{matrix}H\\Kk\end{matrix}\right)^2$,	$\left(\begin{matrix}H\\Sti\end{matrix}\right)^2$,	
Alloys of simple radicals	HCu,	$CuPt$,	CuZ,	dioic*
Alloys of complex radicals	$\left(\begin{array}{c\|c}H & H\\Am & Kk\end{array}\right)$,	$\left(\begin{array}{c\|c}H & H\\Am & Sti\end{array}\right)$,	$\left(\begin{array}{c\|c}H & H\\Kk & Sti\end{array}\right)$,	dioic.
Alloys of simple with complex radicals	$\left(\begin{matrix}H\\Am\end{matrix}\right)H$,	$\left(\begin{matrix}H\\Kk\end{matrix}\right)H$,	$\left(\begin{matrix}H\\Sti\end{matrix}\right)H$,	

The known stibethyl would in this way be an alloy of the simple radical H, with the compound radical $\left(\begin{matrix}H\\Sti\end{matrix}\right)$, or so to speak, dioic-hydrostibethyl, whilst the true stibethyl, analogous to kakodyl would be $\left(\begin{matrix}H\\Sti\end{matrix}\right)^2$ and didymic.

Hydrostibethyl put in the presence of chlorine, would give rise to the combination $Cl^2 + \left(\begin{matrix}H\\Sti\end{matrix}\right)H$, one atom of chlorine saturating $\left(\begin{matrix}H\\Sti\end{matrix}\right)$ and the other atom saturating H; so that this combination, constituting the ordinary chloride, would be represented as a double chloride of hydrogen, and the real stibethyl. The ordinary sulphide $S + \left(\begin{matrix}H\\Sti\end{matrix}\right)H$, corresponding to $S + KH$, would be a double sulphide of hydrogen, and the real stibethyl, or indeed a sulphide of hydrostibethyl. It would be interesting to examine how hydrostibethyl comports itself with weak acids, or with an

---

* *Didymics*, or twin radicals; dioic formed by the union of one volume of a radical of one family, with one volume of a radical of another family.

alcoholic solution of bichloride of platinum, so as to ascertain whether or not salts of the real stibethyl are capable of existing.

Tellurethyl is evidently a dioic radical, formed, perhaps, of $\left(\begin{matrix}C^2H^5\\C^2H^5T\end{matrix}\right)$. In this form, like hydrostibethyl, it combines with two atoms of chlorine. We are thus led to inquire, whether all the dioic radicals ought not to combine with two atoms of chlorine, or rather, whether the biacid bases (the neutral salts of which contain two molecules of a monobasic acid) are not biacid, in consequence of their being dioic. Thus, tellurethyl, hydrostibethyl, stannethyl, would be dioic, and consequently, biacid radicals. These bodies must not be confounded with the didymic radicals of semibenzidam, and flavine, &c., which likewise give rise to biacid salts, for these latter salts are probably *acid* salts, like the bichlorhydrates of quinine and cinchonine, and not *neutral* salts, like the bichloride of tellurethyl.

According to Hofmann, triethylamine and trimethylamine are only ammonias, in which three atoms of hydrogen are replaced by three atoms of ethyl or of methyl. We may, however, represent triethylamine as ammonia, in which each atom of hydrogen is modified by the presence of etherine, and, consequently, formulate it thus: $N\left(\begin{matrix}H\\Et\end{matrix}\right)^3$.

Ethylamine, diethylamine, triethylamine, &c., being *modified ammonias,*—ammonium, ethylammonium, kakodyl, stibethyl, &c., are *modified hydrogens.*

The modified ammonias retain the basic characters of ammonia, and the modified hydrogens likewise retain the metallic characters of hydrogen, so that as I have before observed, hydrogen is *the* metal of organic chemistry.

This manner of regarding the constitution of ammonium, namely, with one atom of hydrogen situated differently from the other three, enables us to understand the singular anomalies which exist, between the salts of mono, bi, and triethylammonium and those of tetrethylammonium. We have in this way, no necessity for considering the first mentioned compounds as salts of ammonia, and the second as salts of ammonium.

In conclusion, the theory of ammonia appears to me to be equally true with that of ammonium, and ammoniacal salts appear to have their atoms disposed in such a manner, that it is impossible for us to say, whether they contain ammonia rather than ammonium. Hence, the manner in which we formulate these salts, matters but little; we have only to consider simplicity, conveniency, and analogy.

Basyles.—I have divided these compounds into two classes, the diabasic and the non-diabasic. In the first class we find uranyle which can be transported from one salt to another by the method of ordinary double decomposition, and in the second nitryle, or X, or NO^2, which plays the part of hydrogen, but cannot be transported from one salt to another by the method of ordinary double decomposition.

It may appear singular, to arrange, in the same class, uranyle, antimonyle, ferryle, &c., and nitric oxide, peroxide of nitrogen, and arseniosyle AsO, or what comes to the same thing, to put into the same class, the basyl-oxides comprising:

Oxide of uranyle	$(U^2O)^2O$
Oxide of ferryle	$(Fe^2O)^2O$
Oxide of aluminyle	$(Al^2O)^2O$
Oxide of antimonyle	$(SbO)^2O$

and the basyl-acids comprising;

Oxide of arseniosyle	$(AsO)^2O$,	or arsenious anhydride
Oxide of arsenyle	$(AsO^2)^2O$,	or arsenic anhydride
Oxide of nitrosyle	$(NO)^2O$,	or nitrous anhydride
Oxide of nitryle	$(NO^2)^2O$,	or nitric anhydride
Oxide of boryle	$(BO)^2O$,	or boric anhydride.

I acknowledge that I have felt some degree of hesitation in publishing these relations for the first time. But the composition of the nitroprussiates, and the arseniosylic and antimonylic sulphates, does not permit me to doubt the analogy which exists, between the oxide of uranyle and the oxide of nitryle. And, moreover, in what part of the list I have just given, are we to establish the line of demarcation? We should be disposed to locate it between the bodies which play the parts of bases, and those which play the parts of acids, and, consequently, between teroxide of antimony and anhydrous arsenious acid, or precisely between two bodies which have the greatest resemblance to one another, between two bodies which are isodimorphous. Hence, any separation of the first term from the last, appears to me to be an impossibility.

We have seen above, that the salts of uranyle have all the properties of neutral salts, and as we desire to employ a notation which shall accord analogous formulæ to analogous bodies, we are obliged to consider uranyle as a radical, that is to say, as a body which like potassium, may be transported from one salt to another, without effecting any change in the neutrality of each. True it is, that by the adoption of this view, we should make the protoxide of uranium play the parts both of a metal and of an oxide; a result which would be considered as somewhat improbable. Recollecting, however, that one and the same simple body may have several equivalents, according to the several functions that it fulfils, we may regard the free protoxide of uranium as an oxide of *uranosum* $=U^2O$, and the uranic oxide as an oxide of *uran*$=(U^2O)^2\,O$, so that the oxide of uranosum, U^2O, would be isomeric, but not identical with uranyle $(U^2O)^2$.

We have equally seen, that nitryle $(NO^2)^2$ is very frequently substituted for hydrogen H^2, and ought equally to be considered as a radical; that it is the same with nitrosyle $(NO)^2$, and, consequently, with ferryle, boryle, antimonyle, arseniosyle, &c.

It is to be observed, that all these radicals are dyadic like the hydrogen whose part they play. In combination, they are H, $\begin{matrix}H\\Am\end{matrix}$, NO, NO^2, U^2O, &c., and when set free they become H^2, $\left(\begin{matrix}H\\Am\end{matrix}\right)^2$, $(NO)^2, (NO^2)^2, (U^2O)^2$&c.

From nitryle and uranyle I have argued up to ferryle and arsenyle; Gerhardt has proceeded very much further, and from nitryle and the oxide of nitryle, or anhydrous nitric acid, has drawn conclusions with regard to all the monobasic anhydrous acids.

Thus, according to him, anhydrous acetic acid would be the oxide of acetyl (othyl) $(C^2H^3O)^2O$ didymic,—anhydrous benzoic acid, the oxide of benzoyl $(C^7H^5O)^2O$ didymic, and the aceto-benzoic anhydride as a double oxide of benzoyl and acetyl (othyl)$=$ $\left\{\begin{matrix}C^2H^3O\\C^7H^5O\end{matrix}\right\}O$,* dioic.

I am far from denying either the analogies, or the deductions that Gerhardt has drawn therefrom, deductions which would compel us also to adopt Williamson's opinion, concerning the constitution of the hydrated acids.

But as in this work, I have proposed to avoid hypotheses, and to see if it be not possible to construct a rational system based only upon experimental laws, I shall not proceed any further with this discussion on the nature of radicals, but shall show how

---

* Gerhardt's formulæ were not, I believe, deduced from the above course of reasoning.—(W. O.)

the practical applications of the theory may be made use of, without any reliance upon hypothesis.

I employ, as I have already stated, synoptical formulæ, as a means of indicating, not the arrangement of the atoms, but simply the analogies existing between certain classes of bodies. I acknowledge, in common with the rest of the world, that the ammoniacal nitrate is a nitrate; consequently, if I represent nitrate of potash by $K.NO^3$, I must give to nitrate of ammonia a similar formula, namely, $NH^4.NO^3$.

Now, whether NH^4 does or does not exist is a matter of no consequence, it is enough that my formulæ express the analogy of the two nitrates; the second of them, moreover, indicates that the sum of the proportional numbers NH^4 is transported from one kind of salt to another, without altering the generic characters belonging to the class of salts, of which it thus becomes a member.

It matters little, I repeat, whether NO^2 does or does not exist, is or is not a radical. Experiment shows us, that in a multitude of different bodies, we may set free 1, 2, 3, 4, 5, and 6 atoms of hydrogen, and replace them by exactly the same number of atoms of NO^2, without altering the neutrality, the acidity, or the alkalinity of the bodies in which the exchange has been effected. I express this fact by the aid of synoptic formulæ, which represent normal and nitro compounds in a similar manner.

The monobasic anhydrous acids are bodies of a special nature, and, consequently, require special formulæ. I have compared the nitrous, arsenious, and boric anhydrides with the oxide of uranyle, and as I represent the composition of this latter by

$$(U^2O)^2 + O,$$

so do I give similar formulæ to the above-mentioned anhydrides:

$$(NO)^2 + O \qquad (As\,O)^2 + O \qquad (BO)^2 + O.$$

The analogy between nitrous anhydride and oxide of uranyle, appeared to me to have reference to the number of the atoms which they respectively contained, and I never thought of comparing the acetic with the nitrous anhydride.

I consider that Gerhardt is more consequent than I was, and therefore I adopt his opinion, not with regard to the arrangement of the atoms, but with regard to the analogies which exist between the acetic and nitrous anhydrides; and as I represent the latter by $(NO)^2 + O$, so must I represent the former by $(C^2H^3O)^2 + O$.

Metoyles.—Dumas has summed up his opinion concerning the constitution of the ethers, by comparing them to ammoniacal salts; or, in other words, if sal-ammoniac is a hydrochlorate, so also is chlorhydric ether; but if the former body is a chloride of ammonium, then is the latter a chloride of ethyl. All chemists have adopted this opinion of Dumas; but some have considered with him, that the ethers are salts of etherine; whilst others, with Liebig at their head, have preferred the doctrine of ethyl.

I might repeat here the remark I have made in reference to sal-ammoniac, to the effect, that chlorhydric ether may be but a chloride of *etherened hydrogen* $Cl + \left(\begin{matrix}H\\E\end{matrix}\right)$, and free ethyl but hydrogen modified by etherene $\left(\begin{matrix}H\\E\end{matrix}\right)^2$.

But another question ought, first of all, to be resolved; namely, do the ethers constitute salts?

Were we to put aside all kinds of theoretical considerations, and confine ourselves to an examination of facts, it would be very difficult to find any analogy between ethers and salts. What relations are there between their respective physical properties? What relations are there between ethers which are not, and salts which are, obedient to the law of ordinary double decomposition, and directly decomposable by acids, bases, and salts?

How can we admit, that the soluble sulphovinate of baryta is an association of sulphate of baryta, insoluble in all re-agents, and of sulphate of ethyl, which is incapable of dissolving the least trace of sulphate of baryta?

By what caprice does it happen, that the sulphovinates, phosphovinates, carbovinates, and oxalovinates of potash, do not produce any precipitates with salts of barium, strontium, calcium, and lead?

It may be urged, that by ebullition, or in the course of time, we may convert sulphovinate of baryta into sulphate of baryta. True, but may we not, in the same manner, transform oxamide into oxalate of lime, or into oxalic acid and ammonia, although it contained neither acid nor ammonia? The conclusion may be easily enough deduced.

We attack benzine by nitric acid,—water and nitrobenzide are produced; here the oxygen of the water must have been furnished by the nitric acid. We treat essence of bitter almonds by nitric acid—,water and a nitro-essence are produced; and although the original essence contained oxygen, no one doubts but that the oxygen of the eliminated water was derived from the nitric acid. We cause the same acid to act upon very combustible, but otherwise very dissimilar, bodies; upon naphthaline, upon phenic acid, upon benzoic acid, upon lignine, &c. In every instance water is disengaged; and from the analogies of the reactions, no one doubts but that, in every instance, the oxygen of the water was derived from the nitric acid.

Why then, when we operate upon alcohol—upon a body so little oxidated, and so combustible — upon a body which does not yield water even to the most hygroscopic substances—why do we suppose that, in this case, the oxygen of the eliminated water proceeds, not from the acid, but from the combustible body—the alcohol? Facts must not be misconstrued by hypothetical views of the constitution of bodies; and by having exclusive reference to the facts, we are forced to admit that, in the formation of nitric ether, it is the *acid* which has furnished the oxygen, that has burned a portion of the hydrogen of the alcohol, and converted it into water.

What conclusion is to be drawn from these correlations? It is, that nitric ether is not a salt, is not a nitrate, since it does not contain nitric acid.

A nitrate is a hydrogen salt, of which the *hydrogen* has been set free, and replaced by a metal, or by uranyle, or by ammonium.

Nitric ether is a hydrogen nitrate, of which one atom of *oxygen*, and probably, also, an atom of hydrogen, have been set free, and replaced by a residue of the elements of alcohol.

A sulphate is a hydrogen salt, of which the *hydrogen* has been set free, and replaced by a metal, or by a radical playing the part of a metal; whilst sulphuric ether is a hydrogen sulphate, in which two atoms of oxygen have been set free, and replaced by a residue of the elements of alcohol. I do not intend to say, that the residue of the elements of alcohol has taken the geometrical place of the oxygen, or that it plays the same part as did the oxygen, but simply, that oxygen has been removed from the original body, and that alcohol, minus hydrogen, has entered into the new product.

Let us see how this manner of regarding the ethers is supported by analogy.

We treat ammonia, aniline, benzine, naphthaline, wood spirit, alcohol, potato-oil, &c., by sulphuric acid. We obtain, on the one hand, sulphamide, sulphanilide, sulphobenzide, sulphonaphthalide, sulphuric methol, sulphuric alcohol, sulphuric amylol, &c.; and on the other hand, sulphamic, sulphanilic, sulphobenzidic, sulphonaphthalic, sulphomethylic, sulphovinic, and sulphamylic, &c. acids.

The same reactions obtain throughout:

Sulphamide	.... $\mathrm{H^2SO^4 + 2\,H^3N \quad - 2\,Aq}$
Sulphanilide	.... $\mathrm{H^2SO^4 + 2\,C^6H^7N - 2\,Aq}$
Sulphobenzide	.... $\mathrm{H^2SO^4 + 2\,C^6H^6 \quad - 2\,Aq}$
Sulphonaphthalide	.... $\mathrm{H^2SO^4 + 2\,C^{10}H^8 \quad - 2\,Aq}$
Sulphomethylide	.... $\mathrm{H^2SO^4 + 2\,CH^4O \quad - 2\,Aq}$
Sulphethylide	.... $\mathrm{H^2SO^4 + 2\,C^2H^6O - 2\,Aq}$
Sulphamylide	.... $\mathrm{H^2SO^4 + 2\,C^5H^{12}O - 2\,Aq.}$

Acids.	Sulphamic	.... $\mathrm{H^2SO^4 + H^3N - Aq}$
	Sulphanilic	.... $\mathrm{H^2SO^4 + C^6H^7N - Aq}$
	Sulphobenzidic	.... $\mathrm{H^2SO^4 + C^6H^6 - Aq}$
	Sulphonaphthalic	.... $\mathrm{H^2SO^4 + C^{10}H^8 - Aq}$
	Sulphomethylic	.... $\mathrm{H^2SO^4 + CH^4O - Aq}$
	Sulphovinic	.... $\mathrm{H^2SO^4 + C^2H^6O - Aq}$
	Sulphamylic	.... $\mathrm{H^2SO^4 + C^5H^{12}O - Aq.}$

The sulphamic, sulphobenzidic, sulphovinic, &c. acids, the oxamic, oxalanilic, oxalovinic, &c. acids, and the carbamic, carbanilic, carbovinic, &c. acids, are all monobasic, decomposable by distillation, capable, under certain circumstances, of absorbing water, and regenerating the bodies from which they sprang, susceptible, under certain circumstances, of being transformed into sulphamide, sulphobenzide, sulphovinide, &c.,—oxamide, oxanilide, oxalovinide, &c.,—carbamide, carbanilide, carbovinide, &c.,—having the property of forming with baryta, strontia, lime, and lead, soluble sulphamates, sulphovinates, oxamates, oxalovinates, carbamates, and carbovinates, &c.

We cannot admit that sulphobenzidic acid is an acid sulphate; why then, should we admit such a conclusion with regard to sulphovinic acid?

All these bodies appear to have the same constitution. Nevertheless, according to the theory of radicals, they must be formulated as follows (Dualistic notation, Berzelius equivalents):

Acids.	Sulphamic	$H^4N^2.SO^2 + H^2O.SO^3$
	Sulphanilic	$C^{12}H^{12}N^2.SO^2 + H^2O.SO^3$
	Sulphonaphthalic	$C^{20}H^{14} + S^2O^5 + H^2O$
	Sulphonitronaphtalic	$C^{10}H^8.S^2O^5 + C^{10}H^4O.N^2O^3 + H^2O$
	Sulphochloronaphthalic	$C^{10}H^8.S^2O^5 + C^{10}H^4.Cl^2 + H^2O$
	Sulphovinic	$C^4H^{10}O.SO^3 + H^2O.SO^3$.

We have yet another proof of the analogy between the ethers and the amides, benzides, naphthalides, &c.

In the ethyl theory, succino-vinic acid, would be an acid succinate of ethyl, corresponding to the acid succinate of ammonium.

In the theory of diamerides, it would correspond to succinamic acid.

When we cause an acid succinate, or an acid sulphate, or an acid phtalate, or an acid camphorate, &c., of ammonium, to lose one atom of water, we obtain the monobasic succinamic, sulphamic, phtalamic, camphoramic, &c., acids; consequently, if succinovinic acid corresponds to the acid succinate of ammonium, it ought by the loss of an atom of water, to give rise to a new acid, analogous to succinamic acid.

When we cause the succinamic, camphoramic, phtalamic, phtalanilic, &c., acids, to lose an atom of water, we obtain the neutral bodies, succinimide, camphorimide, phtalimide, phtalanil, &c., consequently, if succinovinic acid be analogous to succinamic acid, it ought, by the loss of an atom of water, to give rise to a neutral body. This is what really happens, and hence we conclude, that succinovinic acid is not analogous to acid succinate of ammonium, but on the contrary to succinamic acid.

Nevertheless, I do not conceal from myself that, by adopting in the ethyl theory, the modifications that I have proposed, by considering alcohol as a biethylic oxide, by comparing ethyl to hydrogen, and representing it when in combination by Et, when free by Et^2, that this theory, I say, gives us so simple an idea of the composition of the ethers, that it deserves to be taken into serious consideration.

At the commencement of this chapter I stated, that before inquiring, whether or not the ethers contained ethyl, we ought in the first place to know, whether or not they were salts: if they ought to be arranged in the category of salts, they must obviously be placed in the *non-diabasic* division. But is there not a contradiction in the term non-diabasic salt? Is not the distinguishing character of a salt precisely that of being diabasic? We see, that to resolve the question raised by the theory of the ethers, we must not only learn, whether or not they are salts, but must mount a step higher, and determine rigorously, what we understand by the word *salt*. How far we are from being agreed upon the signification of terms, about which the whole of chemistry revolves!

A salt is usually said to be the product of the union of an acid with an oxide; yet Baudrimont affirms, that the metal lead is a salt. Such an opinion may be considered unworthy of refutation. We may remark in the first place, that the preceding definition is applicable neither to chlorides nor to sulphides. The following would however, be more general. "A salt is a molecular type, which contains a metal or hydrogen: a *metal* that is capable by means of a double decomposition of being replaced immediately by some other metal, or by hydrogen;—hydrogen which may be replaced by any metal whatever." Consequently, sulphate of potash, chloride of hydrogen, sulphide of potassium, and sulphide of hydrogen are alike salts. That, despite their metallic appearance, the sulphides of antimony, lead, and iron, are salts, is incontestable. The phosphide of antimony, and consequently the arsenide of antimony, are also salts. In what does the arsenide of antimony differ from an alloy of antimony? Thus, the alloys are salts. If now, in the arsenide of antimony, we replace the arsenic by an analogous body, by antimony itself, we shall have an antimonide of antimony; hence metallic antimony is a salt; and by the action of arsenic thereupon, we have a double decomposition produced, as seen below,

$$\mathrm{Sb\,Sb} + \mathrm{As\,As} = \mathrm{Sb\,As} + \mathrm{Sb\,As}.$$

Have we not arrived at the same conclusion with respect to the dyads? Have we not seen, that hydrogen is a hydride of hydrogen; chlorine, a chloride of chlorine, &c.?

If the posphides, arsenides, and sulphides are salts, are not the nitrides likewise? Is not the trimercuric nitride Hg^3N a salt? Is not the bimercuric Hg^2HN, is not the monomercuric HgH^2N, and consequently is not their correspondent the trihydric nitride H^3N? Thus, as we have already said, ammonia is a salt of hydrogen, and consequently a tribasic acid. Who will dare to settle the question by saying, this which is to the right is a salt,—this which is to the left is not so?

In conclusion, if the nitrate of ethyl is a salt, its formula should accord with that of the nitrates; if it is not a salt, it ought to be noted as a diameride. Thus for my part, the question that I agitate, is not one of theory but of experiment. Are the ethers salts? Their notation, their classification, their nomenclature, all depend upon the solution of this question. If the possible existence of non-diabasic salts could be proved, the objections that I have made as regards the solubility of sulphovinate of baryta, would immediately fall to the ground; for after that, it would be easy to prove, that the sulphovinate of baryta ought to be soluble, that it ought not to be decomposable into sulphate of barium, and sulphate of ethyl; and lastly, that sulphate of soda ought not to form in a direct manner a double salt with sulphate of ethyl.

Rhyzonyles.—Among these radicals, we arrange cyanogen, sulphocyanogen, ferrocyanogen, mellon, the radicals of Davy, such as SO^3, SO^4, &c.

There exists a multitude of chemical types, binary, ternary, quaternary, &c., that can exchange the metals they contain for some other metals; these are my saline types, or salts. When we put two types of this description into contact with one another, as for instance the chloride of barium, and the margarate of potassium, the two metals reciprocally replace one another, and we obtain a chloride of potassium, and a margarate of barium. From this fact, most chemists deduce these two consequences; firstly, that potassium is analogous to the barium which it replaces; secondly, that margarogine or $C^{17}H^{33}O^2$ is analogous to the chlorine which it replaces. This latter consequence appears to me to be about as correct as the following; supposing that we have two polyhedrons, the one with four, the other with a hundred faces. We remove an angle from each of the figures, and we put the angle of the first in the place of the angle of the second, and reciprocally the angle of the second in the place of the angle of the first.

The two exchanged angles fulfil the same functions, and we thence conclude, that the two mutilated polyhedra, each minus an angle, are analogous to one another.

Such in effect is the theory of Davy, which, if it be not admitted by all chemists in every circumstance, is applied by nearly all, to the cyanides, sulphocyanides, mellonides, &c.

For my part I confess, that I do not understand this distinction; I do not see in what the sulphocyanides differ from the cyanates, the mellonides from the cyamelurates; still less do I understand the establishment of a distinction between the sulphocyanides and the cyanates, while none is established between the sulphocarbonates and the carbonates.

All the reasonings that have been put forth for the admission of radicals of this kind, are about as solid as the following:—We have a molecular group PO^4M^3, representing a phosphate; and as M^3 is capable of being replaced by K^3, Fe^3, Mn^3, &c., we conclude, that the atoms have this disposition

$$PO^4 + M^3,$$

and, consequently, that PO^4 is a radical analogous to nitrogen, which also gives rise to tribasic salts $N + M^3$.

But as we may also replace O^4 by S^4, Se^4, we ought to acknowledge the existence of the following grouping:

$$PM^3 + O^4,$$

and as on the other hand we may replace PM^3 by SM^2, so as to form a sulphate, we must admit that PM^3 is analogous to SM^2.

We may yet replace the phosphorus by arsenic or antimony, and ought thence to represent the phosphate by,

$$P + M^3O^4.$$

Whether the cyanides are represented thus, $CN + M$, or thus, $CM + N$, or thus, $NM + C$, or thus, $\frac{C}{NM}$, the action of metals, oxides, acids, or salts upon them, will not become more clear, neither will the phenomena be more comprehensible.

I can, indeed, understand why margaric acid should be represented by

$$C^{17}H^{33}O^2 + H;$$

because out of the 34 atoms of hydrogen, there is one that comports itself differently to the rest. But in the cyanides, I do not see any motive for separating the hydrogen or metal from the carbon and nitrogen.

It may be urged in reply, that cyanogen exists in the free state, and is analogous to chlorine. The analogy that we remark between these bodies, is of the same order as that which exists between chlorine and margarogine.

In what point does chlorine comport itself like cyanogen? Does it, in the presence of water, give rise to a compound analogous to oxamide, or to oxalate of ammonia? Does it combine with sulphuretted hydrogen? Are the cyanates or the fulminates analogous to the hypochlorites, or the chlorates? How can the fulminates be combinations of cyanogen, since they are prepared by the action of nitric acid upon alcohol, since they fulminate like the picrates, and consequently, contain their nitrogen in the state of NO, or NO^2, and not in the state of cyanogen?

I shall revert further on to the existence of cyanogen, and to that of the radicals in general.

Liebig considers carbonic oxide as a radical. This body having a composition that distinguishes it from all the other radicals, I propose to devote some few minutes to its consideration.

When we make a cursory examination of compound bodies, we perceive, that in a large proportion of them, all the atoms are represented by even numbers. Such is the case with acetic acid, $C^2H^4O^2$, and butyric acid $C^4H^8O^2$, &c. But it is remarkable, that all these divisible formulæ belong to bodies that contain both monads and dyads. I do not know of any one instance among bodies composed exclusively of monads, such as SO^2, SO^3, TeO^2, TeO^3, TeS^2, TeS^3, CO, CO^2, CS^2, SiO or SiO^3, &c.[*]

I have already said, that all the radicals having formulæ not in accordance with the law of even numbers, cannot exist in the free state, at least without becoming doubled at the instant of elimination. Thus kakodyl is in combination C^2H^6As, but when set free it becomes $C^4H^{12}As^2$; that is to say, that radicals in combination occupy one volume, as does the hydrogen which they replace. Hence every free radical ought to be divisible.[†]

But carbonic oxide CO, in the free state occupies two volumes, and is indivisible; hence if it be a radical, it cannot replace hydrogen, chlorine, a metal, or any dyad whatsoever. Can it then play the part of carbon, oxygen, or sulphur; that is to say, of a monad? If so, we should have to admit, that CO, or two volumes, may play

---

[*] We may also remark, that there are no compound bodies formed of three different monads. Compounds that contain dyads only, appear to be equally indivisible, as, for instance, NH^3, HCl, PCl^3, PCl^5, PCl^2N, &c. We might, indeed, adduce the solid and liquid phosphides of hydrogen P^4H^2 and P^2H^4, but we have no proof of the exactness of these formulæ. The iodide of phosphrous P^2I^4 would be an exception.

[†] This has reference only to didymic radicals; with dioic radicals the case is different. Thus tellurethyl $C^4H^{10}Te$ is indivisible, and under this form it combines with Cl^2 as does stibethyl. Hence it is probably a dioic radical formed of

$$\begin{pmatrix} C^2H^4 \\ C^2H^4Te \end{pmatrix} + H^2 \text{ or of } \begin{pmatrix} C^2H^5 \\ C^2H^5Te \end{pmatrix}$$

We are thus led to believe in the existence of another tellurethyl—

$$(C^2H^4Te)^2 + H^2 \text{ or } (C^2H^5Te)^2$$

which, under the influence of chlorine, would divide itself into two, in order to produce the chloride $C^2H^5T.Cl$.

the part of O, or one volume; a circumstance of which we have no example throughout chemistry.

I shall not stop to examine, whether or not the thousands of radicals and of copulæ that are admitted in the school of Berzelius (*vide* his last "*Traité de Chimie*," that of Lœwig, &c.) ought to be considered as such. Prior to their receiving the right of an asylum in science, I hope that *eurhyzene* will first of all enjoy the privilege.

Some years back I made the following announcement:

"I have just discovered a radical which I shall call eurhyzene, and which I shall represent by Eu^2 analogous to Cl^2. For the present I shall pass over its composition, and confine myself to indicating its preparation and principal combinations. We may obtain it, by treating eurhyzhydric acid by peroxide of manganese and sulphuric acid: we have the following reaction:

$$\text{“}Mn^2O^2+SO^3+Eu^2H^2=Mn^2O.SO^3+H^2O+Eu^2.$$

"Eurhyzene put into contact with potassium, gives rise to the eurhyzide of potassium KEu, and this salt treated with sulphuric acid, sets free eurhyzhydric acid:

$$\text{“}H^2SO^4+2\ KEu=K^2SO^4+2\ HEu.$$

"This acid when acted upon by potassium, disengages hydrogen and forms eurhyzide of potassium.

"When we add to chloroform a small quantity of water and of eurhyzhydric acid, we obtain a chloro compound analogous to chloroform:

$$\text{“}CHCl^3+H^2O+HEu=CH\left\{\begin{matrix}O\\Eu\end{matrix}\right.+3\ HCl,$$

"namely, the eurhyzidoformic acid.

"If we treat chloroform by eurhyzhydric acid only, we obtain an eurhyzide of carbon, analogous to the formylic chloride of carbon:

$$\text{“}CHCl^3+H^2Eu^2=CEu^2+3\ HCl.$$

"Potassic eurhyzide forms with benzoic chloride a potassic chloride and a benzoic eurhyzide. We may obtain similarly the eurhyzides of methyl and ethyl, &c. Eurhyzene can, by a direct action, remove the hydrogen from a very great number of organic substances, and its resemblance to chlorine is carried so far, that it forms with sulphurous acid, a body analogous to sulphuric oxichloride SO^2Eu^2, and with carbonic oxide a body analogous to carbonic oxichloride $CO\ Eu^2$.

"Lastly, it exists both free and in combination, and like all the radicals, it contains an uneven number of dyads."

In announcing my discovery to several persons, I asked them, if eurhyzene had not a greater title than cyanogen to be admitted to the rank of a compound radical. I received a reply in the affirmative; but when I added, that this radical was no other than oxygenated water, they would no longer acknowledge its right to the appellation. Does then the admission of radicals into science depend, as does that of bibasic acids, not upon the properties of the bodies, but upon the authority of the chemist who makes the proposition?

THEORY OF RESIDUES.

When we cause nitric acid to act upon benzine, water and nitrobenzide are produced. Gerhardt admits, that the oxygen of the water being formed from the acid, all the hydrogen should proceed from the benzine. He supposes, moreover, that the residue of the elements of the acid, or $H\ NO^2$, forms a group attached to the residue of the elements of benzide, or C^6H^4, which forms another group, so that nitrobenzide is formed of two residues, as indicated in the formula $C^6H^4.HNO^2$.*

He admits also, that by the action of chloride of benzoyl upon ammonia, we obtain benzamide, a body formed of a benzoic and of an ammoniacal residue.

The same reasoning may be applied to all the amides, ethers, anilides, &c., so that according to Gerhardt, all copulated bodies would be combinations, containing, in the state of distinct groups, the residues of the bodies that had served to form them.

There exists some doubt with regard to the meaning of this theory. Does Gerhardt propose to indicate by his formulæ, the arrangement of the atoms of copulated bodies, or does he simply intend to represent their mode of formation?

It seems to me, that we must adopt the latter conclusion; for Gerhardt commences by declaring, that it is impossible for us to

---

* This mode of considering nitrobenzide does not accord with Gerhardt's more recent theoretical notions. He now represents the above compound as benzine, in which one atom of H is replaced by one atom of NO^2, thus $C^6H^5NO^2$. —(W. O.)

know the atomic arrangement of compound bodies, which we ought, therefore, to represent by empiric formulæ. We must regard these *residuary* formulæ, simply as destined in certain cases to facilitate a manifestation of analogies, and a comparison of reactions.

Moreover, by considering the residuary formulæ as the expression of a theory concerning the arrangement of atoms, we should fall immediately into the same difficulty as we have encountered with regard to copulæ and radicals. The same questions would be again raised; only, instead of asking which are the copulæ, and which are the radicals, we should have to ask, which are the residues that exist in such and such a body? what functions do they fulfil? can they exist in the free state?

I will take benzamide as an example. We may prepare it firstly, with chloride of benzoyl and ammonia, when we have for the residues

$$\begin{array}{l} C^7H^5O\,Cl + H^3N \\ \quad -Cl - H \\ \hline C^7H^5O \quad + H^2N; \end{array}$$

secondly, with benzoic acid and ammonia; when we have for the residues

$$\begin{array}{l} C^7H^6O^2 + H^3N \\ \quad -O \; - H^2 \\ \hline C^7H^6O \; + HN; \end{array}$$

that is to say, that, in the first case, the two residues are benzoyl and amide; in the second case, hydride of benzoyl and imide.

As another example, we will take sulphonaphthalic acid; when prepared by the aid of sulphuric acid and naphthaline, it ought to contain two residues, according to the equation:

$$\begin{array}{l} H^2SO^4 + C^{10}H^8 \\ \; -O \quad\; - H^2 \\ \hline H^2SO^3 + C^{10}H^6. \end{array}$$

We may, also, prepare this acid by means of sulphuric anhydride and naphthaline; in which case the sulphonaphthalic acid is not a residuary compound, but is the result of a simple union of the anhydride and naphthaline. Thus we see that the question is quite as intricate as that of radicals.

CHEMICAL TYPES.

The idea of chemical types has been gradually introduced into science, in proportion to the advances that have been made therein. Strictly speaking, we may attribute this idea to the earliest chemists, who made use of the expressions, iron pyrites, copper pyrites,—white, blue, and green copperas,—or even of sulphuret of iron, sulphuret of copper. Nevertheless, as we understand it at the present day, this idea is dependent upon the atomic theory ; and consequently, its origin must be sought for in the writings of the chemist, who first represented two salts of the same class, by two similar formulæ. It is certain, that Berzelius, in attributing to the sulphates the seleniates and the chromates the formulæ $MO.SO^3$, $MO.SeO^3$, $MO.CrO^3$, had a perfectly clear idea of chemical types. So also had the chemists who associated the chlorates with the bromates and iodates, the chlorides with the bromides and iodides. Mittscherlich, by his discovery of isomorphism, brought the idea into still greater prominence.

Nevertheless, the subject was always in a somewhat undecided state; the terms were not defined with sufficient precision, and chemists were contented to consider, in a vague manner, as belonging to the same chemical type, certain compounds which contained the same number of atoms, and which presented a certain analogy in their properties.

Baudrimont, who was, I believe, the first to make use of the expression, chemical type, considered, with Berzelius, that the sulphates, seleniates, tellurates, and chromates, were salts of the same type, but differed from him by employing empiric formulæ; consequently, he represented the atomic arrangement of the preceding salts by the formula RO^4M.

Indeed, at first sight, the idea of types might seem to be independent of any theory concerning the arrangement of atoms: for whether we note the sulphates thus, $MO.SO^3$, or thus, $M.SO^4$, is but of little consequence; for from the moment that we represent all the above salts in the same manner, do we admit, that they belong to the same type. Such appears to have been the idea of Dumas, when, some years back, he directed the attention of chemists to this subject.

But the question is far from being thus simple, it is surrounded by a thousand difficulties; and to establish a theory of types, is to establish a chemical classification, based upon the number, nature, functions, and arrangement, as well of simple, as of compound atoms.

Supposing that the question be put, as to whether oxides and chlorides belong to the same type. A more simple question cannot be proposed; nevertheless, some chemists, representing the above bodies by the formulæ MO and MCl, admit the identity of type; whilst others, representing them by MO and MCl^2, or, as does Gerhardt, by M^2O and MCl, reject this identity.

There is, moreover, a difference of opinion even among the chemists who make use of the same formulæ MO and MCl; for according to some of them, oxygen and chlorine play the same parts, while according to others, they do not: so that among the former set, the identity of type is admitted, and among the latter, denied.

The case will be rendered more evident by the following example: we are asked, whether the cyanates and the sulphocyanides belong to the same type. There will be no hesitating for a reply among the chemists who consider oxygen, sulphur, selenium, and tellurium, as equivalent bodies.

But we know that opinions are divided in reference to the above question, and that in general, the type $M^2O.Cy^2O$ is attributed to the cyanates, and the type $M^2.Cy^2S^2$ to the sulphocyanides. If to the chemists who admit the functional equivalence of the simple bodies I have just mentioned,—who consider the sulpho, bisulpho, and trisulpho carbonic ethers as belonging to the same type,—if to them we were to put the question, do the pentasulphide, hyposulphite, and sulphate of potassium, belong to the same type, the reply would certainly not be unanimous.

$$\mathrm{Et.CO^3} \qquad \mathrm{Et.C}\left\{\begin{matrix}\mathrm{O}\\ \mathrm{S^2}\end{matrix}\right. \qquad \mathrm{Et.C}\left\{\begin{matrix}\mathrm{O}\\ \mathrm{S^2}\end{matrix}\right. \qquad \mathrm{Et.CS^3}$$

$$\mathrm{KS^5} \qquad \mathrm{K}\left\{\begin{matrix}\mathrm{S^2}\\ \mathrm{O^3}\end{matrix}\right. \qquad \mathrm{K}\left\{\begin{matrix}\mathrm{S}\\ \mathrm{O^4}.\end{matrix}\right.$$

I have said, that the idea of chemical types appears to be independent of all theory concerning the arrangement of atoms. This is perfectly true, up to a certain point. But if it is not necessary to know the atomic arrangement of the two bodies that we compare, nevertheless we must know, whether it is the same for one as for the other, be the arrangement what it may. The question thus put (and the actual state of our knowledge does not permit us to put it otherwise) becomes extremely simplified; for we have not to occupy ourselves with the real arrangement of the atoms, but only to ascertain, whether or not it is the same for such and such other body.

Nevertheless, the subject is still surrounded by numerous difficulties, as may be seen by the following questions.

Potash- and ammonia-alum are isomorphous, susceptible of crystallising together in all proportions; do they belong to the same type?

Every one allows, that the carbonates of lime and of magnesia, which are isomorphous with one another, and contain the same number of atoms, are moulded upon the same type. Is it the same for dolomite?

We are ignorant of the arrangement of the atoms in the acetates; we only desire to know whether it is the same in the acetate of potash, as in that of ethyl. We wish to know, whether the acetates of methyl and of ethyl belong to the same type. If we pronounce for the affirmative, we can only do so by admitting in these ethers, the existence either of ethyl and methyl, or of etherene and methylene. But then the oxides of methyl, ethyl, and amyl, &c., should belong to the same type; and the conclusion would be the same for methylene, etherene, and amylene, &c.; also, for the formic, acetic, butyric, and margaric, &c. acids; and consequently the formiate of methyl, and the margarate of amyl would be arranged in the same type.

We cannot touch a body without raising up a difficulty. Identity of type signifies identity of atomic arrangement. Carbonate of lime crystallises differently from that of baryta; can we say, that they belong to the same type? If we reply in the affirmative, how are we to conceive that two bodies which crystallise differently from one another, and which consequently have not the same atomic arrangement, belong nevertheless to the same type. This is indeed contradictory; can we then admit that two bodies may belong to the same type, and yet not have the same atomic arrangement? If so, what then becomes of our notion of a type?

In considering over this subject, I have myself introduced a considerable modification in the idea usually formed of a type. For ammonia, and the so-called iodide of nitrogen, there were two different types; for etherines, and the chloro-, bichloro-, trichloro,- and quadrichlo-etherines, there were five others employed. I have previously expressed my ideas upon this subject, and I only revert to them, for the purpose of showing the new difficulties in this way called forth. I presume that others will agree with me in admitting, that chlorine by its substitution for hydrogen in the molecule of carbonic ether, does not change the type of the compound. Then do I ask, is it not the same in all other cases? for example, when Dutch liquid and chloro-hydrochloric ether ($C^2H^4Cl.Cl$) become completely chlorinated. If an affirmative reply be given, a difficulty of a new kind will immediately oppose itself.

Chloro-hydrochloric ether and Dutch liquid being isomeric, cannot have the same atomic arrangement, cannot belong to the same type. Hence, if in becoming per-chlorinated, each of the two bodies preserves its atomic arrangement, we ought to obtain two isomeric perchlorides of carbon, C^2Cl^6, one possessing the arrangement of hydrochloric ether, the other that of Dutch liquid. Such, however, is not the case; for the two chlorides of carbon are identical, and consequently, at some time during the process, the type of one of the bodies employed, was destroyed, and replaced by that of the other.

In addition to this modification, I have introduced two others, which are far from being adopted by chemists. I confine myself to recalling them to the recollection of the reader. The first consists in reducing ferrous and ferric, manganous and manganic salts to the same type; and the second, in attributing certain simple bodies to the same type as certain compound bodies, as instanced with chlorine, hydrogen, and chlorhydric acid.

Dumas, has in his turn, proposed new modifications of the idea that we had of chemical types. But having treated this subject rather as a poet, than as a philosopher, it is not easy to comprehend his exact meaning, and we might even draw from his theory, deductions that he would be the first to repudiate. Dumas admits that not only chlorinated, but even oxidised bodies, belong to the same type, as the hydrogenised bodies, from which we may derive them by equivalent substitution. Thus, according to him, alcohol and acetic acid, despite the difference of their properties, belong to the same type; consequently, carbonic acid, CO^2, should belong to the type of Marsh gas CH^4, alcohol C^2H^6O, to the type C^2H^8. Tartaric acid, $C^4H^6O^6$, to the type C^4H^{18}, &c. Nevertheless, a little further on, he has admitted an alcoholic type, and an acetic acid type, differing one from the other.

No matter what the material, says Dumas; no matter whether the statue be of bronze, or marble, or ivory, it is always the same statue, the same type. And indeed, little does it matter, whether the sulphate be a salt of copper, of iron, or of lead; it always belongs to the same type.

But where then are we to stop? Do sulphate of ammonia, sulphuric ether, and alum belong to the same type? If so, what do we mean by a type? All the difficulties I have above indicated, again present themselves.

If hydrogen plays the part of the metals, if chlorine and oxygen, play the part of hydrogen, if sulphur and selenium play the part of oxygen, if the material itself is of no consequence, if we ought only to consider the number and the arrangement of the atoms, then the following bodies ought to belong to the same type, CO^2, SO^2, $C\cancel{H}^2$, $\cancel{N}O^2$, MnO^2 $C\cancel{C}l^2$, $C\cancel{N}\cancel{H}$, &c.

Dumas certainly does not proceed quite so far as this; he says, that for two bodies to belong to the same type, it is not sufficient, that they should contain the same number of atoms; but they must, in addition, have the same atomic arrangement. Then how are we to know, whether the compounds I have just adduced, have, or have not, the same arrangement? Dumas' theory is too general; by its poetic colouring, it lends itself to false interpretations; it is a programme, of which we await the realization.

SECTION SECOND.

CONSTRUCTION OF THE SERIES.—CLASSIFICATION OF THE SERIES.

CONSTRUCTION OF THE SERIES.

It will be easy for us now to abandon theory for experiment; we will simply say, that compounds of the same series contain the same number of atoms of carbon, that they readily metamorphose themselves one into another, and that they have a composition referrible to one of the following divisions:

The first division will comprise a hydrocarbon, and its chloro, bromo, nitro, &c., derivatives; these bodies constitute the nuclei?

The second division may be represented by the nucleus, plus 1, 2, or 3 molecules of one of the following dyads:—H^2, Cl^2, Br^2, I^2, Fl^2.

The third division, by a nucleus, plus 1, 2, or 3, molecules of one of the following monades O, S, Se, Te;

And the fourth, by a nucleus, plus H^2O, H^2S, H^2Se, or H^2Te.

To this series we must yet add another division, that shall comprise the *anhydrides*, the composition of which may be represented by a compound of the third division, minus $\frac{1}{2}$, 1, or 2 atoms of water. We shall arrange these bodies under two heads:

1°. Into *anhydrides*, properly so called, or bodies of the third class, minus that quantity of water which precisely represents their saturating capacity; and

2°. Into dianhydes, or bodies of the third class, minus a quantity of water that represents the double of their saturating capacity.

Thus monobasic acetic acid gives rise to an anhydride $C^2H^4O^2 - \frac{1}{2}$ Aq, or 2 $C^2H^4O^2$—Aq;[*] monobasic formic acid to a dianhyde CH^2O^2—Aq; bibasic carbonic acid an anhydride, CH^2O^3—Aq; and bibasic lactic acid, an acid of an entirely different class, gives rise both to an anhydride and a dianhyde

$$C^6H^{12}O^6\text{—Aq, and —2 Aq.}$$

These are the principal divisions comprised in the first part of the series, or that devoted to the aplones.

The second part contains the *diamerones;* these bodies are formed by the union of aplones belonging either to the same, or to different series, and with or without elimination of water and chlorhydric acid. Confining ourselves to the best known instances, we have said, that the halo and hydrodiamerides contain the residues of the body which have served to form them.

If there were but one single general process for the preparation of these diamerides, it would be very easy for us to construct a hypothesis concerning their residues, and to employ it as a means of classification. But we know, that one and the same body may be prepared according to several different processes, so that we cannot admit the invariable existence of any one particular residue, even of any residue at all. Sulphobenzidic acid, for instance, being prepared by the direct union of sulphuric anhydride and benzine, without any elimination of water.

Nevertheless by having recourse to a very simple convention, we may readily resolve the above difficulty.

---

[*] The monobasic anhydrides should, properly, be placed among the diamerides, but in deference to custom, or as a provisional arrangement, we may leave them among the other anhydrides.

In determining the nature of a diamerone, we will make use of water as the touchstone; that is to say, we will ascertain whether the preparation of the body is accompanied by any separation of water; and if so, by what quantity; or what comes to the same thing, we will ascertain the quantity of water it absorbs in dedoubling itself.

We select water for the following reasons:—as being the hydric acid, it represents the acids; as being the oxide of hydrogen, it represents the bases; and it is equally a representative of the salts, for similarly to these latter bodies does it yield itself to saline double decomposition; moreover, it contains the two extreme elements oxygen and hydrogen, which in the composition of organic compounds, occupy the positions of all the other simple bodies, with the exception of carbon, and the analogues of nitrogen.

Lastly, we select water, because it is in its presence, that all the reactions of organised bodies take place; and because in our laboratories, it most frequently takes part in the metamorphoses effected; either by combining with the bodies to which it is presented, or by separating from the bodies with which it was combined.

Having thus selected our touchstone, we have yet to make another choice equally important, namely that of the preparation or equation of the body, we wish to assay. But this is already done, for now it is impossible for us to choose any other equation than that in which water constitutes one of the terms. It is true, that among the various equations for the preparation of certain diamerides, we may not always meet with one that contains water as a term; but it is easy for us to transform mentally these equations into the one we require. Thus, for the equation representing the formation of phospham (which has hitherto been obtained only by the action of phosphoric chloride upon ammonia), we may substitute the following:

$$PO^4H^3 + 2\ H^3N - 4\ Aq = PHN^2,$$

which represents phospham as a product of the action of phosphoric acid upon ammonia, with an accompanying elimination of water.

It would be equally possible for us to reduce the equations of the halodiamerides to hydratic equations, as shown in the following example which represents the formation of chlorophosphide of nitrogen:

$$PO^4H^3+\left\{\begin{matrix}ClH\\ ClH^4N\end{matrix}\right\}-4\ Aq=PCl^2N.$$

A much simpler method, however, is to refer the formation of this body to the action of phosphoric chloride, and to make a separate class of the halodiamerides.

Having thus reduced the preparation of the hydrodiamerides to a single process, it will be easy for us to classify them, or rather our classification is already made, for we have but to transport hither our great table of the diamerides (*vide* page 240) and then to arrange each compartment in a line with its label, which will serve to designate the bodies contained.

To this table we will yet attach certain other divisions as seen below:

DIAMERONES.

I. Hydrodiamerides and diamerides.(*)	Diamerines or alkaloids	by $A+B$ or $B+B'$
	Diameramides	by $A+B$
	Diameracids	by $A+(A'$ or $B)$
	Diameraies	by $B+B'$
	Syndiamerides	by $n(A+B)$.
II. Halodiamerides.		
III. Paradiamerides	Adelphi	diadelphi triadelphi polyadelphi
	Synheteres.	

The diamerines are alkaline; the diameramides, neutral; the diameracids, as their name indicates, acid; the diameraies neutral; and the syndiamerides (which are bodies formed by the condensation into a single molecule of several molecules of the diamerides) may be neutral, acid, or alkaline. Thus the cyanuric, cyameluric, mellonhydric acids, &c., are syndiamerides.

The paradiamerides are bodies but little known; I divide them arbitrarily into adelphi, or compounds formed by the union of

---

* I make use of the name diameride to designate such of the hydrodiamerides as are prepared by means of at least one acid.

A and A′ designate the acid, B and B′ the non acid bodies.

aplones of the same series; and synheteres formed by the union of aplones of two different series, as instanced by formobenzoylic acid $CH^2O^2 + C^7H^6O$.

The diadelphi contain two aplones, whether identical or dissimilar, belonging to the same series; as for instance, benzoine $= 2\ C^7H^6O$, and green hydrokinone $= C^6H^4O^2 + C^6H^6O^2$.

The triadelphi and the polyadelphi contain a greater number of aplones belonging to the same series.

The subdivisions of the hydrodiamerides are those of our great table; we shall reproduce them further on, together with those of the paradiamerides.

CLASSIFICATION OF THE SERIES.

Our typical series being completed, we will now endeavour to construct a new series, with another nucleus,—that is, with another hydrocarbon,—say, for instance, C^8H^8. Let us classify with this hydrocarbon, all the bodies to which it gives origin, that retain the same number of carbon atoms, and let us compare all these bodies with those of the preceding series.

Two things might happen: either the members of the second series might have a composition analogous to that of the corresponding members of the first series, and yet have dissimilar properties; or the members which were possessed of similar properties might not have an analogous composition.

Thus we might, possibly, have the following parallel:

	1st series.	2nd series.
Hyperhalydes	$C^{10}H^{10}.Cl^2$	C^8H^7Cl
Acids	$C^{10}H^{10}.O^2$	$C^8H^8.O$
Alcohols	$C^{10}H^{10}.H^2O$	$C^8H^8.O^2$
Aldehydes	$C^{10}H^{10}.O$	$C^8H^8.O^6$.

If this were really the case, we should not derive any great advantage from the construction of our series or chemical trees; for by placing in juxtaposition the two trees which had the greatest resemblance to one another, we should find, that the analogous parts did not fulfil the same functions. The roots of the one and the leaves of the other would serve for nutrition; the organs of generation would be represented in the one by the stamens, and in the other by the corolla, &c.

But when I published my first series, I relied with confidence upon the following principle:—

If two analogous bodies undergo the same metamorphoses, the products will still be analogous.

This is the principle of analogy; that which guided the chemists to whom we owe the discovery of the second alcohol, the second amide, the second amidic acid,—that which enabled them to predicate the metamorphoses, as well as the composition of the products to which they gave origin.

But how far may we follow this guide without falling into error? how far may we make use of it as a means of classification?

We have two analogous bodies, formic, and acetic acid; from each of them we abstract H^2O^2, and substitute instead NH; one of the products thus obtained is acid (cyanhydric acid), the other is neutral (acetonitryle). We have here two other analogous bodies, the bicarbonate and bicamphorate of ammonia; from each of them we subtract H^4O^2, and the one product is cyanic acid, and the other camphorimide. Citric acid, which is tribasic, continues so after the loss of H^2O. And, in the same circumstances, tartaric acid, from being bibasic, becomes monobasic,—whilst alloxanic acid, from being bibasic, becomes changed into a neutral body.

Let us take the two bibasic acids, camphoric and alloxanic, and let us submit them to the action of the same reagents. The one gives rise to a diamide, an amidic acid, and a di-imide, &c.; whilst the other produces mycomelinic acid, uramilic acid, uramile, murexid, murexan, and many other bodies, which do not appear to offer any analogy with the products obtained from camphoric, or from any other bibasic acid.

I conceive, that in the presence of such facts, chemists may be very guarded, and may consider analogy as only a somewhat questionable index.

Nevertheless, I have always felt great confidence in this principle, and have been disposed to consider the exceptions as only apparent anomalies, which would, sooner or later, receive their explanation, and accord with the rule. Thus, as has been seen, I have raised doubts concerning the nature of the functions usually attributed to the cyanhydric and cyanic acids; and it will be seen further on, that the alloxanic and dialuric acids, despite the contrary appearance, do comport themselves exactly as does the camphoric acid.

On the other hand it is possible, that the characters upon which we rely for the determination of analogies, have not the values that we attribute to them. Thus, at one time, naturalists attached a great value to the exterior forms of animals, and to the medium in which they lived; and, consequently, they arranged whales and seals among fishes. At the present day, when less value is accorded to the medium, and more to the interior form, the preceding animals are classed among the lower ranks of the mammalia. There are even some naturalists, who, from an attentive examination of the intelligence, and the hand of the seal, are disposed to give it the first place after that of man.

Formerly, metallic aspect had a great value, and tellurium was placed among the metals. Solubility and taste were not less influential; so that boric acid was placed among the salts, and carbonate of lime excluded therefrom.

At the present day, the greatest importance is attributed to electro-chemical characters, and, consequently, the neutral trichloraniline is separated from the basic bichloraniline, and cyanhydric acid from neutral acetonitryle.

For our part we attach but a secondary value to these characters; since we know that one and the same body, as glycocine, may play the parts of an acid, of a base, and of a neutral body.

If we glance at the general aspect of our series, we shall recognise a remarkable agreement between the composition and the functions of corresponding terms; and if here and there we meet with some irregularities, this will not be a sufficient reason for our displacing the bodies in which they are manifested, any more than we should be justified in separating the white lily from the bulbiferous lily, in consequence of the latter, instead of bearing its bulbs upon its roots, bearing them upon the axis of its leaves.

Several methods present themselves to us for the classification of the series; or, what comes to the same thing, for the classification of the hydrocarbons.

We may remark, in the first place, that there are not any hydrocarbons which contain a greater number of *molecules*, or equivalents of hydrogen, than of molecules of carbon, with the exception of certain hyperhydrides, in which the number of hydrogen molecules exceeds the number of carbon molecules by one unit only ($CH^2.H^2$, $C^2H^4.H^2$, $C^3H^6.H^2$, &c.); but at present we need not occupy ourselves with this description of carbides.

The following are the means afforded to us for the classification of the series.

Firstly.—We might associate, in the same order, all the carbides that contain the same quantity of carbon, and subdivide the orders into series, according to the number of the *molecules* of hydrogen. We should then have the following divisions:—

FIRST ORDER, C.

First Series.
CH^2.

SECOND ORDER, C^2.

First series.	Second series.
C^2H^2	C^2H^4

THIRD ORDER, C^3.

First series.	Second series.	Third series.
C^3H^2.	C^3H^4.	C^3H^6.

I shall revert to this method presently.

Secondly.—We might associate in one and the same order, all the hydrocarbons which present the same relation between the carbon and the hydrogen; and subdivide the orders into series, according to the number of the molecules of hydrogen, thus:—

FIRST ORDER, nCH^2.

1st series.	2nd series.	3rd series.	4th series.	5th series.
CH^2.	C^2H^4.	C^3H^6.	C^4H^8.	C^5H^{10}.

SECOND ORDER, nC^2H^2.

1st series.	2nd series.	3rd series.	4th series.	5th series.
C^2H^2.	C^4H^4.	C^6H^6.	C^8H^8.	$C^{10}H^{10}$.

THIRD ORDER, nC^3H^2.

1st series.	2nd series.	3rd series.	4th series.	5th series.
C^3H^2	C^6H^4	C^9H^6	$C^{12}H^8$	$C^{15}H^{10}$.

FOURTH ORDER, nC^3H^4.

1st series.	2nd series.	3rd series.	4th series.	5th series.
C^3H^4.	C^6H^8	C^9H^{12}	$C^{12}H^{16}$	$C^{15}H^{20}$.

This is the classification which I have hitherto adopted, and which offers incontestable advantages, as far as regards the first order, in which are found methylene, etherene, propylene . . . . . . melessine,—the formic acetic propionic . . . . melissic acids; methyl, ethyl, propyl, ... melissyl.

I know that the distribution of this order was received with but little favour; that chemists were much surprised to see me place in succession, carbonic, formic, margaric, and stearic acids; to see me confound in the same class, formic acid and the fatty acids, on the one hand, and acetic acid and alcohol on the other. But I believe, that at the present day, many chemists have reversed their first judgment, and are very nearly adopting my classification.

We know that the perfectioning of this order is due, in a great measure, to Gerhardt, whose equivalents have enabled us to redress many errors; and to Dumas, who has given a corrected list of several of the acids which this order contains. With regard to the other orders, the advantages which they offer are questionable. To the hydrocarbons, C^5H^8, $C^{10}H^{16}$, $C^{15}H^{24}$, $C^{20}H^{32}$, we attach the combinations of citrene, of the essential oils of turpentine and copaiva, of carvene, of colophene, and of the pinic and sylvic acids. But these instances of association are too few in number, and are not sufficiently warranted.

Thirdly.—In following out my first order, Gerhardt has adopted a particular relation which he terms the relation of homology. Two bodies are homologous, when they differ from one another by n times CH^2. Thus, the following compounds on the same horizontal line are homologous.

$$\begin{array}{llll}
C\,H^2, & C^2H^4, & C^3\,H^6, & C^4\,H^8, \ldots\ldots \\
C^8H^2, & C^9H^4, & C^{10}H^6, & C^{11}H^8, \ldots\ldots \\
C\,H^2O, & C^2H^4O, & C^3\,H^6O, & C^4\,H^8O. \ldots\ldots
\end{array}$$

Let us see how we might, *à priori,* justify the employment of this method,—setting out from my first order as from a relation perfectly established between the number of the atoms, and the properties of the bodies which appertain to this order. If we admit as a point perfectly well established, *that when two analogous bodies* (and consequently two corresponding bodies in two series of our first order), *are submitted to the same metamorphoses, the new products will still be analogous;* it is evident, that if from $C^{10}H^{20}$, and from $C^{11}H^{22}$, we subtract CH^2, the two residues C^9H^{18}, and $C^{10}H^{20}$, will be both analogous, and homologous; that if from $C^2H^4O^2$, and from $C^5H^{10}O^2$ we abstract H^2O, the two residues will be both analogous. and homologous; that if from $C^5H^{10}O^2$, and $C^6H^{12}O^2$, we abstract CO^2, the two residues C^4H^{10}, and C^5H^{12} will be both analogous and homologous; and that if from the analogous and homologous, carbonates of methyl and of ethyl respectively, we subtract CO^2, the two residues, methol and ethol would be still analogous and homologous; and that if from $2C^2H^4O^2$, and from $2C^4H^8O^2$ we abstract $CO^2.H^2O$, the two residues, acetone and butyrone, will still be analogous and homologous.

My principle then, pushed to these last subtractions, ought to have led me to the consideration of homology. But somehow, I do not know why, it never occurred to me to apply my principle, in the cases where the two bodies compared, lost or gained carbon.

It was not from any development of this principle, that Gerhardt arrived at the relation of homology; but simply from comparing the properties of the bodies themselves.

If homologous bodies did not present an analogy of properties, we should have to reject this classification; but that they do present this analogy, is obvious from a glance at the homologous compounds of the series CH^2, C^2H^4, C^3H^6, &c. It is true that these series have been already associated without the aid of homology, and that their analogy might be attributed to the geometrical relations which I have indicated.

But in addition to this series, we meet with others in which the members are also analogous and homologous; such are, for example, the pyridic, phenic, toluic, xylenic, mesytic, and cymenic series.

Nevertheless I ought to remark, that there is sometimes an analogy between two series without there being any homology; as in the benzoic and cinnamic series. I propose to classify the homologous series in the following manner. To determine the order of a hydro-carbon, I take the figure which represents the *difference* between the number of the molecules of carbon, and the number of the molecules of hydrogen, which figure I augment by *one unit.*

It must be remembered that two atoms of hydrogen or H^2, represent but one molecule, then:

$C-H^2$, C^2-H^4, C^3-H^6, $C^4-H^8=0$.
which augmented by $1=1$, gives the first order;

C^2-H^2, C^3-H^4, C^4-H^6, $C^5-H^8=1$,
which augmented by $1=2$, gives the second order;

C^3-H^2, C^4-H^4, C^5-H^6, $C^6-H^8=2$,
which augmented by $1=3$, gives the third order;

C^4-H^2, C^5-H^4, C^6-H^6, $C^7-H^8=3$,
which augmented by $1=4$, gives the fourth order.

I divide these orders into series, of which the number is given directly by the number of the *molecules* of hydrogen.

Thus the *ratio of difference* augmented by unity, indicates the order; and the number of the molecules of hydrogen, designates the series.

FIRST ORDER.

1st series.	2nd series.	3rd series.	4th series.	5th series.
CH^2	C^2H^4	C^3H^6	C^4H^8	C^5H^{10}.

SECOND ORDER.

1st series.	2nd series.	3rd series.	4th series.	5th series.
C^2H^2	C^3H^4	C^4H^6	C^5H^8	C^6H^{10}.

THIRD ORDER.

1st series.	2nd series.	3rd series.	4th series.	5th series.
C^3H^2	C^4H^4	C^5H^6	C^6H^8	C^7H^{10}.

I should certainly have adopted this classification in the tables I have appended to this work, both on account of the principle from which I deduce it, and in consequence of the regularity of the numbers.

But as, beyond the first order, the number of series is but very inconsiderable, we shall not, *at the present day,* derive any great advantage from this classification. I therefore prefer, *provisionally,* employing the following.

Fourthly.— I divide all compounds, horizontally, into two great classes:

1. The *oligoxides* (very numerous), of which the monadides do

not contain more than two atoms of oxygen in the monobasic, or more than four atoms of oxygen in the bibasic acids:

2°. The *polyoxides,* of which the monadides contain more than two atoms of oxygen in the monobasic, and more than four atoms of oxygen in the bibasic acids.

Oligoxides.

1	2
A	B

Polyoxides.

I then divide both classes by a single vertical line, so that all bodies will be distributed in a square of four compartments.

The *first compartment* contains all the compounds which belong to the series CH^2, C^2H^4, C^3H^6, &c.; that is to say, to methylene, etherene, propylene, butyrene, &c. These compounds, in addition to the analogies which I have already pointed out, manifest the following very remarkable peculiarity. The members of the superior series are capable of passing successively into the inferior series; as, for instance, when, by oxidation, wax and the margaric, stearic, and cetic acids, become successively converted into suberic, œnanthylic, pimelic, adipic, caprylic, valeric, butyric, succinic, and acetic, &c. acids; and the members of the inferior series are capable of entering regularly into the superior series, as when the cyanide of methyl passes into the ethylic, and the cyanide of ethyl into the propionic series, &c.

The *second compartment* contains all the other series of the oligoxides. Among these there is a very considerable number of bodies, which are possessed of the common property of passing from one series into another, and of finally transforming themselves into various compounds of the phenic series. Thus the members of the naphthalic, alizaric, phthalic, creosotic, cinnamic, terebic, coumaric, anisic, indigotic, salycilic, and benzoic series, transform themselves into benzine, aniline, phenol, picric acid, and chloranil; as if all these members contained a phenic nucleus, which became gradually unmasked in the reactions. I group, provisionally, the series of this compartment in the following manner:

SECOND ORDER C^2.

Single series.
C^2H^2.

THIRD ORDER C^3.

First series.	Second series.
C^3H^2	C^3H^4.

FOURTH ORDER C^4.

First series.	Second series.	Third series.
C^4H^2	C^4H^4	C^4H^6,

and so on. The *order* is given directly by the carbon, and the *series* by the hydrogen. This is the first of the methods I have already given, with this difference, that I have here abstracted the last term of each order, and with these last terms have formed the first compartment.

The *third compartment* A is an appendix to the first. It contains compounds which ordinarily transform themselves into products belonging to the first compartment, and which, perhaps, are but diamerones of a peculiar description. Thus, sugar may be a diadelphide of carbonic ether, in the same manner as cyanuric acid is a triadelphide of cyanic acid.

The *fourth compartment* B, is an appendix to the second. It contains bodies which frequently transform themselves into products belonging to the second division, and which are, perhaps, but diamerones of a peculiar description. Thus euxanthic acid may be but a diameracid, which finally transforms itself into a phenic compound, the oxypicric acid.

The following table is divided by horizontal and vertical lines into squares, which contain organic compounds, distributed according to my method. The vertical lines have reference to the numbers and their relations; the horizontal lines, to the functions of the bodies.

OLIGOXIDES.

COMPARTMENT FIRST. COMPARTMENT SECOND.

	ORDERS		I.					II.	III.		IV.		
	SERIES		1°	2°	3°	4°	5°	1°	1°	2°	1°	2°	3°
APLONES.	nuclenides	hydrocarbons	CH^2	C^2H^4	C^3H^6	C^4H^8	C^5H^{10}	C^2H^2	C^3H^2	C^3H^4	C^4H^2	C^4H^4	C^4H^6
		halydes	CCl^2	C^2H^3Cl				C^2Cl^2					$C^4H^2Cl^4$
		nitrides	CHX	C^2H^3X				C^2HX					$C^4H^4X^2$
	dyadides	hyperhydrides	$CH^2.H^2$	$C^2H^4.H^2$				$C^2H^2.H^2$					$C^4H^6.H^2$
		dihalydes	$CH^2.Cl^2$	$C^2H^4Cl^2$				$C^2H^2.Cl^2$					$C^4Cl^6.Cl^2$
		terhalydes	$CH^2.Cl^4$	$C^2H^4Cl^4$				$C^2H^2.Cl^4$					$C^4H^3Cl^3.Cl^4$
		hexhalydes	$CH^2.Cl^6$	$C^2H^4Cl^6$				$C^2H^2.Cl^6$					$C^4H^6.Cl^6$
	monadides	monalides	$CH^2.O$	$C^2H^4.O$				$C^2H^2.O$					$C^4H^6.O$
		deuterides	$CH^2.O^2$	$C^2H^4.O^2$				$C^2H^2.O^2$					$C^4H^6.O^2$
		tritonides	$CH^2.O^3$	$C^2H^4.O^3$				$C^2H^2.O^3$					$C^4H^6.O^3$
	anhydrides		A—x Aq.										
	monadyades	udolides	$CH^2.H^2O$	$C^2H^4.H^2O$				$C^2H^2.H^2O$					$C^4H^6.H^2O$
DIAMERONES.	hydrodiam	diamerines	A or B + B′—xAq.										
		diameramides	A + B—xAq.										
		diameracides	A + A′ or B—xAq.										
		diameraies	B + B′—xAq.										
		syndiamerides											
	halodiam												
	paradiam	adelphi											
		synheteres											

POLYOXIDES.

ORDERS		A	B
DIAMERO-APLONES.	Acids.	Tartaric, malic.	Gallic, Choloidic.
	Neutral bodies.	Sugar, mannite.	Phloretine.
	Diameramides.	Malamide.	Opianamide.
	Diameracids.	Malamic.	
	&c.		

REMARKS.

a. In examining the functions of the simple bodies, we have not admitted the capability of oxygen for playing the part of hydrogen. Nevertheless it would appear, that in the nuclenides, one molecule of oxygen may replace one molecule of hydrogen, without these nuclenides losing the property of forming halydes, hyperhalydes, monalides, deuterides, tritonides, &c. This opinion is founded upon the following considerations: when we compare the composition and the properties of the salicylic and benzoic series, we perceive that the parallelism of these two series is sustained, even to the minutest details; but with this difference, that there is always one more atom of oxygen in the salicylic than in the benzoic compounds; and moreover, that this atom of oxygen appears to comport itself differently from the rest. Were we to admit, that the two series contained the same nuclenides, we could not conceive why salicylous acid, which has the same composition as benzoic acid, should be possessed of different properties; or why benzoic acid, which so closely resembles salicylic acid, should yet have a different composition. In giving to the two series the same nuclei, we should formulate the component terms as follows:

Benzoic Series C^7H^6.

Benzal	$C^7H^6\ .O$
Chloro-benzal	$C^7H^5\,Cl.O$
Nitro-benzal	$C^7H^5\,X.O$
Sulpho-benzal	$C^7H^6\ .S$
Benzoic acid	$C^7H^6\ .O^2$
Chlorobenzoic acid	$C^7H^5\,Cl.O^2$
Nitrobenzoic acid	$C^7H^5\,X.O^2$
Hydrobenzamide	$3\,C^7H^6\ .N^2$
Nitrohydrobenzamide	$3\,C^7H^5\,X.N^2$
Benzamide	$C^7H^6.O.NH$, &c.

Salicylic Series C^7H^6.

Salicylal	$C^7H^6\;.O^2$
Chloro-salicylal	$C^7H^5\,Cl.O^2$
Nitro-salicylal	$C^7H^5\,X.O^2$
Sulpho-salicylal	$C^7H^6\;.OS$
Salicylic acid	$C^7H^6\;.O^3$
Chloro-salicylic acid	$C^7H^5\,Cl.O^3$
Nitro-salicylic acid	$C^7H^5\,X.O^3$
Hydro-salicylamide	$3\,C^7H^6\;.O^3.N^2$
Nitrohydro-salicylamide	$3\,C^7H^5\,X.O^3.N^2$
Salicylamide	$C^7H^6\;.O^2.NH$, &c.

This singular discordance induced me to think, that the atom of oxygen in excess might indeed belong to the nucleus. Let us then agree to refer the atom of oxygen in excess to the nucleus, as if the salicylic compounds contained C^7H^6O derived from C^7H^8.

According to this convention, the two series would be formulated as follows:

Benzoic series.

Benzene	C^7H^6
Benzal	$C^7H^6\;.O$
Chlorobenzal	$C^7H^5Cl.O$
Nitrobenzal	$C^7H^5X.O$
Sulphobenzal	$C^7H^6\;.S$
Benzoic acid	$C^7H^6\;.O^2$
Nitro-benzoic acid	$C^7H^5X.O^2$
Benzamide	$C^7H^6\;.O.NH$
Benzhydramide	$3\,C^7H^6\;.N^2$, &c.

Salicylic series.

Toluene	C^7H^8
Salycene	C^7H^6O
Salicylal	$C^7H^6\;O.O$
Chlorosalicylal	$C^7H^5Cl\,O.O$
Nitrosalicylal	$C^7H^5X\,O.O$
Sulphosalicylal	$C^7H^6\;O.S$
Salicylic acid	$C^7H^6\;O.O^2$
Nitrosalicylic acid	$C^7H^5X\,O.O^2$
Salicylamide	$C^7H^6\;O.O.NH$
Salicylhydramide	$3\,C^7H^6\;O.N^2$, &c.

Consequently, the salicylic series would be associated with the toluic, the latter containing the nucleus C^7H^8, and the former the derived nucleus C^7H^6O.

But by uniting these two series into one only, insurmountable inconveniences as regards nomenclature would result; consequently, I prefer to separate the two series under the name of *branches:* then the series toluosalicylic would be divided into two branches or sub-series, the toluic and the salicylic.

The phenic C^6H^6 and kinonic C^6H^4O series being united under the name of the phenokinonic series, this latter would be divided into the first branch or sub-series the phenic, and the second branch or sub-series the kinonic.

It would be the same for all the other series, which would divide themselves into two branches. It is to be observed, that the different terms of the two branches of the same series, frequently pass into one another, as instanced in the phenokinonic, butyrosuccinic, naphthalizaric, &c., series.

Can then two, three, or four equivalents of oxygen be substituted for hydrogen in the nuclei, without causing these nuclei to lose their fundamental characters? I do not know, and at this present time we can only frame hypotheses upon the subject. We might, indeed, consider bibasic mesoxalic acid $C^3H^2O^2.O^3$ as a derivative of $C^3H^6.O^3$, and monobasic cholesteric acid $C^8H^{10}O^3.O^2$ as a derivative of $C^8H^{16}.O^2$; but these formulæ would only throw confusion both into the classification and the notation. I will nevertheless, point out the sole reaction which accords with this manner of viewing the subject. Lithofellic acid contains $C^{20}H^{36}O^4$; by the action of nitric acid it gives rise to another acid containing, according to Malaguti and Sarzeau, $C^{20}H^{28}NO^{11}$. If we replace this formula by the following $C^{20}H^{27}NO^{10}$, which appears to me more probable, we might account for its formation as follows:—Lithofellic acid, by an exchange of H^8 for O^4, becomes at first $C^{20}H^{28}O^8$, and then H being exchanged for NO^2, gives rise to $C^{20}H^{27}XO^8$. Lithofellic acid appearing to be bibasic (it loses H^2O by heat), would be noted thus:

$$C^{20}H^{36}O.O^3$$

And the first term by .... $C^{20}H^{28}\ .O^5.O^3$
And the second term by .... $C^{20}H^{27}XO^5.O^3$;

but this is one hypothesis based upon another.

β. From what we have just said, it is obvious, that in the oligoxides we may meet with monobasic acids, which contain three atoms of oxygen, and bibasic acids, which contain four, and which, in consequence, ought to be associated with the polyoxides. But by having regard to the distinction I have just made, we may leave these acids among the oligoxides, since the oxygen of the nucleus ought not to be taken into account, as regards the monalides, deuterides, and tritonides.

Thus butyric acid $C^4H^8.O^2$, which is a deuteride, becomes changed by oxidation into bibasic succinic acid $C^4H^6O.O^3$, which is a tritonide and not a 4-*ide.*

γ. Having thus classified the above seriated bodies, there yet remain others, which are unattached to the preceding by any relations, which are quite isolated therefrom, and of which we know neither the functions nor the metamorphoses. It is evident that such bodies cannot find a place in our classification: it would be as reasonable to desire the classification of a plant, whose stalk or leaf only is known to us.

Lastly, there are others which fulfil, perhaps, new functions, and which have no analogies among the bodies hitherto known; we must, therefore, wait for the discovery of other bodies enjoying the same properties, when they will readily find a place in a new family or in a new genus.

For the present, I make a general appendix of all these bodies, and establish the following divisions among them:

1°. ALKALOIDS.

2°. VEGETABLE SUBSTANCES.

- *a.* Acids
- *b.* Neutral principles
- *c.* Essential oils
- *d.* Resins
- *e.* Colouring matters.

3°. ANIMAL SUBSTANCES.

- *a.* Uric combinations,

(these are seriated in respect to one another, but I am unable to localise the series.)

- *b.* Various.

4° INCRYSTALLISABLE SUBSTANCES.

Fibrin, albumen.

The alkaloids must sooner or later become classified in the various series among the diamerines, as is aniline in the phenic series. Nevertheless, though referring this body to its proper series, I also place it among the alkaloids, because I think it desirable to have all these compounds reunited in the same class.

δ. The diamerones have a double or triple aspect, and according to the position in which we regard them, so are we disposed to refer them sometimes to one series, sometimes to another. Thus formanilide might equally well be placed in the formic as in the anilic series. Here some convention is necessary. I place all the diamerones in the series of the acids from which they originated. With regard to the diameraies, formed as they are from two bodies, neither of which is acid, they also may be classed in a similar manner, by considering one of the two bodies as acid in respect to the other, thus benzal-anilide might be placed in the series of benzal.

As regards salicine, a diameray of glucose and saligenine, in order to pass from the known to the unknown, we must place it in the series which last presents itself for study, and, consequently, in the glucosic series, since this comes after the salicylic.

Moreover, I have placed nearly all the diamerones in two different places, because I believe that the reader would like to have all the ethers of alcohol in one and the same group, and all the camphoric amides in another specific group.

ε. From what I have just said (δ), we ought to place the ethers, amides, &c., in the groups appertaining to the mineral acids; but it will be recollected, that we have previously made a more general convention, that of comprising all compounds of carbon within the limits of organic chemistry, and, consequently, the monobasic hydrochloric, hydrobromic, hydroiodic, chloric, bromic, iodic, nitric, &c., ethers, will be placed at the head of the amides of alcohol, the other monobasic ethers coming in succession, according to the number of their orders and series.

The bibasic hydric, hydrosulphuric, hydroselenic, sulphurous, sulphuric, silicic, &c., ethers, will be placed at the head of the diamides of alcohol, and then will follow the other bibasic ethers according to the numbers of their orders and series. I shall give, moreover, a general table of the order in which I arrange the metals and other mineral substances.

ζ. Instead of the vertical classification or that by series, such as I have given it in my tables, we might substitute the horizontal classification, that is to say, we might alter the position of the preceding table, so as to render the series horizontal, and the functions vertical. We should then have tables which contained,—the first, all the hydrocarbons; the second, the halydes; the third, the hyperhalydes; the fourth, the protonides; the fifth, the deuterides; and, so on.

PART FIFTH.

GENERAL CLASSIFICATION.

SECTION FIRST.

FUNDAMENTAL PRINCIPLES.—THEORY OF DERIVED NUCLEI. (CARENIDES).—THEORY OF THE DIAMERIDES.—SYNOPTIC FORMULÆ.

FUNDAMENTAL PRINCIPLES.

IN the first part of this work, I showed how the principles which are ordinarily relied upon, for the classification of bodies, are uncertain or contradictory. It may be remembered, that for the oil of Gaultheria, we hesitated between ten or twelve different places; and when we endeavoured to set out from a single principle, that of compound radicals, we exposed ourselves at each step, to the risk of falling into more and more embarrassing hypotheses.

I now proceed to expose the fundamental principles, upon which my own classification is established. They are the following:—

1°. *Combinations are formed according to very simple relations; and metamorphoses are also produced in virtue of very simple equations.*

I will cite the composition of one of the most complex bodies, that of myricine $= C^{46}H^{92}O^{2}$, which, despite its high numbers, may be represented by 1 molecule of cetic acid, plus 1 molecule of melissic alcohol, minus 1 molecule of water; that of cetic acid may be represented by 1 molecule of cetine, plus 2 molecules of oxygen; that of melissic alcohol, by 1 molecule of mellissine, plus 1 molecule of water. Lastly, that of cetine or melissine, by an equal number of molecules of carbon and hydrogen.

Instead of these really simple relations, let us inquire into those which are ordinarily admitted. Myricine would then contain $C^{92}H^{184}O^{4}$, and would be composed of 1 molecule of anhydrous cetic acid, and 1 molecule of oxide of melissyl.

These two latter bodies, $C^{32}H^{62}O^{2}.O$, and $C^{60}H^{122}.O$, would not be susceptible of any further simplification, in consequence of the numbers 62 and 122, or in equivalents 31 and 61, being indivisible.

When fifteen or eighteen years ago, I first put forward this principle, it was very far from being adopted; and even at this present day, I do not know of any one who is disposed to entirely recognise its justness. Moreover, at every step we meet with inacceptable formulæ and equations, such as the following:—

Proteine	$C^{40}H^{62}N^{10}O^{12}$,
Fibrine	$10\,C^{40}H^{62}N^{10}O^{12} + SP^{2}$;
Fibroine	$C^{39}H^{62}N^{12}O^{17}$;
Sponge	$20\,C^{39}H^{62}N^{12}O^{17} + I^{2}P^{10}S^{3}$,
Bromate of cobaltammon	$6\,B^{2}O^{5} + Co^{4}O^{3} + 14\,H^{3}N + 12H^{2}O$,
Anorthite	$(3\,SiO^{3} + 9\,R^{2}O) + (8\,SiO^{3} + 8R^{4}O^{3}.)$

Action of carbonic acid upon a carbonate of magnesia.

$$11(\ 8\,CO^{2}.\ 9Mg^{2}O.5\,H^{2}O) +\ 2\,CO^{2},$$
$$= 9(10\,CO^{2}.11Mg^{2}O.5\,H^{2}O) + 10\,H^{2}O,$$

Action of potash upon a chlorinated product of methol.

$$3\,C^{12}H^{16}Cl^{10}O^{5} + 9\,K^{2}O + 8\,H^{2}O$$
$$= 18\,ClK + 4\,CH^{2}O^{2} + 6\,C^{4}H^{8}O^{3} + 2\,C^{4}H^{4}Cl^{6},$$

Decomposition of rubian by acids.

$$C^{56}H^{68}O^{30}\begin{cases} = 4\,C^{14}H^{10}O^{4} + 14\,H^{2}O\,; \\ = \ C^{14}H^{10}O^{5} +\ 2\,C^{14}H^{12}O^{4} + 12H^{2}O. \end{cases}$$

Decomposition of ruberythric acid by acids.

$$C^{72}H^{80}O^{4} = C^{60}H^{38}O^{19} + C^{12}H^{24}O^{12} + 9H^{2}O.$$

Certainly chemists have perceived for a long time past, that combinations and reactions not unfrequently take place in very simple relations; but, from the preceding formulæ and equations, it is clear, that they never thought of adopting the principle I have just adduced.

2°. I admit with all chemists, *that the properties of compound bodies depend upon the nature, the number, and the arrangement of the atoms.* But I admit moreover, *that order or arrangement has fre-*

quently a greater influence upon the properties of the body, than has the nature of the material of which it is composed.

I have here in view the different chloro-substitutions,—isatine, chlorisatine, &c.

3°. *The properties of compound bodies depend likewise, upon the functions fulfilled by their constituent simple bodies.*

This may be considered simply as a variation of the preceding principle: nevertheless it must be remembered, that we have attributed several equivalents to the same body, according to the functions that it fulfils, and consequently the distinction that I have drawn is necessary.

But, for the application of this principle, we ought to have a table of simple bodies arranged according to their functions, after the following fashion:—

C	O	H	H	N
C	S	Cl	K	P
C	Se	Br	Na	As
C	Mn	I	Mn	Sb
C	Fe	Mn	Fe	

We here perceive manganese to occupy three different places; in the second series, in consequence of the manganates; in the third, in consequence of the permanganates; and in the fourth, in consequence of the salts of manganese. It ought even to occupy two different places in this fourth series; one by the side of magnesium, in consequence of the salts of manganosum, and the other by the side of aluminium, in consequence of the salts of manganicum.

I ought not to omit remarking, that Hœfer in his classification of simple bodies, first conceived the idea of placing iron and manganese by the side both of magnesium and of aluminium.

Rigorously speaking, it is not iron that is the analogue of aluminium and magnesium, but the combinations of ferric oxide, that are analogous to those of alumina, and the combinations of ferrous oxide that are analogous to those of magnesia. Hence I believe it would be preferable, for the preservation of the analogies, to give to the different equivalents of iron, different names, weights, and symbols, as in the following table.

Oxygen	O	Magnesium	Mg	Aluminium	al
Sulphur	S	Cobaltosum	Co	Cobalticum	co
Ferran	Fe	Ferrosum	Fe	Ferricum	fe
Mangan	Mn	Manganosum....	Mn	Manganicum....	mn.

In studying the nature of substitutions, we have seen, that however numerous were the simple bodies that entered into an organic compound, we might always reduce them to the three following,—carbon, hydrogen, and oxygen; nitrogen being added thereto as a representative of ammonia, or of nitrous or nitric acids.

I put aside silicon, tantalum, titanium, &c., to which at this present time I am unable to assign a suitable place: consequently, when we meet with a compound of this description, C^2Cl^4KPS, by having regard to the functions which each of the constituent simple bodies fulfils, we readily reduce it to the normal type, C^2H^5NO. It must however be well understood, that we except from this rule, those cases in which a mineral acid is united, for example, with an alkaloid or an alcohol, to form a salt, an amide, an ether, &c. Thus, the sulphate of ammonium $SO^4H^2.N^2H^6$ ought not to be reduced to the type $H^8N^2O^5$, nor sulphanilide $SO^2C^{12}H^{12}N^2$ to the type $C^{12}H^{12}N^2O^3$, nor chloric ether $ClO^3H.C^2H^4$ to the type $C^2H^6O^3$, &c.

4.° *The relations which exist between the number of the atoms of carbon, and the number of the atoms of hydrogen, of oxygen, of nitrogen, &c., exert such an influence upon compound bodies, that any two bodies which manifest similar relations, are likewise possessed of similar properties.*

Up to this time we have been satisfied with affirming, that any alteration of the number of the atoms which enter into a compound body, effects an alteration in the properties of that body.

This result flows naturally from the principle, that the number of the atoms exercises an influence upon the properties of the compound. Thus, oxide of carbon has no resemblance to carbonic acid.

In my first attempts at classification, I pointed out the relations which exist between the carbon and hydrogen, ($n\,CH^2$) of methylene, etherene, butyrene, cetene, &c.; between the carbon and hydrogen, ($n\,CH^2$) of formic, acetic, butyric, cetic, margaric, &c., acids,; between the carbon and the hydrogen of ($nC^2H^4+H^2$), of the radicals methyl, ethyl, amyl, &c., between the carbon and hydrogen ($nC^2H^4—H^2$), of the anhydrous formic, acetic, stearic, &c., acids; and between the carbon and hydrogen (nC^5H^4) of the citrenic, terebenic, camphoric, pinic, and sylvic, &c., combinations. It was from a reliance upon these ratios, that I considered myself justified in placing, contrary to the received ideas on the subject, formic, acetic, stearic, and margaric acids in the same class.

I likewise pointed out the ratios which exist, between the number of the atoms of hydrogen in the hydrocarbons, and the sum of the atoms of hydrogen, chlorine, and bromine, in the halydes and hyperhalydes.

I also called the attention of chemists to other ratios of the same description, which were not in every case based upon perfectly exact formulæ. Frequently, and sometimes with reason, did I take the liberty of altering formulæ, so as to make them coincide with my ideas.

At the present day, when so many errors have been rectified by experiment, I shall point out fresh ratios, and shall avail myself of them in my classification; but I am far from being able to give anything like completeness to this subject; mine is only an attempt that deserves to be further prosecuted. Thus we remark, that in the simple monobasic acids (I do not speak of combinations containing nitrogen), there is nearly always 1 volume of a hydrocarbon for 1 volume of oxygen; in the simple bibasic acids, 1 for 2; and in the aldehydes, 2 for 1. In the complex acids (diameracids, sulphobenzoilic acid, &c.) we unquestionably find other ratios. Moreover, we find others in carbonic acid, and in salicylic and anisic acids; but, as we shall presently see, these last ratios may be reduced to the two former.

If certain acids,—as the citric, meconic, lactic, euxanthic, tannic, &c., present very different ratios, it is because they are likewise possessed of very different properties from the preceding acids, and possibly are complex acids.

Certain azotised bodies,—as the uric, alloxanic, dialuric, &c. combinations, present an appearance of unusual ratios, and of metamorphoses, without analogues in science. I hope, however, to show that these ratios and metamorphoses are not at all of an extraordinary character.

5°. In common with the majority of chemists, I admit *that there is a certain predisposition in the arrangement of atoms;* but distinctively from them, I believe *that it is impossible for us to know this arrangement, but that we may nevertheless ascertain, whether in any one particular body it is the same as in some other body.*

Thus I admit, that the atomic arrangement is the same in benzoic acid and in nitrobenzoic acid; in acetic acid and in chloracetic acid; in isatine and in chlorisatine; in benzamide and in benzoic ether: although I cannot, in any one of these cases, say what the arrangement really is.

6°. *To determine in a classification, the place that any particular body ought to occupy, regard must be had, not only to the nature, number, and arrangement of its constituent atoms, but also, and chiefly, to its metamorphoses, or its generation.*

I shall revert to this subject presently.

As a summary of the preceding observations it is evident, that in a perfect classification regard must be had,

To simplicity of composition;

To simplicity of equations;

To the relations which exist in the numbers of the atoms;

To the nature and number of the elements;

To their functions, and to those of the compound bodies;

To the arrangement of the atoms;

To all the metamorphoses;

To analogy, gaseous volume, density, isomorphism;

To the boiling point, quantity of heat evolved by combustion, &c.

If bodies were well classified, we should have, at one and the same time, a classification of their functions, vapour densities, metamorphoses, &c.

I will explain myself by an example: the hydrocarbons nCH^2 are upon the same level in my classification. The density of their vapours increases according to the numbers 1, 2, 3, 4; their boiling points increase progressively according to a certain law, the quantity of heat developed by their combustion also follows a regular law; their metamorphoses resemble one another; the number of atoms increases progressively, although the simplicity of the formulæ remains the same:

$$CH^2, \qquad C^2H^4 \ldots . \qquad C^{30}H^{60};$$

and lastly, they would probably present an analogy in their forms, at least if we may judge from the analogy which exists between the formate, acetate, propionate, and butyrate of copper, and between certain methylic and vinic ethers.

The only difficulty to be guarded against is the following, namely, the possibility of the principles and characters upon which we rely contradicting one another, and thus throwing our classification into confusion. It will not do for us to have one class based upon functions, and another based upon composition, or upon atomic arrangement; for then we should fall back into the inconveniences of the ordinary classifications, where one single body may be found in a dozen different places.

Consequently, it is necessary for us to subordinate the characters one to another, in the same way that naturalists subordinate the number, situation, and function of the different organs. I shall endeavour to attain this object in the following chapter.

Idea of the Series.

Since the discovery of the galvanic battery, chemists have invariably distributed bodies into three grand classes, which comprise respectively, positive, negative, and neutral bodies. The neutral bodies, which ordinarily bear the name of salts, are considered to be formed by the union of two simple bodies, whether simple or compound, of which one is positive, and the other negative. When this union takes place between two compound bodies, the negative bears the name of acid, the positive that of oxide, or alkali.

So strong is this tendency to consider neutral bodies as salts, that even when chemists meet with bodies differing from one another as widely as do sugar, chloretherine, oxamide, and iodide of nitrogen, they hasten to form hypotheses upon their atomic arrangements by which they may prove, that the above bodies have a saline constitution; and that one of them is a carbonate of ethyl, another a chloride of acetyl, another an amide of carbonic oxide, and the last a double iodide of nitrogen and ammonium. Lastly, as the basis of all these classifications, we find the following divisions:

Simple radicals,
Compound radicals,
Acids,
Alkalies,
Salts.

The divisions that I employ have no relation with the preceding. Thus, I have already said, that I confound acids, oxides, and salts, in one and the same class, under the common name of salts.

In considering all chemical bodies, I attend primarily to their *simple* or *compound* nature, and hence distribute them into the two principal divisions of simple and compound bodies. According to the *nature of the constituent elements*, do I divide the latter class into nearly as many families as there are simple bodies. Among these families, that of carbon, or of organic compounds, takes its place. This family I split up into horizontal layers, and thus obtain divisions deduced from the *functions* of the members, and then I separate it anew into vertical sections, and thus obtain *series* deduced from the principle of *generation;* concerning which series I propose to enter more into detail.

The dominant principle made use of in the natural sciences, for the purposes of classification, consists in the association of bodies according to their resemblances.

Let us see whether or not this principle is applicable to a chemical classification,—whether or not we ought to place side by side, those bodies which most resemble one another. Clamours will, without doubt, be raised, at the idea of separating bodies which manifest analogous properties, but the alarm will be unnecessary; for I hope, by setting out from a more elevated point of view, to show, that although placing together bodies which are devoid of resemblance, it is at the same time possible for me to associate into one class, those bodies which most resemble one another.

The majority of chemical substances have, so to speak, several faces, and according to the face which we take as the term of comparison, so are we forced to refer the body to totally opposite classes. Let us take oxalic ether as an example. Regarded as an oxalic compound, it ought to be placed along with the oxalates and oxamide; regarded as an ethylic compound, it must be arranged along with the sulphuric, carbonic, and camphoric ethers; and under another point of view, we ought to place it with the oxalates of methyl, butyl, amyl, cetyl, &c.

In any of these cases, it would be removed from bodies, to which it presents many similarities.

These considerations have led me to demand, whether the character of resemblance is really that which possesses the greatest value in chemistry.

Supposing, for an instant, that the various species of the vegetable kingdom, were fractioned in such a manner, that their different parts, such as roots, stems, buds, leaves, petals, stamens, and seeds, were found variously disposed upon the surface of the globe; would a botanist collect all the roots into one class, all the leaves into another, all the stamens into a third? Certainly not: for observation and cultivation would show him, that certain stems engender certain buds and certain leaves; that these leaves are susceptible of modifications, and become transformed into calycinal, staminal, and carpellary leaves, of a certain nature; that these carpels engender seeds of a special structure, which in their turn reproduce the stem, leaves, and other organs.

He would be necessarily led to group into one entity, all these beings, so dissimilar in their appearance; but this is precisely what has been done by nature in the creation of distinct vegetable species. Hence I would ask, is it not conformable to the true spirit of science, to group chemical substances into aggregations, of which the different parts, though at the first glance dissimilar, shall engender one another reciprocally, and shall represent as a whole (if I may be permitted the expression) a real chemical tree?

Supposing our chemical tree to be formed; it is evident, that (certain of the constituent parts having no greater resemblance to one another, than have the leaves of an oak to an acorn) the study of this tree will be somewhat difficult; since, after having studied one object we shall pass to another, frequently having no other relation with the preceding, than that of a common origin.

But the study of our chemical tree being once achieved, if we place by its side the tree which most resembles it, the study of this latter will become extremely easy; for continuing our comparison, we already know how to distinguish the stem, buds, leaves, &c., and how these parts metamorphose themselves one into another.

The principle of mutual generation, being thus propounded as the basis of a chemical classification, I must give some explanation as to what I mean by the expression chemical generation. When a compound body is treated with certain reagents, we may have either generation or destruction. There is *generation*, when the produced body can in its turn engender the body from which it sprang. Thus, acetic acid gives rise to chloracetic acid, from which the acetic acid can be reproduced. There is *destruction*, when the property of reproduction does not exist; for instance, matacetone is a product of the destruction of sugar. (For further details *vide* page 167, *Article*, Symmetrical reactions.)

The bodies which thus reciprocally engender one another, serve as the elements for the construction of our trees, or *chemical series*.

Hitherto, chemists have not succeeded in reconstructing all compounds, by means of those to which they can give origin.

Therefore, in default of the preceding, we must have recourse to other characters, when we would learn, whether two bodies belong to the same series.

If several compounds, without loss of carbon, metamorphose themselves into one and the same body, we may arrange them in one single series; and we may conclude, that sooner or later, we shall be able to metamorphose them into one another. Thus I arrange in the same series, phenic acid, benzine, kinone, and aniline, each of which may be transformed into chloranil without loss of carbon.

But in addition to the character I have just given, there is still another property which is common to all the compounds of the same group, and which enables us to trace the limits of the group. I propose to explain this circumstance, first of all, in a theoretical manner; but as in the first page of this work, I undertook to base none of my views upon hypothesis, I shall give the theory in a separate chapter, and then immediately revert to facts as the only solid basis of a good classification.

THEORY OF DERIVED NUCLEI (CARENIDES).

If I may be permitted to follow up the comparison which I have just instituted, I would ask, if a botanist might not be able to ascertain, independently of generation, or metamorphosis, whether two isolated parts, a leaf and a petal for example, belonged to the same plant? The thing would, without doubt, be difficult in our present state of knowledge; but is it not conceivable, that by the aid of a more perfect dissection, we might some day succeed in discovering, that all the parts of the same plant contain something in common, an embryo, a mother cell,—the presence of which, in all the organs, will enable us to understand why they are all capable of transforming themselves into one another?

Be this as it may, I have endeavoured to ascertain, whether there is not in all the different parts of our chemical tree, something analogous to this mother cell; in one word, a *nucleus* common to all the compounds of the same series, a nucleus which would enable us to understand, why all these compounds can reciprocally engender one another.

On several occasions I have insisted strongly upon the stability of the halydes,—of these molecular groups, which incessantly re-appear in our reactions; and I have also called attention to the relative instability of the hyperhalydes. I was always astonished at seeing naphthaline, though six, seven, or eight times chlorinated by equivalent substitution, yet resist the action of heat and alkalies, whilst this same naphthaline, once or twice chlorinated, but not by substitution, was destroyed by the action of these two reagents, and in every case a halyde produced. From considering the crystalline form, the analogy, the re-actions, and principally the stability of naphthaline, and the halydes, I conclude, that they constitute one unique group, or nucleus, which enters as such into the composition of the hyperhalydes. These latter, consequently, contain two groups; the one, formed of naphthaline or its halydes, the other, of the excess of chlorine.

It is true we might equally account for the stability of the one class, and the instability of the other, as also for the analogy which exists between the compounds of each of them, by supposing, that the hyperhalydes contain, not a *chlorinated*, but a *hydrochlorinated* group, as seen in the second members of the following equations;

$$C^{10}H^8 + Cl^4 = C^{10}H^6Cl^2 + H^2Cl^2$$
$$C^{10}H^7Cl + Cl^4 = C^{10}H^5Cl^3 + H^2Cl^2,$$
$$C^{10}H^6Cl^2 + Cl^4 = C^{10}H^4Cl^4 + H^2Cl^2, \text{ \&c.}$$

It is this latter mode of viewing these compounds that, in the first instance, I proposed; subsequently I abandoned it, and adopted in its stead, the arrangements indicated by the first members of the above equations. The compound $C^{10}H^6Cl^2 + Br^4$, heated to above 100°C, is decomposed in $C^{10}H^6Cl^2$ and Br^4, which result would be impossible, if one part of the bromine were in the state of bromhydric acid, as in formula $C^{10}H^4Cl^2Br^2 + H^2Br^2$.

If then, in the above compound, the bromine does not exist in the state of bromhydric acid, neither will the chlorine of the analogous and isomorphous compound $C^{10}H^6Cl^2 + Cl^4$, be in the state of chlorhydric acid, nor by parity of reasoning in the compounds $C^{10}H^7Cl + Cl^4$, $C^{10}H^8 + Cl^4$.

If naphthaline and its halydes continue as such, when combined with an excess of chlorine or bromine, so likewise do they continue, when combined with oxygen to form aldehydes or acids. Consequently, $C^{10}H^8 + O$ will not give rise to $C^{20}H^{14}O + H^2O$, and $C^{10}H^8 + O^2$, will not form a hydrated acid of the formula $C^{20}H^{14}O^3 + H^2O$.

Having regard to the preceding considerations, observing moreover that in the aldehydes, and in the formic, acetic, propionic, ... margaric, and melissic acids, the carbon is to the hydrogen, in the ratio of molecule to molecule, or of one atom to two atoms, whilst these simple ratios become irregular, if we suppose that in the above compounds, a part of the hydrogen, constitutes a hydrate or hydruret, as seen in these examples; $C^5H^8O^3+H^2O$, $C^{10}H^{18}O^3+H^2O$, $C^{20}H^{38}O^3+H^2O$, $C^{60}H^{118}O^3+H^2O$, or indeed, $C^{60}H^{118}O^4+H^2$, &c,; and lastly, recollecting the relations which exist between the forms of the halydes, and those of the hyperhalydes of naphthaline, relations somewhat obscure it is true, but still sufficient to indicate, that in the atomic arrangement of both classes there is a certain something in common; I draw the following conclusions:

1°. That the hydrocarbons and their halydes, form analogous groups or nuclei,—stable as regards the number and arrangement of the atoms, but variable as regards their nature. Thus, we may have hydrogen, chlorine, bromine, peroxide of nitrogen, or other bodies, occupying the place of hydrogen.

2°. That the hyperhalydes, and the corresponding aldehydes, and acids, all contain a hydrocarbon, or halyde, which constitutes a separate group.

In a word, I conclude, that the combinations of etherine, or bihydrocarbon, have the following arrangements;—

Halydes.	Hyperhalydes.	Aldehydes.	Acids.
”	$C^2H^4\ .H^2$	”	”
C^2H^4	$C^2H^4\ .Cl^2$	$C^2H^4\ .O$	$C^2H^4\ .O^2$
C^2H^3Cl	$C^2H^3Cl\ .Cl^2$	$C^2H^3Cl\ .O$	$C^2H^3Cl\ .O^2$
$C^2H^2Cl^2$	$C^2H^2Cl^2.Cl^2$	$C^2H^2Cl^2.O$	$C^2H^2Cl^2.O^2$
$C^2H\ Cl^3$	$C^2H\ Cl^3.Cl^2$	$C^2H\ Cl^3.O$	$C^2H\ Cl^3.O^2$
$C^2\ \ Cl^4$	$C^2\ \ Cl^4.Cl^2$	$C^2\ \ Cl^4.O$	”

In applying the same reasoning to the combinations of methylene, propylene, butyrene, amylene, ... cetine, and melissine; to the combinations of benzene, phene, toluene, cymene, &c., in placing side by side, their halydes, hyperhalydes, aldehydes, and acids, and observing the harmony, the elegance, and the extreme simplicity of their formulæ, I cannot help considering the above, to be a representation of the real arrangement of the atoms.

Following out these ideas, let us construct a tree, or a series, with any hydrocarbon whatever, taken as the nucleus, say for instance $C^{10}H^{10}$. For this purpose, let us bring together all the bodies which mutually generate one another, and contain the above nucleus, and let us then dispose them in the following manner:—

	Nuclenides Fundamental Nucleus	$C^{10}H^{10}$.
DYADIDES. (Hyperhalydes.)	Hyperhydride	$C^{10}H^{10}+H^2$;
	Dihalyde	$C^{10}H^{10}+Cl^2$;
	Tetrhalyde	$C^{10}H^{10}+Cl^4$;
	Hexhalyde	$C^{10}H^{10}+Cl^6$;
MONADIDES	Monalide	$C^{10}H^{10}+O$;
	Deuteride	$C^{10}H^{10}+O^2$;
	Tritonide	$C^{10}H^{10}+O^3$;

or better still

Xeromonadides	Xeride	$D-Aq\frac{1}{2}$
	Dixeride	$D-Aq$
	Anhydride	$T-Aq$
	Di-anhydride	$T-Aq^2$.
Monodyadides	Udolides	$C^{10}H^{10}+H^2O$.

The dyadides contain dyads in addition to the nucleus.

The monadides contain monads in addition to the nucleus.

The monodyadides contain dyads and monads in addition to the nucleus.

The words monalide, deuteride, tritonide, have reference only to the composition of the monadides, and not to any predictions concerning their nature or functions. Were we to arrange all bodies in this manner, we should have too great a number of small series. But we have a very simple means for reducing this number, by augmenting that of the bodies which enter into each of the series.

Indeed, to every one of the tables, similar to the preceding, we may attach a host of different varieties. For this purpose, we shall be obliged to act in opposition to the general proceeding of chemists; we must unite what they separate, and separate what they unite. We shall imitate the botanists, who arrange in the species *Rose,* the white, the yellow, and the variegated rose, and do not attach any importance to the colours of their petals, though formed of very different chemical compounds; that is to say, that in the matter now under consideration, we shall attach more importance to the number and arrangement, than to the nature of the atoms.

Let us recollect that chlorine, iodine, bromine, fluorine, the nitric residue X, and the nitrous residue Y, may be substituted for hydrogen, and, to a certain extent, fulfil its functions. Consequently, let us take the fundamental nucleus of the preceding table, and let us effect in it various equivalent substitutions; that is to say, let us set free 1, 2, 3, . . . 10, atoms of hydrogen, and replace them by the same number of atoms of chlorine, bromine, iodine, fluorine, X and Y, we shall thus obtain a great number of compounds, which we will call nuclenides, or *derived nuclei*, and which, we will arrange immediately after the fundamental nucleus.

Let us now introduce into the dyadides, monadides, and monodyadides, these derived nuclei, in the place of their constituent fundamental nucleus; then we shall have a host of derived dyadides, monadides, &c.

Lastly, we shall augment considerably the compounds of the same series,—on the one hand, by replacing the hydrogen by metals, in those bodies which are capable of undergoing this kind of transformation, as are the deuterides and tritonides,—and on the other hand, by replacing the oxygen of the monadides and monodyadides by sulphur, selenium, or tellurium.

Our original series, in being thus enlarged, will not become more complicated; it will then present the following appearance:—

	Carbhydride		$C^{10}H^{10}$
NUCLENIDES	Carbhydride	halydo	$C^{10}H^{9}Cl$
			$C^{10}Cl^{10}$
			$C^{10}Br^{5}Cl^{5}$
		nitro	$C^{10}H^{8}X^{2}$
		nitroso	$C^{10}H^{9}Y$
		halydo-nitro	$C^{10}H^{6}Cl^{3}X$, &c.
DYADIDES (Hyperhalydes).	Hyperhydride		$C^{10}H^{10}+H^{2}$
	Dihalyde		$C^{10}H^{10}+Cl^{2}$
			$C^{10}Cl^{10}+Cl^{2}$
	Tetrhalyde		$C^{10}H^{10}+Cl^{4}$
			$C^{10}Br^{10}+Cl^{4}$
	Hexhalyde		$C^{10}H^{10}+Cl^{6}$
			$C^{10}H^{5}Cl^{5}+Cl^{6}$
			$C^{10}H^{4}Br^{4}X^{2}+Cl^{6}$
			$C^{10}Cl^{3}Br^{3}I^{3}X+Br^{6}$
MONADIDES	Monalide		$C^{10}H^{10}+O$
			$C^{10}Cl^{10}+O$
			$C^{10}H^{10}+S$
			$C^{10}Cl^{10}+S$
	Deuteride		$C^{10}H^{10}+O^{2}$
			$C^{10}H^{9}K+O^{2}$
			$C^{10}Cl^{9}K+O^{2}$
			$C^{10}H^{8}X^{2}+O^{2}$
			$C^{10}H^{10}+S^{2}$
	Tritonide		$C^{10}H^{10}+O^{3}$
			$C^{10}H^{9}K+O^{3}$
			$C^{10}Cl^{8}K^{2}+O^{3}$
			$C^{10}H^{10}+\left\{\begin{matrix}S\\O^{2}\end{matrix}\right.$
			$C^{10}H^{10}+S^{3}$
			$C^{10}H^{8}K^{2}+S^{3}$
MONODYADIDES	Udolide		$C^{10}H^{10}+H^{2}O$
			$C^{10}Cl^{10}+H^{2}O$
			$C^{10}H^{10}+H^{2}S$
			$C^{10}Cl^{10}+H^{2}S$, &c.

This table, we perceive, does not in any way resemble those which are ordinarily employed. It contains 30 or 40 bodies, which, in the system of Berzelius, would be separated from one another, and be distributed in a dozen different classes. If we replace $C^{10}H^{10}$ by C^2H^4, we shall have the compounds of the bi-hydrocarbon series, which comprises Dutch liquid, perchloride of carbon, chloride of acetyl, aldehyde, acetic acid, chloracetic acid, alcohol, ether, &c.

Chemists have known, indeed, for a long time past, that the bodies I have just adduced, metamorphose themselves into one another; but, pre-occupied with the theory of radicals, they never thought of associating them in the above described manner. Thus Liebig places alcohol and ether in one class, because he supposes that they both contain the same radical ethyl; whilst aldehyde and acetic acid he places in another class, as both containing acetyl; I do not know where he places the chloro-compounds. Dumas unites in the same class, all the bodies in which he supposes the existence of the compound C^4H^8: hence he includes etherine, Dutch liquid, alcohol, and ether; but he rejects acetic acid, in which he supposes, or did suppose, the atomic arrangement $C^4H^6O^3.H^2O$. He also excludes aldehyde, perchloride of carbon, &c.

The series $C^{10}H^{10}$, such as I have just represented it, is far from being completed. We do not perceive amides, ethers, amidic acids, nor, in one word, any diamerone; the preceding compounds constitute the *aplones* only. I proceed now to consider this second part of the series, first of all regarding it in a theoretical point of view.

THEORY OF THE DIAMERIDES.

On the Existence of Radicals.

In examining the compound radical theory, I put aside the important question, concerning the capability or non-capability of these radicals, to exist in the free state. As this question is intimately connected with the theory of the diamerides. I propose now to make it the subject of our consideration.

In the presence of cyanogen, kakodyl, ethyl, benzoyl, &c., which have been isolated, it may appear somewhat strange to ask, whether or not compound radicals can exist in the free state. My question is, without doubt, badly proposed: I ought to have asked, whether the free cyanogen, ethyl, kakodyl, &c., are indeed the bodies, the existence of which is admitted respectively in the cyanides, ethers, kakodylic salts, &c.; and whether there is any possibility of our being able to isolate the radicals of the sulphocyanides, persulphocyanides, or of the acetic, butyric, and citric acids.

This question may appear to be of too subtle a character, but in order to show that the question may be proposed, and ought to be resolved, I may adduce benzoyl, which no one considers as the radical of the benzoic combinations; also peroxide of nitrogen, the existence of which in nitro compounds is not admitted by the partisans of copulæ; also free ethyl, analogous to marsh gas, and not to a simple body.

Having then to study the products which result from the action of compound bodies upon one another, I shall, for the better examination of the subject, recede some few steps, and inquire into the action of a simple upon a compound body.

Chloronaphthaline was, at one time, considered as a chloride analogous to the chloride of acetyl, and containing $C^{10}H^{7}+Cl$. At that time I made the following observations. This compound is not a combination of chlorine with the radical $C^{10}H^{7}$, but is the representative of naphthaline $C^{10}H^{8}$, of which indeed it is but a variety. Naphthaline, submitted to the action of chlorine, can lose an atom of hydrogen; the residue, or $C^{10}H^{7}$, deprived of the hydrogen atom, would be destroyed, were it not for some other atom taking the place of the hydrogen which was set free. In this instance, it is the chlorine which occupies the place in question; and the naphthalic edifice being thus supported, conserves its arrangement. $C^{10}H^{7}$ is an incomplete body; is a polyhedron deprived of one of its edges, and would be destroyed but for the substitution of some equivalent edge in its place.

I say now, in addition, that $C^{10}H^{7}$ cannot exist, in consequence of the uneven number of its atoms.

In order to avoid its destruction, some dyad atom, such as chlorine or bromine, must be introduced, so as to fill up the void otherwise presented, and form a new body with an even number of dyads.

Naphthaline, submitted to the action of nitric acid, still loses an atom of hydrogen; and the same residue $C^{10}H^{7}$ unites, not indeed with a simple body, but with the remainder of the elements of nitric acid, or NO^2, which thus replaces the missing atom of hydrogen.

But reciprocally, we might say, that nitric acid HNO^3 is a complete polyhedron; and that naphthaline, in removing therefrom the elements HO, has left a residue NO^2, which cannot exist in consequence of its uneven number. Hence the residue of the elements of naphthaline would have to fill up the void presented by the residue NO^2, and form a new complete polyhedron, $C^{10}H^7NO^2$, with an even number of dyads.

Ammonia is a complete polyhedron; we cannot remove from it an angle of hydrogen without destroying it.

Amide, or amidogen, NH^2, cannot exist, in consequence of its uneven number of atoms.

Chloride of benzoyl is a complete polyhedron, a variety of the essential oil of bitter almonds. We cannot remove from it its edge of chlorine without destroying it; for the residue, or benzoyl, in consequence of its uneven number, is incapable of existing. But if ammonia and chloride of benzoyl be placed in contact with one another, the first will lose H, and the second Cl; and the two residues, being incapable of existing separately, will reciprocally serve as angles for one another. NH^2 will fill up the void occasioned by the abstraction of Cl, and C^7H^5O will fill up the void occasioned by the abstraction of H. To render this reciprocal replacement of the two residues intelligible, I will suppose, that in ammonia and chloride of benzoyl the atoms are arranged so as to form hexagonal figures.

Fig. 1.

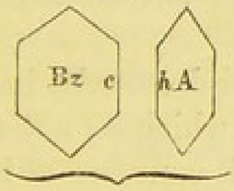


Fig. 2.

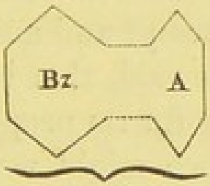
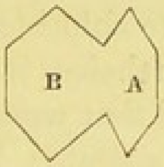


Fig. 3.



B*z* and A, *fig* 1, represent chloride of benzoyl and ammonia at the moment when they react upon one another,—the face *c* being opposed to the face *h*, which is to be set free. B*z* and A, *fig* 2, represent the two residues during the reaction, and B, A, *fig*. 3, the two residues after the reaction having reciprocally filled up the two voids formed in A and B.

Fig. 3 represents a diameride, or a figure capable of being divided into two parts B and A, on the sole condition, however, of B having its missing face restored to it, either by hydrogen or chlorine, and A also having restored to it, its missing face, or an equivalent thereto.

Under a certain point of view chloronaphthaline $C^{10}H^7Cl$ might be compared to the diameride *fig* 3. B would represent the naphthaline and A the chlorine. This diameride might split itself up into B and A, but only on the condition of restitution. It would seem at first sight, that while B or the naphthalic residue must of necessity take up the angle which is wanting to it, that A, or chlorine, being a simple body, need not do so. But it must not be forgotten, that chlorine is a dyad, and when free it consists of Cl^2.

If in benzamide, the atoms are disposed as in *fig* 3, can we say, that this compound contains two separate groups or radicals, benzoyl and amide; and can we hope to isolate them? This figure does not present two isolated groups, it contains neither benzoyl nor amide; there is a certain predisposition in the arrangement of the atoms, so that we are enabled to conceive the possibility of dividing the figure into A and B, but only on the condition of rendering these two parts in accordance with the law of even numbers, for we repeat, neither benzoyl nor amidogen, in consequence of their uneven numbers, are capable of existing. If we replace ammonia by aniline we shall have benzanilide with a grouping analogous to that of *fig* 3. In this grouping there is neither benzoyl nor anilic amide, but there is a something appertaining to benzoic acid or chloride of benzoyl, and a something appertaining to aniline.

These two proxies, so to speak, will not be intermingled with one another; but the carbon will exist under two forms, ready to regenerate chloride of benzoyl and aniline.

Nevertheless it will be said, that benzoyl does exist in the free state, and that were it not for its properties which do not resemble those of a simple body, we might very well conceive of its existence in the benzoic combinations. Let us examine the value of this objection. Supposing we attempt to abstract water from acetic acid $C^2H^4O^2$, in order to obtain the anhydride; were it to yield H^2O, we should obtain C^2H^2O, which is not the anhydride. To procure the anhydride we must either abstract $\frac{1}{2}\ H^2O$, which is impossible, or else two atoms of the acid must unite with one another. Then we shall have

$$2\ C^2H^4O^2 - H^2O = C^4H^6O^3.$$

Can we therefore say, that acetic anhydride existed in the acetic acid from which it was obtained? That would be to say, that the containing, is smaller than the contained substance. True it is, that we may attribute to acetic acid the formula

$$C^4H^8O^4,$$

and, consequently, suppose therein the existence of the anhydride. But this would not serve to remove the difficulty, for if $C^4H^8O^4$ were the formula of acetic acid, $C^8H^{12}O^6$ would become that of the anhydride.

I believe that I have shown, with a superabundance of proofs, that if the cyanides, and the kakodylic, and ethylic chlorides contain CNM, ClC^2H^6As, ClC^2H^5; then cyanogen, kakodyl, and ethyl, in the free state must contain C^2N^2, $C^4H^{12}As^2$, and C^4H^{10}. May we not then conclude, as for the acetic anhydride, that these radicals are incapable of existing in the combinations from which they were extracted.

We may remark in the first place, an essential difference between the composition of acetic anhydride and that of the radicals, the formula of the first being indivisible whilst those of the radicals are always divisible into two equal parts, thus kakodyl $=2\ C^2H^6As$, cyanogen 2 CN, and ethyl $2\ C^2H^5$. But as free hydrogen, or H^2, divides itself into two parts to form the chloride, bromide, and nitrate of hydrogen, HCl, HBr, HNO^3, may we not admit from analogy, that the radicals are binary, and that they dedouble themselves to form cyanides, chlorides, and nitrates? This is the point we will now proceed to examine.

When zinc is made to act upon chloride of kakodyl, chlorine is abstracted and kakodyl set free. This reaction can only take place upon the condition of 2 molecules of kakodyl taking part therein. The reaction is not

$$Zn + C^2H^6As.Cl = ZnCl + C^2H^6As,$$

for in the first place, zinc is a dyad, and can only be made use of in the entire state, or Zn^2; and secondly, C^2H^6As in consequence of its uneven number is incapable of existing.

Therefore, we must have

$$Zn^2 + 2\ C^2H^6As.Cl = 2\ ZnCl + C^4H^{12}As^2.$$

It remains then to be known, whether kakodyl is $C^4H^{12}As^2$, or indeed $(C^2H^6As)^2$ analogous to H^2 or Zn^2.

Let us return to our hexagons, let A and A, two equal hexagons, represent two molecules of chloride of kakodyl, the two faces of chlorine *cc*, being upon the point of being set free by the zinc.

Fig. 4.

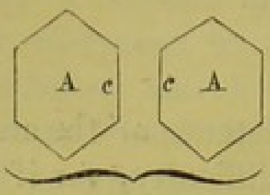
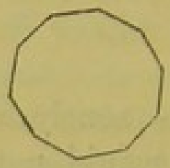


Fig. 5.

Fig. 6.



After the removal of these two faces, the two residues, in order to avoid their destruction, either unite to form a complex molecule, that is, a diamerone *fig* 5, or they are confounded into a simple decagonal molecule *fig* 6.

If the atoms are disposed as in *fig* 6, that is to say, if free kakodyl, is not the radical of the kakodylic combinations, then it ought to behave itself with chlorine, as does a simple molecule of naphthaline, aniline, or acetic acid; it ought, in fact, to produce the following compounds,

$$\begin{array}{l} C^4H^{12}\ \ As^2+Cl^2 \text{ or } Cl^4 \\ C^4H^{11}Cl\ As^2 \\ C^4H^{11}Cl\ As^2+Cl^2 \\ C^4H^6\ Cl^6As^2 \quad \&c., \&c. \end{array}$$

If, on the contrary, the atoms are disposed as in *fig* 5, if kakodyl is a diamerone, then the chlorine ought to divide it into two equal parts by effecting a replacement of the missing angles: we should then have

$$(C^2H^6As)^2+Cl^2=C^2H^6As\ Cl+C^2H^6As\ Cl.$$

Then we might be allowed to say, that free kakodyl is the radical which exists in the kakodylic salts; but even then we ought to add, that it does not form a group altogether isolated, that its existence is, so to say, conditional, that it is an incomplete body which has need of a complement to prevent its destruction.

Since free kakodyl comports itself as I have supposed in the last equation, we may admit, that it is indeed the divisible radical which gives rise to the kakodylic combinations,—whether or not it be a *kakodinic hydrogen*, as I admitted in one of the preceding chapters.

From the chloride or iodide of ethyl, we may obtain ethyl, an incomplete body, which in the nascent state doubles itself so as to form, either a diamerone with the carbon under two forms, or a decagonal figure with the carbon under one form only.

To decide this question, we treat ethyl with chlorine, it behaves itself as does naphthaline, bihydrocarbon, or, better still, as does marsh gas, which is indivisible; it undergoes chlorine substitutions, but it does not dedouble itself so as to regenerate the chloride of ethyl. We must hence conclude, that it is not a radical, and that it does not exist in the ethylic combinations, any more than does acetic anhydride in the acetic combinations.

If the ethers do contain ethyl, if this ethyl should some day be set free, its formula will be represented by $(C^2H^5)^2$. An isomeride of the ethyl with which we are acquainted, it ought under the influence of chlorine to be able to divide itself into two parts, and regenerate chloride of ethyl.

We may admit, that certain radicals exist as such in certain combinations, but that once set at liberty, they comport themselves quite differently from simple bodies. Such is, for example, the case with peroxide of nitrogen, which exists in nitro-compounds in the incomplete form NO^2, but when set at liberty, it doubles itself, and gives rise to the compound $(NO^2)^2$, which does not manifest the properties of a simple body. Thus when we cause chlorine to act upon nitronaphthaline, NO^2 is set at liberty, not according to the equation

$$C^{10}H^7X + Cl = C^{10}H^7Cl + X$$

(for we know that a demi-molecule of free chlorine cannot exist) but according to the equation

$$2\,C^{10}H^7X + Cl^2 = 2\,C^{10}H^7Cl + X^2.$$

What I have just said with regard to peroxide of nitrogen, may, without doubt, be applied to other bodies, which, though incapable of existing free, may in certain combinations *occupy the place* of a simple body.

Such may be the case with uranyle, amidogen, and even sometimes with ethyl itself. These bodies would seem to act, by their mass, as occupants of the voids occasioned by the departure of the simple bodies; but they do not fulfil the functions of these latter, and they modify, to a greater or less degree, the properties of the compounds into which they enter.

This reasoning might also be applied to the cyanogen of the cyanides, and of chloride of cyanogen,—in which bodies it does not form a separate entity.

Let us admit for an instant, that these two bodies have the constitution shown in the formulæ CMN, $CClN$. We know, that when the latter of them is put in the presence of aniline, the chlorine abstracts one atom of hydrogen therefrom, and that melaniline, $C^{13}H^{13}N^{3}$, is simultaneously formed. But this melaniline is alkaline, as is chloraniline and nitraniline; and, moreover, it comports itself with free cyanogen exactly as does aniline. We have

$$\text{With aniline} \quad \ldots\ldots \quad \left\{\begin{matrix} C^{6}H^{7}N \\ C^{6}H^{7}N \end{matrix}\right. + C^{2}N^{2} = \text{cyaniline.}$$

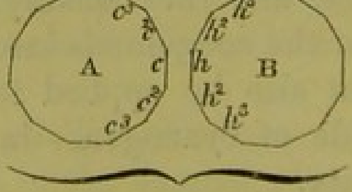
$$\text{With melaniline} \ \ldots\ldots \quad \left\{\begin{matrix} C^{6}H^{7}N \\ C^{6}H^{6}CyN \end{matrix}\right. + C^{2}N^{2} = \text{cyamelaniline.}$$

The analogy of these two bases, and the connexion of the two formulæ, is such, that we cannot refuse to accord to them the same constitution; consequently, cyamelaniline is cyaniline, in which one atom of hydrogen is replaced by Cy or CN, which however is not cyanogen, but the residue of the body, which we term the chloride of cyanogen. This residue is no more cyanogen than is aldehyde butyric acid; it only occupies the place of the hydrogen which is wanting, exactly as is the case with the nitrous vapours in nitraniline.

We have endeavoured to account for the changes which take place, when two compound bodies, by their action upon one another, eliminate a single atom of water, or of chlorhydric acid, as when chloride of benzoyl, or benzoic acid, acts upon ammonia or aniline. Let us now examine the product which is formed, when benzoic acid and ammonia eliminate two atoms of water to form benzonitryle $C^{7}H^{5}N$. Are we to consider this body as a compound of the form $C^{7}H^{5}+N$, or of the form $C^{7}H^{4}+NH$, or indeed, as is generally admitted, as a cyanide, $=C^{6}H^{5}+CN$?

The water disengaged, is formed by the action of the hydrogen of the ammonia upon the oxygen of the acid. The two new voids are still filled, but by smaller residues of the ammonia and acid. The two residues are neither isolated nor confounded; they form a new diameride, susceptible of division, on the condition of having the missing angles restored.

Fig. 7.



Let A, *fig* 7, be a chloride, or polygon, with four, five, or six faces of chlorine, and B an alkaloid, or a hydrogenised polygon.

In acting upon one another, they may lose successively the faces h and c, then h^2 and c^2, h^3 and c^3, &c., thereby giving rise successively to the halo-diamerides, represented by the *figures* 8, 9, and 10.

Fig. 8.

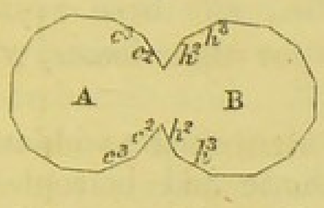


Fig. 9.

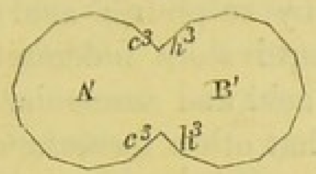
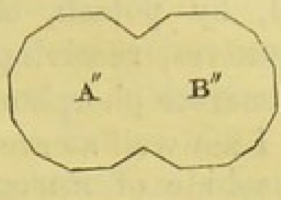


Fig. 10.



We see that the residues are neither separated nor confounded; and that, as a consequence of their construction, they are predisposed to division into A′ and B′, A″ and B″, &c., but always upon the condition of having restored $c\ c^2\ c^3$, &c, $h\ h^2\ h^3$, &c., or of equivalent indemnities.

Thus with the perchloride of phosphorus and ammonia, we may have successively

$$PCl^5 + H^3N - HCl = (PCl^4.H^2N)$$
$$(PCl^4.\ H^2N) - HCl = (PCl^3.H\ N)$$
$$(PCl^3.\ H\ N) - HCl = (PCl^2.\ \ N).$$

I do not admit, then, that in the three new compounds there are the radicals H^2N, HN, N, PCl^4, PCl^3, and PCl^2. Nevertheless, the two residues are not confounded; in each of the three compounds there is a something indicative of ammonia, and a something indicative of perchloride of phosphorus, or what comes to the same thing, of phosphoric acid. In treating these three compounds by water, ammonia, chlorhydric acid, potash, heat, &c., we shall obtain a great number of new combinations, each, however, containing two representatives, always ready at the call of the chemist, to regenerate,—the one ammonia, and the other phosphoric acid.

Let us take the compound PCl^2N, or the chlorophosphide of nitrogen, and instead of the $3\,HCl$ which it has lost, let us give to it an indemnity of another nature: for example, by means of ammonia. Then we shall have

$$PCl^2N + H^3N - H^2Cl^2 = PHN^2 \text{ phospham ;}$$

phospham treated by water will give

$$PHN^2 + H^2O = PH^3N^2O \text{ phosphamide ;}$$

and phosphamide, by heat, will give off ammonia, and produce biphosphamide:

$$PH^3N^2O - H^3N = PNO.$$

This same chlorophosphide of nitrogen, by the action of water, will, according to circumstances, transform itself into azophosphoric, or biazophosphoric acid.

If we now treat the chlorophosphide of nitrogen, phospham, phosphamide, biphosphamide, azophosphoric, and biazophosphoric acid, by potash, or by sulphuric acid; then all these representatives, receiving equivalent indemnities for their losses, will regenerate phosphoric acid and ammonia.

I am well aware, that other formulæ are attributed to chlorophosphide of nitrogen, phospham, azophosphoric and biazophosphoric acids; but Gerhardt and I have previously said, and I do not fear to repeat the assertion, that the formulæ in question are as inexact, as the reactions therewith would be incomprehensible.

If we were to consider the preceding metamorphoses as the result of affinities, independent of atomic arrangement, we should necessarily conclude that aniline and chloraniline ought to form compounds in a manner different from that of ammonia; that the diamerides of this last body, for example, ought with potash to give rise to chloride of potassium. But I consider myself warranted in predicting, that they would regenerate the acid and chloraniline from which they were produced. What, moreover, do we know with regard to affinity? Who would expect to see bichlorisatine, under the influence of fused potash, give rise to a carbonate, and not to a chloride of potassium?

What I have just now remarked, with regard to the formation of diamerides from two compound bodies, by the loss of 1, 2, 3, ... molecules of Aq or HCl, is applicable to cases in which a greater number of bodies are concerned.

Thus, phosphoric acid being tribasic, we might obtain with it, a triple salt of ammonia, aniline, and ethylamine. This triple salt might be transformed into ammon-anil-ethylamic triamide, composed of four residues (*fig.* 11). P central or phosphoric, Am, An and Et, angular or alkaline.

Fig. 11

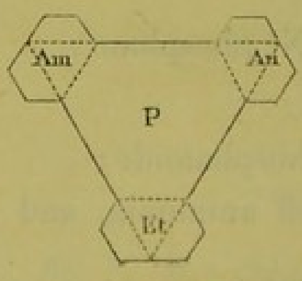
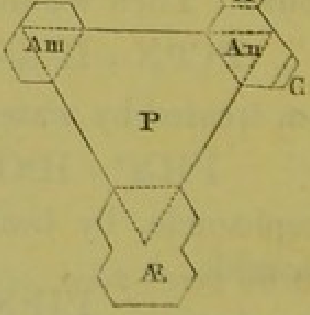
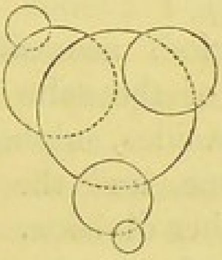


Fig. 12.



We might also imagine a triamide formed (*fig.* 12), 1° by a residue of ammonia Am, 2° by one of nitrochloraniline An X Cl, and 3° by one of ethylamine, or ethylic ammonia Æ. This diameride, according to the nature of the reagents, might divide itself in a variety of ways. Thus, it might regenerate the four compounds from which it was produced, or the nitro chloraniline, and ethylamine might be disengaged with a simultaneous production of phosphamic acid. By the action of sulphuretted hydrogen, it would be capable of transforming itself by an exchange of Ad for X, into another triamide, with a chloro-semibenzidam residue. These diamerides might be compared to an agglomeration of soap bubbles, but with the separating planes removed, so that the two bubbles having lost a portion of their walls, could not be removed from one another, except by the filling up of the two voids left by their separation. We might imagine several bubbles thus agglommerated with one another.

Fig. 13.



We can conceive, that such an edifice, under the influence of a too violent shock, might divide itself in directions not indicated by any of these vacuous planes, so as to produce phosphoric, carbonic, and chlorhydric acids, nitrogen and hydrogen.

If we had all the diamerides under our inspection, and could see their respective arrangements, it would be easy for us to classify them; but this not being the case, I hasten to abandon hypotheses, and once more to resort to experiment.

SYNOPTIC FORMULÆ.

For the representation of compound bodies, two systems are offered for our choice, namely, that of empiric, and that of rational formulæ. By the adoption of the former method, we should be obliged to represent the sulphate of quinine by

$$C^{38}H^{46}N^{4}SO^{8}.$$

I shall pay no further consideration to this plan, since it is not followed by any chemist, to its ulterior consequences.

With the second system, we fall into the labyrinth of hypotheses, copulæ, and radicals; so that even for such a simple body as acetic acid, we may chose from a dozen different formulæ. Moreover, all the hypotheses that have been proposed, considered only as conventional, have the serious inconvenience of being too arbitrary, since one and the same person, in following out one and the same system, may accord to one single body very different formulæ.

Nevertheless, there is one point concerning which the great majority of chemists are agreed, namely, the representation of the ox-acids by water, plus the residue of the elements of the acid. Thus, they consider it more advantageous to write the composition of sulphuric and acetic acids thus:

$$SO^3+H^2O \text{ and } C^4H^6O^3+H^2O,$$

than in the following manner,

$$SH^2O^4 \text{ and } C^2H^4O^2.$$

Now this former notation, necessitates a separation of the acids into two classes, and of the salts likewise into two classes; the chlorides, sulphides, cyanides, sulphocyanides, and mellonides, have to be arranged in one, and the sulphates, cyanates, and cyamelurates, &c. in the other division.

I have just now glanced at several treatises on chemistry, which have been published of late years, and with the exception of certain works written entirely under the influence of the ideas of Berzelius, I perceive in all of them the greatest contradiction, or rather indifference, in the manner of representing the composition of bodies. The same author makes tartaric acid a bibasic, and sulphuric acid a monobasic compound; of essential oil of bitter almonds he makes a hydride, and of aldehyde, a hydrate; he considers the cyanates as oxacids, and the sulphocyanides as hydracids, one amide is a hydrate, and another is not, &c.

It is evident, that dualistic formulæ, though stronglyheld to, are no longer believed in, and that one formula is not cared for more than another, provided that they both be dichotomic, after the fashion of that of alum, which is divisible into water, and a double salt, this latter into two simple salts, each of these into acid and oxide, and each acid and oxide into two simple bodies.

Does not then, this nearly unanimous accordance in the employment of formulæ, I will not say dualistic, but dichotomic, does it not depend upon the nature of the human mind, which loves incessantly to divide, subdivide, or in one word, seriate the objects of its studies, so as to assist the memory by the establishment of generalities for each division and subdivision? Do not the majority of chemists, without perhaps being aware of it, seek simply by the aid of their divided and subdivided formulæ, for a means of retaining the composition and the functions of the bodies to which these formulæ apply? If so, the problem, the solution of which we are seeking, namely, the arrangement of atoms in compound bodies, will be reduced to the following:

Required a conventional system, by the aid of which we may readily retain the composition of bodies, and give to analogous bodies, analogous formulæ.

We should in this way have the advantages of both empiric and rational formulæ, without their inconveniences.

In occupying myself with the resolution of this problem, I have not concealed from myself the difficulty of the task, and I am far from thinking that I have effected its solution in a satisfactory manner. Nevertheless, I believe I am justified in giving the result of my researches, because they may perhaps direct the attention of other chemists to the perfectioning of my method, or to the production of a better one.

This will be particularly desirable at this present time, in consequence of systems concerning atomic arrangement, having received a new impulse. As it is not probable that the present theories will endure for any length of time, it would be advantageous for all the world to have a neutral ground, upon which errors may be acknowledged, and agreement be arrived at.

I employ *synoptic formulæ,* by the aid of which, I endeavour to manifest certain numerical relations presented by seriated bodies, and to give to analogous bodies analogous formulæ. Thus, if I accorded to the sulphates this formula,

$$SM^2 + O^4,$$

and if I considered sulphatic ether as a sulphate, I should represent it also by

$$SEt^2 + O^4,$$

but if, on the contrary, I regarded it as a diamide, I should give to it the formula of the diamides. Be the formula that I employ what it may, for example that of the diamides, it might be considered as a hypothesis; for it is not demonstrated to the satisfaction of every one, that this ether really is a diamide.

But on attentive examination it will be seen, that we have not to ascertain, whether in this ether there is such or such an atomic arrangement, but simply to determine, whether it has the properties of a salt or of a diamide. Here then, we are in the land of experiment.

It is true, that so long as we are unable to decide the above point with regard to sulphatic ether, we must rest satisfied with attributing to it an empiric, or else a more or less probable synoptic formula. It cannot indeed be otherwise, for our system consists in a representation of the function of a body by means of its formula. To demand more than this, would be to require a naturalist to construct a classification, by the aid of which we might determine the place of an animal, of which we had examined nothing but the skin. If such a classification were possible, it would not represent the relations which exist between this animal and others, and would be, at best, but a bad dictionary. I ought not then, to be expected to give a synoptic formula to betuline or to anemonine. Dualism alone is capable, from simple inspection of the centesimal composition of these bodies, of telling us immediately, whether they are oxides, hyperoxides, ethers, or copulated bodies, and at the same time of giving us the arrangement of their atoms.

Before occupying myself with organic chemistry, I ought to say a few words concerning the manner in which I formulate mineral substances. The great experience I have had in this case, both of empiric and rational formulæ, enables me to declare that the former are preferable to the latter, and will consequently be employed by me. I shall, however, dispose them in such a manner, as to bring out certain regular relations which they present, when compared one with another, as seen in the examples I am about to adduce. The sign +, of which I make use, is simply intended to direct attention to the relations I wish to indicate; advantageous in a synoptic table, it becomes useless in an isolated formula.

Monobasic acids of chlorine, nitrogen, &c.

FlH	ClH	BrH	IH	
	$ClH+O$	$BrH+O$		
	$ClH+O^2$			$NH+O^2$
	$ClH+O^3$	$BrH+O^3$	$IH+O^3$	$NH+O^3$
	$ClH+O^4$		$IH+O^4$	

Bibasic acids of sulphur, &c.

H^2O	H^2S	$S^2.O^6H^2$	SH^2+O^3	SeH^2+O^3	TeH^2+O^3
H^2O	H^2S^2	$S^3.O^6H^2$	SH^2+O^4	SeH^2+O^4	TeH^2+O^4
	H^2S^3	$S^4.O^6H^2$	$SH^2+\begin{cases}O^3\\S\end{cases}$		
	H^2S^4	$S^5.O^6H^2$			
	H^2S^5[*]				

Acids of phosphorus, arsenic, &c.

	PH^3	As H^3
Monobasic	PH^3+O^2	
Bibasic	PH^3+O^3	As H^3+O^3
Tribasic	PH^3+O^4	As H^3+O^4
	PH^3+S^4	As H^3+S^4
	PH^3+O^3S	As H^3+O^3S.

As we are ignorant of what constitutes a neutral borate or silicate, and as we do not know, whether or not there are para-meta-, &c., boric, and silicic acids, the best we can do, until we become better instructed on these points, is to represent the acids by BHO^3 and SiH^2O^2.[†]

With regard to the pyro-, meta-, para-, iso-, &c., phosphoric, arsenious, arsenic, titanic, stannic, tungstic, silicic, &c. acids, the ratio which exists between the anhydrous acid and the base being variable, ought to be expressed. Unfortunately, we are ignorant of the composition of the majority of these salts, for we do not know, whether the water they contain is or is not essential to their constitution. Empiric formulæ are, in these instances, the best, for the ratio of the acid to the base is rendered as apparent by them, as by dualistic formulæ.

The composition of the acids being known, that of the anhydrides, chlorides, and salts, is readily deduced therefrom, especially that of the latter class of bodies; for it is sufficient to remark, that the basic hydrogen may be exchanged for its equivalent of any metal whatsoever. We have previously shown, that from a knowledge of the composition of the anhydrides only, we cannot deduce the composition of salts. Thus, who would imagine

---

[*] Whether or not this acid really exists is a matter of no consequence, it is sufficient that we have a quinque sulphide of potassium and of ammonium. Similarly with regard to carbonic acid CO^3H^2 it is sufficient for us to have metallic carbonates. These formulæ of the acids represent saline types. (L.)

[†] Making silicic acid tribasic, and dividing the usual equivalent of silicon by three, we shall have:

$$SiO^3.\ 3H^2O = Si^3O^3.3H^2O = Si^3H^6O^6 = SiH^2O^2.$$

I believe that the above formula of boric acid is misprinted, it should be BHO^2, thus:

$$B^2O^3.H^2O = B^2H^2O^4 = BHO^2.$$

(W. O.)

that the three anhydrides,—hypophosphorous, phosphorous, and acetic, P^2O, P^2O^3, $C^4H^6O^3$, would give rise to salts containing $P^2O + M^2H^4O^3$, $P^2O^3 + M^4H^2O^3$; and $C^4H^6O^3 + M^2O$?

With regard to double, triple, acid, basic, and hydrated salts, as well of mineral as of organic chemistry, I have already indicated (*vide* salts, acid, hydrated, &c.) how their composition ought to be represented.

I should not object, in any case, to substitute the following for my fractional formulæ:—

$$\left.\begin{matrix} SO^4FeZ + 3\,Aq \\ SO^4Am^2 + 3\,Aq \end{matrix}\right\} \text{instead of } SO^4Fe_{\frac{1}{2}}Z_{\frac{1}{2}}Am + 3\,Aq.$$

$$\left.\begin{matrix} 3\,(SO^4\overset{\text{v}}{\dot{A}}l^2 + 6\,Aq) \\ SO^4K^2 + 6\,Aq \end{matrix}\right\} \text{instead of } SO^4K_{\frac{1}{2}}\overset{\text{v}}{\dot{A}}l_{\frac{3}{2}} \quad + 6\,Aq.$$

$$\left.\begin{matrix} 2\,(CO^3Na^2 + 6\,Aq) \\ CO^3K^2 + 6\,Aq \end{matrix}\right\} \text{instead of } CO^3K_{\frac{2}{3}}Na_{\frac{4}{3}} \quad + 6\,Aq.$$

Only I consider the second method preferable, when we wish to give a table of the salts of the same acid, as in these examples:

CO^3H^2	SO^4H^2
CO^3KH	SO^4KH
CO^3K^2	SO^4K^2
$CO^3K_{\frac{2}{3}}Na_{\frac{4}{3}}$	$SO^4K_{\frac{1}{2}}\overset{\text{v}}{\dot{A}}l_{\frac{3}{2}}$
CO^3CaMg	SO^4CaNa.

Let us now proceed to organic chemistry.

To represent the composition of the aplones, I shall simply make use of the formulæ I have given in my hypothesis of derived nuclei. This is the same as saying, that the aplones have a composition that may be represented by a constant nucleus (or its chloro-derivatives), plus 1, 2, or 3 dyadic or monadic molecules. So that if we represent the fundamental nucleus by R, and its derivatives by R′ R″ R‴, &c., the aplones will have the following formulæ:—

R	R'
$R+Cl^2$	$R'+Cl^2$
$R+Cl^4$	$R'+Cl^4$
$R+Cl^6$	$R'+Cl^6$
$R+O$	$R'+O$
$R+O^2$	$R'+O^2$
$R+O^3$	$R'+O^3$
$R+H^2O$	$R'+H^2O$
$RO^2-\frac{1}{2}$ & 1 Aq	$R'O^2-\frac{1}{2}$ & 1 Aq,
RO^3-1 & 2 Aq	$R'O^3-1$ & 2 Aq,

and so on for R'' R''' R'''', &c.

If attention be then paid to the ratios I have pointed out, between the carbon and hydrogen of the different orders and series, it will be seen, that two or three minutes suffice for the reception of a perfectly clear idea of the half of organic substances, and for the retention of their composition.

With regard to the diamerones, or rather to the diamerides; by means of the names I have given to them, nothing is more easy than to retain their composition, and even to represent it by formulæ, which, at the same time, indicate their functions. Thus we might represent

Acetamide	....	$C^2H^4O^2+H^3N-H^2O$
Acetalese	....	$C^2H^4O^2+H^3N-2H^2O$
Oxamide	....	$C^2H^2O^4+2H^3N-2H^2O$.

But these formulæ indicate an operation to be performed,—we must substitute for them others in which the operation has been effected. For this purpose two methods present themselves; the one founded upon the notation for salts of ammonia, the other upon the notation for salts of ammonium. In the first case we have only to write the alkali, alcohol, or hydrocarbon, &c., after the acid, with an intermediate septum; then, by abstraction of water, taking the oxygen from the acid, and the hydrogen from the other compound, the residue, without making any re-arrangement in the letters, will give the synoptic formula of the diameride. Thus:—

Acetate of aniline	$= C^2H^4O^2$	C^6H^7N
By subtraction of	O	H^2
There remains acetanilide	$= C^2H^4O$	C^6H^5N
And by a further subtraction of	O	H^2
There remains anilic acetalese	C^2H^4	C^6H^3N

But as these formulæ do not designate the genus of the diameride, I add to them a figure preceded by the minus sign (−), which figure indicates the quantity of water eliminated, as in these examples:—

$$\text{Acetanilide} \quad \ldots\ldots \quad = \quad C^2H^4O \overset{-1}{|} C^6H^5N$$
$$\text{Acetalese} \quad \ldots\ldots \quad \ldots\ldots \quad = \quad C^2H^4 \overset{-2}{|} C^6H^3N.$$

In the second case we add the alkali, alcohol, hydrocarbon, &c., to the basic hydrogen of the acid, so as to form a salt of ammonium, anilum, alcoholum, hydrocarbum, &c., and then make the abstraction of water, as in the preceding case. Instead of separating the acid from the base by a septum, I now employ a parenthesis thus:—

Acetate of ammonium........ $C^2O^2H^3\,(H^4N)$
Acetamide .... $C^2O\overset{-1}{H}{}^3\,(H^2N)$
Acetalese .... $C^2H^3\overset{-2}{(}N).$

This notation shows that all the amides have analogous formulæ, and that it is the same with the diamides, amidic acids, &c.; thus

Amides.

Acetamide .... $C^2O\overset{-1}{H}{}^3\,(H^2N)$
Acetanilide .... $C^2O\overset{-1}{H}{}^3\,(C^6H^6N)$
Acetic ether .... $C^2O\overset{-1}{H}{}^3\,(C^2H^5O)$
Formic ether .... $C\,O\overset{-1}{H}\,(C^2H^5O).$

Diamides.

Carbamide .... $CO\,(\overset{-1}{H}{}^2N)\,(\overset{-1}{H}{}^2N)$ or $CO\,(\overset{-2}{H}{}^2N)^2$
Carbamides $\begin{cases}\text{anil-ammon.} & CO\,(\overset{-1}{C}{}^6H^6N)\overset{-1}{(}H^2N) \\ \text{ethyl-ammon} & CO\,(C^2\overset{-1}{H}{}^5O)\,(\overset{-1}{H}{}^2N)\end{cases}$

Oxamide		$C^2O^2\,(\overset{-1}{H}{}^2N)\,(\overset{-1}{H}{}^2N)$
Oxamides	anil-ammon	$C^2O^2\,(\overset{-1}{C}{}^6H^6N)\,(\overset{-1}{H}{}^2N)$
	ethyl-ammon	$C^2O^2\,(\overset{-1}{C}{}^2H^5O)\,(\overset{-1}{H}{}^2N)$
	methyl-ethyl	$C^2O^2\,(\overset{-1}{C}\,H^3O)\,(\overset{-1}{C}{}^2H^5O)$.

Amidic acids.

The acid oxalate of ammonia being

$$C^2O^4\,(H^4N)\,H,$$

we ought to have

Oxamic acid	$C^2O^3\,(\overset{-1}{H}{}^2N)\,H$
Oxamates	$C^2O^3\,(\overset{-1}{H}{}^2N)\,M$
Carbamic acid	$C\,O^2\,(\overset{-1}{H}{}^2N)\,H$
Carbanilic acid	$C\,\overset{-1}{O}{}^2\,(C^6H^6N)\,H$.

By the action of chlorhydric acid upon alcohol, there is produced, as in the formation of the oxacid ethers, a species of combustion, of which water is the result; but in this case, the acid yields hydrogen,—and the alcohol, oxygen, and a portion of the hydrogen. Hence, to formulate chlorhydric ether in such a manner as to indicate the analogy of its formation with that of the other ethers, we must proceed as follows:—

$$\begin{array}{r|l} ClH & C^2H^6O \\ H & H\,O \\ \hline Cl & \overset{-1}{\rceil}\,C^2H^5, \end{array} \qquad \text{chlorhydric ether.}$$

We have seen that when nitric acid acts upon alcohol it behaves in a similar manner, that is to say, it furnishes for the combustion, the whole of the oxygen and a part of the hydrogen, whilst the remainder of the hydrogen is supplied by the organic matter:—

$$\begin{array}{r|l} NHO^3 & C^2H^6O \\ HO & H \\ \hline N\;\;O^2 & \overset{-1}{\rceil}\,C^2H^5O. \end{array}$$

It will be remembered, that we have already agreed to represent nitric and nitrous products, as derivatives of a hydrogenised type, by the replacement of X or Y for H; consequently, we may formulate nitric ether, as above produced, in this manner. Representing NO^2 by X, we shall have

$$X \mid C^2H^5O\,;$$

or more simply

$$C^2H^5XO.$$

Nitrous acid forms the only exception to the observations we have made with regard to the oxygen acids.*

The halodiamerides must be formulated with ammonia and not with ammonium, as there do not appear to exist any combinations of the chlorides in question with ammonia. Consequently, I shall represent the chlorophosphide of nitrogen by the following formula:—

$$\begin{array}{c} P\,Cl^5 + H^3N \\ \;\;Cl^3 \quad H^3 \\ \hline P\,Cl^2 \overset{-3}{\mid} N. \end{array}$$

In this case, the negative figure indicates the quantity, not of water, but of chlorhydric acid disengaged; it might preferably, for the avoidance of any confusion, be placed underneath the formula, thus:

$$P\,Cl^2 \underset{-3.}{\mid} N$$

If there existed a corresponding anilic compound, it would be denoted in the same manner:—

$$\begin{array}{lcl} P\,Cl^5 + & & C^6H^7N \\ \;\;Cl^3 & & \;\;H^3 \\ \hline P\,Cl^2 & \underset{-3}{\mid} & C^6H^4N. \end{array}$$

With regard to diameraies and adelphides, I see no other way of representing them than by empiric formulæ, or, what comes to the same thing, by formulæ deduced from a certain reaction, chosen out from among several, for the assistance of the memory. I admit willingly, that it is for each one to arrange these formulæ as may seem best to him; thus he may represent glucose as formed from two molecules of carbonic ether, or from three molecules of acetic acid, &c.

I will add a word or two concerning the notation of the simple bodies. Hitherto I have made use of a capital and of a small

---

* We had just agreed to abstract the oxygen from the acid, and the *whole* of the hydrogen from the other body.

letter to indicate respectively ferrosum and ferricum. When we have to deal with copper, chrome, or even manganese, this notation becomes inconvenient. I prefer indicating by particular signs the state in which the metal is found. Thus, I surmount the initials of ferrosum, manganosum, and cupricum, by the sign $\wedge$, which sign I reverse for ferricum, manganicum, &c.

With regard to the atom of manganese in the manganates and permanganates, and the atoms of the metals which form the simple radicals manganyle, ferryle, uranyle, antimonyle, &c., I surmount the initials by the sign $+$. Thus I shall write

Oxides	Ferrous, manganous, platinous,	$\overset{\wedge}{Fe}{}^2O$, $\overset{\wedge}{Mn}{}^2O$, $\overset{\wedge}{Pt}{}^2O$
	Ferric, manganic, platinic	$\overset{\vee}{Fe}{}^2O$, $\overset{\vee}{Mn}{}^2O$, $\overset{\vee}{Pt}{}^2O$
Ferrates, manganates....		$\overset{+}{Fe}K^2O^4$, $\overset{+}{Mn}K^2O^4$
Permanganates		$\overset{+}{Mn}KO^4$*
Oxides of uranyle, ferryle, &c.		$\overset{+}{U}{}^2O^3$ $\overset{+}{Fe}{}^2O^3$ $\overset{+}{Sb}{}^2O^3$
	or	Uy^2O Fy^2O Sby^2O
Chlorides of uranyle, &c.		$\overset{+}{U}OCl$ $\overset{+}{Fe}OCl$ $\overset{+}{Sb}OCl$ †
	or	$UyCl$ $FyCl$ $SbyCl$.

Sometimes I employ the syllable Am to designate ammonium; then I represent:

Ammonium	Platinoso	$\hat{A}m$
	Biplatinico	$\overset{\vee}{A}\overset{\vee}{m}$
	Quadrimercuroso	$\overset{=}{A}\overset{=}{m}$
Phosphate of cuprosum, cupricum, and bicuprosammonium		$PO^4\,\bar{C}u\,\hat{C}u\,\overset{=}{A}m$
Phosphate of ferrosum, ferricum, and ferryle		$PO^4\,\overset{\wedge}{Fe}\,\overset{\vee}{Fe}\,Fy$

---

* Strictly speaking, the maganese of the manganates ought not to be represented by the same sign as the manganese of the permanganates; for in the manganates, $\overset{+}{Mn}$ is a monad like the sulphur it replaces, whilst in the permanganates $\overset{+}{Mn}$ is a demidyad, like the chlorine it replaces, but if two different signs were used, they would have to represent the same weight.—(L.)

† $O = 16.\ \overset{\wedge}{Fe} = 28.\ \overset{\vee}{Fe} = 18.66.\ \overset{+}{Fe} = 56.$
The antimony of antimonyle need not be marked with a + inasmuch as its weight is unaltered, and so for the other basylic teroxides.—(W. O.)

I employ the same letters to designate, ammonia and ammonium,—aniline and anilum,—quinine and quinum; but the manner in which they are placed on the one hand, and the introduction of the small letter h on the other, distinguish sufficiently well between the alkali and its radical.

Thus I write:—

Sulphates	Ammonia	....	$SO^4H^2 + Am^2$	or	SO^4Amh^2—ammonium.
	Quinine	....	$SO^4H^2 + Q^2$	or	SO^4Qh^2—quinum.
Acid sulphates	Ammonia	....	$SO^4H^2 + Am$	or	SO^4AmhH—ammonium.
	Quinine	....	$SO^4H^2 + Q$	or	SO^4QhH—quinum.

SECTION SECOND.

NOMENCLATURE.

THE discovery of a good chemical nomenclature is a problem so beset with difficulties, that from a thorough examination of them, we should be inclined to renounce the task of solution.

Our object is to find names which fulfil the following conditions:

1°. Of being simple, euphonic, and in harmony with the names to which we are habituated.

2°. Of being able to adapt themselves readily to all languages.

3°. Of indicating the composition of bodies.

4°. Of indicating their functions.

5°. Of being easy to retain in the memory, so that the nomenclature in actual use may be abandoned and the new one adopted, with but a very slight effort of memory.

6°. Of being independent of all hypothetical ideas concerning the arrangement of atoms.

Minus the first condition, the resolution of the problem would be comparatively easy. I made several attempts, in which the vowels and consonants had a numerical value which varied with their position; but the names that I thus obtained resembled too much those of Gmelin, so that I entertained but little hope of seeing them adopted.

After numerous endeavours I have at last arrived at the following method, which is yet capable of being further perfected.

That I have not myself rendered it more perfect, is due to the circumstance, that during the time I was occupied with its construction, I could not divest myself of the idea, that it would be almost impossible to persuade chemists to abandon their present nomenclature, and to adopt a new one in its stead, and that, consequently, it was useless for me to devote much attention to the subject. I believe now, that this reasoning was erroneous; and that it may happen that my present nomenclature, such as it is, will be rejected; whilst if I had succeeded in disembarrassing it of certain defects, it might have been accepted.

I, therefore, present my nomenclature, as well as my classification and notation, and submit them to the judgment of chemists as attempts only,—capable, however, of being further perfected, should they chance to be adopted.

Nomenclature of the series.

I employ two different names, or two monosyllables, with which to construct the names of compounds belonging to one and the same series. Let us take for example the series of etherine; I make use of the two roots *deut* and *eth*, the first serves to designate etherine C^2H^4, and the second hydro-etherine, or $C^2H^4+H^2$. The termination *ene* is applied to the two hydrocarbons, and to all their derivatives.

The root *deut*, serves for the monadides and anhydrides; the root *eth*, for the dyadides and monodyadides; or rather, the dyadides have *ad libitum* one or other root without any kind of inconvenience resulting therefrom.

When a body undergoes a chloro-,nitro, &c., substitution, I add to its name the words mono, bi, tri, &c., chloro, nitro. So also with the sulphur compounds; but it must not be forgotten, that the word *bichloro* signifies, that the compound has lost two atoms of *hydrogen* and gained two atoms of chlorine; whilst the word *bisulphuro* indicates, that the compound has lost two atoms of *oxygen*, and gained two atoms of sulphur.

With this nomenclature, we cannot always avoid the use of names of extreme length, such as that of *trisulphuro-carbonate of ammonia and nitrochloraniline.*

The inconvenience, however, is not very great; for these names have reference to such bodies only as are but little known, and in the above instance, to a variety of the carbonate of ammonia and aniline. The same circumstance obtains in natural history, where the length of the name is in inverse proportion to the importance of the variety; as for example:—*Rhododendron arboreum flore rubro.* These are the names I apply to the deuto-ethenic series:—

Deutene		C^2H^4	bicarburetted hydrogen
Deutene	chloro	C^2H^3Cl	chloride of aldehydene, or acetyl
	bibromo	$C^2H^2Br^2$	
	tri-iodo	C^2HBI^3	
	per or quadrichloro	C^2Cl^4	chloride of carbon
	nitro	C^2H^3X	
	nitroso-nitro	C^2H^2XY	
Ethene and hydro-deutene		$C^2H^4 + H^2$	methyl
Bichloride of	deutene	$C^2H^4 + Cl^2$	Dutch liquid
	chlorodeutene	$C^2H^3Cl + Cl^2$	
	quadrichlorodeutene	$C^2Cl^4 + Cl^2$	perchloride of carbon
Tetrachloride of	deutene	$C^2H^4 + Cl^4$	
	nitrodeutene	$C^2H^3X + Cl^4$	
Hexachloride of	deutene	$C^2H^4 + Cl^6$	
	bibromodeutene	$C^2H^2Br^2 + Cl^6$	
MonAlides	deutal	$C^2H^4 + O$	aldehyde
	bichlorodeutal	$C^2H^2Cl^2 + O$	
	sulphurodeutal	$C^2H^4 + S$	
	chloro sulphurodeutal	$C^2H^3Cl + S$	
	tribromo sulphuro do.	$C^2HBr^3 + S$	
	potassic deutal, or deutalate	$C^2H^3K + O$	
DeutErides	deuteric acid		
Deuterate	hydric	$C^2H^4 + O^2$	acetic acid
	potassic	$C^2H^3K + O^2$	
	chloro	$C^2H^3Cl + O^2$	
	chloro-potassic	$C^2H^2ClK + O^2$	
	trichloro-potassic	$C^2Cl^3K + O^2$	
TritOnides	deutonic acid	$C^2H^4 + O^3$	
Anhydrides	deuteric anhydride	$C^4H^6O^3$	anhydrous acetic acid*
	deuteric dianhyde	C^2H^2O	
	deutonic anhydride	$C^2H^2O^2$	
Udolides	ethol	$C^2H^4 + H^2O$	
	chlorethol	$C^2H^3Cl + H^2O$	
	sulphurethol	$C^2H^4 + H^2S$	
	chloro-sulphurethol	$C^2H^3Cl + H^2S$	
	perchloro-sulphurethol	$C^2Cl^4 + Cl^2S$.	

---

* We have already remarked that the monobasic anhydrides ought to be placed among the diamerones.

REMARKS.

A. The words chlo*rides*, tetrachlo*rides*, &c., have the defect of recalling the functions of chloride of potassium, chloride of ammonium, &c. Some other termination would be preferable.

B. The names of the monAlides, which contain one atom of oxygen, are terminated by the first vowel *a*;

The names of the deutErides, which contain *two* atoms of oxygen, are terminated by the second vowel *e*;

The names of the tritOnides, which contain *three* atoms of oxygen, are, nevertheless, terminated by the fourth vowel *o*, since *i* is reserved for the alkaloids.

C. The terminal consonants are arbitrary, excepting for the udOLides, which form methol, ethol, valol, &c.

We may say then:

Deut-al, deut-ase, deut-am, &c.;
Deute-ric, deute-sic, deute-tic, &c.;
Deuto-nic, deuto-dic, deuto-sic, &c.

Only, to avoid too great a resemblance in the words, we must employ, where possible, different consonants for the monalides, deuterides, and tritonides.

D. I reserve the consonant *n* as much as possible for the hydrocarbons and the alkaloids. Consequently, I do not say deutenic, protenic, benzenic, &c., acids, nor deutane, protane, benzane.

E. Parallel to each series I place a second one, of which the nucleus represents that of the first series, minus a molecule of hydrogen, plus a molecule of oxygen. Let us designate this second series or second branch, by the two roots *ox* and the variable, then we shall have:

Oxal	$C^2H^2O + O$,
Oxedate	$C^2H^2O + O^2$,
Oxolate	$C^2H^2O + O^3$.

It now remains for us to give names to the diamerones, but we have already done so at least for the diamerides. We have only to transport hither our great table, and to complete the list of the names of the genera.

Anamides	Mono-di-tri-tetr-anamides	$A^n + B - 1$(*);
	,, alesides....	$A^n + B - 2$;
	,, azilides	$A^n + B - 3$;
	,, anosides...	$A^n + B - 4$;
	,, enasides....	$A^n + B^2 - 1$;
	,, enelides....	$A^n + B^2 - 2$;
	,, elisides	$A^n + B^2 - 3$;
	,, emonides .	$A^n + B^2 - 4$;
	,, ilanides....	$A^n + B^3 - 1$;
	,, iresides	$A^n + B^3 - 2$;
	,, idilides	$A^n + B^3 - 3$;
	,, inosides....	$A^n + B^3 - 4$;
	,, osalides	$A + B^4 - 1$;
	,, omelides ..	$A + B^4 - 2$;
	,, onilides....	$A + B^4 - 3$;
	,, oronides...	$A + B^4 - 4$.

Since the acid may be mono, bi, tri, or quadribasic, it is clear, that we may have several varieties of diameracids.

If we suppose deutonic acid to be bibasic, we shall say :—

Acids .	deuton-amic	$A'' + H^3N - Aq$;
	deuton-anilic	$A'' + C^6H^7N - Aq$;
	deuton-etholic	$A'' + C^2H^6O - Aq$;

If we suppose it tribasic,

Acids .	deuton-amic	$A''' + H^3N - Aq$;
	deuton-etholic	$A''' + C^2H^6O - Aq$;

Acids .	deuto-diamic	$A''' + 2\,H^3N - 2\,Aq$;
	deuto-diethelic	$A''' + 2\,C^2H^6O - 2\,Aq$;

Lastly, if we suppose it quadribasic,

Acids .	deuton-amic	$''A'' + H^3N - Aq$;
	deuto-diamic	$''A'' + 2\,H^3N - 2Aq$;
	deuto-triamic	$''A'' + 3\,H^3N - 3Aq$;
	deuto-trietholic	$''A'' + 3\,C^2H^6O - 3Aq$;
	deuto-biammo-etholic	$''A'' + \left.\begin{matrix}2\,H^3N\\ C^2H^6O\end{matrix}\right\} - 3Aq$;

---

* We have made an exception for the amides, di, tri, and tetramides.

If the rules I have given concerning the acid and neutral characters of the diamerides, did not present any exception, several of the preceding names would never have to be made use of, such as those of osalide, omelides, onilide, oronide; for from what we have previously said, these names can only apply to the diamerides of the quadribasic acids.

But,

$$''A''+B^4-1=(''A''+B-1)+3\ B.$$

This then is a salt of ammonium, and the quadribasic acid being supposed to be the deutonic, the salt must be denominated the deutonamate of ammonium.

$$''A''+B^4-2=(''A''+B^2-2)+2\ B.$$

This will be another salt, the deutodiamate of ammonium.

$$''A''+B^4-3=(''A''+B^3-3)+B.$$

This will be another salt, the deutotriamate of ammonium.

With regard to the oronides, we made an exception for them, and have given to them the name of tetramides. Deutonamide would thus have for its formula:

$$''A''+B^4-4.$$

I have supposed, that both the monalides and udolides may give rise to alkalies by an exchange of NH for O. Consequently, the *diamerines* contain both *monalines* and *udolines* ;

Deutal....	$C^2H^4O+H^3N-H^2O$	would give rise to deutine,
Ethol	$C^2H^6O+H^3N-H^2O$	would give rise to ethine.

For the diameraies we might imitate the names of the diamerides, and say for example,

Deutal-amide (supposing it not to be alkaline)	$C^2H^4O+H^3N-$ Aq ;
Deutal-alese	$C^2H^4O+H^3N-2$ Aq.

But we have already remarked, that non-acid bodies, which are without any saturating capacity, can combine with the alkaloids in several proportions; consequently, for the azilides, alesides, &c., we are obliged to make use of the words bi, tri, quadri, &c., to designate the quantity of that neutral body, which is supposed to act as an acid in respect to the other.

Thus we must say:—

Bi-deutal-amide	$2\ C^2H^4O + H^3N - Aq$;
Tri-deutal-enelide	$3\ C^2H^4O + 2\ H^3N - 2\ Aq$;
Tri-deutal-eliside	$3\ C^2H^4O + 2\ H^3N - 3\ Aq$;

and in supposing the ammonia replaced by aniline, we should have to say anilic bideutalamide, anilic trideutalenelide, &c. These words are, however, too complicated, and as the bodies to which they apply are not at all common (hydrobenzamide, thialdine, &c.), we might provisionally give to them any names whatever.

Let us now pass to another series, of which the nucleus is C^7H^6, and let us name this series the *benzo-picrolic;* then by substituting the roots *benz* and *picr* for the preceding ones, we shall have:—

Benzene		C^7H^6
Hydrobenzene or picrene....		$C^7H^6 + H^2$
Chloride of benzene		$C^7H^6 + Cl^2$
Benzal		$C^7H^6 + O$
Acids	benzelic	$C^7H^6 + O^2$
	benzoric	$C^7H^6 + O^3$
Picrol		$C^7H^6 + H^2O$
Benzine		$C^7H^5\ (\overset{I}{\bar{N}}H^2)$
Picrine		$C^7H^7\ (\overset{I}{\bar{N}}H^2)$
Benzelamide		$C^7H^5O\ (\overset{I}{\bar{H}}{}^2N)$
Benzelamide	benzinic...	$C^7H^5O\ (\overset{I}{\bar{C}}{}^7H^6N)$
	picrinic	$C^7H^5O\ (\overset{I}{\bar{C}}{}^7H^8N)$.
Etc....		

I make use of the following roots for the series of the first order:—

Series	proto-metholic	$C\ H^2$ and $C\ H^4$
,,	deuter-etholic	$C^2\ H^4$ and C^2H^6
,,	tere-triadolic	$C^3\ H^6$ and C^3H^8
,,	tetra-butolic	$C^4\ H^8$
,,	pento-valolic	$C^5\ H^{10}$
,,	hexo-caprolic	$C^6\ H^{12}$
,,	septo-hebdolic	$C^7\ H^{14}$

Series	octo-tragolic	C^8H^{16}
,,	novo-pelolic	C^9H^{18}
,,	dece-rutolic	$C^{10}H^{20}$
,,	ende-rutolic	$C^{11}H^{22}$
,,	dyode-laurolic	$C^{12}H^{24}$
,,	jalep	$C^{12}H^{22}O$
,,	fato-lœvolic	$C^{13}H^{26}$
,,	myro-lœvolic	$C^{14}H^{28}$
,,	baleno $\alpha, \beta, \gamma, \delta, \epsilon$	$C^{15}H^{30}$
,,	ceto-cepholic	$C^{16}H^{32}$
,,	margaric	$C^{17}H^{34}$
,,	bassic $\alpha, \beta, \gamma, \delta$	$C^{18}H^{36}$ $C^{19}H^{38}$
,,	ico-vigolic	$C^{20}H^{40}$ $C^{21}H^{42}$
,,	behno-morolic	$C^{22}H^{44}$ $C^{23}H^{46}$
,,	hore-sorolic	$C^{24}H^{48}$ $C^{25}H^{50}$ $C^{26}H^{52}$
,,	cero-photolic	$C^{27}H^{54}$
,,	phœbe-dianolic	$C^{28}H^{56}$ $C^{29}H^{58}$
,,	men-apiolic	$C^{30}H^{60}$

DEFINITIONS AND OBSERVATIONS.*

The NUCLENIDES, or NUCLEI, of each series, contain a constant number of atoms of hydrogen, haloid bodies, or compound radicals, such as peroxide of nitrogen.

At present we do not know of any bodies which contain a fewer number of atoms than the nuclei. The deuteric dianhyde C^2H^2O, putting the carbon on one side, contains but three atoms, whilst in the nuclenides there are four; but in this case the atom of oxygen counts for two atoms or one molecule of hydrogen.

The nuclenides combine neither with acids nor with bases. By the action of bibasic acids, they may give rise to diamerides.

---

* I should like to have added to these definitions an account of the properties of the genera under examination. I should like to have compared the fusing and boiling points, the atomic volumes, the quantities of heat disengaged by combustion, &c., of the hydrocarbons, the monalides, deuterides, udolides, &c., but the materials for the carrying out of such a work are wanting.

Thus with sulphuric acid, and the naphthalic nuclenides, we obtain naphthalic sulphamide (sulphonaphthalide), and the chloro-bromo, nitro, bichloro, trichloro, and quadrichloro-sulpho-naphthalic acids. They can combine directly with 2, 4, or 6 atoms of chlorine, or undergo a regular series of substitutions, by losing as many atoms of hydrogen as they gain atoms of chlorine, bromine, &c.

They may be divided into

1°. *Carbhydrides*, which are the hydrocarbons, or nuclei, to which all the compounds constituting the series may be referred. All hydrocarbons are not carbhydrides. I have previously divided them into hydrocarbons, properly so called, and into hyperhydrides. This division is probably insufficient. Thus in the series of bihydrocarbon, in addition to the nucleus itself, we have the hyperhydride $C^2H^4+H^2$, or hydruret of ethyl, obtained by means of ethylic cyanide and potassium, and also another hyperhydride or methyl, isomeric with the preceding compound. This last hyperhydride does not appear to belong to the methylic series; for under the influence of chlorine, it does not dedouble itself, to reproduce either methylic chloride, or any of its derivatives.

There exists, also, another hydrocarbon ethyl, C^4H^{10}, but this body no more belongs to the ethylic, than does methyl to the methylic series; it is the hyperhydride $C^4H^8+H^2$ of the butyric series.

If at any future time we should succeed in discovering the real ethyl, its composition ought to be represented by

$$2\ C^2H^4+H^2,$$

we should then have four hydrocarbons in the ethylic series

Carbhydride (fundamental nucleus)	C^2H^4
Hyperhydride (from ethylic cyanide)	$C^2H^4+H^2$
Hyperhydride isomeric (methyl)	$C^2H^4+H^2$
Ethyl	$2C^2H^4+H^2$.

The first of these bodies combines directly with chlorine, giving rise to $C^2H^4+Cl^2$.

The second, by treatment with the same reagent, yields substitution products only, C^2H^4+HCl and $C^2H^4+Cl^2$. I do not know, whether this last is or is not identical with Dutch liquid.

The third, also experiences equivalent substitutions, and produces $C^2H^4 + HCl$, and $C^2H^4 + Cl^2$. This last compound being gaseous is certainly not identical with Dutch liquid.

The fourth, by the action of chlorine, ought to give rise to the following reaction

$$2\ C^2H^4.H^2 + Cl^2 = 2\ C^2H^5Cl,$$

that is to say, it ought first of all to form ethylic chloride, and subsequently the compound $C^2H^4Cl^2$ isomeric with Dutch liquid.

2°. *Halydes.* Very stable compounds, which are decomposed neither by distillation nor by an alcoholic solution of potash. (*Vide* page 185, Art. CHLORO-SUBSTITUTIONS.)

3°. *Nitrides.* Compounds which are ordinarily red or yellow, and are capable of being volatilized without decomposition.

But if they require a high temperature to enter into ebullition, or if they are heated too suddenly, they inflame and detonate in closed vessels.

By the action of sulphuretted hydrogen, of sulphurous acid, or of certain combustible bodies, they may be deoxidated more or less completely. The mononitrated compounds, when submitted to the action of sulphuretted hydrogen or sulphurous acid, lose all their oxygen O^2, and absorb only one molecule or two atoms of hydrogen, in this way giving rise to alkaloids. When this change is effected by the agency of sulphurous acid, which thereby passes into the state of sulphuric acid, diameracids are produced. The binitrated compounds either undergo a partial reduction, one X only being replaced by Ad, when a nitro-alkaloid results—or they undergo a complete reduction, and give rise to a biamidic alkaloid (semibenzidam). By the action of an alcoholic solution of caustic potash, they are decomposed into products which have not yet been sufficiently studied. We only know, that from nitro-benzide there are produced in the first place azobenzide, and subsequently azotobenzide, the composition of which bodies may be represented by nitro-benzide minus oxygen. It is remarkable, that azoto-benzide is of an orange colour, like the nitro-compounds, and that, like them, it gives rise to an alkaloid (benzidine) by the action of sulphuretted hydrogen.

Hitherto, the carbhydrides of the first order, nCH^2, have not furnished us with a single nitride.

4°. The *halonitrides* partake of the properties both of the halides and the nitrides. By the action of sulphuretted hydrogen they would probably give rise to chloro- and bromo-alkaloids.

The DYADIDES, of which the composition may be represented by a nucleus, plus 1, 2, and 3 molecules of the following dyads—H^2, Cl^2, Br^2, I^2, F^2, and even M^2, are divisible into:

1°. *Hyperhydrides.*—These are hydrocarbons, which when treated with chlorine, comport themselves differently from the carbhydrides. By the action of this reagent they undergo equivalent substitutions, but the products thus formed are attackable by alkalies, whilst those furnished by the carbhydrides are not so.

We do not know, whether the hyperhydrides, like the carbhydrides, are capable of producing diameracids with sulphuric acid. There are, indeed, many acids of which the composition may be represented by SO^3 plus a hyperhydride: such are the hyposulphomethylic $SO^3 + CH^4$, the hyposulphethylic $SO^3 + C^2H^6$, and the hyposulphamylic $SO^3 + C^5H^{12}$, acids. But we are ignorant as to whether these acids are products of sulphuric or of sulphurous acid: on the second hypothesis, they will be respectively the sulphomethylous, sulphethylous, and sulphamylous acids. Hitherto, we are not acquainted with any hyperhydride containing more than two atoms of hydrogen in excess of the nucleus. The members of this class appear to be capable of producing certain metallic varieties, such as zinc-methyl $CH^2 + ZnH$, and zinc-ethyl $C^2H^4 + ZnH$.

The trichloro-hyperhydride of the methylic series, forms an amide with chlorosulphalic acid; this is Berzelius's and Marcet's compound, the composition of which may be represented by

$$SO^3HCl + CCl^3H—Aq.$$

2°. *Dihalides.*—These bodies contain one dyadic molecule in excess of the nucleus. This molecule may be homogeneous, that is to say, formed of 2 halogeneous atoms, or heterogeneous, that is to say, formed of 1 atom of hydrogen and 1 atom of a halogen, as instanced in the two following bodies:

$$C^2H^4 + HCl, \qquad C^2H^4 + Cl^2,$$

which represent, the one an isomeride of chlorhydric ether, the other of Dutch liquid. Concerning their properties, *vide* page 185, Art. CHLORO SUBSTITUTIONS.

3°. *Tetrhalides.*—These bodies contain 2 dyadic molecules, or 4 atoms in excess of the nucleus. These atoms may be of different natures, as in the following examples :—$C^{10}H^8 + Cl^2Br^2$. With regard to their properties *Vide* page185, Art. CHLORO SUBSTITUTIONS.

I will add one word only, concerning the manner in which they comport themselves with sulphuric anhydride. The carbhydrides and halides combine directly therewith, giving rise to diameracids. The tetrhalides, at least those of naphthaline, are decomposed with elimination of chlorhydric and formation of a diameracid, probably in accordance with the following reaction:

$$C^{10}H^{8}.Cl^{4}+SO^{3}=SO^{3}.C^{10}H^{6}Cl^{2}+H^{2}Cl^{2},$$

that is to say, that a halyde is formed, which then unites with the sulphuric anhydride.

Hitherto, the carbhydrides and the hyperhydrides of the first order, nCH^2 and nCH^2+H^2, have not given rise to a single tetrhalide.

4°. *Hexalides.*—These bodies contain 3 molecules, or 6 dyadic atoms in excess of the nucleus. Like all other hyperhalydes, when submitted to the action of potash, they yield chlorhydric acid, and give rise to halydes.

Certain hyperhalydes, when submitted to the action of ammonia, have either not undergone any alteration, or have simply yielded chlorhydric acid.

The MONADIDES, of which the composition may be represented by a nucleus plus 1, 2, and 3 atoms of the following monads:—O, S, Se, Te, are divisible into:

1°. *Monalides*, which as a rule correspond to the compounds ordinarily designated by the name of aldehydes. They are neutral bodies; but very many of them are capable of exchanging 1 atom of hydrogen for 1 atom of potassium, and certain other metals. These species of salts are generally very unstable, and are decomposable by water. Nevertheless salicylic aldehyde, or salicylous acid combines readily with the majority of the metals. So also do the nitro-derivatives of phenylic aldehyde (bi- and tri-nitrophenic acids).

By the action of ammonia, the monalides undergo very various metamorphoses. The most simple case presented to us, is that in which 1 equivalent of ammonia and 1 equivalent of an aldehyde react upon one another to produce an alkaloid. Thus we have with

$$\text{Aldehyde}\left\{\begin{array}{lll}\text{phenylic} & \ldots & C^{6}H^{6}O+H^{3}N-Aq=\text{aniline}\\ \text{ordinary} & \ldots & C^{2}H^{4}O+H^{3}As-Aq=\text{kakodine.}\end{array}\right.$$

With other proportions, either various neutral bodies are produced, or else alkaloids, as seen in the following examples:

$$\text{Aldehyde}\left\{\begin{array}{lll}\text{ordinary sulpho} & 3\,C^2H^4\ \ S + \ \ H^3N - \ \ H^2S & = \text{thialdine}\\ \text{benzoic} \ \ldots\ldots & 3\,C^7H^6\ \ O + 2\,H^3N - 3\,H^2O & = \text{amarine}\\ \text{furfuric} \ \ldots\ldots & 3\,C^5H^4O.O + 2\,H^3N - 3\,H^2O & = \text{furfurine.}\end{array}\right.$$

Under the influence of oxygenants, the monalides pass into the state of deuterides (acids), and their mono-chloro-varieties, when submitted to the action of water or alkalies, pass into the same state. Thus we have with

$$\text{Aldehyde}\left\{\begin{array}{ll}\text{benzoic} \ \ldots\ldots & C^7H^6\ \ O + \ \ \ O = \text{benzoic acid}\\ \text{chlorobenzoic} & C^7H^5ClO + H^2O = \text{benzoic acid} + HCl.\end{array}\right.$$

The monalides have certain relations with the alcohols. We might say, that the former are to the carbhydrides, what the latter are to the hyperhydrides:

$$\begin{array}{llll}\text{Deutene} & C^2H^4 & \text{Ethene} & C^2H^4.H^2\\ \text{Deutal} & C^2H^4 + O & \text{Ethol} & C^2H^4.H^2 + O.\end{array}$$

Moreover several monalides are capable of giving rise to combinations analogous to the ethers and vinic acids. Thus we are acquainted with a considerable number of acids, formed from sulphurous acid, and the benzoic, salicylic, cuminic, anisic, capric, œnanthylic, &c., aldehydes, in virtue of the equation:

$$H^2SO^3 + \text{Aldehyde} - \text{Aq}.$$

2°, *Deuterides,* which are monobasic acids.

We have already said, that the acids are salts of hydrogen, or hydrogenised molecular types, of which one or several atoms of hydrogen may be replaced by any metal whatsoever. This definition, though based upon the fundamental character of the acids, does not yet suffice to isolate these bodies from all others; for we meet with many compounds which possess this character to a greater or less degree, and which, notwithstanding, are never accounted acids; such a body for instance is ammonia, which is capable of exchanging 1, 2, and 3 atoms of hydrogen for an equal number of atoms of certain metals. To the above mentioned character then, we must add the following: acids redden the colour of litmus, effervesce with carbonates, destroy the alkalinity of bases, and are capable of forming ethers. But on a more close examination, we perceive, that all these characters are but varieties of the first or fundamental one; for the appearance of the red colour of litmus, indicates to us, that the acid under examination has exchanged its hydrogen for the metal of blue litmus; the disengagement of carbonic acid shows, that the metal of the carbonate has taken the place of the hydrogen of the acid; the destruction of alkalinity is also due to the exchange of hydrogen for a metal; and, lastly, the formation of an ether may be regarded as the exchange of hydrogen for a compound body which fulfils the functions of a metal.

Nevertheless, there exist bodies which neither redden the colour of litmus, nor produce effervescence with carbonates, and which are yet considered as acids. This may be easily understood by an inquiry into the cause of the alteration of the litmus colour, and of the effervescence of the carbonates. These two phenomena prove, that the acid under examination is capable of displacing the red acid of litmus, and the gaseous acid of the carbonates, or as is ordinarily said, it is more powerful than these two acids. But there may exist bodies more feeble than the two latter, which will, nevertheless, be classed among acids. Lastly, we are acquainted with insoluble acids, which, on that account, are without action upon test paper.

Certain differences, however, do exist between phosphuretted hydrogen, ammonia, pthalimide, succinimide, isatine, &c., on the one hand, and acids on the other. The first mentioned bodies combine only with certain metals, they do not unite directly with oxides, except in a very few cases, and the species of salts which they form do not, as a rule, yield themselves to ordinary double decomposition: whilst the acids, properly so called, combine with all the metals, unite directly with metallic oxides, and, together with all their salts, participate in double decompositions with the greatest ease. But even these characters are not absolute, for though phosphuretted hydrogen and ammonia do not with oxide of sodium form directly a phosphide and a nitride—though argentic pthalimide with chloride of barium does not produce barytic pthalimide—neither does carbonic acid combine directly with alumina and ferric oxide; nor does carbonate of potash, when added to a salt of gold or platinum, precipitate the carbonates of these metals.

Thus then, the acids are not possessed of exclusive characters, by which they can be completely separated from all other bodies. Nevertheless, by having regard to their composition, and to their relations with certain bodies, I believe it will be extremely difficult to misunderstand their nature. I will explain myself by an example:—We are acquainted with the remarkable relation which exists between the homologous aldehydes $n\mathrm{CH}^2+\mathrm{O}$, and these same aldehydes superoxidised nCH^2+O^2. We know that the first are neutral, though capable of combining with potassium and a small number of metals, whilst the second are acid. If then in the series

$$\begin{array}{lllll} CH^2O & C^2H^4O & C^3H^6O & \ldots & C^{50}H^{100}O \\ CH^2O^2 & C^2H^4O^2 & C^3H^6O^2 & \ldots & C^{50}H^{100}O^2, \end{array}$$

we found that all the inferior terms were acid, whilst all the superior terms, with one exception only, $C^{20}H^{40}O$, were neutral; if, moreover, this exceptional term formed neither ethers nor amides; if while combining with the majority of the metals, it refused to combine with ammonia; and if lastly, by its melting point, boiling point, crystalline form, metamorphoses, &c., it occupied an exactly intermediate position between the terms $C^{19}H^{38}O$ and $C^{21}H^{42}O$, ought we to exclude it from the class of the aldehydes, and transport it into that of the acids? I believe, that we ought not; and from similar considerations I shall place the salicylate of methyl or gaultheric acid, not in the class of acids, but rather in that of ethers.

In conclusion; if for the determination of the functions of a body, we have regard to the action which it exerts upon oxides, carbonates, and litmus,—to the double decomposition of its salts and to their number,—if moreover, we take into account its composition and metamorphoses (formation of ethers, amides, vinic, amidic acids, &c.), as also the relations which it has with other bodies of analogous composition,—I believe it will be easy for us to determine its acid or non-acid nature.

I have just said, that the deuterides are monobasic acids (I shall revert presently to the question of basicity), nevertheless an exception might be adduced in the case of oxyphenic acid or pyrocatechine, which is bibasic. But I have several observations to make upon this apparent exception. We ought to have the following series:

Phene or benzine	C^6H^6
Phenal or phenic aldehyde	C^6H^6+O
Monobasic acid	$C^6H^6+O^2$.

Oxyphenic acid would appear to be the acid of this series, for it is obtained from morin, which according to circumstances transforms itself sometimes into phenal, sometimes into oxyphenic, and sometimes into oxypicric acid. I would ask in the first place, whether the body in question is indeed an acid? We may remark, that it has also been designated by the name of *pyrocatechine*, whence we should conclude, that its acid properties are not well marked. We are acquainted with its lead salt only, and we know that with certain neutral bodies, and with feeble acids, lead frequently gives rise to salts containing an excess of oxide. But I leave this last objection on one side, since there exists a derivative of oxyphenic acid, namely, the oxypicric $C^6H^3X^3+O^2$ (if, indeed, it does not contain O^9 instead of O^8), which gives rise to bibasic salts.

That the acid in question constitutes the real phenic deuteride, appears to me to be very doubtful, inasmuch as St. Evre has obtained from benzoic acid (the intimate relations of which with the phenic series are well known to us) two acids, namely, the chlorophenylic and nitrochlorophenylic, which are respectively represented by $C^6H^5Cl+O^2$ and $C^6H^4\,X\,Cl+O^2$, and are *monobasic*. And since the rule, *that every acid, no matter what its degree of basity, conserves that degree of basity when undergoing chloro- and nitro- substitutions*, is hitherto without exception; we thence conclude, that the chloro- and nitro-chlorophenylic acids are derived from a monobasic acid $C^6H^6+O^2$, which is indeed the real phenic deuteride. With regard to pyrocatechine, it has obviously a relation of propinquity with the phenic series; but we are unable at the present time to determine its functions with certainty.

We have now to consider the saturating capacities of the acids.

The weight of the molecule of an acid being known, how are we to ascertain its saturating capacity?

Nothing is more simple in appearance; we determine the quantity of hydrogen which can be replaced by its equivalent of metal: if 1 atom of hydrogen is replaced by 1 atom of metal, the acid is monobasic; if 2, 3, &c. atoms of hydrogen are replaced by 2, 3, &c. atoms of metal, the acid is bi-, tri-, &c. basic. Nevertheless there are cases in which somewhat serious difficulties present themselves. We do not require to know, whether tartaric acid, for example, is mono- or bi- basic, that is to say, whether or not its formula ought to be doubled, for we have already examined this question in all its details; but representing the acid by $C^4H^6O^6$, we require to know, how many of its hydrogen atoms, it is capable of exchanging for an equal number of metallic atoms. It is generally admitted, that two atoms of hydrogen may be exchanged for 2 atoms of any metal whatever. I would ask, whether we are perfectly sure, that the acid is unable to yield up 3, 4, 5, and even 6 atoms of hydrogen, in exchange for an equal number of atoms of a metal?

Since we have considered hydrogen as a metal, it would seem, that an acid ought to be as many times basic as it contains atoms of hydrogen; that the acetates ought to be quadribasic, and the tartrates sexbasic. Is this deduction, then, completely contrary to experience?

We know that when trichloracetic acid is treated with potassium, there is formed a salt, which, by the action of water, is transformed into ordinary acetic acid.

The emetics heated to 200° C contain only 2 atoms of hydrogen, and the 4 atoms eliminated are shown to be replaced by their equivalents of two metals; whence we ought to conclude, that tartaric acid is quadribasic.

Gallic acid $C^7H^6O^5$ is bibasic. Nevertheless the gallate of tin contains $C^7H^2Sn^4O^5$, and the gallate of lead $C^7H^2Pb^4O^5$.

Isotartridic acid $C^4H^4O^5$, which is monobasic, loses at least 2 atoms of hydrogen when heated with an excess of litharge.

Succinic acid, which is bibasic, seems to form two lead salts, which contain respectively $C^4H^3Pb^3O^4$ and $C^4H^3Pb^3O^4+Pb^2O$.

Marsh gas, which has no saturating capacity whatever, can, nevertheless, in certain circumstances, exchange 1 atom of hydrogen for 1 atom of zinc.

It appears to me, that by strongly heating certain *basic* salts of lead, we may succeed in eliminating a quantity of hydrogen greater than that which corresponds to the basity of the acid. Thus, the precipitated gallate of lead is probably in the first instance a basic salt $=C^7H^4Pb^2O^5+Pb^2O$, and not $C^7H^2Pb^4O^5+H^2O$. When this salt comes to be heated, it disengages, not water which existed in the salt, but water formed at the expense of the hydrogen of the acid and the oxygen of the oxide of lead in excess.

It would seem then, from what I have just said, that under certain circumstances a monobasic acid may exchange more than 1 atom, and a bibasic acid more than 2 atoms of hydrogen; in a word, that the basity of an acid is rather a habitual than an absolute property.

Nevertheless, if we compare the properties of the monobasic, with those of bi, tri, and quadribasic acids; if we attend to the number of amides and ethers formed by these acids; if we recollect that monobasic acids do not give rise to ethers with 2 atoms, nor bibasic acids to ethers with 3 atoms of ethyl; and if we have regard to the rarity of ultrabasic salts, and to the circumstances under which they are formed, we need never be long in doubt concerning the basic measure of an acid.

These reflections were suggested to me by aspartic or malamic acid, which in its quality of amidic acid of bibasic malic acid, ought to be monobasic, whilst we know that in reality it exchanges 2 atoms of hydrogen for 2 atoms of metal.

I have previously remarked, that the properties of the salts of this acid would lead us to consider it as monobasic, and that its bimetallic salts ought to be viewed as ultrabasic. Thus, then, the composition of the aspartates proves to us, that in this case a single character is not sufficient to define the basic measure of an acid, but that we must have regard to several characters, and that sometimes the principal character may lead us into error.

The word bibasic has several different significations; thus, we say, that $C^4H^4Pb^2O^6$ is a bibasic tartrate of lead, and that $C^4H^4Pb^2O^6+2Pb^2O$ is also a bibasic salt. To avoid this confusion, I shall designate the different neutral, acid, basic, and ultrabasic salts of the same acid, as follows:

	Tartaric acid	$C^4H^6O^6$
Tartrates	potassic	$C^4H^5K\ O^6$
	bipotassic	$C^4H^4K^2\ O^6$
	biplumbic	$C^4H^4Pb^2O^6$
	hydrobasic plumbic	$C^4H^4Pb^2O^6+Pb\,HO$
	bibasic plumbic	$C^4H^4Pb^2O^6+\ Pb^2O$
	quadribasic plumbic	$C^4H^4Pb^2O^6+2\ Pb^2O$
	quadriplumbic	$C^4H^2Pb^4O^6$
	quadribasic-quadriplumbic	$C^4H^2Pb^4O^6+2\ Pb^2O$
	antimonylo-potassic	$C^4H^4SbyK\ O^6$
	tristibico-potassic	$C^4H^2sb^3K\ O^6$.

3°. *Tritonides*, which are bibasic acids.

The composition of the tritonides may be represented by a carbhydride plus 3 molecules of oxygen, or by a carbhydride minus 1 molecule of hydrogen plus 4 atoms of oxygen. Thus with $C^{10}H^{10}$ we may have both $C^{10}H^{10}+O^3$ and $C^{10}H^8O+O^3$.

Carbonic acid (CH^2+O^3) is perhaps the only tritonide which contains but 3 atoms of oxygen. Homologically, we should be led to admit the existence of other analogous acids $C^2H^4+O^3$, $C^3H^6+O^3$, &c. Of these bodies but one very doubtful example is know to us, namely œnanthic acid, of which the formula is generally represented by

$$C^{14}H^{28}+O^{3}.$$

According to the very recent experiments of Delffs, this acid is constituted of $C^{9}H^{18}+O^{2}$, and is monobasic. How then did it happen, that the saturating capacity and vapour density of œnanthic acid and its ether were at first found to accord with the formula C^{14}? How was it, that this acid, like the majority of bibasic acids, gave rise to an anhydride by simple distillation, as also to a derivative which was quadrichlorinated according to the old, but would become $\frac{4}{7}$ chlorinated with the new, formula.

In default of œnanthic, we might indeed cite rocellic acid $C^{12}H^{24}+O^{3}$; but here also several doubts may be raised. Schunck represents this acid by the formula

$$C^{12}H^{23}O^{3},$$

which ought necessarily to be transformed into

$$C^{12}H^{24}+O^{3} \text{ or into } C^{12}H^{22}O+O^{2}.$$

In the first case it would be bibasic, in the second monobasic. Unfortunately we know but of one salt, namely, the rocellate of lead, the neutrality or basity of which it is difficult for us to decide upon; for we are unable to say, whether it contains $C^{12}H^{22}Pb^{2}+O^{3}$, or $C^{12}H^{21}PbO^{3}+PbHO$. We might possibly adduce anacardic acid $C^{20}H^{28}O^{3}$ if it were better known.*

Glycolic acid, $C^{2}H^{4}O^{3}$, would appear to be an exceptional tritonide, for under the above form it is monobasic. But we are ignorant as to whether or not its formula ought to be doubled, and itself thus rendered a homologue of bibasic lactic acid.

The tritonides with 4 atoms of oxygen are sufficiently numerous, and possess in a marked degree the characters of bibasic acids. We are acquainted with the following members belonging to our first order:—

---

* *Vide* my observations in the Tables.

Oxalic	$C^2H^2O+O^3$
——	$C^3H^4O+O^3$
Succinic	$C^4H^6O+O^3$
Pirotartric	$C^5H^8O+O^3$
Adipic	$C^6H^{10}O+O^3$
Pimelic	$C^7H^{12}O+O^3$
Suberic	$C^8H^{14}O+O^3$
Sebacic	$C^{10}H^{18}O+O^3$
Ipomic	
——	$C^{20}H^{38}O+O^3$.*

It is worthy of note, that all these acids may be obtained by the action of nitric acid upon the monobasic acids of our first order. Oxalic acid itself may be obtained by the action of moist chlorine upon acetic acid; we have in this case the equation

$$C^2H^4O^2+O^3=C^2H^2O^4+H^2O,$$

similarly to that of butyric acid:

$$C^4H^8O^2+O^3=C^4H^6O^4+H^2O.$$

Of tritonides belonging to the other orders, we are acquainted with the following:—

Mellic	$C^4H^2 \quad O+O^3$
Maleic	$C^4H^4 \quad O+O^3$
Citraconic	$C^5H^6 \quad O+O^3$
Itaconic	
Mesaconic	
Lipic	
Chloranilic	$C^6H^2Cl^2O+O^3$
Phtalic	$C^8H^6 \quad O+O^3$
Terephtalic	
Nitroterephtalic	$C^8H^5X\ O+O^3$
Camphoric	$C^{10}H^{16} \quad O+O^3$
Chrysamic	$C^{14}H^4X^4\ O+O^3$
Aloeresinic	$C^{16}H^8X^4\ O+O^3$.

It is observable, that the majority of these last tritonides are also obtained by the action of nitric acid.

The deuterides are volatile without decomposition, and the tritonides very nearly so. I say nearly so, since the majority of

---

* Phycic acid probably contains $C^{20}H^{39}NO^3$. Supposing it to be an amidic acid, by abstracting H^3N and adding H^2O, we should have $C^{20}H^{38}O+O^3$ bibasic.

them, when volatilising, undergo a partial decomposition, and give rise to anhydrides; this is never the case with the deuterides.

I need not revert to the properties of bibasic acids, having entered into considerable details, upon the subject in a former part of this work.

The *anhydrides* have a composition which may be represented by a deuteride or a tritonide, minus the elements of water. We shall divide them into two principal classes:

1°. *Monanhydrides*, or the anhydrides of the monobasic acids. For their formation the presence of 2 atoms of acid is required, as in the example:

$$\underset{\text{Acetic acid.}}{2\,C^2H^4O^2} = \underset{\text{Acetide.}}{C^4H^6O^3} + H^2O.$$

Hitherto, it has not been possible to obtain bodies of this class, either by heating the deuterides, or by treating them with bodies having a powerful affinity for water. We have elsewhere indicated their mode of preparation.

From their properties and constitution, these bodies ought to be placed among the diamerones, for they are evidently complex bodies formed of two groups. When produced from one single acid they are *didymic*, when from two different acids *dioic*.

Thus, according to Gerhardt,

$$2\,C^2H^4O^2 \quad \text{would give} \quad \left\{\begin{matrix} C^2H^3O \\ C^2H^3O \end{matrix}\right\} O + H^2O$$

$$\left.\begin{matrix} C^2H^4O^2 \\ C^7H^6O^2 \end{matrix}\right\} \quad \text{would give} \quad \left\{\begin{matrix} C^2H^3O \\ C^7H^5O \end{matrix}\right\} O + H^2O$$

When added to water, they do not mix therewith, but dissolve more or less gradually, and regenerate the monobasic acids. With ammonia, they do not give rise to amidic acids, but to amides.

I have previously shown, that the anhydrides N^2O^3, N^2O^5, Sb^2O^3, B^2O^3, As^2O^3* can in certain cases play the part of oxide of uranyle. It remains to be shown, how far the acetic, butyric, benzoic, &c. anhydrides, resemble the above-mentioned bodies.

2°. *Dianhydrides*, or anhydrides of the bibasic acids. The majority of these compounds may be obtained directly by

---

* The arsenious, boric, phosphoric, &c., anhydrides, may be considered as mono- bi- or tri-basic anhydrides. Thus P^2O^5 is the anhydride of metaphosphoric, phosphoric, and pyrophosphoric, acids; B^2O^3 may be the anhydride of a boric type containing BO^2H.

de-hydrating their acids. We have described their properties elsewhere.

In addition to the above two classes, we might yet establish two others which should comprise respectively:

3°. *Anhydroses*, the composition of which may be represented by 1 molecule of a monobasic acid, minus 1 molecule of water: thus formic acid $CH^2O^2 - H^2O = CO$ carbonic oxide or formiose. But very few of these bodies are known to us; pyromargarol and pyrostearol may, however, be adduced as examples. The monobasic acids which do not belong to the class of deuterides may also give rise to anhydroses; as for instance, isatinic acid which forms isatine, and benzilic acid which forms benzile. Isatine and benzile have indeed but very little analogy with carbonic oxide, pyromargarol and pyrostearol. It is clear, that the class of anhydroses must be separated into several divisions, if all these different bodies are to be retained in it.

4°. *Dianhydroses*, the composition of which may be represented by a bibasic acid, minus 2 atoms of water. The tritonides do not furnish a single body belonging to this class. From among the other bibasic acids I can only adduce lactic acid, which gives rise to dilactide or lactose.

The MONODYADIDES comprise but a single group, that of the *udolides*, of which the composition may be represented by a carbhydride, plus a molecule of water. To this division are referred the alcohols properly so called, or the alcohols of the first order, $nCH^2 + H^2O$.

Among the other orders, there may be found bodies which have analogous compositions, but of which the properties are not well known.

Thus, thiosinamine, when heated with potash, gives rise to a product which is probably the acroleic alcohol $C^3H^4 + H^2O$. Assafœtida, appears to contain a homologous sulphur alcohol $C^5H^8 + H^2S$. Oreoselone would be an alcohol $= C^7H^4O + H^2O$; oreoseline, the ether, $= 2\,C^7H^4O + H^2O$; and athamantine, the valerianate. We might regard saligenine as a salicylic alcohol $= C^7H^6O + H^2O$; peruvine as a cinnamic alcohol $= C^9H^8 + H^2O$; and essence of peppermint $C^{10}H^8 + H^2O$, also as an alcohol.

I have previously considered the ethers as hydrodiamerides; on the other hand, all chemists regard the ethers, including ether properly so called, as forming with their alcohols but a single group of analogous compounds.

In placing alcohol among the aplones, and its ethers among the diamerones, I dissever the very natural ties which unite the former with the latter bodies. I do not pretend to justify this separation; quite the contrary. There is here a trifling apparent difficulty, which will require our attention for a minute or so.

We have said, that an ether is a compound which, under the influence of water, can regenerate the acid and the alcohol from which it was produced. Let us write down several formulæ of this regeneration.

1°. $C^2H^5NO^3 + H^2O = H\,NO^3 + C^2H^6O$
2°. $C^2H^5Cl + H^2O = H\,Cl + C^2H^6O$
3°. $C^2H^6S + H^2O = H^2S + C^2H^6O$
4°. $C^2H^6O + H^2S = H^2O + C^2H^6S$
5°. $C^2H^6O + H^2O = H^2O + C^2H^6O$

No objection can be made as regards the first three equations; the third contains the term C^2H^6S, which satisfies our definition. The fourth is the inverse of the third; it is true, that in this case we suppose that C^2H^6O is decomposed, not by the agency of oxygen-water but under that of sulphuretted-water, which comes to the same thing. But as the terms C^2H^6O and H^2O correspond to the terms C^2H^6S and H^2S, we may indifferently make use of the former or of the latter, and may consequently propose the fifth equation. But this seems to be absurd, for it indicates that alcohol being an ether, may, in common with other ethers, decompose water and regenerate on the one hand the alcohol, and on the other hand the water from which it was produced.

This absurdity arises from the meaning we attach to our definition of the ethers. Considered from a certain point of view, the general formula of the ethers is applicable to alcohol; considered from another point of view, with reference to the actual decomposition by water or alkalies, it becomes absurd. But instead of taking alcohol as the term of comparison, we might select sulphalcohol, or even chlorhydric ether. In this last case we should say, that an ether is a body which, under the influence of chlorhydric acid, dedoubles itself, and gives origin to chlorhydric ether, and to the acid from which it was produced: then chlorhydric ether, which serves as the term of comparison, would be excluded from the class of ethers, whilst alcohol would enter therein. It is the same with the majority of definitions of this description, where the body, which serves as the term of comparison, is excluded, in appearance at least, from the class to which it belongs. We might define the sulphates by saying, that they are salts which give a sulphatic precipitate with chloride of strontium. But the sulphate of strontium, which in this manner serves as the term of comparison, would, by this definition, be excluded from the class of sulphates, since its solution does not give a precipitate with the solution of chloride of strontium. It would be the same with sulphate of barium, were we to take it as the term of comparison.

In conclusion, alcohol being indivisible under the influence of water, may be placed among the aplones; being, however, divisible under the influence of sulphydric and chlorhydric acids, it ought to be placed among the diamerones, along with the amidic acids, and by the side of sulphydrovinic acid, to which it corresponds, constituting, as it does, ox-hydrovinic acid. I leave it among the aplones, only for the sake of convenience, since we must be acquainted with its properties before we can study those of the ethers, in the midst of which bodies, however, would be its proper position.

At the head of the DIAMERONES I have placed the RADICALS; these I have divided into *metoyles* and *alcinyles*. As with two or three exceptions only, these bodies are purely hypothetical, I shall not add anything to what I have previously said concerning them.

We now come to the ALCINIDES, or alkaloids. This class is not in harmony with the others; for its establishment I make use of a property, for that of the others I have relied constantly upon composition. Thus, the establishment of this new class throws our classification into a certain confusion, of which it is well to be forewarned.

The hydrodiamerides come after the alcinides, but among these last mentioned bodies will be found urea, flavine, and many other alkaloids which are also hydrodiamerides. I could indeed have comprised these bodies in the class of hydrodiamerides, which I might have divided at first according to composition, and then subdivided according to properties; thus, the diamides might have been subdivided into neutral diamides, and into alkaline diamides, such as urea and flavine. The following consideration prevented me from adopting this plan.

In the first place I was embarrassed by cyaniline, and the other cyano-alkalies which, though they may be easily considered as hydrodiamerides, could not without some difficulty be located in any of the established subdivisions; and, moreover, there exist alkaloids (such as those corresponding to tellurethyl and stannethyl) which it would be difficult to consider as hydrodiamerides.

Lastly, another motive of convenience decided me upon placing the alkaloids apart, and at the head of the diamerones, for nearly all of these latter bodies are obtained by means of the alkaloids, and it is obviously advantageous to place these bodies in advance of their combinations. This order must, however, give place to a better one, when we become better acquainted with the generation and metamorphoses of the alkaloids.

The alkaloids may be subdivided into

1°. *Monalines,* which proceed from the action of ammonia upon the monalides, according to the equation

$$A + B - Aq.$$

2°. *Udolines,* which may be considered as products of the action of ammonia upon the udolines, according to the equation

$$A + B - Aq.$$

3°. *Alkaloids* analogous to semi-naphthalidam and semi-benzidam. The monalines may be considered as carbhydrides which have exchanged 1 atom of hydrogen for 1 atom of amidogen; the alkaloids of this division may be considered as carbhydrides which have exchanged 2 atoms of hydrogen for 2 atoms of amidogen.

4°. *Cyanalcines* analogous to cyaniline, dicyanomelaniline, &c.

5°. *Ureas,* as urea properly so called, flavine, &c.

6°. *Alkaloids* analogous to tellurethine and stannethine.

7°. *Alkaloids* analogous to quinine, &c.

8°. *Hydralcines* analogous to amarine, furfurine, thialdine, &c., which proceed from the action of ammonia upon the monalides, according to various equations.

Although the alkaloids would appear to form a well characterised class (by the property they possess of being able to unite directly with acids so as to form salts), nevertheless, as with the acids and many other bodies, we are sometimes embarrassed when called upon to decide, whether such and such a compound is or is not an alkaloid. We need only refer to glycocine, leucine, asparagine, &c., and even to trichloraniline. With regard to this last substance no hesitation can possibly be required, since it lacks the fundamental property of the alkaloids, since it does not combine with any acid whatever. We might compare aniline and its chloro-derivatives to a magnetised bar, capable of sustaining a certain number of indivisible balls of iron, which bar, by a gradual loss of its magnetic power, would be able to support only 4, 3, 2, and 1 ball, and at last be incapable of supporting even a single ball, although in this last case it would still remain magnetised. In the same manner, when aniline gradually becomes chlorinated, so does its affinity for acids diminish; bichloraniline retains chlorhydric acid but very feebly, and trichloraniline is no longer able to unite therewith. Nevertheless it seems to me, to be impossible for us to separate these two anilines from one another, and consequently trichloraniline must be left among the alkaloids. In this case, as for the acids, aldehydes, amides, &c., we must have regard, not only to the properties, but to the relations of composition, mode of formation, and of propinquity, which exist between one body and those which surround it.

I divide the HYDRODIAMERAIES into two principal classes, the one comprising the *diamerides* formed by one or several acids, and the other, the *diameresides* formed by the union of non acid bodies.

I have already entered into abundance of details concerning the hydrodiamerides (*vide* page 240, Table of 64 divisions); and have nothing further to add upon the subject.

So also with regard to the *halodiamerides*, which are to the hydrodiamerides, what the chlorides are to the oxides and acids.

It remains for me to say some few words concerning the PARADIAMERIDES, which I have already divided into *polyadelphides* and *synheterides*, and which form a sort of appendix, comprising bodies that are but little known, and that will eventually be divided in a more convenient manner, and even possibly be referred to some of the preceding classes.

The polyadelphides are formed by the union of several molecules of compounds belonging to the same series, the synheterides by the union of several molecules of compounds belonging to different series.

Among the paradiamerides we shall necessarily meet with every variety of compound: hydrocarbons as stilbene; aldehydes as benzoine; acids as the benzilic; anhydroses as benzile; amides as benzilam and benzilime, &c., whence will arise fresh analogous subdivisions.

At the end of each series I shall place an appendix, containing bodies of which the nature is not well determined.

After the bodies divided by regular order and series, will come

1°. *Polyoxides*, among which will reappear mono-, and poly-basic acids, anhydrides, amides, amidic acids, &c.

2°. Certain *vegetable and animal matters*, among which we shall establish divisions analogous to the preceding.

The nomenclature of the compounds of mineral chemistry leads to some embarrassment, in the cases where these bodies enter into combination with organic substances. I was upon the point of modifying this nomenclature, so as to make it in harmony with the preceding; but I thought that it would be preferable to defer this alteration for some little time, until the confusion had still further increased, and the number of dithionic, trithionic, metaphosphoric, nitrosulphuric, sulphazic, sulphammonic, azophosphoric, biazophosphoric, &c., acids, had become much more considerable.

THE END.

PRINTED BY HARRISON AND SONS,
ST. MARTIN'S LANE.


CAVENDISH SOCIETY