

**On a difficulty in isomorphism and in the received constitution of the oxygen-salts, in a letter to Professor Mitscherlich of the University of Berlin / from Thomas Clark.**

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ON A DIFFICULTY IN ISOMORPHISM AND IN THE  
RECEIVED CONSTITUTION OF THE OXYGEN-SALTS.

A LETTER

ON A DIFFICULTY IN ISOMORPHISM AND IN THE  
RECEIVED CONSTITUTION OF THE OXYGEN-SALTS.

OF THE UNIVERSITY OF


BERLIN

1851

THOMAS CLARK, M.D.

PROFESSOR OF CHEMISTRY IN HARVARD COLLEGE

ABRIDGED



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*to D Kilgour*  
*from The Author.*

ON A DIFFICULTY IN ISOMORPHISM AND IN THE  
RECEIVED CONSTITUTION OF THE OXYGEN-SALTS,

IN

A LETTER

TO

PROFESSOR MITSCHERLICH,

OF THE UNIVERSITY OF

BERLIN,

FROM

THOMAS CLARK, M.D.,

PROFESSOR OF CHEMISTRY IN MARISCHAL COLLEGE,

ABERDEEN.



## P O S T S C R I P T.

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The Chemical Symbols made-use-of in this Letter, are essentially those of Berzelius. According to his Tables, the elements and atomic weights represented by such symbols are, as under—

Hydrogen, .....	H	6.25
Azote, .....	N	88.5
Oxygen, .....	O	100.
Magnesium, .....	Mg	158.
Cyanogen, .....	Cy	164.5
Sulphur, .....	S	201.
Iron, .....	Fe	339.
Manganese, .....	Mn	346.
Chrome, .....	Cr	352.
Potassium, .....	K	490.
Barium, .....	Ba	857.

Three other elements require special notice. Chlorine, Sodium, and Silver, in the course of this letter, have been regarded, sometimes as having atomic weights according to the standard of Berzelius, and sometimes as according to the double of that standard. The symbols of Berzelius for these three elements, I have adhered to, when regarding their atomic weights according to his Tables; but when regarding the atomic weights of those elements as doubled, I have employed other symbols, having more a reference to their English names.

Chlorine, .....	Cl	221.5	.....	Ch	443.
Sodium, .....	Na	291.	.....	So	582.
Silver, .....	Ag	1351.5	.....	Sv	2703.

In transcribing all those numbers, I have dispensed with minute decimal fractions.



*J. C.*

# TO PROFESSOR MITSCHERLICH,

OF BERLIN.

SIR,

I do myself the honour of addressing to you some observations tending to remove, in your doctrine of Isomorphism, a discrepancy arising from a fact stated in your valuable paper on the Acids of Manganese. The proposed observations have an immediate object that happens to be of the greater interest, inasmuch as they cannot accomplish that object, without going far to modify our conceptions of Oxygen-salts and Oxygen-acids.

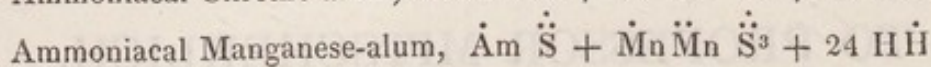
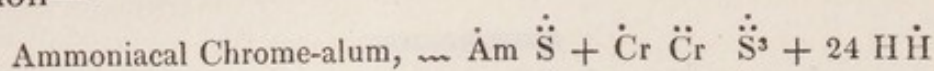
In various of your papers illustrative of Isomorphism, you have proved that Sulphur, Selenium, Chrome, and Manganese, have the power of replacing each other, in compounds, without affecting the resulting form, and that Silver, in certain compounds, is replaced, in like manner, by Sodium. The evidence that these conclusions rest upon, cannot be better shown to be stable, than by putting it in array. The salts in each of the four columns of the following table are like each other in form, but different, in that respect, from any of the salts contained in the three other columns.

	<i>of Potash.</i>	<i>of Soda (Na).</i> <i>of Silver (Ag).</i>	<i>of Soda with</i> <i>Water.</i>	<i>of Silver with</i> <i>Ammonia.</i>
<i>Sulphate</i> ~ K $\ddot{S}$	Na $\ddot{S}$	Na $\ddot{S}$ + 10 H H		Ag $\ddot{S}$ + 4 N H <sup>3</sup>
		Ag $\ddot{S}$		
<i>Seleniate</i> ~ K $\ddot{Se}$	Na $\ddot{Se}$	Na $\ddot{Se}$ + 10 H H		Ag $\ddot{Se}$ + 4 N H <sup>3</sup>
		Ag $\ddot{Se}$		
<i>Chromate</i> ~ K $\ddot{Cr}$	—	Na $\ddot{Cr}$ + 10 H H		Ag $\ddot{Cr}$ + 4 N H <sup>3</sup>
		—		
<i>Manganate</i> K $\ddot{Mn}$	—	—	—	—

In the foregoing table, the substituting power of Manganese has least of evidence to support it, in as far as this metal occurs therein, as an element, only once. But what-

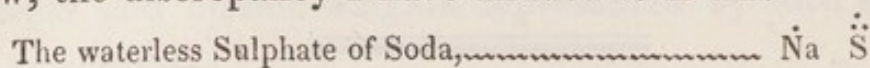


ever want of evidence may be supposed to arise hence, is well supplied in the two following salts, alike in form and constitution—



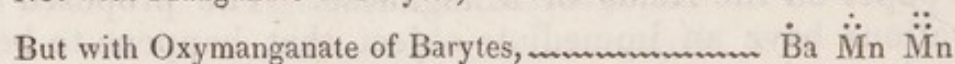
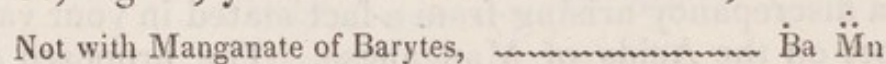
(where Am is Ammonium =  $\text{N}^3 \text{H}^3$ ).

Now, the discrepancy I have alluded to is this—



and, of course, the isomorphous salts  $\ddot{\text{Ag}} \ddot{\text{S}}$ ,

$\ddot{\text{Na}} \ddot{\text{Se}}$ ,  $\ddot{\text{Ag}} \ddot{\text{Se}}$ , you found to be of like form,



This discrepancy, which, occurring *in such a case*, appeared to me very startling on the first perusal of your paper, I propose to show, may be removed, by regarding the salts in question, as we may reasonably do, notwithstanding our preconceived notions to the contrary, to be as much alike in constitution, as you have proved them to be in form.

That you may the better judge of the ground I proceed on in offering such a suggestion, I may advert previously to a change, similar, in its reasons, to the one I am going to suggest—a change, however, which the notions of Chemistry prevalent on the Continent do not admit or call for, but which your paper is calculated to bring about in regard to one point of doctrine, on which the British Chemists differ from the Continental. While, by both, the atoms of Oxygen, Potassium, Sulphur, and Manganese, are held at proportional weights, the atom of Chlorine is held by us at double the weight it is held by you. Between these two views of the atomic weight of Chlorine, the choice, I apprehend, must be decided by your discovery, that the Oxymanganate of Potash corresponds in form with the Oxychlorate. Representing these compounds in their *ultimate* components, we have, according to

Your view and ours,  $\sim \text{K} + 8 \text{ O} + 2 \text{ Mn}$  Oxymanganate of Potash.

Yours,  $\sim \text{K} + 8 \text{ O} + 2 \text{ Cl}$  } Oxychlorate of Potash.

Ours,  $\sim \text{K} + 8 \text{ O} + \text{ Ch}$  }

(Ch, representing our atomic weight of Chlorine, being double

Cl, representing your weight of the same atom).



Your doctrine of Isomorphism—that is, THE FACT ascertained in other instances, that, in compounds different in some of their components, but agreeing in the number of the atoms of those components, the resulting form is often the same—this doctrine comes in between those two views, as a witness on behalf of Nature, to enable us to decide which is true. The doctrine itself, indeed, I am well aware, is little heeded by some Chemists, who seem therein swayed chiefly by a certain indolence that hinders them from letting their attention dwell on difficulties, existing, no doubt, and to be looked-for, in the early history of a discovery so pregnant with consequences. But there is a quality of isomorphous bodies that should arrest the attention of any Chemist, however devoted to the details and practice of Chemistry, and however averse to speculation. It is not, that compounds differing in their components, but alike in constitution and form, approach each other so near in properties, as the Phosphates and the Arseniates, or as the various individual Alums are found to do, discordant as at least some of such compounds manifestly are in the character of their ultimate components; but it is, that compounds, when alike in constitution and form, although different in elements, have, as was first established many years ago by Beaudant and Wollaston, the property of crystallizing together *in proportions that are indefinite*, yet in such a manner as to produce crystals, perfect in their form, and as clear throughout their mass as if they were pure and unmixed, and with so little disturbance to the harmony of the mixed compounds, as, whenever they happen to be of different colours, so to blend these as to produce tints, corresponding in depth to the proportions of the various coloured compounds that make up the crystalline mixture. Strange it is, to find slighted in importance, the triumphant doctrine that, in achieving this discovery, overthrew the last obstacle to the establishment of Definite Proportions, and laid open to the Chemist the mystery of the Mineral Kingdom.

While abiding by this your doctrine, and proceeding on a like principle to what has just now been illustrated in the case of the Oxymanganate and the Oxychlorate of Potash, it is possible, I conceive, to remove that unlikeness of constitution, so apparent in the two following salts of like form—

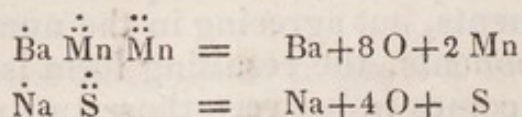
The Oxymanganate of Barytes, ..... Ba  $\ddot{\text{Mn}}$   $\ddot{\text{Mn}}$

The waterless Sulphate of Soda, ..... Na  $\ddot{\text{S}}$

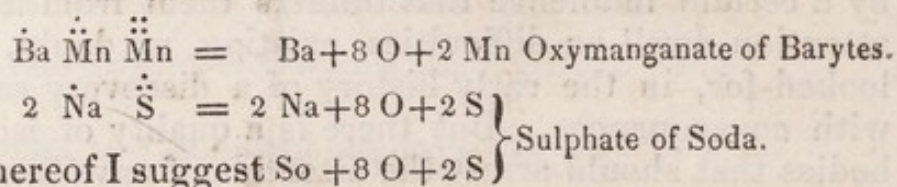
These two salts, we may better compare, unswayed by any



theory, by regarding them in their ultimate components, thus—



But, as Manganese is isomorphous with Sulphur, we can, better still, compare the two salts by taking the ultimate components of two atoms of Sulphate of Soda, thus—



Instead whereof I suggest  $\text{So} + 8 \text{ O} + 2 \text{ S}$

(where So stands for the atom of Sodium, being, in weight, double the received atom, which is represented by Na).

Comparing together, as here we do, so much of each of the salts as contains eight atoms of Oxygen, we find two atoms of Manganese substituted, without affecting the form of the compound, by two atoms of Sulphur. This is a like substitution to what you have shown takes place in the Manganate and the Sulphate of Potash. Manganese and Barium, in the proportion here assumed to be that of atom for atom, may be regarded as possessing a like power of substitution, since, taken in that proportion, and in succession, Manganese, Iron, Calcium, Barium, have been found to replace each other in compounds, without causing an alteration in form. Therefore we are sure that, in the Oxymanganate of Barytes, the Manganese is to the Barium in the proportion of two atoms to one. Again, the relation of the atoms of Sodium and Silver, in the proportional weights generally assigned to these metals, may be regarded as demonstrated by your discovery, that, in compounds, these metals, in such proportions, may replace each other, without any change in the form. But I am aware of no sufficient proof, heretofore adduced, establishing the relation of Sodium or Silver, in respect of atomic weight, to Manganese, to Sulphur, to Oxygen, or to Barium, in such a way at least as to forbid our either doubling or halving the received atomic weights of Sodium and Silver. Thus, in the Oxymanganate of Barytes and the Sulphate of Soda, while regarding the atomic weight of Manganese as fixed, we cannot doubt that the atomic weight of Barium should neither be halved nor doubled, but we are quite at liberty to enquire, Whether the atomic weight of Sodium should be halved or doubled? So that, in regard to these two salts—



*First*, We find, in the one, two atoms of Manganese, in the other, two atoms of Sulphur—bodies proved to be isomorphous.

*Second*, We find eight atoms of Oxygen in each.

*Third*, Therefore, the question to be resolved shrinks into this one point—In two salts of a similar form, and otherwise composed alike, are we to regard Barium, which is in the proportion of *one* atom, as being substituted by Sodium, in the proportion of *one* atom, or in the proportion of *two* atoms?

Now, if—as I think, justly—we regard

The Oxymanganate of Potash, as containing.....	K + 8 O + 2 Mn
And the Oxychlorate, as containing .....	K + 8 O + 2 Cl
And not (assuming 2 Cl = Ch).....	K + 8 O + Ch

How can we hesitate in considering

The Oxymanganate of Barytes, as containing .....	Ba + 8 O + 2 Mn
And the waterless Sulphate of Soda, as containing .....	So + 8 O + 2 S
And not .....	2 Na + 8 O + 2 S ?

Without renouncing, or, at least, disregarding the known analogies of Chemistry, I own I do not perceive how to evade the conclusion, that Sodium and Silver should each have its atomic weight doubled, and that the Oxymanganate of Barytes is, not only similar in form, but analogous in composition, to the waterless Sulphate of Soda, and, of course, to the waterless Seleniate of Soda, and to the Sulphate and the Seleniate of Silver.

But, even in two salts of a like form, we cannot regard analogy as fulfilled, merely by their containing in each a like number of corresponding ultimate components, partly of the same kind, and the rest isomorphous. Those ultimate components may form intermediate compounds, which, and not elementary bodies that are mere ultimate components, may be the real constituents of the salts. Besides, in isomorphous compounds, we should look, not so much for analogy of composition, as for analogy of constitution. When scrutinized for this purpose, the salts in question present a difficulty that Chemists can overcome, as far as I can see, only by taking up a position, less repugnant to reason, than it may be to their habits of thinking.

Every Chemist is aware, that the prevailing opinions respecting the constitution of Oxygen-salts—that Sulphate of



Soda, for instance, consists of Sulphuric acid and Soda—were adopted long before the elements of such salts were known to the extent that they now are. We are old enough to remember how much the ideas of Chemists were staggered at the discovery of the metals Potassium and Sodium, especially when it was found that common salt, while it could readily be proved to contain Sodium, could not, by any device of ingenuity, or industry of investigation, be proved to contain Soda. However much habit may since have worn off surprise, the published researches of the ablest Chemists of the time, evince, that the discovery of those metals was conceived to be little consistent with what were then, and what with many still are, the received notions respecting Ammonia and the Ammoniacal Salts. The extravagant assumption of a combination so improbable, ideal, and untangible, as what was called The Hydrochlorate of Soda, was but a proof, that Chemistry had, on a sudden, outgrown the old garment of theory that had once afforded to the whole body of its facts a fit and ample covering, but which was now so inadequate that it could not be drawn over the nakedness of any one part, without making bare some other.

Subsequent researches, belonging more definitely to our own time, seem to have had more effect in unsettling former doctrines respecting the salts, than in establishing any new doctrine. But the opinions entertained by Chemists respecting the constitution of Oxygen-salts appear to be chiefly two. In the instance of Sulphate of Soda, one of these opinions regards the basis as the alkali Soda ( $\text{Na} \ddot{\text{S}}$ ), the other as the metal Sodium ( $\text{Na} \ddot{\text{S}}$ ). When the basis of the salt is conceived to be Soda, Oil of Vitriol must be regarded as a compound of Sulphuric Acid and Water ( $\text{H}\ddot{\text{H}} \ddot{\text{S}}$ ); but when the basis of the salt is conceived to be Sodium, the same liquid must be regarded as a hydrogen acid ( $\text{H}^2 \ddot{\text{S}}$ ). Whatever uncertainty there may be as to which of these views is to be preferred, none exists, in my mind, as to the constitution of the Ammoniacal salts, so far at least as regards the portion of them that corresponds with Potassium in the analogous compounds containing this metal; for, that Potassium is, in every such compound, substituted by Ammonium ( $\text{N}^2 \text{H}^8$ ), I hold to be a point as well established as any within the range of ascertained Chemistry. Quite consistent with such a view of the Ammoniacal salts, however, is either of the forementioned opinions respecting the Oxygen-salts. The recommendation of simplicity and analogy belongs



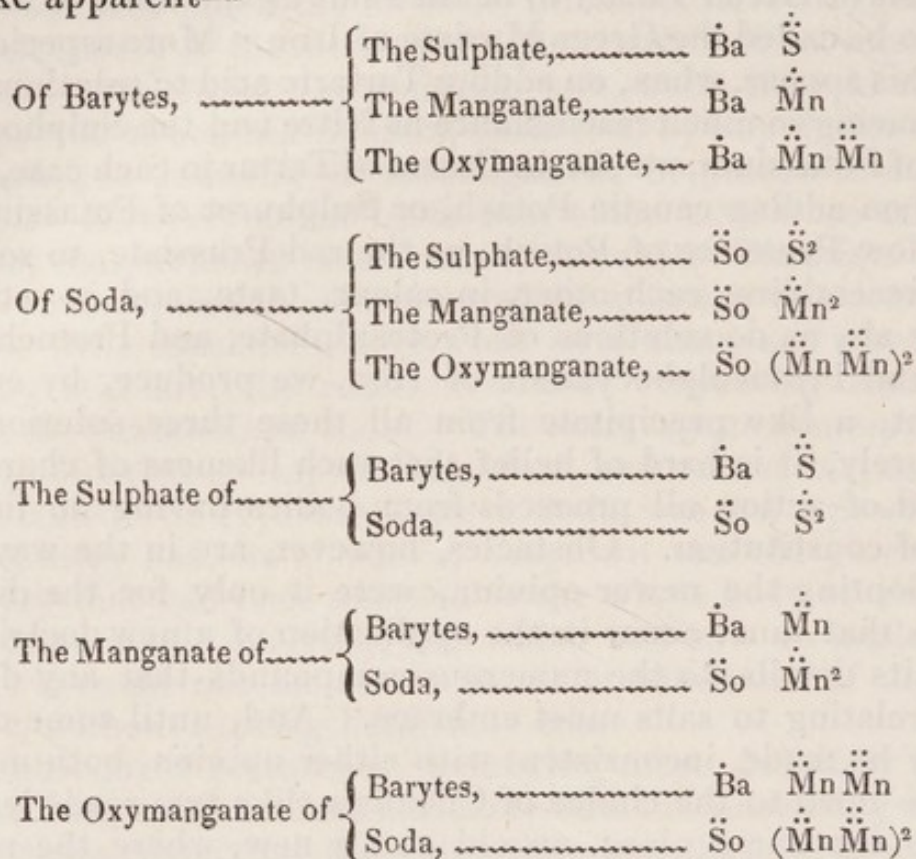
to the newer opinion, which regards the basis of Glauber's salt to be the same as that of Common salt—the basis of Nitre to be the same as that of Sulphocyanide of Potassium—the basis of Green Vitriol to be the same as the basis of what used to be called the Green Muriate of Iron. More especially does this appear, when, on adding Tartaric acid to solutions of salts having so much resemblance as Nitre and the Sulphocyanide of Potassium, we obtain Cream of Tartar in each case, or, when, on adding caustic Potash, or Sulphuret of Potassium, or yellow Prussiate of Potash, or the red Prussiate, to solutions resembling each other, in colour, taste, and in action on the air, as do solutions of Protosulphate, and Protochloride, and Protosulphocyanide of Iron, we produce, by each reagent, a like precipitate from all these three solutions; for, surely, it is hard of belief that such likeness of character and of action all proceeds from bodies having no likeness of constitution. Obstacles, however, are in the way of our adopting the newer opinion, were it only for the difficulties that must occur in the application of a new doctrine, in all its details, to the numerous compounds that any doctrine relating to salts must embrace. And, until some discovery be made, inconsistent with either opinion, both must remain open to the choice of Chemists, like two roads leading to the same place, an old and a new, where the new way, although the straighter and the more level, is yet avoided by the concourse of travellers, as happening to be the rougher, and less agreeable and easy, from the single circumstance of its being new.

These things I recall on the present occasion, conceiving that, if the suggestion be well founded, that Oxymanganate of Barytes is analogous in constitution to the Sulphate of Silver and to the waterless Sulphate of Soda—wherein is implied that the received atomic weights of Sodium and Silver must be doubled—then, a point is established inconsistent with the older opinion respecting the constitution of the Oxygen-salts and Oxygen-acids; so that, precluded from that opinion, Chemists, in reference to the newer opinion, may be in the situation of travellers, who, finding an old road shut-up, are compelled to proceed on the new-made road that lies before them, consoling themselves, as they go, by considering, how soon usage will give it smoothness.

The suggested analogy between the Oxymanganate of Barytes and the two Sulphates already named, is, in part, consistent with the usual conception of Oxygen-salts and Oxygen-acids, and, in part, inconsistent. So long as we only compare the salts of Soda among themselves, or the salts of

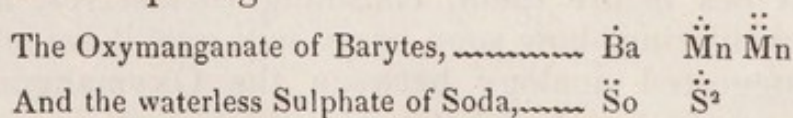


Barytes among themselves, or even when we compare such of the salts of Barytes and of Soda as are produced from the same acid, no discrepancy arises, as the following formulas will make apparent—



Here, in consequence of the atomic weight of Sodium being doubled, Soda becomes a Binoxide ( $\ddot{\text{So}}$ ), corresponding with the Peroxide of Tin ( $\ddot{\text{Sn}}$ ), while Barytes remains a Protoxide ( $\dot{\text{Ba}}$ ), corresponding with the Protoxide of Tin ( $\dot{\text{Sn}}$ ). Accordingly, the differences of constitution that appear in the foregoing formulas, between, on the one side, the Sulphate, and the Manganate, and the Oxymanganate of Barytes, and, on the other, the salts of Soda formed from the same acids, are precisely such as would occur between the proto and per-salts that these acids would respectively produce, when combining with the Protoxide and the Peroxide of Tin. Thus far, then, of discrepancy, there is none.

But, on comparing



discrepancy appears; for here we are presented with two salts, alike in form and in the number of their ultimate com-



ponents, but having these components combined together so as to form intermediate compounds quite unlike in constitution. The base of the first salt contains *one* atom of oxygen—the base of the second, *two* atoms of oxygen; the acid of the first contains *seven* atoms of oxygen—the acid of the second, *six* atoms of oxygen. One of two alternatives, therefore, is forced on our adoption. Either, retaining the foregoing formula for Sulphate of Soda, we must assimilate thereto the one for Oxymanganate of Barytes, or, retaining the formula for Oxymanganate of Barytes, we must assimilate thereto the one for Sulphate of Soda. Now, can we adopt either alternative? You shall judge, after considering the following attempt—

I.—Retaining the formula for the Sulphate of Soda, and adopting a corresponding one for the Oxymanganate of Barytes, we must likewise alter the formula for Oxymanganate of Soda; but the other formulas do not need to be altered. When thus modified, the list of the Salts already given will stand, as follows—

Sulphate of Barytes, .....	Ba	$\ddot{S}$
Manganate of Barytes, .....	Ba	$\ddot{Mn}$
Oxymanganate of Barytes, .....	Ba	$\ddot{Mn}^2$
SULPHATE OF SODA, .....	So	$\ddot{S}^2$
Manganate of Soda, .....	So	$\ddot{Mn}^2$
Oxymanganate of Soda, .....	So	$\ddot{Mn}^4$

The constitutions here assigned to the several salts imply, among others, the three following suppositions.

1. The basis of the Barytic Oxymanganate contains, not Barytes, but the Peroxide of Barium, which has not in any other instance been ascertained to constitute the basis of a salt.

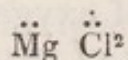
2. The basis of the alkaline Oxymanganate is not Soda, nor Peroxide of Sodium, but an unknown Oxide of Sodium, with a third more Oxygen than the Peroxide, and, atom for atom, a third more than even the acid with which it is combined.

3. The Acid in each Oxymanganate, is not Oxymanganic acid, but the Manganic.

In the instance of the Oxymanganate of Barytes, the extravagance of such suppositions is a little mitigated, by our knowledge, that Manganic acid is readily convertible into the Oxymanganic, and that Peroxide of Barium is an obtainable compound, although not ascertained to be the basis of any

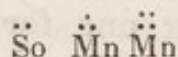


salt. But analogy would extend like assumptions to cases where no such circumstances of mitigation would exist. For example, the Oxychlorate of Magnesia, whose formula would become



would present us with a basis that is not Magnesia, but an unknown Oxide of Magnesium, and an Acid that is not the Oxychloric, nor even the Chloric, but some other, not known, nor named.

In the instance of the Oxymanganate of Soda, it might, perhaps, be thought that part of the difficulties that have been enumerated might be avoided by allowing its formula to remain unaltered—



But, indeed, the difficulties would not thus be made fewer—they would be merely of a different character. By retaining this formula for the Oxymanganate of Soda, we would be involved in the inconsistency of admitting the Barytic Oxymanganate to contain the same acid as is in the Manganate either of Barytes or of Soda, while we assume that the Alkaline Oxymanganate contains a different acid.

II.—Adopting the alternative of retaining the received views of the constitution of the Oxymanganate of Barytes, and assimilating thereto our views of the constitution of the Sulphate of Soda, consistency compels us to adopt the following formulas—

Sulphate of Barytes, .....	$\ddot{\text{Ba}} \ddot{\text{S}}$
Manganate of Barytes, .....	$\ddot{\text{Ba}} \ddot{\text{Mn}}$
OXYMANGANATE OF BARYTES, .....	$\ddot{\text{Ba}} \ddot{\text{Mn}} \ddot{\text{Mn}}$
Sulphate of Soda, .....	$\ddot{\text{So}} \ddot{\text{S}} \ddot{\text{S}}$
Manganate of Soda, .....	$\ddot{\text{So}} \ddot{\text{Mn}} \ddot{\text{Mn}}$
Oxymanganate of Soda, .....	$\ddot{\text{So}} \ddot{\text{Mn}} \ddot{\text{Mn}}^3$

In this list, the alterations on the formulas are limited to the salts of Soda. Those alterations have given rise to the following difficulties—

1. The basis of all the Oxygen-salts of Soda is assumed to be an unknown Oxide of Sodium, retaining half as much Oxygen as is in Soda.

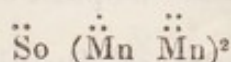
2. The Sulphate of Soda is assumed to contain, not Sulphuric acid, but another undiscovered acid, having in com-



bination additional oxygen, and, by a like assumption, Manganate of Soda contains, not Manganic acid, but the Oxymanganic.

3. The Oxymanganate of Soda is assumed to contain, not Oxymanganic acid, but another acid, composed of Manganese 4 atoms, and Oxygen 15 atoms.

Here, again, it may be supposed that material difficulties may be avoided by retaining without alteration the first formula for the Oxymanganate of Soda—



But this would involve us in the new inconsistency of assuming the Soda-Manganate to have, as a constituent, the same acid as the Oxymanganate either of Soda or of Barytes, while we admit that the Barytic Manganate is constituted by a different acid.

I do not know whether you, or other Chemists, may see any way of reconciling with the constitution commonly assigned to the Oxygen-salts, the notion that Sulphate of Soda and Oxymanganate of Barytes are analogous in constitution. I profess I can see none. The difficulties already pointed out, as consequences of admitting that analogy, have occurred while our attention was limited to those two, and four or five other, salts; but how would such difficulties be multiplied and aggravated, were we resolutely to trace the consequences of that admission, throughout all the wide and varied field of chemical combination? Wherefore, all idea of analogy of constitution between the two salts in question, I would renounce as chimerical, did I not believe that such analogy is quite reconcilable with the constitution of Oxygen-salts and Oxygen-acids, according to the other and better view. I say *better view*, and I will give reasons; but, wishing to be brief, I will confine my observations to what may be called internal evidence, arising from a consideration of the constitution of the Oxygen-salts, according to both views, as modified by the known results of analysis.

$\Delta$  being employed to represent an atom of any metal that may be conceived to be in the basis of any Oxygen-salt, the following formulas will exemplify the constitution of Sulphates, assumed to contain bases oxidized in different degrees, according to the view commonly taken of such salts—



*Instances.*

- I.  $\Delta \dot{\text{S}}$  { Protosulphate of Tin—of Iron—of Manganese.  
Persulphate of Mercury—of Copper.
- II.  $\Delta \dot{\text{S}}$  Protosulphate of Mercury—of Copper.
- III.  $\ddot{\text{S}}^2$  Persulphate of Tin.
- IV.  $\Delta \ddot{\text{S}}^3$  { Persulphate of Iron—corresponding Sulphate of  
Manganese—Sulphate of Alumina— of Chrome.

These four descriptions of Sulphates contain each one atom of oxide. The first and second contain each one atom of acid ; but—what demands most attention—the third contains *two* atoms of acid, and the fourth, *three* atoms of acid. But, admitting that each of these four descriptions of Sulphates contains one atom of oxide, and that the first and second contain each one atom of acid, analogy would lead us to expect that the third and fourth sorts would also contain one atom of acid in each. Sulphurous acid, on being farther oxidized, so as to become Sulphuric acid, does not, in consequence of having acquired more Oxygen, combine with more Potash, in order to form a neutral salt, and, indeed, Hyposulphuric acid, which is undoubtedly more oxidized than the Sulphurous, combines, for the same Sulphur, with only half as much Potash. Chemists, guided, as they may conceive, only by the result of analysis, may, it is true, choose to regard, as a rule of combination, that any oxide, the basis of a salt, requires, for neutralization, as many atoms of acid, as itself contains of atoms of Oxygen. But we are too apt to regard, as the result of analysis, what is merely our own arbitrary expression of that result. The objection to our admitting, as a law of Nature, that oxides combine with acids according to such a rule, lies in this—that not only does such a rule imply that oxides, in their combinations, observe a law different from what bodies not oxides observe, but it implies that one class of oxides observe a rule of combination, different from another class of oxides. This will at once appear on considering the following Table, where  $\Delta$  and  $x$  stand for any two oxidizable metals, and where the combination of the oxides of each metal is represented as taking place, reciprocally in the same number of atoms of each oxide as the other combining oxide contains of atoms



of Oxygen. The Table gives first the compound of the two protoxides ( $\dot{\Delta} \dot{X}$ ).

	$\dot{X}$	$\ddot{X}$	$\dot{X} \ddot{X}$	$\ddot{X}$
$\dot{\Delta}$	$\dot{\Delta} \dot{X}$	$\dot{\Delta}^2 \ddot{X}$	$\dot{\Delta}^3 \dot{X} \ddot{X}$	$\dot{\Delta}^3 \ddot{X}$
$\ddot{\Delta}$	$\ddot{\Delta} \dot{X}^2$	$\ddot{\Delta} \ddot{X}$	$\ddot{\Delta}^3 (\ddot{X} \dot{X})^2$	$\ddot{\Delta}^3 \ddot{X}^2$
$\dot{\Delta} \ddot{\Delta}$	$\dot{\Delta} \ddot{\Delta} \dot{X}^3$	$(\dot{\Delta} \ddot{\Delta})^2 \ddot{X}^3$	$\dot{\Delta} \ddot{\Delta} \dot{X} \ddot{X}$	$\dot{\Delta} \ddot{\Delta} \ddot{X}$

A little study of the structure of this table, and consideration of its contents, will evince, that, consistently with the rule according to which it is framed, any two oxides, in combining together so as to form neutral compounds—which may be supposed the simplest sort of combination that can take place between two oxides—ought to combine *in such proportions only that each oxide would contain an equal quantity of Oxygen*. How remote this is from the fact, it were superfluous to say. Impossible, therefore, to be general in its application, the supposed rule can only be regarded as partial. But partiality is unlike a law of Nature, and indeed the partiality disappears whenever we regard the Oxygen-salts as having metals, and not oxides, for their bases. The general formulas of the neutral Sulphates are then transformed, as follows—

$$\dot{\Delta} \dot{S} = \dot{\Delta} \ddot{S}$$

$$\dot{\Delta} \dot{\Delta} \dot{S} = \dot{\Delta}^2 \ddot{S}$$

$$\ddot{\Delta} \dot{S}^2 = \dot{\Delta} \ddot{S}^2$$

$$\dot{\Delta} \ddot{\Delta} \dot{S}^3 = \dot{\Delta}^2 \ddot{S}^3$$

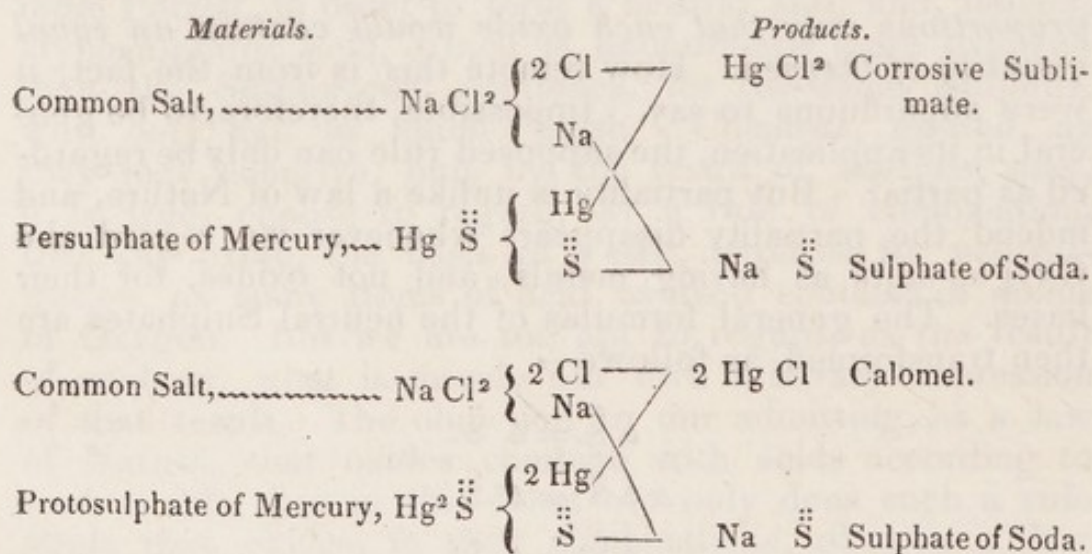
When taking this altered view of the Sulphates, a striking fact is brought into light. So much of the Oxygen as the common view regards as belonging to  $\dot{\Delta}$ , always, in neutral salts, occurs exactly in the supplementary proportion neces-

sary to make up the acid-radical,  $\ddot{S}$ . Hence, according to the new view, the anomaly of one class of oxides combining according to a rule different from other oxides, and from other bodies, disappears; for, according to this view, when



Oil of Vitriol, regarded as a Hydrogen-acid ( $\text{H}^2 \ddot{\text{S}}$ ), acts on an oxide, it is not a simple combination that takes place, but a double decomposition, resulting in a neutral salt and water, precisely as takes place when Hydrochloric acid acts on oxides. While, therefore, on regarding Oxygen-salts as having metals for their bases instead of oxides, the anomalous aspect of such of them as are formed from oxides of high degrees of oxidation disappears, we do not need, in taking this view, to seek any new supposition to stand upon. Nor can it escape your observation, that, regarded in this view, all the oxygen is in a state of unity; whereas the former view presented it broken asunder, like a sphere, into two irregular parts, which, when examined apart, seemed neither of them thoroughly symmetrical, but which, being joined again, conceal all that before appeared irregular, attesting at once the violence that had rent them asunder, and the unity of the artist's design.

Such unity of all the Oxygen in any neutral salt, is remarkably confirmed by the action of the two Sulphates of Mercury on common Salt, in producing, by sublimation, Corrosive Sublimate and Calomel. The following diagrams indicate the actions—



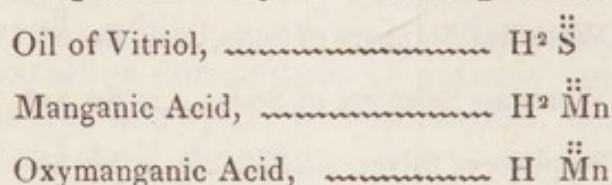
These undeniable actions appear to me to demand evidence, such as never yet has been adduced, in proof of the usual explanation that, in undergoing mutual decomposition by another neutral salt, every neutral Sulphate divides its own Oxygen so as to leave, with the metal it contained, one-fourth, while transferring, to the new Sulphate produced, the remaining three-fourths.

To avoid becoming unseasonably tedious by insisting on such details, I shall draw them to a close, trusting that enough has been stated to establish, that no Chemist is



obliged to reject any view, otherwise well founded, merely because that view is inconsistent with the doctrine of Oxygen-salts having oxides for their bases, provided he perceive that the view in question is not inconsistent with the doctrine of Oxygen-salts having metals for their bases. Accordingly, I proceed to show that the suggested analogy of Oxymanganate of Barytes and the waterless Sulphate of Soda, although inconsistent with the former doctrine, is quite consistent with the latter.

Regarded as Hydrogen-acids, the acids of the Salts we have been more particularly considering would be

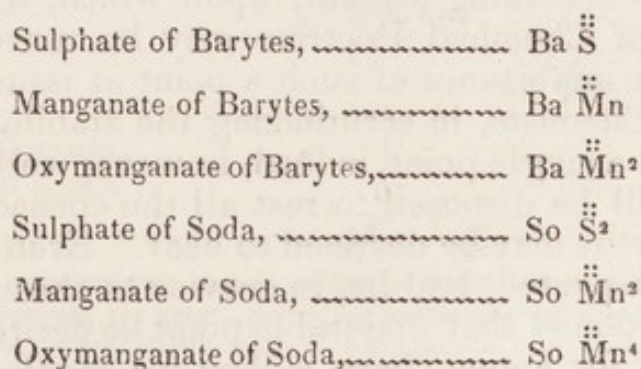


I am not sure that Chemists have taken much notice of the varying proportions of Hydrogen in its acids, so far as that element replaces the metallic bases of neutral salts. But, of the following four Hydrogen acids, the Hydrogen varies, without any doubt, in the first and second, and, with much probability, in the third and fourth—

- I. Hydrochloric Acid, .....  $\text{H Cl}$
- II. Sulphuretted Hydrogen, .....  $\text{H}^2 \text{S}$
- III. Hydro-ferricyanic Acid,\* .....  $\text{H}^3 (\text{Fe Cy}^6)$
- IV. Hydro-ferrosocyanic Acid,† .....  $\text{H}^4 (\text{Fe Cy}^6)$

Sulphuretted Hydrogen, you will observe, has here, in respect of Hydrogen, the same relation to Hydrochloric acid that I have supposed Oil of Vitriol to have to Oxymanganic acid, assuming both of these to be Hydrogen acids.

Regarded as having metals for their bases, the salts themselves would be constituted, as follows—



\* Acid that forms with Potash the red Prussiate.

† Acid that forms with Potash the yellow Prussiate.



Remembering the relation of the acids, as just now explained—remembering that in the salts, constituted as this table sets forth, Barium has to Sodium the same relation as Tin, in its proto-compounds, has to Tin, in its per-compounds—I cannot, in the view here presented, perceive any difficulty requiring elucidation, nor any obstacle to forbid our admitting, as analogous in constitution, the salts that have called for all this consideration, in consequence of their being alike in form. These, represented as analogous, are, as follows—

Oxymanganate of Barytes, ~~~~~ Ba  $\ddot{\text{Mn}}^2$

Waterless Sulphate of Soda, ~~~~~ So  $\ddot{\text{S}}^2$

Waterless Seleniate of Soda, ~~~~~ So  $\ddot{\text{Se}}^2$

Sulphate of Silver, ~~~~~ Sv  $\ddot{\text{S}}^2$

Seleniate of Silver, ~~~~~ Sv  $\ddot{\text{Se}}^2$

(Silver, in all that went before, being represented by Ag, at the usual atomic weight, but here by Sv, at double that weight).

Throughout the foregoing observations, I desire to be understood, as regarding the suggested analogy of Oxymanganate of Barytes and the other salts in question, not as a main proof, nor indeed as one of the proofs, of the doctrine of Oxygen-salts having metals for their bases, but only as a refutation of the rival doctrine, that such salts have oxides for their bases.

Thus, in its consequences, threatening to shake what Chemists have been accustomed to consider as most fixed, the difficulty in Isomorphism that I have pressed upon your attention, is not, like some former difficulties, one of mere detail—rectified, perhaps, by adverting to the water of crystallization, and, when rectified, leaving unaffected all the other details, and all former views of Chemistry. Here, on the contrary, is a difficulty concerning a point, upon which, when granted, the world of Chemical Doctrine may be moved. Proportional to the importance of such a point at issue, will be the caution of Chemists, in scrutinizing the stability of the evidence. On a single point, indeed, however well established, few men will be disposed to rest all the consequences that the one at issue may be destined to bear. Even Archimedes, it may be suspected, had he, in answer to the enthusiasm of his wish, obtained that one stable point he desired, would, in the moment for action, have sighed for another. Content, therefore, with depicting to Chemists the consequences of this difficulty, I leave the issue to be determined, as it can only be, by some future instance, equally unequivocal, of coinci-



dent form and constitution in compounds of Sodium, or Silver, compared with compounds of Barium, or Strontium, or Lead, or Calcium, and, perhaps, I might add other metals. Such coincidence, in respect of constitution, will accord, it may be supposed, either with the received atoms of Sodium and Silver, or with those atoms doubled. That the coincidence shall prove according to the received atoms of those metals, is rendered little probable by the fact, that, according to that standard, many coincidences in constitution are already known, without any coincidence in form having been yet observed; whilst, according to those atoms doubled, scarce any crystalline compounds of entirely coincident constitution are as yet known.\* If observation, which must be the final arbiter, shall determine one coincidence more to accord with the doubled atoms of Sodium and Silver—then, for aught I can see, the doctrine of Oxygen-salts having oxides for their bases must at once be abandoned; but if observation shall determine any coincidence to accord with the received atoms of Sodium and Silver—then, if we admit coincidence in form, we must also admit discrepancy of constitution, for though Barium substitute these metals, in compounds, without affecting the form, it must be *in the proportion, both of atom for atom, and of one atom for two atoms*—then, too, must we seek for an explanation of all known coincidences, however striking, in form and in constitution, in the emptiness of some such phrase as “a random-concurrence in the chance-disposition of atoms”—and, then, must all the specious fabric of Isomorphism, stable though it seems, vanish—like a dream.

SIR,

I am,

Yours, with sincere esteem,

Thos. Clark.

MARISCHAL COLLEGE,  
Aberdeen, April 1, 1836.

\* Supposing that the present atomic weight of Sodium should be doubled, the following formulas would represent, according to the received constitution of Oxygen-salts, and to the *present* atomic weights, some salts of Soda and of Barytes that might prove of coincident form—

