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AN
EPITOME
OF
CHEMISTRY,
IN
THREE PARTS.

PART I,

INTENDED TO FACILITATE, TO THE STUDENT, THE ACQUISITION OF CHEMICAL KNOWLEDGE, BY MINUTE INSTRUCTIONS FOR THE PERFORMANCE OF EXPERIMENTS.

PART II,

DIRECTIONS FOR THE ANALYSIS OF MINERAL WATERS; OF EARTHS AND STONES; OF ORES OF METALS; AND OF MINERAL BODIES IN GENERAL. AND

PART III,

INSTRUCTIONS FOR APPLYING CHEMICAL TESTS AND RE-AGENTS TO VARIOUS USEFUL PURPOSES.

BY

WILLIAM HENRY.

London,
Printed for J. Johnson, No. 72, St. Paul's Church-Yard,
by
R. and W. Dean and Co., Manchester.

1801.

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PREFACE.

THE small volume, which I now offer to the public, is one of humble pretensions: yet its plan and objects appear to me sufficiently distinct, from those of every other compendium of chemistry, to authorize the addition of one more to the extensive list of elementary works. The "Chemical Pocket Book" of Mr. Parkinson, and the "Description of a Portable Chest of Chemistry," translated from the German of Gottling, and published in the year 1791, might, perhaps, from the similarities of title and size, be supposed to have precluded the necessity of this publication. A very cursory comparison, however, of Mr. Parkinson's work, with this manual, will evince that the plan and objects of the two books are totally different. To the work of Mr. Gottling, the present bears, indeed, a nearer resemblance; but the co-incidence is not such, as to supersede the utility of this epitome. The enumeration of tests for mineral waters; the instructions for applying these reagents; and the rules for detecting adulterations, are subjects common to both. But the progress of chemical knowledge, during the last ten years, has been so rapid, as to enable me to make numerous additions to the information of Mr. Gottling; and to induce me materially to vary the arrangement, under which it was offered. It may be added, that the ancient nomenclature of chemistry, employed throughout Mr. Gottling's work, must render it nearly unintelligible to students of the reformed system.

The arranged series of experiments was suggested to me as proper for publication, by a written catalogue, which I drew up, more than two years ago, of the experiments performed during my course of chemical lectures. This I deem it necessary to state; because something similar is to be found in an excellent manual, lately published by Bouillon La Grange.

Another object, which I propose to be fulfilled by this epitome, is, that it may serve as a companion to the collections of chemical substances, which I have been induced, by the repeated applications of students of this science, to fit up for public sale. The utility of these collections has, hitherto, been limited, by the want of a concise but comprehensive code of instructions for their use. With the concurrent aid of the first part of this work, and of a corresponding chest of chemical re-agents, the labours of the student cannot fail to be much facilitated: for one of the principal difficulties in studying the science, experimentally, is the acquisition of a great variety of substances; many of which are not easy of attainment. The directions for analyzing waters, and mineral bodies in general, I shall enable any one to apply practically, by corresponding collections of chemical tests, of so small a bulk, as to add, in the least possible degree, to the incumbrances of the traveller.

In a work, professedly compiled from others, new and original information is not to be expected; and it cannot be necessary to quote all the authorities for facts. If there be any one author, to whom I owe most, it is certainly to Mr. Kirwan, whose interesting and masterly works comprehend almost every subject of chemical enquiry. The directions for analyzing minerals are translated, with additions and alterations, from Vauquelin's paper, in the 30th volume of the Annales de Chimie.

I have now only to intreat the candid indulgence of the reader towards the errors and omissions which will doubtless be found in this work; and in apology for which, I have to alledge, that on undertaking the publication, I had a prospect of considerably more leisure, than fell to my lot in the prosecution of it.

Manchester, March 9th, 1801.

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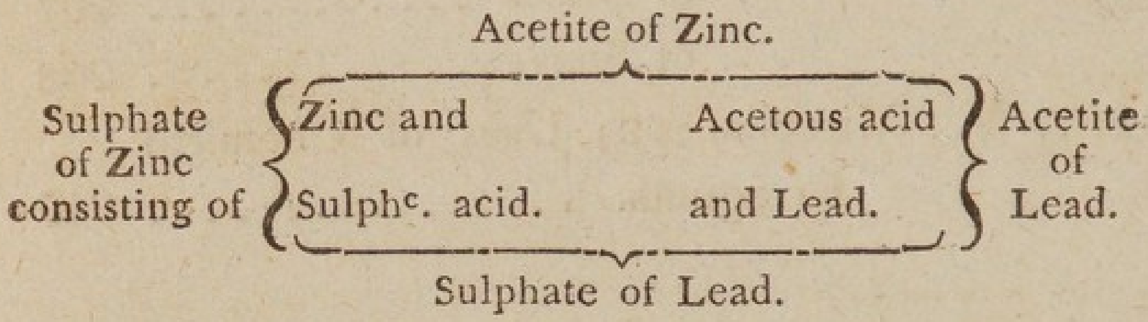
ERRATA.

THE reader is requested to correct, with a pen, the following errors of the press, some of which materially affect the sense; especially those marked with asterisks.

For the diagram, in page 7, which is scarcely intelligible, the following may be substituted:



* page 8	line	17,	*for*	102	*read*	172
23	——	23	——	steam	——	stream
		29	——	made	——	mode
25	——	20	——	expended	——	expanded
33	——	13	——	appear	——	appears
53	——	14	——	requires	——	acquires
82	——	5	——	explore	——	explode
83	——	31	*dele*	again	——	
86	——	29	*for*	carboriate	——	carbonate
90	——	8	——	earths	——	earth
92	——	last	*before.*	water	*insert*	1 oz. of
93	——	4	*for*	these	*read*	those
96	——	8	——	metals	——	metal
110	——	13	——	deposit	——	deposits
120	——	6 from bottom	——	by	——	in
* 129	——	16		does not return	——	returns
130	——	23	——	termed	——	turned
146	——	31	——	are	——	an
191	——	26	——	become	——	becoming.

LIST OF ELEMENTARY BOOKS

on

CHEMISTRY.

THE following list comprehends a selection of a few elementary works on Chemistry, which are sufficient for the purpose of the general reader. To have offered such a catalogue, as would compose a complete chemical library, would have occupied too much room; and perhaps would not have been of much utility.

1. Lavoisier's Elements of Chemistry, 8vo.
2. ——— Works, from the French, by Henry, 1 vol. 8vo. and a pamphlet.
3. Chaptal's Elements of Chemistry, 3 vols. 8vo.
4. Nicholson's First Principles of Chemistry, 8vo.
5. ——— Chemical Dictionary, 2 vols. 4to.
6. Thomson's Translation of Fourcroy's Chemistry, 3 vols. 8vo.
7. Gren's Principles of Chemistry, 2 vols. 8vo.
8. La Grange's Manual of Chemistry, 2 vols. 8vo.
9. Pearson's Chemical Nomenclature, 2d edition, 4to.
10. Parkinson's Chemical Pocket Book.
11. Nicholson's Philosophical Journal, published monthly.
12. Philosophical Magazine, published monthly.

To the above may be added a large work, lately published, in France, by M. Fourcroy; and which Mr. Nicholson is now translating. It wll be entitled "A System of Chemical Knowledge," and will extend to several 8vo. volumes.

OF J. JOHNSON,

No. 72,

ST. PAUL'S CHURCH-YARD, LONDON

may be had,

A general View of the Nature and Objects of Chemistry, and of its Application to Arts, and Manufactures, by WILLIAM HENRY, 8vo. 1s. 6d.

And the following Works

By Thomas Henry, F. R. S. &c.

1. An Account of a Method of preserving Water at Sea, 8vo. pamphlet.

2. Experiments and Observations on the following subjects:

1. On the preparation, calcination, and medicinal use of Magnesia.
2. On the solvent qualities of calcined Magnesia.
3. On the variety in the solvent powers of quicklime, when used in different quantities.
4. On various absorbents as promoting or retarding putrefaction.
5. On the comparative antiseptic powers of vegetable infusions prepared with lime, &c.
6. On the sweetening properties of fixed air.

8vo. price 2s. 6d.

3. Essays Physical and Chemical, by M. Lavoisier, translated from the French, 8vo. 7s.

4. Essays on the Effects, produced by various Processes, on Atmospheric Air, with a particular

View to an Investigation of the Constitution of Acids, translated from the French of Lavoisier, 8vo. 2s. 6d.

N. B. The two foregoing works afford an historical view of the progress of pneumatic chemistry; and a full and very interesting devellopment of those accurate and admirably conceived experiments of M. Lavoisier, which serve as the basis of the reformed system of chemical science.

5. Memoirs of Albert de Haller, 12mo. 3s.

A

CONCISE EPITOME

OF

CHEMISTRY.

PART I.—SECTION I.

ADVICE TO PERSONS WHO ARE ENTERING ON THE STUDY OF CHEMISTRY.

THE few suggestions, which I am about to offer, are addressed peculiarly to those, who have not the opportunity of attending chemical lectures; and who have no other means of acquiring a knowledge of chemistry, except from books, and from the evidence of experiments.

The principal difficulty, experienced by all, who embark in a scientific pursuit, unaided by the advice of an instructor, is the attainment of the best adapted books. In Chemistry, fortunately, this difficulty is limited to selection only: For we have, in the English language, many elementary works, both original and translated, of great merit. I shall, at present, however, confine myself to the mention of very few; of such only, as are sufficient to convey, to a person of tolerable understanding and competent education, a general acquaintance with chemical science; and I shall afterwards subjoin a list of other books, necessary to those, who intend to pursue the study more extensively.

Of all the introductory treatises on Chemistry, that of Mr. Lavoisier is certainly the one, from which a person, entering, for the first time, on this study, will derive most pleasure and advantage. The first part of this work, comprehending the more general doctrines of Chemistry, should be perused with attention, and clearly understood, before the reader proceeds any further. It may, even, be necessary, that, previously to the remainder of this work, he should study other elementary books, such as those of Chaptal, Fourcroy, and Nicholson. These works will supply the deficiencies of Lavoisier's Elements, especially on the subject of chemical affinity, the divisions and laws of which are essential to be known, as the ground-work of all chemical explanations. After having made himself master of the more general truths of Chemistry, as delivered in the first part of Lavoisier's and in the first volume of Chaptal's Elements, and also of the principles of the new nomenclature, the student will be qualified to reap advantage from the performance of experiments. In repeating these, he may either follow the order which I shall presently point out; or he may assume, as the basis of his arrangement, the general propositions laid down by Chaptal or Fourcroy; referring to the following section, for more minute and specific directions.

In the conducting of experiments, I would recommend great attention to neatness and to order. Let every jar or vial have a label fixed to it, denoting the substances it may contain, (except in cases, where the nature of the contents is evident from mere inspection) and the date and object of the experiment. I would caution the student, not to engage in many different experiments at once; the consequences of which are, that the attention is distracted, and that many interesting changes pass unnoticed. It will contribute to form a habit of accurate observation, if the appearances, that occur in experiments, be regularly and distinctly noted down; and such an exercise will tend, also, to facilitate the acquirement of the art of describing chemical phenomena, to do which, with selection and precision, is far from being an universal talent.

In advising an attention to neatness, however, I am far from recommending a frivolous regard to show, or even too scrupulous a nicety about the appearance of apparatus. With the aid merely of florence flasks, of common vials, and of wine glasses, some of the most interesting and useful experiments may be made; and in converting these vessels to the purpose of apparatus, a considerable saving of expence will accrue to the experimentalist.

SECTION II.

AN ARRANGED SERIES OF EXPERIMENTS, WHICH SHOULD EITHER, WHOLLY OR IN PART, BE PERFORMED BY THE STUDENT OF CHEMISTRY.

IN the selection of these experiments, I shall generally choose such as may be undertaken by persons not possessed of an extensive chemical apparatus. On some occasions, however, it may be necessary, in order to complete the series, that others should be included, requiring, for their performance, instruments of considerable nicety. The same experiment may, perhaps, in a few instances, be repeatedly introduced, in illustration of different principles; but this repetition will be avoided as much as possible. Each experiment will be preceded by a brief enunciation of the general truth, which it is intended to illustrate.

ART. I. CHEMICAL AFFINITY, SOLUTION, &c.

For these experiments, a few wine glasses, or in preference deep ale glasses, will be required, and a florence flask for performing the solutions.

1. *Some bodies have no affinity for each other.* Oil and water, or mercury and water, when shaken together, do not combine, the oil always rising to the surface, and the mercury sinking to the bottom.

2. *Examples of Solution.* Sugar or common salt in water; chalk in dilute muriatic acid.*

3. *Influence of mechanical division in promoting the action of chemical affinity, or in favouring solution.* Lumps of chalk or marble in dilute muriatic acid, compared with the same bodies in powder. In the common arts of life, the rasping or grinding of wood and other substances, are familiar examples.

4. *Hot liquids are more powerful solvents than cold ones.* Cold water, after having taken up as much as it can of sulphate of soda, will dissolve still more when heated; and the portion, which has been dissolved in consequence of applying heat, will separate again, in a regular form, when the liquor cools. This last appearance affords an instance of *crystallization.*

5. *A very minute division of bodies is effected by solution.* Dissolve two grains of sulphate of iron in a quart of water, and add a few drops of this solution to a wine glass full of water, into which a few drops of tincture of galls have been fallen. The dilute infusion of galls will speedily assume a purplish hue. This shews that every drop of the quart of water, in which the sulphate of iron was dissolved, contains a notable portion of the salt.

6. *Some bodies dissolve much more readily and copiously than others.* Thus an ounce measure of distilled water will dissolve one third its weight of sulphate of soda; one sixteenth of sulphate of

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* I omit, purposely, the distinction between solution and dissolution.

potash; and only one five hundredth its weight of sulphate of lime.

7. *Mechanical agitation facilitates solution.* Into a wine glass full of water, tinged blue with the infusion of litmus, let fall a small lump of solid tartarous acid. The acid, if left at rest, even during some hours, will only change to red that portion of the infusion, which is in immediate contact with it. Stir the liquor, and the whole will immediately become red.

8. *Bodies do not act on each other, unless either one or both be in a state of solution.* A. Mix some dry acid of tartar with dry carbonate of potash. No combination will ensue till water is added, which acting the part of a solvent promotes the union of the acid and alcali, as appears from the violent effervescence.

B. Spread thinly on a piece of tinfoil, three or four inches square, some dry nitrate of copper, and wrap it up. No effect will follow. Unfold the tinfoil, and having sprinkled the nitrate of copper with very little water, wrap it up again as quickly as possible, pressing down the edges closely. Considerable heat attended with fumes will now be excited; and if the experiment has been dexterously managed, even light will be evolved. This shews that nitrate of copper has no action on tin, till in a state of solution.

9. *Two bodies, having no affinity for each other, unite by the intervention of a third.* Thus, the oil and water, which, in expt. 1st, could not, by agitation, be brought into union, unite intimately on adding a little caustic potash. The alcali, in this case, acts as an intermedium.

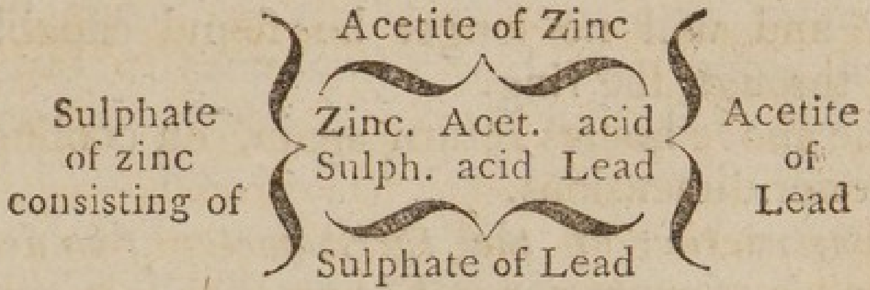
10. *Saturation illustrated.* Water, after having taken up as much common salt as it can dissolve, is said to be saturated with salt. Muriatic acid, when

it has ceased to act any longer on lime, is said to be saturated.

11. *The properties, characterizing bodies when separate, are destroyed, by chemical combination.* Thus muriatic acid and lime, which, in a separate state, have each a most corrosive taste, lose this entirely, when mutually saturated; the compound is extremely soluble, though lime itself is very difficult of solution; the acid no longer reddens vegetable blue colours; nor does the lime change them, as before, to green.

12. *Simple elective affinity illustrated.* (A) Add to the combination of oil with alcali, formed in expt. 9th, a little dilute sulphuric acid. The acid will seize the alcali, and set the oil at liberty, which will rise to the top. In this instance, the affinity of alcali for acid is greater than that of alcali for oil. (B) To a dilute solution of muriate of lime, add a little of the solution of pure potash. The potash will seize the muriatic acid, and the lime will fall down, or be *precipitated.*

13. *Double elective affinity exemplified.* In a watery solution of sulphate of zinc, immerse a thin sheet of lead. The lead will remain unaltered, as will, also, the sulphate of zinc; because zinc attracts sulphuric acid more strongly than lead. But let acetite of lead be mixed with sulphate of zinc. The lead will then go over to the sulphuric acid, while the zinc passes to the acetous. The sulphate of lead, being insoluble, will fall down in the state of a white powder; but the acetite of zinc will remain in solution. The changes, that occur in this experiment, will be better understood from the following scheme.



For an explanation of these diagrams, which the student will find it highly useful to understand, I refer to Bergman's Treatise on Elective Attractions.

ART. II. PROPERTIES AND EFFECTS OF THE MATTER OF HEAT, OR CALORIC.*

Effects of Caloric of Temperature, or Uncombined Caloric.

1. *Caloric expands all bodies.* (A) The expansion of liquids is shewn by that of the mercury of a thermometer. (B) That of aëriform bodies, by holding, near the fire, a bladder partly filled with air, the neck of which is closely tied, so as to prevent the inclosed air from escaping. The bladder will soon be fully distended, and may even be burst by continuing and increasing the heat. (C) The expansion of solids is shewn, by heating a rod of iron, of such a length as to be included, when cold, between two points, and the diameter of which is such, as to allow it to pass through an iron ring. When heated, it will have become sensibly

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* I omit giving a connected series of experiments on Light, because the effects, produced by this agent, are, generally speaking, more complicated than those of Caloric. Thus, for example, the action of light frequently depends on its property of de-oxidating bodies; and facts of this kind cannot be understood, without an acquaintance with the class of metallic oxyds. In the progress of this section, however, many instances will be given of the chemical efficiency of Light.

longer; and will no longer be found capable of passing through the ring.

All the above bodies return again, on cooling, to their former dimensions.

2. *Construction of the thermometer founded on the principle of expansion.* For an excellent account of the method of constructing thermometers, which is too long to be inserted in this place, see Nicholson's Principles of Chemistry, book 1st. chapter 3d.

3. *Equal increments or decrements of heat produce equal increments or decrements of expansion in the mercury of the thermometer.* Mix a pound of water, at 172°, with a pound at 32°. Half the excess of the uncombined Caloric, in the hot water, will pass to the colder portion; that is, the hot water will be cooled 70°, and the cold will receive 70° of temperature; therefore, 102 — 70, or 32 + 70, = 102; will give the heat of the mixture. To attain the arithmetical mean, exactly, several precautions, however, must be observed. (See Crawford on Animal Heat, p. 95, &c.)

4. *Uncombined caloric has a tendency to an equilibrium.* Any number of different bodies, at various temperatures, if placed under similar circumstances of exposure, all acquire a common temperature. Thus, if in an atmosphere at 40°, we place iron filings heated to redness; boiling water; and various other bodies of different temperatures, they will soon affect the thermometer in the same degree.

5. *Power inherent in bodies of conducting Caloric; and the conducting power various in different bodies.*

(A) Solid bodies convey heat in all directions, upwards, downwards, and laterally; as may be shewn by heating one end of an iron rod, and holding it in different directions.

(B) Some bodies conduct caloric much more quickly than others. Coat two rods, of equal length and thickness, the one of glass, the other of iron, with wax, at one end of each only; and then apply heat to the uncoated ends. The wax will be melted much sooner from the end of the iron rod, than from the glass one; which shews, that iron conducts heat more quickly than glass.

C. Liquid and aeriform bodies convey heat on a different principle, from that, observed in solids, viz. by an actual change in the situation of their particles. Take a glass tube eight or ten inches long, and about an inch in diameter. Pour into the bottom part, for about the depth of an inch, a little water tinged with litmus, and then fill up the tube with common water, pouring on the latter extremely gently, so as to keep the two strata quite distinct. When the tube is heated at the bottom, the cold infusion will ascend, and will tinge the whole mass. But if the upper part of the tube be heated, the coloured liquor will remain at the bottom. Other experiments, illustrating the same principle, may be found in Count Rumford's Essays, especially in Essay 7th. Thus a cake of ice will remain unmelted, during several hours, when confined at the bottom of a jar of hot water, which, if fixed at the surface, would be liquified in a few minutes; and water may even be kept boiling, a considerable time, in a glass tube over ice, without melting it.

5. *The boiling point differs in various liquors.* Thus Ether boils at 104°, Alcohol at 182°, and water at 212°. It varies, also, in the same liquor, under different degrees of atmospheric pressure. Thus water will boil, under the exhausted receiver of an air pump, at 180°, or even much less, of Faht. Hence the particles of Caloric are mutually repulsive, and they communicate this repulsive tendency to other bodies in which Caloric is contained. This repulsive power tends to change solids into fluids,

and liquids into aeriform bodies, and is chiefly counteracted by the pressure of the atmosphere. See some beautiful experiments illustrating this position in Lavoisier's Elements, chap. 1.

On the contrary, by considerably increasing the pressure, water may be heated to above 400°, without being changed into vapour.

6. *Uncombined Caloric promotes the action of chemical affinity.* Thus lead and tin do not combine, till melted together. In other instances, Caloric serves as the mean of separating bodies already united. Thus lead and sulphur are disunited, by exposure in a high temperature. In favouring the operation of affinity, caloric seems to act as a solvent; and in decomposing bodies, its effects are perhaps explicable on the principle of elective affinity. Thus, in the foregoing example, sulphur, in a high temperature, or when surrounded by a great quantity of uncombined caloric, is more powerfully attracted by caloric than by lead.

COMBINATIONS OF CALORIC—THE CAUSE OF FLUIDITY.

7. *The sensible heat, or temperature, of ice, not changed by liquefaction.* A thermometer in pounded ice stands at 32°, and at the very same point in the water, which results from the liquefaction of ice.

8. *Yet the ice, during liquefaction, must absorb much caloric.* Expose a pound of water at 32°, and a pound of ice at 32°, in a room, the temperature of which is uniformly the same during the experiment. The water will arrive at the temperature of the room, several hours before the ice is melted. Yet the ice must during the whole of this time be receiving Caloric, because, according to exp. 4. a hotter body can never be in contact with a colder.

one, without imparting heat to the latter. The Caloric, therefore, which has entered the ice, but is not to be found in it by the thermometer, must be chemically combined; just as muriatic acid, by union with lime, loses all its characteristic properties.

9. *The quantity of uncombined caloric that enters into a pound of ice, and becomes united, during liquefaction, may be learned by experiment.* To a pound of water, at 172°, add a pound of ice at 32°. The temperature will not be the arithmetical mean, as in expt. 6, but much below it, viz. 32°. From 102°, therefore, the arithmetical mean, take 32°; the remainder, 70°, shews the quantity of caloric, that combines with a pound of ice, during liquefaction; that is, as much caloric is absorbed by, and unites chemically with, a pound of ice, during its conversion into water, as would raise a pound of water from 32° to 102°.

9. *Other examples of the absorption of caloric, during the liquefaction of bodies,* are furnished by the mixture of snow and nitric acid; or of snow and common salt, both of which, in common language, produce intense cold.* Most neutral salts, also, during solution in water absorb much caloric, and the cold thus generated is so intense as to freeze water, and even to congeal mercury. The former experiment, however, may easily be repeated. Add to 32 drachms of water, 11 drachms of muriate of ammonia; 10 of nitrate of potash; and 16 of sulphate of soda, all finely powdered. The salts may be dissolved, separately, in the order set down. A thermometer, put into the solution will shew that the cold produced is at or below freezing; and a

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* The extraordinary powers of muriate of lime and snow, in generating cold, will be described hereafter.

little water, in a thin glass tube, being immersed in the solution, will be frozen in a few minutes. Various other freezing mixtures are described in Mr. Walker's papers in the Philosophical Transactions for 1787, 88, 89, & 95.

10. *On the contrary liquids, in becoming solid, evolve or give out caloric, or in common language, produce heat.*

(A.) Water, if kept perfectly free from agitation, may be cooled down below 32°; but on shaking, it immediately congeals, and the temperature rises to 32°.

B. To a saturated solution of sulphate of potash in water, or of any salt that is insoluble in alcohol, add an equal measure of alcohol. The alcohol, attracting the water more strongly than the salt retains it, precipitates the salt, and considerable heat is produced.

CALORIC THE CAUSE OF VAPOUR.

11. *Steam has exactly the same temperature as boiling water.* Let a tin vessel be provided, having a hole in its cover, just large enough to admit a thermometer. Fill it partly with water, and let the bulb of the thermometer be an inch or two above the surface of the water. When the water boils, the thermometer, surrounded by steam, will rise to 212°, which is precisely the temperature of the water beneath. Yet water, placed on a fire, continues to receive heat, very abundantly, even when boiling hot; and as this heat is not appreciable by the thermometer, it must be in a state of chemical union.

12. *The absorption of caloric, during evaporation, shewn by experiment.*

Moisten a thermometer with alcohol, or with ether, and expose it to the air, repeating these operations alternately. The mercury of the thermometer will sink at each exposure, because the volatile liquor, during evaporation, robs it of its heat. In this way, (especially with the aid of an apparatus, described by Mr. Cavallo in the Phil. Trans. for 1781, p. 509) water may be frozen in a thin and small glass ball, by means of ether.

13. *On the contrary, vapours during their conversion into a liquid form, evolve, or give out, much caloric.* The heat given out, by the condensation of steam, is rendered apparent by the following experiment. Mix 100 gallons of water, at 50°, with one gallon of water at 212°. The temperature of the water will be raised about 1½ degree. Condense, by a common still tub, one gallon of water from the state of steam, by the same quantity of water, at the same temperature. The water will be raised 11 degrees. Hence, eight pounds of water, condensed from steam, raise 100 gallons of cold water, 9½ degrees more than eight pounds of boiling water; and by an easy calculation, it appears, that the caloric imparted to the 100 gallons by the steam, if it could be condensed in one gallon of water, would raise it to 950°. A pound of water, therefore, in the state of steam, contains more caloric, than a pound of boiling water, in the proportion of 950 to 212.

ART. III. GASSES IN GENERAL.

For performing the necessary experiments on gasses, many articles of apparatus are essential, that cannot be included in a portable chemical chest, which may yet, however, contain the materials for procuring gasses. It may assist the student in obtaining the necessary instruments, if a few of the most essential be here enumerated. I shall mention none, however, except such as are necessary in making a few general experiments on this interesting class of bodies.

The apparatus, required for experiments on gasses, consists partly of vessels fitted for containing the materials that afford them; and partly of vessels adapted for the reception of gasses, and for submitting them to experiment.

1. For procuring such gasses, as are producible without a very strong heat, glass bottles, furnished with ground stoppers, and bent tubes, are sufficient. Of these several will be required of different sizes and shapes, adapted to different purposes. If these cannot be procured, a florence flask with a cork perforated by a bent glass tube, will serve for obtaining some of the gasses.

Those gasses, that require for their liberation a red heat, may be procured by exposing to heat the substances, capable of affording them, in earthen retorts, or tubes; or in a gun barrel, the touch hole of which has been accurately closed by an iron pin. To the mouth of the barrel must be affixed a glass tube, bent so as to convey the gasses, where-ever it may be requisite.

2. For receiving the gasses, glass jars of various sizes are required, some of which should be furnished with necks at the top, fitted with ground stoppers. These jars will, also, be found extremely useful in experiments on the properties and effects of the gasses. Some of them should be graduated into cubical inches.

To contain these jars, when in use, a vessel will be necessary, capable of holding a few gallons of water. This may either be of wood, if of considerable size; or, if small, of tin, japanned or painted. Its size may vary with that of the jars employed; and about an inch and half from the top, it should have a shelf, on which the jars may be placed, when filled with air, without the risk of their being overset.

A glass tube, about 18 inches long, and 3 quarters of an inch diameter, closed at one end, and divided into cubic inches and tenths of inches, will be required for ascertaining the purity of air. It should be accompanied, also, with a small measure, containing about two cubic inches, and similarly graduated. Besides these, the experimenter should be furnished with air funnels, for transferring gasses from wide to narrow vessels. These, and almost every other article of apparatus, necessary for experiments on gasses, may be seen figured in the plates to Dr. Priestley's Experiments on Air, in 3 vols. 8vo.; and in those subjoined to Lavoisier's Elements.

For those gasses, that are absorbed by water, a mercurial trough is necessary. For the mere exhibition of a few experiments on these condensible gasses, a small wooden trough, 11 inches long, 2 wide, and 2 deep, cut out of a solid block of mahogany, is sufficient; but for experiments of research, one of considerable size is required.

Previously to undertaking experiments on other gasses, it may be well for an unpractised experimentalist to accustom himself to the dexterous management of gasses, by transferring common air from one vessel to another of different sizes.

Of experiments illustrative of the nature of gasses in general, it may be proper to mention one or two, that shew the mode in which caloric exists in this class of bodies. In vapours, strictly so called, as the steam of water, caloric seems to be retained with but little force; for it quits the water, when the vapour is merely exposed to a lower temperature. But, in gasses, caloric is united by very forcible affinity, and no diminution of temperature, that has ever yet been effected, can separate it from some of them. Thus the air of our atmosphere, in the most intense artificial or natural cold, still remains in the aëriform state. Hence is derived the essential character of gasses, viz. that they shall remain aëriform, under all variations of pressure and temperature; and in this class, are, also, included those aërial bodies, which, being condensed by water, require confinement over mercury. The following experiment will shew that the Caloric, contained in gasses, is chemically combined.

Into a small retort, put an ounce or two of common salt, and about half its weight of sulphuric acid. By this process, a great quantity of gas is produced, which might be received and collected over mercury. But, to serve the purpose of this experiment, let it pass through a glass balloon, having two openings (as in the 4th plate of Lavoisier, fig. 1. G.), into one of which the neck of the retort passes, while, from the other, a bent tube proceeds (E of the same fig.), which ends in a vessel of water. Before closing the apparatus, let a thermometer be included in the balloon, to shew the temperature of the gas. It will be found, that the mercury, in this thermometer, will rise only a few degrees, whereas the water, in the vessel which receives the bent tube, will soon become boiling hot. In this instance, Caloric flows from the lamp to the muriatic acid, and converts it into gas; but the heat, thus expended, is not appreciable by the thermometer, and must, therefore, be chemically combined. The caloric, however, is again evolved, when the gas is condensed by water; and, in this experiment, we trace it into combination, and again into the state of uncombined caloric.

For demonstrating the influence of variations of atmospheric pressure on the formation of gasses, better experiments, cannot be devised than those of Lavoisier. See his Elements, chap. 1.

ART. IV. OXYGENOUS GAS.

1. *Oxygenous gas may be procured from various substances.*

A. From oxyd of manganese, heated to redness in a gun barrel, or earthen retort; or from the same oxyd, heated by a lamp in a retort or gas bottle, with half its weight of strong sulphuric acid.

B. From the red oxyd of lead (the common red lead used by painters) heated either with or without sulphuric acid.

C. From various other oxyds, as will be hereafter mentioned.

D. From nitrate of potash (common saltpetre) made red hot in a gun barrel, or in an earthen retort.

E. From oxygenated muriate of potash, heated in a small glass retort, coated with clay; or in an earthen retort. The oxygenous gas, thus produced, is much purer than that obtained in any other mode, especially the last portions, which should be kept separate.

This gas has the following properties:

2. *It is not absorbed, by water,* or at least is so sparingly absorbed, that when agitated in contact with water, no perceptible diminution takes place.

3. *All combustible bodies burn in oxygenous gas with greatly increased splendor.*

(A.) A lighted wax taper, fixed to an iron wire, and let down into a vessel of the gas, burns with great brilliancy. (See Lavoisier's 5th plate, fig. 8.) If the taper be blown out, and let down into a vessel of the gas, while the snuff remains red hot, it instantly rekindles, with a slight explosion.

B. A red hot bit of charcoal, fastened to an iron wire, and immersed in the gas, throws out beautiful parks.

C. The light of phosphorus, placed on a little tin cup, and burnt in this gas, is the brightest that can be in any mode produced.

D. Procure some thin harpsichord wire, and twist it round a slender rod of iron or glass, so as to coil it up in a spiral form. Then withdraw the rod, and tie a little thread round one end of the wire, for about the length of $\frac{1}{20}$ inch, which end is to be dipped into melted sulphur. The other end of the wire is to be fixed into a cork; so that the spiral may hang vertically. Fill, also, with oxygenous gas, a bottle capable of holding about a quart, and set it with its mouth upwards. Then light the sulphur, and introduce the wire into the bottle of gas, suspending it by the cork. The iron will burn with a most brilliant light, throwing out a number of sparks, which fall to the bottom of the bottle, and generally break it. This accident, however, may frequently be prevented by pouring sand into the bottle, so as to lie about half an inch deep on the bottom. (See Lavoisier's 4th plate, fig. 17.)

E. A little of Homberg's pyrophorus, a substance to be hereafter described, when poured into this gas, immediately flashes like inflamed gun-powder.

4. *During every combustion in oxygenous gas, the gas suffers a material diminution.* To exhibit this experimentally, in a manner perfectly free from all sources of error, would require such an apparatus, as few persons are likely to possess. The apparatus required, may be seen described in the 6th chapter of Lavoisier's Elements. The fact may, however, be shewn less accurately, in the following manner. Fill, with oxygenous gas, a jar of moderate size, which has a neck and ground glass stopper at the top. Then, with the assistance of a stand, formed of bent iron wire, (like that shewn in the plate to Nicholson's Chemistry, fig. 16,) place a shallow tin

vessel, containing a bit of phosphorus or sulphur, three or four inches above the level of the water of a pneumatic trough. Invert the bell of oxygenous gas, cautiously and expeditiously, over this cup, so as to confine it with its contents in the gas, and pressing down the jar to the bottom of the trough, open the stopper. A quantity of gas will immediately rush out, and the water will rise to the same level within the jar as without. When this has taken place, set fire to the sulphur or phosphorus by an iron wire, and instantly put in the stopper. The first effect of the combustion will be a depression of the water within the jar; but when the combustion has closed, and the vessel has cooled, a considerable absorption will be found to have ensued.

5. *All bodies, by combustion in oxygenous gas, acquire an addition to their weight; and the increase is in proportion to the quantity of gas absorbed.* To prove this by experiment, requires, also, a complicated apparatus; and the reader, who cannot possess himself of this, must remain satisfied with the account given by Lavoisier of his experiments, establishing the principle, in chapter 5th of his Elements.

6. *Oxygenous gas supports, eminently, animal life.* It will be found that a mouse, bird, or other small animal, will live six times longer in a vessel of oxygenous gas, than in one of atmospherical air of the same dimensions.

7. *This effect seems connected with the absorption of oxygen by the blood.* Pass up a little dark coloured blood into a jar partly filled with oxygen gas, and standing over mercury. The gas will in part be absorbed, and the colour of the blood will be changed to a bright and florid red. This change to red may be shewn by putting a little blood into a common vial filled with oxygenous gas, and shaking it up.

ART. V. AZOTIC OR NITROGEN GAS.

1. Azotic Gas may be procured, though not absolutely pure, yet sufficiently so for the purpose of exhibiting its general properties, in the following manner. Mix equal weights of iron filings and sulphur into a paste with water, and place the mixture in a proper vessel, over water, on a stand similar to that described, Art. IV. No. 4. Then invert over it a jar full of common air, and allow this to stand exposed to the mixture for a day or two. The air, contained in the jar, will gradually diminish, as will appear from the ascent of the water within the jar, till at last, only about three-fourths remain of its original bulk. The vessel, containing the iron and sulphur, must next be removed, by withdrawing it through the water; and the remaining air may be made the subject of experiment.

2. This gas has the following properties:

A. It is not absorbed by water.

B. It immediately extinguishes a lighted candle, and all other burning substances.

C. It is fatal to animals that are confined in it.

D. Plants, however, live in it, and even flourish.

E. When mixed with pure oxygenous gas, in the proportion of one part to three of the latter, it composes a mixture, resembling atmospheric air in all its properties. Of this any one may be satisfied, by mixing three parts of azotic gas with one of oxygenous gas; and immersing in the mixture a lighted taper. The taper will burn as in atmospherical air.

ART. VI. ATMOSPHERIC AIR.

The air of our atmosphere, it appears, therefore, from the foregoing facts, is a mixture, or rather a combination, of two different gasses, viz. oxygenous gas, and azotic gas. The former of these two seems to be the only ingredient, on which the effects of the air, as a chemical agent, depend. Thus, combustible bodies burn in atmospheric air, only in consequence of the oxygenous gas, which it contains; and when this is exhausted, air is no longer capable of supporting combustion.* The abstraction, from the air, of its oxygenous gas, will be rendered apparent by the following experiments.

1. Burn a little sulphur or phosphorus, in the manner described, Art. IV. No. 4. substituting for oxygenous gas, common atmospherical air. The combustion will in this instance be less vivid; will cease sooner; and the absorption, when the vessels have cooled, will be much less considerable, than in the former case.

2. Take two tubes, each a few inches long, closed at one end, and divided into aliquot parts. Fill the one with atmospherical air, the other with oxygenous gas, and invert them in two separate cups filled with a solution of sulphuret of potash. The sulphuret will ascend gradually within the tube of common air, till, after a few days, only about three-fourths of its original volume remain: But in that containing oxygenous gas, it will ascend much higher; and if the gas be pure, will even absorb the whole. The explanation of this fact is, that liquid sulphuret of potash has the property of absorbing oxygen, but not azote. It therefore, acts in atmospheric air, only as long as any oxygenous gas remains; and may be employed as a means of ascertaining the quantity of this gas in the atmosphere at

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* Certain combustible bodies even cease to burn in atmospheric air, long before its oxygenous portion is consumed; for reasons that will hereafter be given.

different times, and in distant places. An improved instrument, thus graduated, has lately been employed by Guyton as an *Eudiometer*.* (See Nicholson's Philosophical Journal, Vol. I. page 268; or Tilloch's Philosophical Magazine, Vol. III. p. 191.)

3. *Atmospheric air ministers to the support of animal life, only in consequence of the oxygenous gas, which it contains.* Air, after having been received into the lungs, and again expired, is found to have lost considerably of its oxygenous part, viz. 10 or 12 per cent. It proves fatal to animals, however, long before the whole of this purer portion is wholly exhausted; and hence it appears, that a considerable proportion of oxygenous gas is even necessary to fit the air for supporting respiration. As the analysis of expired air requires an acquaintance with another gas not hitherto described, viz, carbonic acid, its examination will be postponed to a future occasion.

ART. VI. HYDROGENOUS GAS.

1. *To procure hydrogenous gas* let sulphuric acid, previously diluted with five or six times its weight of water, be poured on iron filings, or on small iron nails, in a gas bottle or small retort. An effervescence will ensue, and the escaping gas may be collected in the usual manner.

This gas has the following properties:

2. *It remains permanent over water,* or is not absorbed in any notable proportion.

3. *It is inflammable.* This may be shewn by the following experiments.

A. Fill a small jar with the gas, and holding it with the mouth downwards, bring the gas into contact

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* Other Eudiometers will be described hereafter.

with the flame of a candle. The air will take fire, and will burn silently with a lambent flame.

B. Fill, with this gas, a bladder which is furnished with a stop cock, and with a small pipe, of diameter less than that of a common tobacco pipe. Press the air out through the pipe, and on presenting a lighted candle the stream will take fire. If this apparatus cannot be procured, a very simple contrivance will answer the purpose. Break off part of an eight ounce vial, within an inch or two from the bottom, by setting fire to a string tied round it, and moistened with spirit of turpentine. The vial will then resemble a jar with an open neck at the top. Next bore a small hole through a cork that fits the neck of the vial, and insert in it part of a common tobacco pipe, which may be fixed into the neck of the bottle, by a cement of resin and bees wax. Then fill the bottle with water, and hold it with the thumb pressed down on the aperture of the pipe, while hydrogenous gas is passed into it. When the bottle is full of gas, remove the thumb, press the bottle down into the water, and on the approach of a candle the steam of air from the pipe will take fire. I prefer this mode of making the experiment to the common one of inflaming the gas as it proceeds, through a small tube, from the bottle in which it is produced; because I have once seen an explosion, and frequently heard of similar accidents, from the latter made of making the experiment.

C. In a strong bottle capable of holding about four ounces of water, mix equal parts of common air and hydrogenous gas. On applying a lighted candle, the mixture will burn, not silently as in expt. A. but with a sudden and loud explosion. If a larger bottle be used, it should be wrapped round with a handkerchief, to prevent the glass from doing any injury, in case the bottle should burst.

D. The same experiment may be repeated with oxygenous gas, instead of atmospherical air; changing the proportions, and mixing only one part of oxygenous gas with two of hydrogenous. The report will be considerably louder. The bottle should be a very strong one, and should be wrapped round with cloth, to prevent an accident.*

E. The same experiment may be made over water, by means of the electric spark. Procure a strong tube about three quarters of an inch diameter, and 12 inches long, closed at one end. About quarter of half an inch from the sealed end, let two small holes be drilled, opposite to each other, and into each of these let a brass conductor be cemented, so that the two points may be distant from each other, within the tube, about one eighth of an inch. Into this tube standing over water, pass about a cubic inch, or less, of a mixture of hydrogenous and oxygenous gasses, in the proportion of two measures of the former to one of the latter. Hold the tube firmly, and pass an electric spark through the mixed gasses. An immediate explosion will take place; after which the gasses, if pure, and in the proper proportion, will be found to have disappeared entirely. If atmospheric air be used, the remaining gas will be found to be unfit for supporting combustion, the hydrogenous gas having robbed it of all its oxygen. Hence, the inflammation of hydrogenous gas, in graduated tubes, has been employed as a mean of measuring the purity of air, and is the principle of Volta's eudiometer.

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* These experiments may, also, be made advantageously, by means of an apparatus, sold under the name of the inflammable air pistol.

F. The diminution of hydrogenous and oxygenous gasses, by the union of their bases, may be shewn, also, by their slow combustion. Fill a tall jar with oxygenous gas; and fill, also, with hydrogen gas, a bladder, furnished with a stop cock, and with a long brass pipe, bent like the letter S. and drawn out to a fine point. On pressing the bladder, a stream of gas will issue from the pipe, which may be set fire to, and brought cautiously under a tall inverted jar of oxygenous gas. By this contrivance, the stream of hydrogen gas will be burnt in a confined portion of oxygen gas; and on continuing the combustion a sufficient length of time, the water will be seen to rise gradually within the jar. On the first impression of the heat, indeed, a quantity of gas will escape from the jar, which will render it difficult to ascertain what degree of absorption has actually taken place. But this loss may be prevented by using a jar with a neck at the top, to which a compressed bladder is firmly tied. The expended air, instead of escaping through the water, will now fill the bladder at the top; and when the experiment has closed, and the vessels have cooled, it may be ascertained, by pressing out the gas from the bladder, what quantity of oxygen gas has been consumed.

When the above experiment is made with the substitution of common air for oxygenous gas, a diminution takes place, but much less considerable; viz. not amounting to one sixth the original bulk of the gas.

4. *Hydrogenous gas has an unpleasant smell.*

5. *Though inflammable itself, it extinguishes burning bodies.* Bring an inverted jar, filled with this gas, over the flame of a candle; and depress the jar, so that the lighted wick may be wholly surrounded by the gas. The candle will immediately be extinguished.

6. *It is fatal to animals.* This may be shewn by confining, in the gas, a mouse, or other small animal.

7. *It is considerably lighter than atmospherical air.*

A. Let a jar, filled with this gas, stand for a few seconds, with its open mouth upwards. On letting down a candle, the gas will be found to have escaped.

B. Place another jar of the gas inverted, or with its mouth downwards. The gas will now be found to remain in the jar, being prevented from escaping upwards by the bottom and sides of the vessel.

C. Fill, with hydrogen gas, a bladder furnished with a stop-cock; and adapt to this a common tobacco pipe. Dip the bowl of the pipe into a lather of soap, and turning the cock blow up the lather into bubbles. These bubbles, instead of falling to the ground, like those commonly blown by children, will rise rapidly into the air. On this property of hydrogen gas, is founded its application to the raising of balloons.

8. *Hydrogenous gas, though fatal to animal life, is not so to vegetables, which grow and even flourish in it.*

ART. VIII. COMPOSITION AND DECOMPOSITION OF WATER.

In Art. VII, (No. 3. E.) it was stated that oxygenous and hydrogenous gasses, when fired over water, in the proper proportion, wholly disappear. To ascertain the nature of the product thus formed, however, the experiment must be repeated over mercury, in a similar manner. When this is done repeatedly, it is found that the product of the combustion is that well known fluid water, which is thus proved to be composed of two elementary ingredients. The water, produced in this mode, is not, however, to be considered as a compound of the two gasses, but only of their bases; for the light and caloric, which constituted the gasses, escape, in considerable part, during the combustion. Every gas, it must be remembered, has at least two ingredients; the one gravitating matter, which, if separate, would probably exist in a solid or liquid form; the other an extremely subtile fluid, termed caloric. In the example before us, caloric (and perhaps light) is a common ingredient both of hydrogen and oxygen gasses; but the two differ in having different bases. The basis of the one is called hydrogen, of the other oxygen; and water may, therefore, be affirmed to be a compound of hydrogen and oxygen. This may be proved in two modes, by synthesis, i. e. by joining together its two elementary ingredients; and by analysis, in other words, by separating the constituent parts of water, and again exhibiting them in a distinct form.

1. SYNTHETIC EXPERIMENTS.

A. Fill, with hydrogen gas, a bladder, furnished with a stop-cock and bent pipe, similar to that described, Art VII. No. 3. F. Then pour into a shallow earthen dish as much quicksilver as will about half fill it, and invert over this a glass bell full of common air and perfectly dry. Expel the hydrogen gas through the pipe; light the stream; and bring it under the glas bell, by raising this, and depressing it into the mercury, as soon as the inflamed gas is introduced. A portion of air will escape at first, in consequence of the rarefaction. As the combustion continues, water will form, and will condense on the sides of the glass. This water is produced by the union of hydrogen with the oxygen contained in atmospheric air.

B. Those persons, who are not possessed of a sufficient quantity of quicksilver, to repeat the above experiment, may substitute the following. Procure a large glass globe, capable of holding three or four quarts, and having two openings, opposite to each other, which may be drawn out for a short distance, like the neck of a retort. Inflame the stream of hydrogen gas, and introduce it into the centre of the globe. The rarefied and vitiated air will ascend through the upper aperture of the globe, and a constant supply of fresh air will be furnished from beneath. By this combustion, a quantity of water will be generated, which will be condensed on the inner surface of the vessel.

C. A simple and ingenious apparatus, less costly than any other intended for the purpose of exhibiting the composition of water, is made by Mr. Cuthbertson, of London. It may be seen described and figured in Nicholson's Journal, Vol. II. p. 235; or in the Philosophical Magazine, Vol. II. p. 317.

D. Those persons, who have the opportunity of repeating this interesting experiment on a large scale, and with an accurate attention to proportion, may consult Lavoisier's Elements.

E. By firing repeated portions of a mixture of oxygenous and hydrogenous gasses, over mercury, a sensible quantity of water will at last be produced.

2. ANALYTIC EXPERIMENTS.

The analytic experiments on water are of two kinds, 1stly, such as present us with one of its ingredients only, in a separate and distinct form; 2dly, such as present us with its two component principles, the hydrogen and oxygen, mixed together in the state of gas.

Of the first kind are the following:

A. Procure a gun barrel, the breech of which has been removed, so as to form a tube open at each end. Fill this with iron wire, coiled up in a spiral form. To one end of the barrel adapt a small glass retort partly filled with water, and to the other a bent glass tube, the open end of which terminates under the shelf of the pneumato-chemical apparatus. Let the barrel be placed horizontally, (or rather with that end, to which the retort is fixed, a little elevated) in a furnace, having two openings in its body opposite to each other, or in a grate like that figured by Lavoisier plate 7, figure 11. Light a fire in the furnace; and when the gun barrel has become red hot, apply a lamp under the retort. The steam of the water will pass over the red hot iron, and will be decomposed. Its oxygen will unite with the iron; and its hydrogen will be obtained in the form of a gas. This is the readiest and cheapest mode of procuring hydrogen gas, when wanted in considerable quantity.

B. The same experiment may be repeated; substituting an earthen tube for a gun barrel, and weighing the iron wire, accurately, both before and after the experiment. The iron will be found to have gained weight very considerably; and if attention be paid to the weight of the water, that escapes decomposition, by an addition to the apparatus, similar to that employed by Lavoisier, (plate 7, fig. 11. S and H.) and to the weight of the gasses obtained, it will be found that the weight gained by the iron, added to that of the hydrogen gas, will make up exactly the weight of the water, that has disappeared. From experiments of this kind, conducted with the utmost attention to accuracy, as well as from synthetic experiments, it appears that water is compounded of 85 per cent. oxygen, and 15 hydrogen, by weight, very nearly. But as hydrogen gas is eleven times lighter than common air, the proportion of gasses, by volume, required to form water, is about two of hydrogen to one of oxygen gas.

C. Water may be decomposed in a similar apparatus over charcoal instead of iron. The results, however, are different in this case, as will appear from a subsequent section.

D. Another mode of effecting the decomposition of water yet remains to be mentioned, in which not the hydrogen but the oxygen is obtained in a gaseous state. This is by the action of living vegetables; either entire, or by means of their leaves only. Fill a clear glass globe with water, and put into it a number of green leaves from almost any tree or plant. A sprig of mint will answer the purpose perfectly well. Invert the glass, and place it with its mouth downwards, in a vessel of water. Expose the whole apparatus to the direct light of the sun, which will then fall on the leaves, surrounded by water. Bubbles of air will soon begin to form on the leaves, and will increase in size, till at last they rise to the top of the vessel. This process may be carried on, as long as the vegetable continues healthy; and the gas, when examined, will prove to the oxygenous gas nearly pure. In this experiment, the hydrogen combines with the plant, to whose nourishment and support it contributes, while the oxygen is set at liberty.

2dly. The processes by which the elementary parts of water are separated from each other, and both presented in an aëriform state, as a mixture of hydrogen and oxygen gasses, are dependent on the agency of electricity.

A. The first of these experiments requires, for its performance, the aid of a powerful electrical machine. This fact was the discovery of a society of ingenious Dutch chemists; and the principal circumstance, in the experiment, is the transmission of electrical shocks, through a confined portion of water. The apparatus employed, in this experiment of Messrs. Deiman and Van Troostwyk, is a glass tube, about one-eighth inch diameter, and 12 inches long, one of the ends of which is sealed hermetically, a gold wire being inserted at this end, and projecting about an inch and half within the tube. About the distance of five-eighths of an inch from the extremity of this, another wire is to be fixed; which may extend to the open end of the tube. The tube is next to be filled with distilled water, and to be placed inverted in a vessel of the same. When thus disposed, electrical shocks are to be passed, between the two ends of the wire, through the water; and if these shocks be sufficiently strong, bubbles of air will be formed at each explosion, and will ascend, till the upper part of the wire is uncovered by the water. As soon as this is effected, the next shock, that is passed, will set fire to the air; and the water will rise again in the tube, a very small quantity of gas remaining. Now as hydrogen and oxygen gasses, in a state of admixture, are the only ones, that are capable of inflaming by the electric shock; and as there is nothing in the tube, besides water, that can afford them in this experiment, we may safely infer, that the evolved hydrogen and oxygen gasses arise from decomposed water.

B. An improved apparatus, exhibiting the same experiment with less trouble to the operator, has been invented by Mr. Cuthbertson, and may be seen described and figured in Dr. Pearson's paper, in the Phil. Trans. for 1797, or in Nicholson's Journal, Vols. 1 and 2.

C. The same experiment may be performed with the aid of an apparatus of great simplicity, and which it is in the power of almost any person to make for himself. This is the newly discovered pile of Signor Volta; a discovery, which, for curiosity, and importance in a philosophical view, ranks with the first that have been made, during the present century. It is constructed in the following manner.

Procure, at a brazier's or copper-smith's, 30, 40, or 50 pieces of zinc or speltre, cast in sand, of the size of half crowns or shillings, but rather thicker. A corresponding number of half crowns or shillings will, also, be required, according to the size of the pieces of zinc, that may be employed. Let an equal number of pieces of woollen cloth be cut of a circular shape, to correspond with the pieces of zinc; and steep these in a strong solution of common salt in water. Then dispose the three substances, alternately, in the following order, silver, zinc, moistened cloth; silver, zinc, &c., till a sufficient number of these triplicates, not less than 20 or 30, have been thus arranged, the silver terminating the pile at the top. In order to facilitate the touching of the bottom piece of silver, it may be well to put under it a slip of tinfoil or dutch leaf, which may project a few inches. Next, let the hands be moistened with salt and water, and on touching the piece of tinfoil with one hand, and the uppermost piece of silver with the other, a shock will pass through the arms, which will be strong, in proportion to the number of pieces of zinc, &c. that are employed.

With this apparatus, the decomposition of water is effected with the utmost facility. Take a narrow glass tube 3 or 4 inches long; fit each end with a cork, penetrated by a piece of slender iron wire, and fill the tube with water. Let the ends of the two wires be distant from each other, about three-fourths of an inch; and let the one be made to communicate with the bottom of the pile, the other with the top. On making this communication, bubbles of air will form, and will ascend to the top of the tube; the wire being rapidly oxydated. In this experiment, water is decomposed: Its oxygen unites with the iron; while its hydrogen appear in the state of gas.

If this experiment be made with the substitution for iron, of some metal that is not oxydated by water, as gold for example, we obtain a mixture of hydrogen and oxygen gasses, as in the experiment of Messrs. Deiman and Van Troostwyk.

In Mr. Nicholson's Journal, a variety of interesting observations on the phenomena, produced by Volta's Galvanic Pile, have been published by Messrs. Nicholson, Carlisle, Cruickshank, Davy, and others.

ART. IX. PROPERTIES AND EFFECTS OF WATER.

1. *Water contains air.* This may be shown by placing a glass vessel of water, under the receiver of an air pump. During the exhaustion of the receiver, bubbles of air will be seen to ascend very plentifully. Much air escapes, also, from water, during ebullition, and may be collected by a proper apparatus.

2. *Water is contained in the air of the atmosphere, even during the driest weather.* Expose to the air in a shallow vessel a little carbonate of potash (not crystallized, but the common salt of tartar.) In a few days, it will have become moist, or *deliquiated.* On the same principle, water, exposed to the air in a shallow vessel, disappears, being dissolved by the atmosphere.

3. *Water dissolves a great variety of solid bodies.* The substances, on which it exerts this effect, are said to be soluble in water; and there are various degrees of solubility, see Art. I. No. 6.

4. *During the solution of bodies in water, a change of temperature ensues.* In most instances, an absorption of caloric, (in other words, a production of cold) is attendant on solution, as in the examples given in Art. II. No. 9. But in other cases caloric is evolved, or heat is produced. Thus common salt of tartar, during its solution in water, raises the temperature of its solvent; and caustic potash, in a state of dryness, does the same still more remarkably. Both carbonated and pure potash, however, when crystallized, observe the usual law; and absorb caloric during solution. Now as their difference in the crystallized and uncrystallized state depends chiefly on their containing, in the former but not in the latter, water chemically combined; we may infer, that the cold, produced during the solution of salts, is occasioned by the conversion of the water, which exists in these bodies, from a solid to a liquid form.

5. *During the solution of salts in water, a quantity of air is disengaged.* This air was, partly, contained mechanically in the salt, and partly in the water. That it does not arise, entirely, from the former source, is proved by varying the experiment, in the following manner. Let an ounce or two of sulphate

of soda be put into a vial; and pour on this as much water as will completely fill the bottle. The air, contained in the pores of the salt, will be thus disengaged; but only a small portion of the salt will be dissolved, agreeably to the principle laid down, Art. I. No. 7. Let the vial be shaken, and the whole of the salt will disappear; a fresh portion of air being liberated during solution. The air, that now appears, is extricated from the water, in consequence of the affinity between the water and the salt, being stronger than that between the water and the air. It is, therefore, a case of single elective affinity.

6. *During the solution of bodies the bulk of water changes.* Take a glass globe, furnished with a long narrow neck (commonly termed a matrass) and put into it an ounce or two of sulphate of soda. Then add as much water as will fill the globe, and about three-fourths of the neck. This should be done with as little agitation as possible, in order that the salt may not dissolve, till required. Mark, by tying a little thread, the line where the water stands; and then agitate the matrass. The salt will dissolve; air will be set at liberty; and, during the solution, the water will sink considerably below its level. This contraction of bulk is owing to the diminution of temperature; and when the water has regained its former temperature, it will also be found, that its bulk is increased by the addition of salt. The Bishop of Llandaff found that water exhibits a manifest augmentation of bulk, by dissolving only the two thousandth part of its weight of salt; a fact sufficiently decisive against that theory which supposes pores in water, capable of receiving saline bodies without an augmentation of volume.

7. *Water has its solvent power increased by diminishing the pressure of the atmosphere.* Into a florence flask, put a pound of sulphate of soda; pour on it barely a pint of water; and apply heat so as to boil the water. The whole of the salt will be dissolved. Boil the solution for several minutes, pretty strongly, so as to drive out the air; and cork the bottle tightly, immediately on its removal from the fire. To prevent, more completely, the admission of air, tie the cork over with bladder. As the vessel cools, an imperfect vacuum will be formed over the solution; for the steam, which arises during the ebullition, expels the air, and takes its place. This steam is condensed again, when the vessel cools. The solution, when perfectly cold, may be shaken without any effect ensuing, so long as the vessel is kept closely stopped; but on removing the cork, and shaking the vessel, the solution will immediately congeal, and heat will be produced. This experiment, besides the principle, which it is peculiarly intended to illustrate, exemplifies, also, the general rule laid down, Art. II. No. 10, viz. that caloric is always evolved, during the transition of bodies from a fluid to a solid state; and it furnishes a fact exactly the converse of that, in which cold is produced, or caloric absorbed, during the solution of salts.

8. It is unnecessary to add any thing, to what has been already said in a former section, respecting the combination of caloric with water, constituting steam; or to the history of the phenomena attending its conversion into ice; except that during the latter change, its bulk is enlarged in the proportion of 9 to 8, and that in consequence of this expansion, water, during congelation, is capable of bursting the strongest vessels; and becomes, also, specifically

lighter. Hence ice always swims on the surface of water.

ART. X. ALCALIS.

General qualities.

The properties, common to all the three alcalis, may be shewn by those of a solution of pure potash.

A. The alcalis change vegetable blue colours, as that of an infusion of violets, to green.

B. They have an acrid and peculiar taste.

C. They serve as the intermedia between oils and water, see Art. I. No. 9.

D. They corrode woollen cloth; and, if the solution be sufficiently strong, reduce it to the form of a jelly.

PURE POTASH AND PURE SODA.

These alcalis may be procured, in a dry state, by evaporating their respective solutions, the mode of preparing which will be hereafter pointed out. The alcalis, thus obtained, are very far from a state of complete chemical purity. Their properties, also, in a solid form, are not particularly interesting; as most of these may be exhibited in a state of solution. It may be proper, however, to state,

A. That they powerfully attract moisture from the atmosphere, or deliquiate.

B. They readily dissolve in water, and produce heat during their solution.

C. They are not volatilized by a moderate heat, and hence have been called fixed alcalis.

PURE AMMONIA.

1. Ammonia, in its purest form, subsists in the state of a gas. In order to procure it, one of the following processes may be employed.

A. Mix together equal parts of muriate of ammonia, and quicklime, each separately powdered; and introduce them into a small gas bottle or retort. Apply the heat of a lamp; and receive the gas, that is liberated, over mercury.

B. To a saturated solution of ammonia in water, or the pure liquid ammonia, in a gas bottle, apply the heat of a lamp, and collect the gas as in A.

2. This gas has the following properties.

A. It has a strong and very pungent smell.

B. It immediately extinguishes flame; and is fatal to animals.

C. It is lighter than atmospheric air. Hence a jar filled with this gas, and placed with its mouth upwards, is soon found to change its contents for common air, which, being heavier, descends, and displaces the ammoniacal gas.

D. It is not inflammable; nor does it explode when mixed with hydrogen gas.

E. It is rapidly absorbed by water. A drop or two of water, being admitted to this gas, confined over mercury, the gas will be immediately absorbed, and the mercury will rise so as to fill the whole of the jar, provided the gas be sufficiently pure. Ice produces the same effect in a still more remarkable manner.

F. Water, by saturation with this gas, acquires its peculiar smell; and constitutes what has been called liquid ammonia; or, more properly, solution of pure ammonia in water. This solution again yields its gas on applying heat, (see No. 1. B.)

G. This gas is decomposed by electricity.—Provide a jar furnished with two conductors (as described, Art. VI. No. 3, E.) and having admitted about a cubic inch of ammoniacal gas, pass through it a succession of electrical discharges. When 150 or 200 shocks have been passed, the gas will have increased to three times its original bulk. Admit a small quantity of water. The gas will not, as before, be completely absorbed by the water; but a part will remain. Hence it appears that some new gas has been generated; and, on examination, it is found to be a mixture of hydrogen and azotic gasses.

H. The decomposition of ammonia may, also, be easily shewn, by galvanizing, with the apparatus described, page 32, a saturated solution of ammonia in water. In this experiment, a considerable quantity of gas is produced. Expose this over a solution of sulphuret of potash. A small part of it will disappear, being oxygenous gas. The remainder consists of hydrogenous and azotic gasses.

ACIDIFIABLE BODIES—ACIDS—COMBINATIONS OF ACIDS WITH ALCALIS.

ART. XI. ACIDS IN GENERAL.

Acids in general have the following properties:

A. *They redden vegetable blue colours.* Hence blue vegetable infusions, and the papers stained with them, are tests of the presence of acids. To a little of the infusion of litmus, add a drop of dilute sulphuric, or any other acid. The colour will immediately change to red.

B. They have a peculiar taste, expressed by the terms acid or sour.

C. *They combine chemically with alcalis, and totally destroy the peculiar properties of those bodies.* Let a few ounce measures of water be tinged blue with genuine syrup of violets. Add some solution of pure potash, and the colour will become green. Then gradually drop in sulphuric acid, much diluted; and, if this be done very cautiously, the blue colour will be restored. In this state, neither the alcali nor acid is in excess; or, in other words, they are exactly *saturated* with each other. One of the most remarkable properties of the alcali and the acid, when separate, disappears, therefore, on combination. And, on further examination, it will be found that all the other characteristics of the components are lost in the compound.

ART. XII. CARBON—CARBONIC ACID—CARBONATES—OTHER BINARY COMPOUNDS OF CARBON.

1. Carbon is obtained, though not absolutely pure, yet sufficiently so for the purposes of exhibition, by charring, in a covered crucible, pieces of oak, willow, hazle, or other woods, from which the bark has been previously peeled. For purposes, to which it is applied in a powdered state, it may be purified, by powdering it, and washing it first with dilute muriatic acid, to separate any earths it may contain, and afterwards with repeated affusions of distilled water.

2. In its aggregated state, carbon is black; perfectly insipid, and free from smell; brittle, and easily pulverized.

COMBINATION OF CARBON WITH OXYGEN.

3. If a piece of charcoal be introduced cold into oxygenous gas, no effect will ensue; but if the charcoal be previously made red-hot, it burns in this gas with considerable brilliancy. To perform this experiment with accuracy, and with the proper attention to the products, it should be made over mercury. The oxygen will unite with the carbon; and the product is a compound of carbon and oxygen, which subsists over mercury in the state of gas. On this account no diminution ensues.

4. Another mode of effecting the combination of carbon with oxygen, is by driving the vapour of water over red-hot charcoal, in an apparatus similar to that described, page 29, B. The water is decomposed; its oxygen combines with the carbon; while its hydrogen combines with another portion of carbon, and forms a compound, which will be hereafter described.

The union of carbon with oxygen, however produced, furnishes a compound, called

CARBONIC ACID.

1. To procure carbonic acid sufficiently pure for the exhibition of its properties, neither of the above processes is adviseable. The student may, therefore, have recourse to another, the rationale of which he will not, at present, understand; but which will be explained afterwards. Into a common gas bottle, put a little powdered marble or chalk, and pour on this sulphuric acid diluted with 5 or 6 times its weight of water. A gas will be produced, which those, who, have an opportunity, may receive over mercury; but a mercurial apparatus is not absolutely

essential; since the gas may be collected over water, if used immediately when procured. Its properties are the following.

A. *It extinguishes flame.* Set a vessel, filled with the gas, with its mouth upwards, and let down a lighted candle. The candle will instantly be extinguished.

B. *It is fatal to animals.* Put a mouse or other small animal into a vessel of the gas, and cover the vessel to prevent the contact of common air. The animal will die in the course of a minute or two.

C. *This gas is heavier than common air.* Let a long glass tube, proceeding from a gas bottle containing the materials (No. 1.), be twice bent at right angles, like those figured in Lavoisier's 4th plate, fig. 1. E. Let the open end of the longer leg reach the bottom of a glass jar, perfectly dry within, and standing with its mouth uppermost. The carbonic acid will expel the common air from the jar, because it is heavier. This superior gravity may be further shewn as follows: When the jar is perfectly filled with the gas (which may be known by a lighted candle being instantly extinguished when let down into it) take another jar, of rather smaller size, and place, at the bottom of it, a lighted taper supported by a stand. Then pour the contents of the first mentioned jar into the second, as if you were pouring water. The candle will be instantly extinguished, as effectually, as if it had been immersed in water.

It is owing to its superior gravity, that carbonic acid gas is often found at the bottom of deep wells and of mines, the upper part of which are entirely free from it. Hence the precaution, used by the sinkers of wells, of letting down a lighted candle, before they venture to descend in person.

D. *Carbonic acid gas is absorbed by water.* Fill partly a jar with this gas, and let it stand a few hours over water. An absorption will gradually go on, till at last none will remain. This absorption is infinitely quicker, when agitation is used. Repeat the above experiment, with this difference, that the jar must be shaken strongly. A very rapid diminution will now take place. In this manner water may be charged with its own bulk of carbonic acid gas; and it acquires, when thus saturated, a very brisk and pleasant taste. This impregnation is most commodiously effected in an apparatus, sold in the glass shops, under the name of Nooth's machine.

E. From water, thus imgregnated, carbonic acid is again set at liberty, on boiling the water, or on exposing it under the receiver of an air pump. During exhaustion, the gas will escape so rapidly, as to present the appearance of ebullition; and will be much more remarkable than the discharge of air from a jar full of common spring water, confined, at the same time, under the receiver, as a standard of comparison.

F. *Carbonic acid gas, when combined with water, reddens vegetable blue colours.* This may be shewn by dipping, into water thus saturated, a bit of litmus paper; or by mixing, with a portion of it, about an equal bulk of the iufusion of litmus. This fact establishes the title of the gas to be ranked among acids.

G. *Carbonic acid gas precipitates lime water.* This character of the gas is necessary to be known; because it affords a ready test of the presence of carbonic acid, whenever it is suspected. Pass the gas, as it proceeds from the materials, though a portion of lime water. This, though perfectly transparent before, will instantly grow milky. Or mix equal measures of water saturated with carbonic acid, and lime water. The same precipitation will ensue.

11. *By the application of the test G, it will be found, that carbonic acid is generated in several cases of combustion.* Fill the pneumato-chemical trough with lime water, and burn a candle, in a jar filled with atmospheric air, over the lime water, till the flame is extinguished. On agitating the jar, the lime water will become milky.—The same appearances will take place more speedily and remarkably, if oxygenous gas be substituted. The carbonic acid, thus formed during combustion, by its admixture with the residuary air, renders it unfit for supporting flame, sooner than it otherwise would be. Hence, if a candle be burnt in oxygenous gas, it is extinguished long before the oxygen is totally absorbed, because the admixture of carbonic acid with oxygen gas, in considerable proportion, unfits it for supporting combustion. Whenever any substance, by combustion in oxygenous gas or common air, over lime water, gives a precipitate, soluble with effervescence in muriatic acid, we may confidently infer that it contains carbon.

1. *The respiration of animals is another source of carbonic acid.* On confining an animal in a given portion of atmospheric air, over lime water, this production of carbonic acid is evinced by a precipitation. The same effect, is, also, produced more remarkably in oxygenous gas. The production of carbonic acid by respiration, may be proved, also, by blowing the air from the lungs, with the aid of a quill, through lime water, which will immediately grow milky. The carbonic acid, thus added to the air, unfits it for supporting life, not merely by diminishing the proportion of oxygen gas, but ap-

parently by exerting a positively noxious effect. Hence a given quantity of air will support an animal much longer, when the carbonic acid is removed as fast as formed, than when suffered to remain in a state of mixture. It has been found that an atmosphere, consisting of oxygen gas, and carbonic acid, is fatal to animals, though it contains a larger proportion of oxygen, than the air we commonly breathe.

2. *Carbonic acid gas exerts powerful effects on living vegetables.* These effects, however, vary according to the mode of its application.

Water, saturated with this gas, proves highly nutritive, when applied to the roots of plants. The carbonic acid is decomposed, its carbon forming a component part of the vegetable, and its oxygen being liberated in a gaseous form.

On the contrary, carbonic acid applied as an atmosphere, by confining a living vegetable in this gas over mercury, is injurious to the health of the plant, especially in the shade. M. Saussure, jun. found that a proportion of carbonic acid in common air, greater than one eighth, is always injurious to vegetation ; but that in this proportion it promotes their growth, and is manifestly decomposed.

CARBONATES IN GENERAL.

Carbonic acid is susceptible of combination with alkalis, earths, and metals, and forms an order of compounds termed carbonates. At present, however, we shall only attend to the results of its union with alkalis.

CARBONATE OF POTASH.

A. *Carbonic acid gas is very abundantly absorbed by a solution of pure potash.* The simplest mode of shewing this is the following. Fill a common vial with this gas over water; and when full, stop it by applying the thumb. Then invert the bottle in a solution of pure potash, contained in a cup, and rather more in quantity than is sufficient to fill the bottle. The solution will rise into the bottle, and, if the gas be pure, will fill it entirely. Pour out the alcaline liquor; fill the bottle with water; and again displace it by the gas. Proceed as before; and repeat the process several times. It will be found that the solution will condense many times its bulk of the gas; whereas water combines only with its own volume.

B. *The changes effected in the alcali may next be examined.* It will be found to have lost much of its corrosive and penetrating taste, and will no longer destroy the texture of woollen cloth; but it still turns green the blue infusions of vegetables. Before its absorption of this gas, no remarkable change ensued, on mixing it with diluted sulphuric acid; but if this, or any other acid, be now added, a violent effervescence will ensue, arising from the escape of the gas, that had been previously aborbed. If the mixture be made in a gas bottle, the gas, that is evolved, may be collected, and will be found to exhibit every character of carbonic acid.

C. In this state of combination with carbonic acid, potash generally occurs in the arts. The potash, and pearlash of commerce; and the salt of tartar and salt of wormwood of the shops, are carbonates of potash of different degrees of purity. The quantity of carbonic acid, contained in these alcalis, may be learned by a very simple experiment. Put one or two hundred grains of the alcali into a florence flask, and add a few ounce measures of water. Take, also, a vial filled with dilute sulpuric acid, and place this, as well as the flask, in one scale. Ballance the two, by putting weights into the opposite scale; and, when the equilibrium is attained, pour gradually the acid into the flask of alcali, till an effervescence no longer ensues. When this has ceased, the scale containing the weights will be found to preponderate. This shews that the alcali, by combination with an acid, loses considerably of its weight; and the exact amount of the loss may be ascertained by adding weights to the scale containing the flask and vial, till the ballance is restored.

D. As it is sometimes of importance to know what proportion of real alcali a given weight of potash or pearlash contains, it may be proper to point out how this information may be acquired. The strength of the alcali is in proportion to the quantity of an acid required to saturate it. Thus if an ounce of one kind of potash requires, for saturation, a given quantity of sulphuric acid; and an ounce, of another kind, requires twice that quantity, the latter is twice as strong as the former. In order, however, to obtain a sufficiently accurate standard of comparison, it will be necessary to employ, constantly, an acid of the same strength. This may be effected, though not with absolute uniformity, yet sufficient for ordinary purposes, by diluting the common oil of vitriol of commerce to the same degree. For example, let the standard acid consist of five parts of sulphuric acid, and one of water. The strength of an alcali will be learned, by observing what quantity of this acid a given quantity of alcali requires for saturation. For this purpose, put half an ounce of the alcali, or any other definite weight, into a jar, with a few ounces of water; weigh the dilute acid employed, before adding it to the alcali; then pour it in gradually, till the effervescence ceases, and till the colour of litmus paper which has been reddened with vinegar, ceases to be restored to blue. When this happens, the point of saturation will be attained. Weigh the bottle, to ascertain how much acid has been added; and the loss of weight will indicate the strength of the alcali. Another less accurate mode of determining the strength is founded on the following property of carbonate of potash.

E. Carbonate of potash dissolves very readily in water, which, at the ordinary temperature, takes up more than its own weight. Hence, when an alcali, which should consist almost entirely of carbonate of potash, is adulterated, as very often happens, with substances of little solubility, the fraud may be detected by trying how much of one ounce will dissolve in two or three ounce measures of water. In this way, I have detected an adulteration of one third. There are certain substances of ready solubility, however, which may be used in adulterating ashes, as common salt for example; and, when this is done, we must have recourse to the above mentioned test, for the means of discovery.

F. Carbonate of potash, in the states which have been already described, is far from being completely saturated with acid. This sufficiently appears from its strongly alcaline taste. It may be much more highly charged with carbonic acid, by exposing its solution to streams of carbonic acid gas, in a Nooth's machine or other apparatus. When a solution of alcali, after this treatment, is slowly evaporated, it forms regular crystals. In this state the alcali constitutes the crystallized carbonate of potash, which contains, per cent, 40 parts of alcali, 43 of acid, and 17 of water. It has therefore a much larger proportion of water and of acid than the common carbonate, 100 parts of which are composed of 70 parts of alcali, 23 of acid, and 5 of water.

G. The crystallized carbonate differs from the common one in the regularity of its form; in the greater mildness of its taste; in remaining dry when exposed to a moist atmosphere; and in being more sparingly soluble in water, which at the ordinary temperature takes up only one fourth of its weight. When carefully prepared, this is the purest form, in which carbonate of potash can be obtained.

H. Carbonate of Potash, in all its forms, is decomposed by the stronger acids, as the sulphuric, nitric, and muriatic, which unite with the alcali, and set the gas at liberty.

CARBONATE OF SODA.

A. The absorption of carbonic acid gas, by a solution of pure soda, may be exhibited by experiments, similar to those directed to be made on the solution of potash. Indeed every thing, that has been said of the preceding carbonate, will apply to this; except that the carbonate of soda has a less strong affinity for water. Hence it continues dry, when exposed to the atmosphere, and even gives up a part of its water of crystallization, the crystals losing their transparency and something of their weight. Hence, also, it requires a greater quantity of water for solution, than common carbonate of potash, water taking up only half its weight. The crystals, too, differ considerably in form and size from those of the former carbonate.

The carbonate of soda is known in commerce by the names of barilla, fossil or mineral alcali, &c.; but as applied to the uses of the arts it is never met with pure.

CARBONATE OF AMMONIA.

A. Ammonia, in its pure state, exists in the form of a gas, permanent over mercury only; and carbonic acid has, also, the form of an aërial fluid. But when these two gasses are mixed together over mercury, in proper proportions, they each quit the state of gas, and are entirely condensed into a white solid body, termed carbonate of ammonia.

B. Carbonate of ammonia retains, in a considerable degree, the pungent smell of the pure volatile alcali. It is, also, unlike the other carbonates, volatilized by a very moderate heat; and evaporates, without entering previously into a liquid state. The vapour, that arises, may be again condensed; affording an example of *sublimation*. This may be shewn, by applying heat to the carbonate of ammonia in a retort, to which a receiver is adapted. The carbonate will rise, and be condensed in the receiver in the form of a white crust.

C. This carbonate does not attract moisture from the air, but, on the contrary loses weight. Its other properties resemble those of the carbonates of potash and soda. The mode of preparing it will be described hereafter.

COMBINATION OF CARBON WITH HYDROGEN, FORMING CARBONATED HYDROGENOUS GAS.

1. When water is decomposed by passing its vapour over red hot charçoal, we obtain two different products. Carbonic acid is formed, in consequence of the union of the carbon with the oxygen of the water; and the hydrogen of the water, combining with another portion of carbon, constitutes the carbonated hydrogenous gas. The carbonic acid may be separated by lime and water,

mixed together so as to be of the consistence of cream; and the carbonated hydrogen gas will remain pure.

2. This gas has the following qualities.

A. *It is not absorbed by water.*

B. *It is inflammable.* This may be shewn by burning it in the manner directed in the Art. VI. No. 3, B. The colour of the flame, however, may be observed to differ from that of hydrogen gas, inclining rather to a deep blue.

C. *When fired over mercury, carbonic acid gas and water are the products.* In burning pure hydrogen gas, water only is generated; but in the combustion of this gas, two inflammable bodies are present, viz. hydrogen and carbon. The production of carbonic acid may, also, be shewn by burning the gas over lime water, by means of a bladder and bent pipe, as directed, page 27, A. The lime water will soon become milky.

D. *This gas is heavier than pure hydrogen gas,* and even than common atmospheric air. Soap bubbles, blown with it, descend like the common ones; and a jar filled with it, and held inverted a few minutes, exchanges its contents for common air.

ART. XIII. SULPHUR—SULPHURIC ACID—SULPHATES—BINARY COMPOUNDS OF SULPHUR.

SULPHUR.

1. *Sulphur occurs in two different forms;* that of flowers and of stick sulphur. The former is generally purest.

2. *Sulphur is readily fused.* A very gentle heat is sufficient to melt it; and, if very slowly cooled, it forms regular crystals.

3. *Sulphur is volatilized by heat.* A little sulphur

may be put into the bottom of a tube, the mouth of which is loosely stopped with paper, to prevent the free access of air. On applying heat, the sulphur will rise to the top of the tube.

4. *Sulphur does not dissolve in water.*

5. *It is inflammable.* In the open air, it burns with a blue flame, and emits a very penetrating smell. When burnt in a confined portion of common air, an absorption takes place; but the sulphur is extinguished before the whole of the oxygen is consumed. In oxygenous gas, it burns with a very beautiful and brilliant light; and the absorption is more remarkable, but is still far from being complete. The product of both these combustions, is

SULPHURIC ACID.

1. Though this is not the mode, in which sulphuric acid is ordinarily prepared; yet it will be proper for the chemical student to examine the result of this combustion, on account of the simplicity of the process. Let the glass bell, under which sulphur has been burnt, be rinsed out with a little water. This water will have an acid taste; will turn vegetable blue colours red; and will effervesce with carbonated alkalis. It is, therefore, an acid, and, as it is composed of sulphur and oxygen, it is termed, the sulphuric acid. The properties of this acid must be exhibited by a portion of that usually found in the shops, or contained in the chest. They are as follows:

A. *Sulphuric acid has a thick and oily consistence;* as may be seen by pouring it from one vessel into another.

B. *It is nearly twice heavier than water.* This will appear from weighing a small vial filled with the acid; and afterwards filled with distilled water.

C. *In a pure state it is perfectly limpid and colourless.*

D. *When mixed suddenly with water, considerable heat is produced.* A diminution of bulk, also, ensues; that is, one measure of acid and one of water do not occupy the space of two measures, but considerably less. Owing to the heat produced by its admixture with water, the dilution should be conducted very gradually; and the acid should be added to the water by small portions at once, allowing each portion to cool, before a fresh addition be made. On the principle of its attraction for water, is to be explained, also, the rapid increase of weight, which the acid requires when exposed to air.

E. *A perfectly pure sulphuric acid remains quite limpid during dilution.* The sulphuric acid, however, commonly found in the shops, under the name of oil of vitriol, on admixture with water, deposits a white powder, in considerable quantity, consisting of various impurities.

F. *To purify sulphuric acid,* it must be distilled in a glass retort, placed in the sand bed of a reverbratory furnace. This process is a very difficult one; and an inexperienced chemist should, therefore, not attempt it. It may be less perfectly purified by diluting it with an equal weight of water; allowing the impurities to settle; decanting the clear liquor; and evaporating it, to the proper degree, in a glass vessel.

G. *Sulphuric acid is decomposed at the temperature of the atmosphere, by inflammable substances, and acquires a dark colour.* The addition of a little brown sugar, or a drop of oil, to a portion of the acid, imparts to it a brownish hue, which in time changes to black. Hence this acid should always be kept in bottles with glass stoppers; for a small bit of cork, if dropped into a considerable quantity, changes it in the manner that has been pointed out.

H. *In high temperatures, sulphuric acid is still farther decomposed by combustible bodies.* Into a glass retort put such a quantity of sulphuric acid as will fill about one fourth part of it; and add a small portion of powdered charcoal. On applying the heat of a lamp, gas will be produced very abundantly. Let this gas be conveyed, by a tube fixed to the mouth of a retort, and bent in the proper manner, into an inverted jar of water; or, if it can be had, into an inverted jar of quicksilver in a mercurial apparatus. During this operation, the carbon attracts part of the oxygen of the sulphuric acid, and forms carbonic acid gas. But the sulphur is not entirely disoxygenated; and a compound is, therefore, formed of sulphur and oxygen, containing less oxygen than the sulphuric acid. This compound exists in the state of a gas, and its properties may next be examined. To avoid, however, the complication, which the admixture of carbonic acid with this new product introduces into the experiment, it may be proper to prepare it in a mode less objectionable, but the rationale of which cannot at present be explained. This consists, in dissolving one part by weight of quicksilver in two of sulphuric acid, and boiling the mass to dryness. The dried mass, still remaining in the retort, is next to be distilled in a strong sand heat; a glass globe being interposed between the retort and the receiving trough, to condense any acid that may escape decomposition (see Lavoisier's 4th plate, fig. 1. G.) The gas thus obtained, is termed, conformably to the principles of the new nomenclature,

SULPHUREOUS ACID GAS.

Its properties are the following.

A. *It has a pungent and suffocating smell,* exactly resembling that which arises from burning sulphur.

B. *It is heavier than atmospherical air.*

C. *It extinguishes burning bodies, and kills animals.*

D. *It has the property of whitening or bleaching silk.*

E. *It is absorbed by water*; but only in small proportion.

F. *This watery solution does not redden infusion of litmus,* as acids in general do, but totally destroys its colour.

G. *Sulphuric acid, saturated with this gas,* (which may be effected by passing the gas through the acid) *acquires the property of assuming a solid form,* by a moderate reduction of its temperature.

H. *Sulphureous acid is again converted to the state of sulphuric, by restoring oxygen to it.* To a portion of water saturated with this gas, add a little oxyd of manganese, a substance that contains much oxygen loosely combined. The pungent smell of the water, and the other characteristics of sulphureous acid, will soon disappear.

Both these acids are susceptible of combination with alcalis.

COMBINATION OF SULPHURIC ACID WITH ALKALIS.

SULPHATE OF POTASH.

This salt may be formed by saturating the carbonate of potash with sulphuric acid, and crystallizing the solution. Its properties are the following.

A. *It crystallizes* in small six sided prisms, terminated by six sided pyramids, with triangular faces.

B. *It has a bitter taste.*

C. *It decrepitates,* or crackles, when thrown on a red hot iron or on red hot coals, and is volatilized in a strong heat.

D. *Water, at 60° of Fahrenheit, takes up only one sixteenth its weight;* but boiling water dissolves one fifth.

E. 100 parts contain 30.21 acid, 64.61 alkali, and 5.18 water.

G. *This sulphate is decomposed, in high temperatures, by carbon.* Mix any quantity of the salt with one fourth its weight of charcoal finely powdered; and expose the mixture in a crucible, to a strong heat. The carbon will unite with the oxygen of the sulphuric acid, and will escape in the state of a gas. What remains is a compound, hereafter to be described, of sulphur and potash.

SULPHATE OF SODA.

A. This salt forms regular octahedral crystals, of a prismatic or cuneiform figure, the two terminating pyramids of which are truncated near their basis.

B. It has a more bitter taste than the preceding, and melts more easily in the mouth.

C. It swells upon an heated iron, in consequence of the loss of its water of crystallization, and a white powder is left.

D. By exposure to the atmosphere, it effloresces and loses weight.

E. It is very soluble in water, 3 parts of which, at 60° of temperature, dissolve one of the salt; and boiling water dissolves its own weight.

F. It contains per cent. 14 acid, 22 alkali, and 64 water.

C. It is decomposed by charcoal like the preceding salt, and a compound remains of sulphur and soda.

SULPHATE OF AMMONIA.

A. The sulphate of ammonia forms long flattened prisms with six sides, terminated by six sided pyramids.

B. It slightly attracts moisture from the air.

C. It liquefies by a gentle heat, and is volatilized. If a stronger heat be applied, it is decomposed. See Mr. Hatchett's paper, in Phil. Trans. 1796, or Davy's Researches.

D. The pure fixed alkalis, potash and soda, seize the sulphuric acid, and set at liberty the alkali. Hence a strong smell of ammonia arises on the admixture of pure soda or potash with this salt.

The combinations of sulphureous acid with alkalis have no peculiar qualities that are likely to prove interesting to the general student. Those, however, who may wish to pursue this subject, I refer to some interesting papers in the Annales de Chimie, vols. 2 and 24.

BINARY COMPOUNDS OF SULPHUR—1st. WITH ALCALIS.—2d. WITH HYDROGEN.

The combinations of sulphur with the two fixed alkalis, soda and potash, are so similar in properties, that what is said of the one will equally apply to the other.

1. Sulphur may be united with these alcalis either in the dry or humid way. To prepare a sulphuret, in the dry way, mix equal parts of sulphur and of carbonate of potash or soda, in a perfectly dry state; and fuse the mixture in a crucible. The melted mass, when poured out, will have a reddish or liver colour. Or, a sulphuret may be formed by the decomposition of sulphates by charcoal, see preceding G. The process, in the moist way, consists in boiling together powdered sulphur and a solution of

pure potash or soda in a glass vessel. The sulphur is thus dissolved.

2. Sulphurets of alcalis have the following qualities.

A. *In a moist state they emit an offensive smell, and have a disagreeable taste.*

B. *They change to green the colour of violets,* in the same manner as uncombined alkalis.

C. *They blacken the skin,* silk, and other animal substances.

D. *They are decomposed by all acids.* Into a Nooth's machine put a weak solution of sulphuret of alcali, and pass through it streams of carbonic acid gas. In the course of a few days, the sulphur will be precipitated, and a carbonate of alkali obtained. This decomposition ensues, instantly, on adding, to a solution of a sulphuret, any of the stronger acids, as the sulphuric, nitric, or muriatic; and we obtain a compound of the alkali with the respective acid employed.

E. *The liquid sulphurets absorb oxygenous gas.* This may be shewn by the experiments already described. If the change thus effected be examined, it will be found that the oxygen has combined with the sulphur, and formed sulphuric acid, which, uniting with the alcali, has composed the sulphate of potash.

F. If dilute muriatic acid be poured on the solution of sulphuret of potash or soda, a violent effervescence will ensue, and a very offensive gas be disengaged. This gas may be collected over water. It is termed

SULPHURATED HYDROGEN GAS.

1. This gas may be obtained in the foregoing manner; or from a mixture of iron filings and sul-

phur, previously melted together, by means of dilute muriatic or sulphuric acid.

2. Its properties are the following.

A. *Its smell* is extremely offensive, resembling that of putrefied eggs.

B. *It is inflammable,* and burns either silently or with an explosion, accordingly as it is previously mixed or not with oxygen gas or atmospheric air. During this combustion, water results from the union of the hydrogen with the oxygen, and sulphuric and sulphureous acids from that of the oxygen and sulphur.

C. *It tarnishes silver,* mercury, and other polished metals, and instantly blackens white paint.

D. *It is absorbed by water,* which thus acquires the peculiar smell of the gas. It is this gas which gives to the Harrogate and some other natural waters, their peculiar smell.

E. *Water saturated with this gas turns green the infusion of violets,* in this respect producing the effect of an alcali.

F. *It is copiously absorbed by alcalis,* which thus acquire colour, smell, and the property of diminishing oxygen gas. The compounds of this gas with alcalis are termed hydro-sulphurets. Thus, the compound of this gas with potash is named hydro-sulphuret of potash, and differs from the sulphuret of potash, in containing hydrogen besides sulphur. From these combinations, the gas is liberated by acids.

ART. XIV. COMBINATION OF AZOTE WITH OXYGEN, CONSTITUTING NITRIC ACID—NITROUS GAS—NITROUS OXYD—AND COMPOUNDS OF NITRIC ACID WITH ALCALIS.

1. The direct combination of azote and oxygen, affording a decisive synthetic proof of the nature of

this acid, may be effected by passing the electric shock through a mixture of azotic and oxygen gasses. The circumstances of this experiment, however, cannot be understood without the aid of a plate, and of a very detailed description, for both of which I must refer to Mr. Cavendish's paper in the Phil. Trans. for 1785, &c.

2. The analysis of the acid may be obtained by driving it through a red hot porcelain tube, and receiving the generated gasses, which turn out to be a mixture of azotic and oxygenous gasses.

3. The Nitric Acid has the following properties.

A. *It is heavier than water,* in the proportion of 1.5 to 1.

B. *It is perfectly limpid and colourless.*

C. *It gives a yellow stain to the skin.*

D. *It produces heat when diluted with water,* but by no means equal to that excited by diluting sulphuric acid.

E. *It becomes coloured by exposure to the sun's light,* passing first to a straw colour, and then to a deep orange. This effect is produced by the union of the light of the sun with oxygen, in consequence of which the proportion of the acidifying principle to the azote is diminished.

F. *This acid retains its oxygen with but little force.* Hence it is decomposed by all combustible bodies, which are oxydated by it, with more or less rapidity in proportion to their affinity for oxygen. Charcoal decomposes it, and carbonic acid is formed; azotic gas being produced at the same time, if the proportion, and temperature in which the experiment is made, be duly regulated. To effect the complete decomposition of nitric acid by charcoal, it may be driven over that substance made red hot in a porcelain tube.

G. *The acid is also decomposed by metals,* as iron, tin, zinc, copper, &c., and with different phenomena, according to the affinity of each metal for oxygen. This may be seen by pouring some strong nitric acid on iron filings or powdered tin. Violent heat, attended with red fumes, will be produced; and the metals will be oxydated.

H. If the action of metals on nitric acid be more moderately conducted, a new product is obtained in a gaseous state. Dilute some nitric acid with twice its weight of water, and dissolve in this some turnings of copper, or a portion of quicksilver, applying heat if necessary. This must be done in a gas bottle, and the product received over water is

Nitrous Gas.

The properties of this gas are the following.

A. *It is permanent over water.*

B. *When well washed with water it is not acid.* It will be found not to redden litmus paper, when introduced into it through water.

C. *It extinguishes flame,* and is fatal to animals.

D. *When mixed with oxygenous gas, red fumes arise;* heat is evolved; and a diminution takes place; and if the two gasses be in proper proportion and perfectly pure, they disappear entirely. Nitrous acid, at the same time, is re-generated.

E. *The same appearances ensue, less remarkably, with atmospheric air;* and the diminution is only proportionate to the quantity of oxygen gas, which it contains. Thus 100 measures of atmospheric air and 85 of nitrous gas, containing 13 per cent. of azotic gas, are reduced, by admixture, to about 39; and deducting 11 measures for the azotic gas, contained in 85 measures of nitrous gas, we find that the air, under examination, contained 28 per cent. of oxygen gas. On this principle, of its condensing oxygenous but no other gas, is founded the application of nitrous gas to the purpose of eudiometry, or of ascertaining the purity of air. The sources of error, however, in its employment in this mode, are such as to forbid our relying implicitly on the results which it may afford, notwithstanding the improvements lately made in its application by M. Humboldt, (see Annales de Chimie, Vol. 28, p. 123.) I prefer the sulphuret of potash as a more certain test of the purity of air; and in this opinion I have the sanction of M. Berthollet, (see Ann. de Ch. Vol. 34, p. 73).

F. *The generation of an acid, by the admixture of nitrous gas with common air or oxygen gas, may be shewn by the following experiment.* Paste a slip of litmus paper, within a glass jar near the bottom; and into the jar, filled with and inverted in water, pass as much nitrous gas, previously well washed, as will displace the water below the level of the paper. The colour of the litmus will remain unchanged; but, on passing up atmospheric air or oxygen gas, it will be immediately reddened.

G. *That the peculiar acid, thus produced, is the nitrous,* will appear from the following experiment. Into a jar filled with, and inverted in mercury; pass a small quantity of a solution of pure potash; and afterwards, measures of oxygen and nitrous gasses, separately, and in proper proportion. On removing the solution from the jar, and evaporating it, crystals of nitrate of potash will be formed, a salt which is ascertained to be formed of potash and nitrous acid.

H. *Nitrous gas is aborbed by nitric acid,* which by this absorption is considerably changed in its properties. Pass the gas, as it issues from the materials that afford it, through colourless nitric acid. The acid will undergo successive changes of colour, till at last it will become orange coloured and fuming. In this state it is called nitrous acid, because it contains a less proportion of oxygen than the colourless nitric.

I. *The nitrous gas, thus absorbed, is expelled again, by a gentle heat.* This may be shewn by gently heating the acid coloured in expt. G, till it again becomes limpid. In this experiment, light should be excluded.

K. *Nitrous gas is decomposed, by exposure to bodies that have a strong affinity for oxygen.* Thus iron filings, decompose it, and become oxyded, affording a proof of the presence of oxygen in this gas. Sulphuret of potash, &c. have a similar effect.

L. *Nitrous gas is absorbed by the green sulphate and muriate of iron,* which do not absorb azotic gas. To ascertain, therefore, how much azotic gas a given quantity of nitrous gas contains, let it be exposed in a graduated tube over one of these solutions. This information is necessary, previously to deducing, from its effects on atmospheric air, the proportion of oxygen gas.

M. *A very interesting experiment, affording a synthetic proof of the constitution of nitrous gas,* we owe to Dr. Milner, of Cambridge. Into an earthen tube, about 20 inches long, and $\frac{3}{4}$ inch wide, open at both ends, put as much coarsely powdered manganese, as is sufficient nearly to fill it. Let this be placed, horizontally, in a furnace, having two openings opposite to each other. To one end of the earthen tube adapt a retort, containing a strong solution in water of pure ammonia, and to the other a bent glass tube. Let a fire be kindled in the furnace; and when the manganese may be supposed to be red hot, drive over it the vapour of the ammonia. The alcali will be decomposed; its hydrogen, uniting with part of the oxygen combined with the manganese, will form water; while its azote, uniting with another portion of the oxygen, will constitute nitrous gas. The gas, thus generated, may be collected by the usual apparatus.

N. *Another fact, shewing the mutual relation of ammonia and of the compounds of azote, was dicovered some years ago by Mr. Wm. Higgins.* Moisten some powdered tin (which is sold under this name by the druggists) with strong nitric acid; and when the red fumes have ceased to arise, add some quicklime, or solution of pure potash. A strong smell of ammonia will be immediately produced.

GASEOUS OXYD OF AZOTE—NITROUS OXYD OF DAVY.

1. This compound, also consisting of oxygen and azote, but in different proportions, may be obtained by several processes.

A. By exposing common nitrous gas, for a few days, to iron filings, or to various other bodies strongly attracting oxygen, this gas is changed into the gaseous oxyd.

B. By dissolving zinc or tin in dilute nitric acid.—But by neither of these processes, is the gas obtained sufficiently pure, for exhibiting its qualities. To procure it, in a state of purity, the following process is the best.

C. To dilute nitric acid, add carbonate of ammonia, till the acid is saturated. Then evaporate the solution; and, to supply the waste of alcali, add occasionally a little more of the carbonate. Let the solution be evaporated, by a very gentle heat, to dryness. The salt, thus obtained, is next to be put into a glass retort, and distilled with a sand heat not exceeding 500° Faht. The heat of an Argand's lamp is even sufficient. The gas may be collected over water, and allowed to stand a few hours, before it is used; during which time it will deposit a white cloud, and will become perfectly transparent.

The gas, thus obtained, was termed by the society of Dutch chemists, gaseous oxyd of azote, but for the sake of brevity, and as more conformable to the nomenclature of other compounds of azote, I shall use, with Mr. Davy, the name of nitrous oxyd.

This gas has the following properties.

A. *A candle* burns in this gas with a brilliant flame and crackling noise. Before its extinction, the white inner flame becomes surrounded with an exterior blue one.

B. *Phosphorus* introduced into it in a state of inflammation burns with increased splendor.

C. *Sulphur*, introduced into it when burning with a feeble blue flame is instantly extinguished. But when in a state of active inflammation, it burns with a vivid and beautiful rose coloured flame.

D. *Red hot charcoal* burns in it more brilliantly than in the atmosphere.

E. *Iron wire* burns in this gas with much the same appearances as in oxygenous gas.

F. *It is rapidly aborbed by water that has been previously boiled*, about $\frac{1}{30}$ the orginal bulk of the gas remaining uncondensed. A quantity of gas, equal to rather more than half the bulk of the water, may be thus made to disappear.

G. *Water, that has been saturated with this gas, gives it out again, unchanged, when heated.*

H. *It does not change blue vegetable colours.*

I. *It has a distinctly sweet taste*, and a faint but agreeable odour.

K. *It is not diminished* by admixture with either oxygen or nitrous gas.

L. *A mixture of this gas with hydrogen gas, detonates loudly.*

M. *Animals, when wholly confined in this gas, die speedily.*

N. *One of the most extraordinary properties of this gas is exhibited in its action on the human body, when received into the lungs.* When thus employed, it does not prove fatal, because, when received into the lungs, it is mixed and diluted with the atmospherical air, present in that organ. To administer the gas, it may be introduced into an oiled silk bag, or clean bladder, furnished with a stop-cock; and may be breathed repeatedly from the bag, and back again, as long as it will last. The sensations, that are produced, vary greatly in persons of different constitution; but, in general, they are highly pleasurable, and resemble those attendant on the pleasant period of intoxication. Great exhilaration; an irresistible propensity to laughter; a rapid flow of vivid ideas; and an unusual fitness for muscular exertion, are the ordinary feelings it produces. These pleasant sensations, it must be added, are not succeeded, like those accompanying the grosser elevation from fermented liquors, by any subsequent depression of nervous energy.

O. From the experiments of Mr. Davy, it appears that 100 parts by weight of this gas, contain 36. 7 oxygene, and 63. 3 azote, or excluding decimals, 37 oxygen and 63 azote.

NITRATE OF POTASH.

A direct synthetic proof of the composition of this salt may be obtained by saturating nitric acid with potash, either pure, or in a carbonated state. The solution on evaporation yields crystals of nitrate of potash, or nitre.

2. This salt has the following properties.

A. *It crystallizes* in prismatic octahedrons; generally constituting six sided prisms, terminated by two sided summits.

B. *For solution,* it requires seven times its weight of water at 60° of Faht.; and boiling water takes up its own weight.

C. *By the application of a gentle heat, it fuses,* and being cast in moulds, forms what is called Sal Prunelle.

D. *If a red heat be applied, nitrate of potash is decomposed, in consequence of the destruction of its acid.* By distilling it in an earthen retort, or in a gun barrel, oxygenous gas may be obtained in great abundance, one pound of nitre yielding about 12000 cubic inches, of sufficient purity for common experiments, but not for nice purposes.

E. *Nitrate of potash, that has been made red hot, seems to contain an acid less highly oxygenated than the common nitric acid,* and having a weaker affinity for alcalis. For if acetic acid be poured on nitre, that has been thus treated, the nitrous acid is expelled in red fumes; whereas common nitre is not at all affected by acetic acid.

F. *Nitrate of potash is rapidly decomposed by charcoal.* This may be shewn, by mixing two parts of powdered nitre, with one of powdered charcoal, and setting fire to the mixture, in an iron vessel, under a chimney. The products of this combustion, which may be collected by a proper apparatus, are carbonic acid and azotic gasses. Part of the carbonic acid, also, remains attached to the residuary alcali, and may be obtained from it on adding a stronger acid..

G. *Nitrate of potash is also decomposed by sulphur.* Mix powdered nitre and sulphur; and throw the mixture, by little at a time, into a red hot crucible. The sulphur will unite with the oxygen of the nitric acid, and form sulphuric acid; which, combining with the potash, will afford sulphate of potash. The production of the latter salt will be proved, by dissolving the mass remaining in the crucible; and crystallizing it, when a salt will be obtained exhibiting the characters described.

H. A mixture of three parts of powdered nitre, two of carbonate of potash, or common salt of tartar, and one part of sulphur, all accurately mixed together, forms the *fulminating powder,* which explodes with a loud noise when laid on an iron heated below redness.

I. A mixture of five parts of powdered nitre, one part of sulphur, and one of powdered charcoal, composes *gun-powder.* The materials must all be very finely powdered separately; then mixed up together; and beaten with a wooden pestle, a sufficient quantity of water being added to prevent an explosion. The mixture must afterwards be granulated, by passing through sieves, and dried.

K. *Nitrate of potash is also decomposed by sulphuric acid.* Put some coarsely pounded nitre into a retort, with half its weight of sulphuric acid; adapt a receiver; and apply heat. The nitric acid will pass over into the receiver; and in the retort will remain a compound of potash and sulphuric acid.

Nitrate of soda is a salt not possessed of any properties, that are generally interesting. It may be formed, by saturating nitric acid with carbonate of soda, or by distilling common salt (muriate of soda) with nitric acid.

NITRATE OF AMMONIA.

This salt derives importance chiefly from its application to the purpose of obtaining nitrous oxyd; and, as the method of producing it, and of obtaining from it the nitrous oxyd, have been already described, it is unnecessary to add here any thing more concerning it.

MURIATIC ACID—OXYGENATED MURIATIC ACID—AND THEIR COMBINATIONS WITH ALKALIS.

1. The muriatic acid, in its purest form, exists in the state of a gas, permanent over mercury only. For exhibiting its properties, therefore, a mercurial apparatus is absolutely necessary.

2. Muriatic acid gas may be obtained, most commodiously, from dried muriate of soda, in a gas bottle, with half its weight of strong sulphuric acid. It exhibits the following properties.

A. *It has a very pungent smell.*

B. *When brought into contact with common air, it occasions a white cloud.* This is owing to the moisture always present in the atmosphere.

C. *It extinguishes a lighted candle.*

D. *It is very rapidly absorbed by water.* A drop or two of water, admitted to a large jar full of this gas, causes the whole of it instantly to disappear.

3. Water, when charged as highly as possible with this gas, forms the ordinary muriatic acid in a liquid state. This watery solution of muriatic acid has the following properties.

A. *It is heavier than water in the proportion of* 1170 to 1000.

B. *It emits white and suffocating fumes.*

C. *It is not acted on by inflammable substances,* even when considerable heat is applied.

D. *When diluted with water,* no remarkable degree of heat is produced.

E. *It combines with the alcalis,* and constitutes a peculiar genus of neutral salts.

MURIATE OF POTASH.

This salt is not peculiarly interesting.

MURIATE OF SODA.

Muriate of soda is that well known salt, now become a necessary ingredient in the food of man, and of great utility in several of the arts.

1. Its composition may be proved by the direct union of soda with muriatic acid.

2. Its qualities are as follow.

It requires for a solution, twice and a half its weight of water, at 60° of Faht., and hot water takes up very little more. Hence its solution crystallizes, not like that of nitre, by cooling, but by evaporation.

B. *When heated gradually it fuses,* and forms when cold a solid compact mass.

C. If suddenly heated, as by throwing it on red hot coals, it *decrepitates.*

D. *It is not decomposed when ignited in contact with inflammable substances.*

E. *When distilled with sulphuric acid and water,* its acid is disengaged, and we obtain a compound of sulphuric acid with soda.

MURIATE OF AMMONIA.

1. If ammoniacal gas, (see page 38,) and muriatic acid gas be mixed together over mercury, they are immediately condensed; a white cloud is formed; and a solid substance is deposited on the sides of the vessel. This is the muriate of ammonia. Its properties are as follow.

A. *It is volatilized,* without being decomposed, and hence may be sublimed.

B. *It is readily soluble in water,* three parts and a half of which at 60° take up one of the salt. During its solution much caloric is absorbed.

C. *On the addition of a solution of pure potash or pure soda, the alcali is disengaged,* as is evinced by the pungent smell that arises, by the mixture of two bodies perfectly inodorous when separate.

D. *From this salt, sulphuric acid separates the muriatic acid.* This may be proved by substituting it for common salt, in preparing muriatic acid gas.

OXYGENATED MURIATIC ACID.

1. This acid may be formed by either of the following processes.

A. Into a stoppered retort, introduce eight ounces of liquid muriatic acid, and four ounces of finely powdered manganese; and apply the heat of a lamp. A gas will be produced, which may be received over water in the usual manner. From the foregoing materials about 160 cubical inches of gas may be obtained.

B. Mix eight ounces of muriate of soda (common salt) with three ounces of powdered manganese; put them into a stoppered retort, and pour on them four ounces of sulphuric acid, diluted previously with four ounces of water, and which has been suffered to cool after dilution. On applying a gentle heat, gas will be produced as in A.

2. This gas has the following properties.

A. *It has a deep yellow colour.*

B. *It has a pungent and suffocating smell.* In experiments on this gas, great care should be taken that it does not escape, in any considerable quantity, into the apartment; as its action on the lungs is extremely injurious and oppressive.

C. By a temperature of 40°, it is reduced into a liquid form, and is condensed on the sides of the vessel. Hence some chemists have contended that it should be classed among vapours, and not among gasses.

D. *When a burning candle is immersed in the gas, the flame is enlarged, and a dense smoke is produced.*

E. *Phosphorus introduced into it immediately takes fire,* and burns very brilliantly.

F. *Various metals, when minutely divided by filing,* as iron, zinc, bismuth, tin, copper, &c. *take fire in this gas,* and burn with an extrication of heat and light.

G. *Sulphur is oxygenated by it,* and changed into sulphuric acid.

H. *Charcoal, finely powdered and perfectly dry, takes fire in this gas.*

I. *The oxygenated muriatic gas destroys all vegetable colours.* This may be shewn by passing into it, through water, a piece of cloth, or of paper, stained with litmus, the colour of which will speedily disappear. Hence the application of this gas to the purpose of bleaching. Its efficacy, in this mode, may be seen by confining in it a pattern of unbleached calico.

K. *This gas is absorbed by water,* slowly if allowed to stand over it quiescent, but rapidly when agitated.

L. *The watery solution acquires the colour and peculiar smell of the gas;* and has a similar property of discharging vegetable colours. Hence it may be employed in bleaching.

M. *When the watery solution is exposed to a temperature a little above that of freezing water, the gas, which is combined with it, separates, in the form of a liquid heavier than water.*

N. *When this solution is exposed to the direct rays of the sun, the oxygenated acid is decomposed;* its oxygen escapes in the form of a gas; and it is reduced to the state of common muriatic acid. The oxygenous gas may be collected, by exposing the solution in a gas bottle, furnished with a bent tube, which terminates in the pneumato-chemical apparatus.

O. *The oxygenated muriatic acid combines with alkalis,* and forms peculiar compounds.

OXYGENATED MURIATE OF POTASH.

The properties of this salt were discovered by Berthollet. It may be formed by passing the oxygenated muriatic gas, as it proceeds from the mixture of muriate of soda, sulphuric acid, and manganese, through a solution of caustic potash. This may be done by means of Woulfe's apparatus, using only one three necked bottle in addition to the balloon. The solution, when saturated with the gas, may be gently evaporated; and the first products only of crystals are to be reserved for use. Their properties are the following.

A. *They have the form of shining hexaedral laminal or rhomboidal plates.*

B. *One part of the salt requires 17 of cold water for solution; but 5 parts of hot water take up 2 of the salt.*

C. *When the oxygenated muriate is submitted to distillation, in a retort, it first fuses, and on a farther increase of temperature yields oxygenous gas of great purity.* A hundred grains of salt afford 75 cubic inches of gas.

D. *The oxygenated muriate of potash has no power of discharging vegetable colours;* but the addition of a little sulphuric acid, by setting the oxygenated acid at liberty, devellopes this property.

E. *The salt is decomposed by the stronger acids as the sulphuric and nitric acids.* This will be proved by dropping a few grains of the salt into a little strong sulphuric acid. A strong smell will arise, and, if the quantities be sufficiently large, an explosion will ensue. The experiment should, therefore, be made with caution.

F. *This salt exerts powerful effects on inflammable bodies.* (a) Rub two grains into powder in a mortar, and add one grain of sulphur. Mix them very accurately by gentle triture, and then, having collected the mixture to one part of the mortar, press the pestle down upon it suddenly and forcibly. A loud detonation will ensue. Or if the mixed ingredients be wrapped in some strong paper, and then struck with a hammer, a still louder report will be produced.

(b) Mix five grains of the salt with half the quantity of powdered charcoal, in a similar manner. On triturating the mixture strongly it will inflame, but not with much noise.

(c) Mix a small quantity of sugar with half its weight of the salt, and on the mixture pour a little strong sulphuric acid. A sudden and vehement inflammation will be produced. This experiment, as well as the following, requires caution.

(d) To one grain of the powdered salt in a mortar, add about half a grain of phosphorus. The phosphorus will detonate on the gentlest triture, with a very loud report. The hand should be covered with a glove in making this experiment, and care should be taken that the phosphorus, in an inflamed state, does not fly into the eyes.

(e) Oxygenated muriate may be subsituted for nitre in the preparation of gun powder; but the mixture of the ingredients requires great circumspection. It may be proper, also, to state, that this salt should not be kept mixed with sulphur in considerable quantity, such mixtures having been known to detonate spontaneously.

OXYGENATED MURIATE OF SODA.

This salt has no remarkable properties. It differs from the combination of this acid with potash, in attracting moisture from the atmosphere.

With ammonia, the oxygenated muriatic acid does not afford any combination; but decomposes this alkali, when brought into contact with it, whether in a gaseous or liquid state. Westrumb has even asserted that when liquid ammonia is poured into a vessel filled with oxygenated muriatic gas, an inflammation ensues. This appearance, however, I could never produce. The decomposition of ammonia, by oxygenated muriatic acid, is best exhibited, by passing the gas through a bottle filled with a watery solution of ammonia, and having two openings, from one of which a bent tube passes to the pneumato-chemical apparatus, while the other receives the tube that brings the acid gas. The gas, that is produced, will be found to be azotic. The theory of this decomposition will be explained on a subsequent occasion.

This property of ammonia renders it extremely useful in correcting the offensive vapours of the gas, which are sometimes accidentally set at liberty, in places where it is prepared. And when suffocation threatens to come on, in consequence of the fumes of this acid, the most effectual remedy is to hold a stopper, moistened with ammonia, to the mouth and nostrils.

NITRO-MURIATIC ACID.

This acid is a compound of the nitric and muriatic acid, and may be formed by mixing two parts of nitric acid with one of muriatic, and by several other processes, which are pointed out in every elementary book. Its most distinguishing property, that of dissolving gold, will be described hereafter.

ART. XV. PHOSPHORUS—PHOSPHORIC ACID—PHOSPHATES.

1. *Phosphorus is an inflammable substance, and is known by the following characters.*

A. It has generally a flesh red colour; but when carefully purified, may be obtained as free from colour, and as transparent, as bleached wax when melted.

B. It is so soft that it readily yields to the knife.

C. It melts with a very gentle heat. To shew this, it must be covered with water, to prevent it from inflaming.

D. In the atmosphere, it emits a white smoke, and peculiar smell; and a faint and beautiful light arises from it.

2. *Phosphorus is inflamed by the application of a very gentle heat.* According to Dr. Higgins, a temperature of 60° is sufficient to set it on fire, when perfectly dry. It burns with a very brilliant light, a white smoke, and a suffocating smell.

3. *It may be set on fire by friction.* Rub a very small bit between two pieces of brown paper; the phosphorus will inflame, and will set the paper on fire also.

4. *In oxygenous gas it burns with a very beautiful light;* and also in nitrous oxyd, and in oxygenated muriatic acid.

5. *Phosphorus is volatile.* Hence it may be raised by distillation; but to prevent its taking fire on the application of heat, the retort should previously be filled with azotic or hydrogen gas, and the mouth of the retort must be immersed in water. By distillation in this mode, phosphorus is rendered much purer.

6. *Phosphorus may be oxygenated in various modes.*

A. By mere exposure to atmospheric air. Let a stick of phosphorus be placed in a funnel, the pipe of which terminates in an empty bottle. The phosphorus will be slowly oxygenated, and after some time will be wholly changed into an acid, which will fall into the bottle in a liquid state.

B. By combustion in oxygenous gas or atmospheric air. When burnt in this manner, every hundred parts of phosphorus according to Lavoisier, gain an addition of 154. See the account of this experiment, in the 5th chapter of his elements.

C. By the nitric acid. If phosphorus be added by little at once to nitric acid, the nitric acid is decomposed, and its oxygen, uniting with the phosphorus, constitutes phosphoric acid.

D. A similar effect is produced by oxygenated muriatic acid, in a liquid state. The operation of this acid, in a gaseous form, is described, page 72, E.

Accordingly as the phosphoric acid is differently prepared, its degree of oxygenation differs; and its properties are found to vary proportionably. That formed by the spontaneous oxygenation of phosphorus in air, is termed phosphoreous acid, as being oxygenated in an inferior degree; and its compounds are called phosphites; but these last, it may be observed, can scarcely be obtained, because the phosphoreous acid, when combined with alcalis, acquires an addition of oxygen during evaporation.

PHOSPHORIC ACID.

This acid may be obtained from bones, by processes detailed in every elementary book.

A. *It exists in a solid state,* in which it may be obtained by evaporation, and fusion in a crucible.

B. *It is not volatile, nor capable of being decomposed by heat only.*

C. *When distilled in an earthen retort with powdered charcoal, it is decomposed ;* its oxygen, uniting with the carbon, forms carbonic acid, and the phosphorus rises in a separate state. This is the usual and best mode of obtaining phosphorus.

D. *Phosphoric acid unites with the different alcalis, and forms a class of salts termed phosphates*—of these the phosphate of soda is the most important one, since its introduction into medicine by Dr. Pearson ; and the phosphate of ammonia is occasionally used as a flux for the blow-pipe.

Another combination of phosphorus, whose properties render it a fit subject for amusing experiments, is

THE PHOSPHORATED HYDROGENOUS GAS.

1. *This gas may be procured,* by boiling in a retort a little phosphorus with a solution of pure potash. The water is decomposed ; its oxygen, uniting with the phosphorus, forms phosphoric acid, which combines with the alcali ; while the hydrogen dissolves another portion of phosphorus constitutes phosphorated hydrogen gas. In preparing this gas, the body of the retort should be filled as nearly as possible with the alcaline solution, otherwise the gas, when produced, will inflame and diminish the air within theretort, and the water will ascend from the trough.

2. The properties of this gas are the following.

A. *It takes fire immediately on coming into contact wih the air.* This may be shewn by letting it escape into the air as it issues from the retort, when a very beautiful appearance will ensue.

B. *When mixed suddenly with oxygen gas, it detonates.*—This experiment should be made cautiously.

C. *The same phenomena ensues on mixing it with oxygenated muriatic acid gas, or with nitrous oxyd.*

Phosphorus is also soluble in oils; and, when thus dissolved, forms what has been called liquid phosphorus, which may be rubbed on the face and hands without injury. It dissolves, too, in ether; and a very beautiful experiment consists in pouring this phosphoric ether in small portions, and in a dark place, on the surface of hot water.

The phosphoric matches consist of phosphorus extremely dry, minutely divided, and perhaps a little oxydated. The simplest mode of making them is to put a little phosphorus, dried by blotting paper, into a small vial; heat the vial, and when the phosphorus is melted, turn it round, so that it may adhere to the sides. Cork the vial closely, and it is prepared. On putting a common sulphur match into the bottle, and stirring it about, the phosphorus will adhere to the match, and will take fire when brought out into the air.

ART. XVI. BORACIC ACID AND ITS COMBINATIONS.

The Boracic acid is very rarely found native, and is generally the result of chemical operations. Its properties are as follow.

A. *It subsists in a solid state.*

B. *Unlike acids in general, it is not distinguished by a sour taste;* yet it reddens vegetable blue colours, and effervesces with carbonated alcalis.

C. *It is very sparingly soluble in water.*

D. *It is volatile, and capable of being sublimed.*

E. *It dissolves in small proportion in alcohol, and the solution burns with a beautiful green flame.*

F. *It combines with alcalis.* The most important of its combinations is that with soda, known commonly by the name of borax. From this it may be separated by adding sulphuric acid, which forms sulphate of soda, a salt much more soluble than the boracic acid, and therefore easily separable from it.

G. *The borate of soda* contains an excess of alkali, and hence changes vegetable blue colours to green. On the application of a strong heat, it swells and loses its water of crystallization, and, on a further increase of heat, it melts into a glass, which is perfectly transparent when cold.

ART. XVII. EARTHS.

LIME.

1. *Its external qualities.* These may be exhibited in common quicklime, such as is employed for the purposes of building or agriculture. In the same state, also, it is sufficiently pure for demonstrating its chemical properties; but when used for purposes of the latter kind, it should be fresh burnt from the kiln.

2. *Relation of lime to water.*

A. Lime absorbs water very rapidly; with considerable heat, and noise. This may be shewn by sprinkling a little water on some dry quicklime. The above mentioned phenomena will take place, and the lime will fall into powder. The degree of heat produced is even sufficient to set fire to some inflammable bodies. When a sufficient quantity of water has been added to reduce lime into a thin paste, this is called milk or cream of lime.

B. Lime absorbs moisture from the atmosphere, and falls gradually into powder, as when slaked in the foregoing manner.

C. Lime is very sparingly soluble in water, and when thus dissolved, forms what has been termed lime water. This solution tastes of lime; turns vegetable blues to green; and unites with oil, forming an imperfect soap. To prepare the solution, lime is to be slaked to a thin paste, and a sufficient quantity of water afterwards added.—The mixture is to be stirred repeatedly; the lime allowed to settle; and the clear liquor decanted for use.

3. *Relation of lime to inflammable substances.*

A. Lime unites with *sulphur*, both in the dry and humid ways. Mix powdered lime with half its weight of sulphur, and expose them to heat in a covered crucible. The product will be a sulphuret of lime, which will be found to have the property of diminishing atmospheric air, and absorbing oxygenous gas, like other compounds of the same kind. Or boil in a glass vessel, with a sufficient quantity of water, some powdered sulphur and powdered lime. The lime and sulphur will unite; and a liquid sulphuret of lime will be obtained.

B. Another interesting combination of lime is that which it forms with *phosphorus*, or the phosphuret of lime discovered by Dr. Pearson. Take a glass tube about 12 inches long, and $\frac{1}{3}$ of an inch diameter, sealed hermetically at one end. Let this tube be coated with clay, except within about half an inch of the sealed end. Put first into it a drachm or two of phosphorus, cut into small pieces; and then fill the tube with small bits of fresh burnt lime, of the size of split peas. Stop the mouth of the tube loosely with a little paper, in order to prevent the free access of air. Next, heat to rednesss that part of the tube which is coated with clay, by means of some charcoal; and, when the lime may be supposed to be red hot, apply heat to the part containing the phosphorus, so as to sublime it, and to bring the vapour of it into contact with the heated lime. The lime and phosphorus will unite, and will afford a compound of a reddish brown colour. This phosphuret of lime has the remarkable property of decomposing water, at the common temperature of the atmosphere. Drop a small piece of it into a wine glass of water, and in a short time bubbles of phosphorated hydrogen gas will be produced; which, rising to the surface will take fire and explore.

4. *Relation to acids.*

A. Lime has a strong attraction for *carbonic acid*, but not when perfectly dry. (a) If a piece of dry quicklime be passed into a jar of carbonic acid gas over mercury, no absorption ensues. But invert a bottle, filled with carbonic acid gas, over a mixture of lime and water, of the consistence of cream; and a rapid absorption will be observed, especially if agitated.

(b) Let a jar or bottle, filled with carbonic acid, be brought over a vessel of lime water.—On agitating the vessel, a rapid diminution will ensue, and the lime water will become milky.

(c) Leave a shallow vessel of lime water exposed to the air. A white crust will form on the surface; and this, if broken, will fall to the bottom, and be succeeded by another. This is owing to the absorption of carbonic acid gas from the air, by the lime, which is thus rendered insoluble in water.

(d) Lime, when exposed to the atmosphere, first acquires moisture and then carbonic acid; and in a sufficient space of time, all the characters distinguishing it as lime disappear.

(e) Lime has an extremely strong affinity for carbonic acid, which enables it to take this acid from other substances. Thus carbonates of alkalis are decomposed by lime. Slake a given quantity of lime into a paste with water, and add an equal weight of carbonate of potash or soda. Stir the materials together, and wash off the soluble part. The carbonic acid combines with the lime, and the alcali is obtained, in a state of solution, perfectly free from carbonic acid. This is the ordinary mode of depriving the alkalis of carbonic acid.

(f) Lime, when saturated with carbonic acid, forms carbonate of lime. Of this, common chalk may be taken as a fair sample; and in all saturated carbonates of this earth, we find the characters of insipidity and insolubility in water.

(g) Carbonate of lime is decomposed by a strong heat. If distilled in an earthen retort, carbonic acid gas is obtained, and lime remains in the retort, in a pure or caustic state.

(h) It is, also, decomposed by the stronger acids. Put some chalk into a glas bottle, and pour on it diluted sulphuric acid. The sulphuric acid will unite with the lime, and the carbonic acid will be set at liberty.

(i) Carbonate of lime, though scarcely dissolved by pure water, is soluble in water saturated with carbonic acid. The most striking method of shewing this is the following. Add to a jar, about one fourth filled with lime water, a very small quantity of water saturated with carbonic acid. An immediate milkiness will ensue, because the carbonic acid forms with the lime an insoluble carbonate. Add gradually more of the water, impregnated with carbonic acid, shaking the jar as these additions are made. At last the precipitate is redissolved. Hence it appears that lime, with a small proportion of carbonic acid, is insoluble, and, with a still larger, again becomes again soluble in water.

(k) The carbonate of lime, dissolved by an excess of carbonic acid, is again separated, when this excess is driven off. Thus, boiling, which expels the superabundant acid, precipitates the carbonate. Caustic or pure alcalis, also, produce a similar effect.

B. Combination of lime with *sulphuric acid*, or sulphate of lime.

(a) The sulphuric acid expels the carbonic from lime, and we obtain a sulphate of lime.

(b) This substance is very insoluble requiring 500 parts of water at the ordinary temperature, for solution.

(c) It is insipid and free from smell.

(d) It is fusible by a gentle heat.

(e) It is decomposed, when boiled with a solution of carbonate of alkali, a double exchange of principles ensuing.

C. Combination of lime with *nitric acid*. This compound forms a deliquescent salt, of little importance.

D. Combination with *muriatic acid*.

(a) Lime may be brought into union with muriatic acid by dissolving, in the liquid acid, either the pure earth or the carbonate.

(b) The muriate of lime may, also, be formed by boiling together, in a retort, the muriate of ammonia, and lime with water. The lime sets the alkali at liberty, which may be collected in a liquid form in a receiver, and the muriate of lime remains in the retort.

Or it may be obtained from muriate of ammonia and carbonate of lime, in which case we obtain the carbonate of ammonia. For this purpose, powdered sal ammoniac, and dry carbonate of lime, may be mixed together, and put into a glass or earthen retort with a long neck. This neck may terminate in a large glass globe, which should be kept cool by moistened cloth. The carbonate of ammonia will pass over in a solid form, and will condense on the inner surface of the globe.

(c) Muriate of lime, when evaporated to the consistence of a thick syrup, forms on cooling an imperfectly crystallized mass, which may be powdered, and reserved for use.

(d) It powerfully attracts moisture from the air, and hence should be kept closely stopped up.—Like all other deliquescent salts, it is very soluble in water.

(e) The most remarkable property of this salt is its power of generating intense cold, when mixed with snow. This property was discovered some years ago by M. Lovitz, of St. Petersburgh; and has been since applied, in this country, to the congelation of mercury on a very extensive scale.—The proportions, which answer best, are about equal weights of the salt finely powdered, and of fresh fallen and light snow. On mixing these together, and immersing a thermometer in the mixture, the mercury sinks with great rapidity. For measuring exactly the cold produced, a spirit thermometer should be employed. A few pounds of the salt are sufficient to congeal a large mass of mercury. By means of 13 lbs. of the muriate, and an equal weight of snow, Messrs. Pepys and Allen froze 56 lb. of quicksilver into a solid mass. The mixture of the whole quantity of salt and snow, however, was not made at once; but part was expended in cooling the materials themselves.

On a small scale, it may be sufficient to employ 2 or 3 pounds of the salt. Let the mercury, in a very thin glass retort, be immersed first in a mixture of one pound of each; and when this has ceased to act, let another mixture be prepared. The second will never fail to congeal the quicksilver.

The salt thus expended may be again evaporated, and crystallized for future experiments.

The reader, who wishes for further particulars respecting these experiments, is referred to the Philosophical Magazine, vol. 3, p. 76.

E. Lime unites with the *phosphoric acid.*

The phosphate of lime forms a large part of animal bones, which, to obtain their earthy part, must be burnt till perfectly white.

The phosphate of lime is an insipid, and insoluble salt, or rather earth. It is decomposed by sulphuric acid, which sets the phosphoric at liberty. This is the common mode of procuring phosphoric acid from bones.

F. *Fluate* of lime. This is, also, an extremely insoluble compound. The fluor spar, found in Derbyshire and other places, is the only known source of it.—Sulphuric acid decomposes the fluate, and when distilled with this acid, the fluoric acid rises, and may be collected in a leaden receiver.

This acid, when perfectly pure, subsists in the state of a gas, condensible by water. It is the only acid that acts on siliceous earth, and on glass; and owing to the latter property, it may be employed as a mean of etching on glass, as copper is engraved by the nitric acid. See Wilson's paper in Nicholson's Journal, vol. 2, p. 60.

MAGNESIA.

1. *Pure magnesia is white; perfectly tasteless; insoluble in water; and excites no heat when mixed with water.*

2. When exposed to *carbonic acid gas* with the addition of a little water, the gas is absorbed, but much more slowly than by lime.

Carboriate of magnesia effervesces with acids, its carbonic acid being expelled. When exposed to heat, its carbonic acid is also separated, and the magnesia remains pure. In this state it is termed *calcined magnesia.*

Carbonic acid having a stronger affinity for lime, than for magnesia, when carbonate of magnesia is digested with lime water, the lime attracts the carbonic acid from the magnesia, and is rendered insoluble. Hence the taste of lime water is totally destroyed by carbonate of magnesia.

3. *Magnesia combines with sulphuric acid.* When concentrated sulphuric acid is poured on pure magnesia a great degree of heat is produced; and when the two ingredients are perfectly pure, ignition even ensues.

The combination of magnesia with sulphuric acid affords a neutral salt, termed *sulphate of magnesia.* This salt forms small crystals, which have a cool bitter taste, and dissolve readily in water. It is decomposed by pure and carbonated alkalis. If a solution of a pound of the salt, in a pound of boiling water, be mixed, suddenly, with a solution of an equal quantity of carbonate of potash, in the same weight of water, a double decomposition ensues; and the two fluids instantly form a thick solid coagulum. This, when well washed with boiling water, affords the carbonate of magnesia.

The compounds of magnesia with other acids have no properties, that render it necessary to describe them in this place.

ALUMINE, OR ARGILL.

1. *Pure alumine may be obtained* by precipitating a solution of alum in water, by the crystallized carbonate of potash.

2. *It has the following qualities.* It adheres to the tongue; when moistened with water, it forms a cohesive mass; and when heated to redness, it shrinks considerably in bulk, and becomes very hard. It dissolves slowly in all acids. The only combination of importance, is that which it forms with the sulphuric acid.

3. *With sulphuric acid it affords sulphate of alumine, or alum.*

Sulphate of alumine is distinguished by the following characters.

A. It has a sweetish astringent taste.

B. It dissolves in water, 5 parts of which, at 60°, take up one of the salt, but hot water dissolves it in greater abundance.

C. This solution reddens vegetable blue colours; which proves the acid to be in excess.

D. When mixed with a solution of carbonate of potash, an effervescence is produced by the uncombined acid, which, also, prevents the first portions of alkali, that are added to a solution of sulphate of alumine, from occasioning any precipitate.

E. On a further addition of alkali, the alumine is precipitated.

F. Sulphate of alumine, when heated, swells up; loses its regular form; and becomes a dry spungy mass.

G. It is decomposed by charcoal, which combines with the oxygen of the sulphuric acid, and leaves the sulphur attached to the alumine. A combination of alumine, sulphur, and charcoal forms the *pyrophorus of Homberg*. To prepare this, equal parts of powdered alum and brown sugar are melted over the fire, and are kept stirring, till reduced to dryness. The mixture is then to be introduced into a common vial, coated with clay, and to which a glass tube, open at each end, is luted, to allow the escape of the gasses that are produced. The vial must then be set in the fire, surrounded by sand, in a crucible. Gas will issue from the open end of the tube, and may be inflamed by a lighted paper. When this ceases to escape, the crucible may be removed from the fire; and a little moist clay pressed down upon the open end of the tube, to prevent the access of air to the contents of the vial.

The pyrophorus thus formed, is a black and very light powder, which instantly takes fire, when poured out of the bottle into the air; and inflames suddenly in oxygenous gas.

SILEX.

1. Siliceous earth, or silex, may be obtained, tolerably pure, from flints, by the following process. Procure some common gun-flints, and calcine them in a crucible, in a red heat. By this treatment, they will become brittle, and easily reducible to powder. Mix them, when pulverized, with three or four times their weight of carbonate of potash, and let the mixture be fused, in a strong red heat, in a crucible. We shall thus obtain a compound of alkali and siliceous earth. Dissolve this in water; filtre the solution; and add to it diluted sulphuric or muriatic acid. An immediate precipitation will ensue; and, as long as this continues, add fresh portions of acid. Let the precipitate subside; pour off the liquor that floats above it; and wash the sediment with hot water, till it comes off tasteless. Then dry it.

2. Siliceous earth, as thus obtained, has the following qualities.

A. It is perfectly white and tasteless.

B. When mixed with water, it does not form a cohesive mass like alumine; and has a dry and harsh feel to the fingers.

C. It is not acted on by any acid, except the fluoric.

D. When prepared in the foregoing manner, and very minutely divided, silex is soluble in a solution of pure potash. In the aggregated state of flints, however, it is perfectly insoluble in this way, an excellent illustration of the principle laid down, Art. I. No. 3.

E. When mixed with an equal weight of carbonate of potash, and exposed to a strong heat in a furnace, it forms a glass, insoluble in water, and identical, in all its properties, with the glass commonly manufactured. It is owing to the siliceous earths, which it contains, that glass is decomposed by the fluoic acid. Glass, however, has occasionally other ingredients, besides the two that have been mentioned.

F. With a larger proportion of alcali, as three or four parts to one of silex, this earth affords a compound called by Dr. Black, *silicated alkali*. This compound is soluble in water; and affords a good example of the total change of the properties of bodies by chemical union; for in a separate state, no substance whatever is more difficult of solution than silex. The solution of silicated alkali was formerly termed *liquor silicum*, or *liquor of flints*. Acids seize the alcali, and precipitate the silex, which is even separated, by mere exposure to the atmosphere, in consequence of the absorption of carbonic acid, by the alcali.

BARYTES.

1. Barytes, in a pure form, has a sharp, caustic taste; changes vegetable blues to green; and serves as the intermedium between oil and water.

2. It is readily dissolved by boiling water; and the solution, on cooling, shoots into regular crystals, which have the form of flattened hexagonal prisms, having two broad sides with two intervening narrow ones, and terminated at each end by a quadrangular pyramid.

3. These crystals are so soluble, as to be taken up, when heated, merely by their own water of

crystallization. When exposed to a stronger heat, they swell and foam, and leave a dry white powder. At 60°, an ounce of water dissolves only 25 grains of the crystals.

4. Pure barytes has a very strong affinity for *carbonic acid.*

A. Let a solution of pure barytes be exposed to the air. It will soon acquire a pellicle, like lime water, because barytes, when saturated with carbonic acid, is rendered insoluble.

B. Blow, by means of a quill or glass tube, the air from the lungs, through a solution of pure barytes. It will instantly become milky.

C. With a solution of pure barytes, mix a little water impregnated with fixed air. The barytic solution will be immediately precipitated.

D. Barytes, combined with carbonic acid, is termed carbonate of barytes. If this combination be found in the earth, it is termed native carbonate of barytes; if formed by chemical processes, artificial carbonate.

E. The carbonate of barytes is tasteless; insoluble in water; and does not change vegetable blues.

F. Carbonate of barytes is decomposed by exposure to an intense heat. Its carbonic acid is separated, and we obtain the earth in a pure form, as decribed, No. 1.

G. Carbonate of barytes is decomposed by the stronger acids, as the sulphuric, nitric, and muriatic. The two last afford salts, that dissolve readily in water.

5. With sulphuric acid, barytes forms the *sulphate of barytes.*

A. To a solution of pure barytes, add sulphuric acid. A white precipitate will appear, which is the sulphate of barytes.

B. The same compound is formed by adding sulphuric acid to carbonate of barytes; or to a solution of muriate or nitrate of barytes.

C. The sulphate of barytes is one of the most insoluble substances that chemistry presents, requiring, for solution, 43000 times its weight of water.

D. Barytes has a stronger affinity, than any other body, for sulphuric acid.

E. Owing to these properties, the solution of pure barytes, and of the nitrate and muriate of barytes, are excellent and very sensible tests of sulphuric acid, and of all its combinations. Let a single drop of sulphuric fall into a wine quart of pure distilled water. On adding a few drops of one of the foregoing solutions of barytes, a precipitation will ensue.

F. Sulphate of barytes is decomposed by carbonate of potash. Boil the powdered sulphate, with a solution of twice or three times its weight of carbonate of potash. The carbonic acid will pass to the barytes, and the sulphuric to the potash.

STRONTITES.*

1. Strontites, in a state of purity, has a caustic taste; changes vegetable blues to green; and unites oil with water.

2. It dissolves very readily in boiling water; and the solution, on cooling, shoots into regular crytals. These are thin quadrangular plates, sometimes square, oftener parallelograms; not exceeding in length, and not equaling in breadth, quarter of an inch. Of these crystals, water at 60° takes up only

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* I use this name after Dr. Hope, who first established the peculiar nature of this earth (though before suggested by Dr. Crawford); and who discovered its very interesting properties in a state of purity, as well as those of barytes. (See his memoir in the fourth vol. of Edinburgh Transactions).

25 grains. When exposed to heat they undergo the same changes as those of barytes.

3. Pure strontites strongly attracts carbonic acid. This may be shewn by experiments similar to these on barytes. Indeed, the properties of this earth are so similar to those of barytes, that every thing, which has been said of the latter, will apply to strontites.

4. The characteristic distinctions, between the two earths, are derived from the different forms of crystals, and different solubility, of the salts, afforded by their union with the same acid. The salts with base of strontites, are always much more soluble than barytic salts. The salts of strontites have, also, the singular property, when dissolved in alcohol, of tinging its flame, a deep blood red colour.

The remaining earths I omit; because they very seldom occur, and are not likely to become the subjects of experiments to the chemical student. They may be found enumerated and described, in Mr. Parkinson's Chemical Pocket Book.

ART. XVIII. METALS IN GENERAL.

The most interesting quality, general to all the metals, is their relation to oxygen.

1. Some metals are oxydated merely by exposure to atmospherical air, at the ordinary temperature. Such are arsenic and manganese.

2. Other metals are oxydated by exposure to air; but not without a considerable increase of their temperature. Iron, zinc, copper, tin, &c., for example, when made red hot, lose their metallic brilliancy; and are converted into oxyds of different colours.

3. Other metals are not oxydated, even by the combined operation of air and of an increased temperature; such are gold and platina.

4. But even these metals (and all others more readily) are oxydated by acids. Thus the nitro-muriatic and oxygenated muriatic acids first oxydate gold, and then dissolve the oxyd. Iron is oxydated by dilute sulphuric acid, the metal attracting oxygen from the water; and the oxyd of iron, thus produced, is dissolved by the acid.

5. All metals, that are oxydated by air, undergo the same change, much more readily, in oxygenous gas.

6. Some metals are oxydated by water, both at the ordinary temperature of the air, and in high temperatures. Thus iron filings, moistened with water, become oxyded, in consequence of its decomposition; and the vapour of water, passed over red hot iron, is rapidly decomposed, and the iron gains 28 per cent. of oxygen. Other metals, as gold, silver, &c., are not oxyded by water, in any temperature.

7. All metals, in consequence of oxydation, acquire weight. This may be shewn, by keeping a given weight of iron-wire red hot, for some time, in the bowl of a common tobacco-pipe; taking care that dust or ashes do not fall into it.

8. Metals retain oxygen with different degrees of force. Some oxyds, (that of mercury for instance) are reduced to a metallic state by heat only; but others (as that of iron) require the addition of some substance, that attracts oxygen more strongly than the metal retains it. Thus, to reduce the oxyd of iron, charcoal must be added.

9. Metals are precipitated from acids, by each other, not in the form of oxyds, as they are separated by alkalis, but in a metallic form. Thus when a polished plate of iron is immersed in a solution of sulphate of copper, the copper appears, on the surface of the iron, in the state of a metallic coating.

In this case, the iron attracts the oxygen from the copper; and, as no metal is soluble in an acid, unless when combined with oxygen, the copper is precipitated.

Art. XIX. Gold.

1. Gold may be melted, by a moderate red heat.

2. Pure gold is not oxyded by exposure to heat, with the access of air.

3. It is not acted on, by sulphuric, nitric, or muriatic acid, even at the boiling temperature.

4. It is dissolved, however, by nitro-muriatic acid, and also by the oxygenated muriatic acid. A thin sheet of gold introduced into the latter acid, when in a gaseous state, takes fire and burns.

5. The nitro-muriate of gold gives a purple stain to the skin, and is susceptible of crystallization.

6. It is decomposed by alkalis. A solution of pure ammonia separates an oxyd of gold, and a portion of ammonia, uniting with the oxyd, forms a compound, which detonates very loudly in a gentle heat, and is termed *fulminating gold*. It may be exploded by laying a little on a shovel, and applying a very gentle heat over a fire.

7. The solution of gold is, also, decomposed, by certain combustible bodies, which attract the oxygen from the gold and render it insoluble. (A) Into a dilute solution of gold*, contained in a glass jar, put a long narrow slip of charcoal, and expose the whole to the direct light of the sun. The gold will be revived, and will appear on the charcoal in a metallic

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* The nitro-muriate of gold, employed in these experiments, should be previously evaporated to dryness, in order to expel the superfluous acid, and afterwards dissolved in distilled water.

state, exhibiting a very beautiful appearance. The same change, ensues without light; if the solution be exposed to a temperature of 212°.

B. Moisten a piece of white taffeta ribband, with the dilute solution of gold, and expose it to a current of hydrogen gas from iron filings and dilute sulphuric acid. The gold will be reduced, and the ribband will be gilt with the metals. By means of a camel's hair pencil, the gold may be so applied as to exhibit regular figures, when reduced.

C. The same experiment may be repeated substituting phosphorated hydrogen for common hydrogen gas. The reader who wishes for a detail of various experiments of a similar kind, may consult an Essay on Combustion by Mrs. Fulhame, published by Johnson, London, 1794; and also Count Rumford's paper in the Phil. Trans. 1798, p. 449.

8. When a sheet of tin is immersed in a solution of nitro-muriate of gold, the oxyd of gold is precipitated of a purple colour, and when scraped off and collected forms the purple powder of cassius, much employed in enamelling. The same precipitate is obtained by mixing a solution of gold with a solution of tin in muriatic acid.

9. Gold is precipitated from its solvent by ether; but the oxyd of gold is instantly re-dissolved by the ether; and forms the etherial solution of gold.

10. Sulphurets of alkalis unite with gold both in the dry and humid way. To exhibit this, some leaf gold may be digested, with heat, in a solution of sulphuret of potash.

ART. XX. PLATINA.

1. Platina is a white metal, resembling silver in colour, but greatly exceeding it, and indeed all other metals, in specific gravity.

2. It is, of all metals, the most difficult of fusion. It may be melted, however, by a blow pipe, with the aid of oxygenous gas.

3. It is not oxyded, when exposed, red hot, to the air, for a considerable length of time.

4. It dissolves in no acid, except the nitro-muriatic and oxygenated muriatic acids.

5. These solutions are decomposed by alkalis, and, also, by a solution of muriate of ammonia, which last has no effect on solutions of gold.

ART. XXI. SILVER.

1. Silver, also, is a metal, which is difficultly oxyded by the concurrence of heat and air.

2. It is acted on by sulphuric acid, which, when assisted by heat, oxydates, and partly dissolves it.

3. Nitric acid dissolves it with a disengagement of nitrous gas; and the solution, when evaporated, shoots into regular crystals. If the silver be pure, the solution is colourless, otherwise it has a green hue.

4. Muriatic acid does not act on silver. Yet this acid takes silver from others. Thus when muriatic acid is added to nitrate of silver, a white curdy precipitate falls down, in great abundance. This precipitate is decomposed by light; for when exposed to the direct rays of the sun, its colour becomes gradually darker. If fused by a gentle heat, it forms a semi-transparent mass of the consistence of horn, called luna cornea, or horn silver.

5. A solution of nitrate of silver stains animal substances a deep black. Hence it has been applied to the staining of human hair; but when thus employed, it should be very much diluted, and used with great caution, on account of its corrosive quality.

6. The solution of nitrate of silver, when evaporated, forms regular crystals. These crystals fuse, when heated; and being poured, in this state, into moulds, form the common lunar caustic.

7. Nitrate of silver is decomposed by other metals. Thus the surface of a plate of copper, to which a little of the solution is applied, becomes plated over with silver. If a little mercury be poured into a bottle filled with this solution, and the bottle be left some time undisturbed, the silver is precipitated in a beautiful form, resembling the branches of a tree, and which has been termed *Arbor Dianæ*. (See Nicholson's Chemistry, page 249).

8. Precipitate nitrate of silver by lime water; and wash and dry the precipitate. Let this be afterwards put into a vessel of liquid ammonia. It will then assume the form of a black powder, from which the fluid is to be decanted, and the black substance left to dry in the air. This is the celebrated compound termed *fulminating silver*, which detonates with the gentlest heat, and even with the slightest friction. When once prepared, no attempt must be made to inclose it in a bottle; and it must be left undisturbed, in the vessel in which it was dried. Great caution is necessary in the preparation of this substance, and in making experiments on it. It even explodes, when moist, on the gentlest friction.

9. Silver is acted on by sulphurets of alcalis, and by sulpurated hydrogen gas. Both these substances blacken silver, when exposed to their operation; and the common tarnishing of silver has been traced to a similar cause.

ART. XXII. MERCURY.

1. Mercury, or quicksilver, is the only one of the

metals, that retains a fluid form, at the ordinary temperature of the atmosphere.

2. When its temperature is reduced to about 40°, below zero of Faht., it assumes a solid form. This is a degree of cold, however, that only occurs in high northern latitudes; and in this country quicksiver can only be exhibited in a solid state by means of artifical mixtures. See page 85.

3. At about 600° of Faht., mercury boils, and is changed into vapour. Hence it may be driven over by distillation, and may thus be purified, though not accurately, from the admixture of other metals.

4. Mercury is not oxydated, when pure, at the ordinary temperature of the atmosphere; but when boiled for a considerable time, in a glass vessel, with a long narrow neck, it is converted into a reddish brown oxyd.

5. Mercury is dissolved by hot sulphuric acid, and forms a white salt. When this is washed with boiling water, a yellow substance is obtained, called turbith mineral.

6. Mercury is dissolved by nitric acid, and nitrous gas is disengaged. The properties of the solution vary, accordingly as it is made with or without heat, the mercury, in the former case, being more highly charged with oxygen. When the nitrate of mercury is evaporated to dryness, and made very hot, it is changed into a bright red oxyd, which still contains a small portion of acid.

7. Mercury is the basis of a new fulminating compound, lately discovered by Mr. E. Howard. To prepare this powder, 100 grains (or a greater proportional quantity not exceeding 500) are to be dissolved, with heat, in a measured ounce and half of nitric acid. The solution, being poured cold upon two measured ounces of alcohol, previously

introduced into any convenient glass vessel, a moderate heat is to be applied, till effervescence is excited. A white fume then begins to undulate on the surface of the liquor; and the powder will be gradually precipitated, on the cessation of action and re-action. The precipitate is to be immediately collected on a filtre; well washed with distilled water; and cautiously dried in a heat, not exceeding that of a water bath. The immediate washing of the powder is material, because it is liable to the re-action of the nitric acid; and while any of that acid adheres to it, it is very subject to the action of light. From 100 grains of mercury, about 120 or 130 of the powder are obtained. (See Phil. Trans. 1800, p. 214). This powder has the property of detonating loudly in a gentle heat, or by light friction.

8. Mercury is not dissolved by muriatic acid; but may be brought into union with this acid, by double elective affinity. Thus when sulphate of mercury and muriate of soda, both well dried, are mixed and exposed to heat, we obtain a combination of oxyd of mercury and muriatic acid. This compound is the *corrosive sublimate* of the shops. The same components, with a still further addition of mercury, constitute an insoluble substance called *calomel*.

9. The oxyds of mercury are all reduced by heat alone, without the addition of any combustible substance, and afford oxygenous gas.

10. Mercury dissolves gold, silver, tin, and many other metals; and if these be combined with it, in sufficient quantity, the mercury loses its fluidity, and forms an amalgam. A solid amalgam of lead, and another of bismuth, on admixture together, have the singular property of instantly becoming fluid.

ART. XXIII. IRON.

1. Iron is oxyded by the action of air, with the aid of an increased temperature, and gains about 28 per cent. The oxyd, thus obtained, is black.

2. It is oxyded also by water, both at the ordinary temperature of the air, and in a high temperature. Iron filings, moistened with water, acquire rust and become oxyded; and the vapour of water gives up its oxygen to red hot iron, the hydrogen being liberated in an uncombined state, see p. 29.

3. Iron is attacked by most acids. The sulphuric acid, when concentrated, acts but feebly on iron, without the assistance of heat. But when diluted, the iron is first oxyded by the decomposition of the water, and this oxyd is dissolved by the acid. The solution, when evaporated, gives the *sulphate of iron*, which has the following properties.

A. It forms regular shaped crystals, of a green colour, which have an astringent taste, and dissolve readily in water.

B. From this combination, an oxyd of iron is thrown down by alcalis and by earths, varying in colour, with the kind and state of the precipitant.

C. When the iron, contained in this salt, is still farther oxyded, it becomes insoluble in the sulphuric acid, affording an example of a metal soluble only when oxyded to a certain degree. Mere exposure to air is sufficient to precipitate an oxyd of iron; and the effect is rapidly produced, by adding a little oxygenated muriate of potash to a solution of the salt.

D. The sulphate of iron is decomposed by heat alone. When distilled in an earthen retort, the sulphuric acid passes over, and an oxyd of iron remains in the retort.

4. Iron is acted on by the muriatic and nitric acids, and by the last, when concentrated, very violently, so that the acid undergoes a complete decomposition. The compounds, thus obtained, do not admit of being crystallized.

5. Iron may be united, in the way of double elective affinity, with the prussic acid.* Thus when prussiate of potash, and sulphate of iron, both in solution, are mixed together, the prussic acid and oxyd of iron quit their former combinations, and unite together. The beautiful blue precipitate is prussiate of iron.

A. Prussiate of iron is nearly insoluble in water.

B. It is not soluble in acids.

C. It is decomposed by a red heat; the prussic acid being destroyed, and an oxyd of iron remaining.

D. It is decomposed by pure alcalis and earths, which abstract the prussic acid, and leave an oxyd of iron. Thus, when pure potash is digested with prussiate of iron, its beautiful blue colour disappears; and we obtain a compound of potash and prussic acid, or a prussiate of potash.

E. When the prussiate of potash is mixed with sulphate of iron, in which the metal is as little oxyded as possible, the prussiate of iron, that is formed, is of a white colour; but gradually becomes blue, as the iron, by exposure to air, acquires more oxygen. (See Proust's Memoir, in Nicholson's Journal.)

F. The effect of a sympathetic ink may be obtained, by writing with a pen dipped in prussiate of potash. No characters will appear, till the paper is moistened with sulphate of iron, when letters of a

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* This acid will be mentioned hereafter.

prussian blue colour will be apparent. The experiment may be reversed, by writing with sulphate of iron, and rendering the characters legible by prussiate of potash.

6. When sulphate of iron is mixed with an infusion of galls, we obtain a black solution, which is a new combination of oxyd of iron with the gallic acid. This compound is the basis of inks, the other ingredients of which are chiefly added with the view of keeping this suspended.

A. Write upon paper with an infusion of galls. The characters will not be legible, till a solution of sulphate of iron is applied. This experiment may be reversed like the preceding one, No. 5, E.

B. The combination of iron, forming ink, is destroyed by pure and carbonated alkalis. Apply a solution of alcali to characters written with common ink. The blackness will disappear, and the characters will become brown, an oxyd of iron only remaining on the paper.

C. Characters, which have been thus defaced, may again be rendered legible by an infusion of galls.

D. Ink is decomposed by most acids; which separate the oxyd of iron from the gallic acid, in consequence of a stronger affinity. Hence, ink stains are removed by dilute muriatic acid, and by some vegetable acids. Hence, also, if, to a saturated solution of sulphate of iron, there be added an excess of acid, the precipitate no longer appears on adding infusion of galls.

E. Ink is decomposed by age, partly in consequence of the further oxydation of the iron, and partly, perhaps, in consequence of the decay, or escape, of the acid of galls. Hence ink-stains degenerate into iron moulds; and these last are immediately produced, on an inked spot of linen, when washed with soap, because the alkali of the soap abstracts the gallic acid, and leaves only an oxyd of iron.

F. Ink is decomposed by oxygenated muriatic acid, which destroys the gallic acid, and the resulting muriatic acid dissolves the oxyd of iron.

7. Iron is dissolved by water impregnated with carbonic acid. A few iron filings when added to a bottle of aërated water, and occasionally shaken up, impregnate the water with this metal. The solution is decomposed by boiling, and in a less degree by exposure to air.

8. Iron combines with sulphur. (A) A paste of iron filings, sulphur, and water, if in sufficient quantity, will burst into flame. (B) A mixture of one part of iron filings, and three parts of sulphur accurately mixed, and melted in a glass tube, at the moment of union, exhibit a brilliant combustion. (C) This sulphuret of iron rapidly decomposes oxygenous gas. (D) When diluted sulphuric or muriatic acid is poured on it, we obtain sulphurated hydrogen gas.

ART. XXIV. COPPER.

1. Copper is oxydated by air. This may be shewn by heating one end of a polished bar of copper, which will exhibit various shades of colour, according to the force of the heat.

2. Copper does not decompose water, even with the assistance of heat.

3. It combines with strong sulphuric acid, in a boiling heat, and affords a blue salt called sulphate of copper. (A) Sulphate of copper is a regularly crystallized salt, easily dissolved by water. (B) The solution is decomposed by pure and carbonated alkalis. The former however redissolve the preci-

pitate. Thus, on adding pure liquid ammonia to a solution of sulphate of copper, a precipitate appears, which, on a farther addition of the alkali, is redissolved, and affords a beautiful bright blue solution. (C) The sulphate of copper is decomposed by iron. In a solution of this salt immerse a polished plate of iron. The iron will soon acquire a covering of copper in a metallic state.

4. Copper dissolves readily in nitric acid, with a disengagemen of nitrous gas. The salt, resulting from this combination, has the singular property of denotating with tin. See page 5, D.

5. Copper is soluble in muriatic acid, with the aid of heat.

6 When corroded by vinegar, it forms verdigrise.

7. Copper combines with sulphur. A mixture of three parts of copper filings, and one part of sulphur, when melted in a glass tube, exhibits a combustion, more brilliant than that of iron and sulphur.

ART. XXV. LEAD.

1. Lead, when melted, and exposed to the action of the air, becomes covered with a pellicle of oxyd. By long continued exposure to heat, it is converted into oxyds of different colours. This oxydation it is difficult to exhibit on a small scale. The oxyds of lead may, therefore, be examined as they are found in the shops, in the states of minium or red lead; massicot; and litharge.

2. The oxyds of lead give up their oxygen, on the application of heat. When distilled in an earthen retort, they afford oxygenous gas; and still more readily, when distilled with the sulphuric acid.

3. Of all the acids, the nitric acts most strongly

on lead, nitrous gas being disengaged during the solution.

4. The muriatic and sulphuric acids decompose nitrate of lead, and form a difficultly soluble muriate and sulphate.

5. The oxyds of lead decompose muriate of soda. Mix two parts of finely powdered red lead with one of common salt; and form the two into a paste with water, adding more occasionally, as the mixture becomes dry. The alcali will be disengaged, and the muriatic acid will unite with the oxyd of lead. Wash off the alcali; dry the white mass; and fuse it in a crucible. It will form the pigment, called mineral or patent yellow.

6. Lead, when exposed to the vapour of vinegar, is slowly corroded into a white oxyd, or rather carbonate. This, when dissolved in distilled vinegar, and crystallized, forms acetite of lead, or sugar of lead. This acetite of lead, and indeed all the soluble salts of lead, are decomposed by sulphurated hydrogen gas. Hence characters, written with acetite of lead, become legible on exposure to sulphurated hydrogen gas.

ART XXVI. TIN.

The properties of tin must be examined in the state of block tin; what is commonly known by the name of tin, being nothing more than iron plates, with a thin covering of this metal.

1. Tin melts on the application of a moderate heat; by a long continuance of which, it is converted into a grey powder. This powder, when mixed with pure glass, forms a white enamel.

2. Tin is not oxyded by exposure to air with the concurrence of moisture, a property which is the foundation of its use in covering iron.

3. Tin is dissolved by all the three mineral acids.

4. Tin may be brought to combine with the oxygenated muriatic acid by first forming it into amalgam with mercury; triturating this with an equal weight of oxygenated muriate of mercury; and distilling the mixture. The result is a liquid, which emits dense white fumes, when exposed to the air, and was formerly termed the fuming liquor of Libavius.

5. Solutions of tin have the property of precipitating the colouring matter of vegetables, a property which will be noticed hereafter.

ART. XXVI. ZINC.

1. Zinc is melted by a very gentle heat.

2. It is rapidly oxyded by atmospherical air. When thrown into a red hot crucible, it burns with a bright light, and a white oxyd sublimes.

3. It dissolves readily in all the mineral acids. With diluted sulphuric acid, it affords the purest hydrogen gas, that can be obtained. The salt, when evaporated, shoots into regular crystals, called sulphate of zinc.

4. It detonates, when mixed with powdered nitre, and projected into a red hot crucible.

ART. XXVII. BISMUTH.

1. The proper solvent for bismuth is the nitric acid.

2. From this solution, a white oxyd is precipitated by the mere addition of water. This, when well washed, is the pigment called flake-white.

3. This oxyd of bismuth is blackened by sulphurated hydrogen gas.

4. Bismuth forms a component of the fusible mixture of metals, discovered by Sir Isaac Newton. Melt

together in a crucible eight parts of bismuth, five of lead, and three of tin; or three of bismuth, one of lead, and five of tin. The result is a compound, which will be found to melt in a heat less than that of boiling water, and which will even fuse, under the surface of hot water.

ART. XXIII. ARSENIC.

1. Arsenic, as it is to be found in the shops, occurs in the state of a white oxyd, from which the metal may be obtained by the following process. Mix two parts of the white oxyd with one part of black flux,* and put them into a crucible. Invert, over this, another crucible; lute the two together, with a little clay and sand; and apply a red heat to the lower one. The arsenic will be reduced, and will be found lining the inside of the upper crucible, in a form of metallic brilliancy.

2. Arsenic is oxyded by mere exposure to the air. It soon becomes tarnished, and loses its metallic lustre.

3. It is volatile. When laid on a heated iron, it evaporates in the form of a white smoke, and emits a strong smell of garlic.

4. It is acted on by all acids.

5. It gives a white stain to copper. Let a little of the metallic arsenic be put between two small plates of copper; bind these closely together, by iron-wire; and heat them in a fire. The inside of the copper plates will be stained white by the arsenic.

6. The white oxyd of arsenic is soluble in water, which dissolves about $\frac{1}{80}$ of its weight.

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* Black flux is formed by detonating, in a crucible, one part of nitre with two of cream of tartar.

7. The oxyd is soluble in most acids.

8. The oxyd of arsenic, by repeated distillation with nitric acid to dryness, is converted into an acid, termed *arseniac acid*, or acid of arsenic; and also by oxygenated muriatic acid.

9. The oxyd of arsenic, when mixed with powdered nitre, and detonated in a red hot crucible, affords a salt consisting of arseniac acid and potash, and termed *arseniate of potash*

10. Oxyd of arsenic combines with fixed alkalis, both in the dry and humid ways.

11. It is decomposed, when distilled with sulphur, sulphureous acid being disengaged, and a bright red compound of arsenic and sulphur remaining, termed *realgar*. When water, saturated with sulphurated hydrogen gas, is added to the solution of arsenic No. 6, a yellow precipitate is produced.

12. A beautiful green colour, termed, from its inventor, Scheele's green, is obtained by adding a solution of oxyd of arsenic in alkali to a solution of sulphate of copper. (See Scheele's Chemical Essays.)

ART. XXIV. ANTIMONY.

1. Antimony, as it is found in the shops, is a compound of the metal with sulphur. From this, the metal may be obtained by first roasting off the sulphur, and then fusing the oxyd with black flux.

2. Metallic antimony is of a silvery white colour; very brittle; and of a plated or scaley texture.

3. Antimony is easily fused, and when the fire is strongly urged, the antimony, if in a close vessel, may be volatilized.

4. It is oxyded by the concurrent action of heat and air.

5. Antimony is soluble in all acids. When the

regulus is pulverized and distilled with twice its weight of oxygenated muriate of mercury, a compound comes over, into the receiver, of oxygenated muriatic acid and antimony, formerly termed, from its thick consistence, butter of antimony. From this, a white oxyd of antimony is precipitated by the mere affusion of water, which was formerly called Algaroth's powder. This powder, by solution in the acidulous tartrite of potash, affords a tartar emetic of certain efficacy.

6. If the crude sulphuret of animony be boiled with solution of pure potash; the solution, on cooling, deposit a substance formerly termed Kermes mineral.

ART. XXV. MANGANESE.

1. Manganese never occurs in a metallic state; the black substance, known by that name, being a compound of manganese, with a large proportion of oxygen. The metal is obtained by mixing this oxyd, finely powdered, with pitch; making it into a ball; and putting this into a crucible, with powdered charcoal, $\frac{1}{10}$ of an inch thick on the sides, and $\frac{1}{4}$ of an inch deep at the bottom. The empty space is then to be filled with powdered charcoal; a cover is to be luted on; and the crucible exposed, for one hour, to the strongest heat that can be raised.

2. This metal is of a dusky white colour, and bright and shining in its fracture. When exposed to the air, it soon crumbles into a blackish brown powder, in consequence of its oxydation.

3. The metal is soluble in acids, but most readily in the nitrous. It is precipitated by alkalis, in the form of a white powder.

4. The black oxyd of manganese gives up its oxygen, when distilled alone in a retort; or still

more readily and abundantly, if distilled with a mixture of sulphuric acid.

5. It gives up its oxygen to muriatic acid. (See page 71.)

6. The black oxyd contains too much oxygen to dissolve in nitric acid; but when to a portion of this acid in contact with the oxyd, a little sugar is added, and heat is applied, the oxyd is dissolved.

7. The black oxyd of manganese imparts to borate of soda, when melted with it, a violet colour. When this is effected by the blow-pipe, the colour may be destroyed by the interior flame, and again reproduced by the exterior one, or by a small particle of nitre.

8. When powdered manganese, and nitre are mixed together, and thrown into a red hot crucible, the nitric acid is decomposed; and we obtain a compound of highly oxydated manganese with potash. This compound has the singular property of exhibiting different colours, according to the quantity of water that is added to it. A small quantity gives a green solution; a further addition changes it to blue; more still to purple; and a still larger quantity to a beautiful deep purple. Hence this has been termed the chamælion mineral. This property is destroyed by a very small quantity of sulphuret of potash.

9. The rose colour of solutions of manganese, in sulphuric and phosphoric acids, is destroyed, by exposure to the light of the sun, and restored again, when removed into darkness. This effect depends on the de-oxydation of the metal by the sun's rays.

ART. XXVI. COBALT.

1. Cobalt may be purchased in a metallic form, at a price rather exceeding that of pure silver.

2. Cobalt becomes tarnished by exposure to air, but is not easily oxydated, to any extent, by the action of heat and air combined.

3. Its best solvents are the nitric and nitro-muriatic acids; and the solutions have the singular property of forming sympathetic inks. Characters, written with these solutions, are illegible when cold; but, when a gentle heat is applied, they assume a beautiful blue or green colour. This experiment is rendered more amusing, by drawing the trunk and branches of a tree, in the ordinary manner, and tracing the leaves with a solution of cobalt. The tree appears leafless, till the paper is heated, when it suddenly becomes covered with beautiful foliage.

4. Oxalic acid throws down, from solutions of cobalt, a rose coloured precipitate.

5. Cobalt, when oxyded, forms zaffre, which has the property of giving a deep blue colour to glass.

ART. XXVII. NICKEL.

This metal may, also, be procured in the state of a regulus. Its solutions in nitrous and muriatic acids are of a green colour, and are precipitated blue by ammonia, in which the oxyds are, also, soluble.

ART. XXVIII. VEGETABLE SUBSTANCES.

1. VEGETABLE EXTRACT.

This may be obtained, by evaporating the expressed juices of recent vegetables, or their infusions or decoctions. It has the following properties:

A. It is cohesive; of a brownish colour; and generally of a bitterish taste.

B. It is soluble in cold water, but much more readily in hot. Hence the decoctions of certain substances, (Peruvian bark for example) become turbid on cooling.

C. It absorbs moisture from the atmosphere.

D. It is soluble in alcohol and alkalis, but not in acids.

E. When to its solution in water, oxygenated muriatic acid is added, a precipitate is thrown down, which is not soluble, by the same agents as the original extract.

2. MUCILAGE.

This substance in a dry state is commonly known by the name of gum. Gum arabic may be employed as an example.

A. It is brittle, dry, and insipid.

B. It forms a viscid solution with water.

C. It is not dissolved by alcohol.

D. Its solution in water is precipitated by Goulard's extract of lead.

Besides this, there is another kind of mucilage termed viscid mucilage, found in etiolated and young plants, and in the sap of trees, of which it forms a considerable part. It may be obtained by boiling the marshmallow, or quince seeds in water. Its solution is more ropey than that of the gum mucilage, and it becomes sour by exposure to the air.

3. SUGAR AND OXALIC ACID.

1. Sugar is soluble in water, but less readily in alcohol.

2. Sugar, on the application of heat, swells and foams, and a black coal is left.

3. When heated with nitric acid, it is acidified. Put an ounce of white sugar into a retort, with six ounces of nitric acid, and apply a gentle heat. Nitrous gas will be disengaged in great abundance. When the whole of the sugar is dissolved, distill off a part of the acid. The remaining liquor will form regular crystals, which must be again dissolved

in water, and crystallized. Lay this second crop of crystals on blotting paper, to dry. They have the following properties.

A. They are readily soluble in water.

B. They have all the properties of an acid.

C. They are changed into a coal by a red heat.

D. They combine with alcalis, and form neutral salts.

E. This acid has the property of forming an insoluble compound with lime. Into a glass of lime water, let fall a drop or two of solution of acid of sugar. A white precipitate will immediately fall to the bottom of the vessel. The oxalic acid even separates lime, from its combination with other acids. Hence a precipitation ensues, on dropping oxalic acid into a solution of sulphate or muriate of lime.

4. NATIVE VEGETABLE ACIDS, AND ACIDULA.

Native vegetable acids are such as are found, ready formed, in plants or their fruits, and require only pressure, and other simple processes, for their extraction.

A. CITRIC ACID. This exists, in an uncombined state in the juice of lemons and of limes, or loosely combined with mucilage and extractive matter. It may be obtained, in a pure state, by saturating lemon juice with powdered chalk. A white precipitate will fall down, composed of citric acid and lime. To this, sulphuric acid, very much diluted, is to be added. The sulphuric acid will seize the lime, and set the citric acid at liberty; and, when the solution is evaporated sufficiently low, the citric acid will shoot into regular crystals.

This acid is readily soluble in water; and may be applied to all the purposes for which fresh lemons are used.

B. Gallic Acid. This acid exists in the gall nut. It may be obtained, by exposing an infusion of galls in water to the air. A mouldy pellicle will form on the surface of the infusion; and, after some months exposure, small yellow crystals will appear on the inside of the vessel. These crystals must be dissolved in alcohol, to separate them from other substances, and the solution evaporated to dryness.

It may, also, be obtained by sublimation. Pounded galls are to be put into a retort, and heat applied. The gallic acid will rise, and be condensed in the neck of the retort in a solid form.

The gallic acid requires 24 times its weight of cold water for solution, or three parts of boiling water. Alcohol, when cold, dissolves one fourth, or an equal weight, when heated. These solutions redden the infusion of litmus, and strike a deep black with solutions of iron.

C. Malic Acid. This acid exists in the juice of apples, gooseberries, and of some other fruits, and is found mixed with the citric, and occasionally with others. It may be obtained by evaporating the juice nearly to dryness, and then adding alcohol, which dissolves the acids, and leaves the mucilage. To this solution of citric and malic acids in alcohol, chalk is to be added to saturation, and the precipitate to be washed with boiling water, which takes up the malate of lime, and leaves the citrate. The solution of the malate of lime may then be decomposed by sulphuric acid.

The malic acid cannot be crystallized, and, in general, forms deliquescent salts.

D. TARTAREOUS ACID, AND ITS COMBINATIONS.

This acid may be obtained from common cream of tartar, by dissolving it in water, and adding chalk, as long as any effervescence ensues. An insoluble tartrite of lime falls down, which may be decomposed, like the citrate of lime, by sulphuric acid. On evaporating the solution, regular crystals are obtained.

This acid is readily soluble in water. It combines with alcalis. When potash is exactly saturated with it, a neutral salt is obtained, which dissolves very readily in water; but on a still further addition of acid, we obtain a salt, which requires 20 parts of water for solution. This last is identical with common cream of tartar, which is a tartrite of potash, with a considerable excess of acid; and hence has been termed the acidulous tartrite of potash. By adding, to this, as much alkali, as will saturate the excess of acid, it becomes easily soluble; and by again rendering the acid superabundant, it is again rendered insoluble.

E. BENZOIC ACID. This may be obtained from a substance termed gum benjamin, by sublimation. It exists in a solid form, and may be procured at the druggists' shops, under the name of flowers of benjamin. These flowers have manifestly acid properties.

F. The oxalic acid is also found native, in the juice of sorrel, forming a salt with excess of acid, or an acidulum.

5. FIXED OILS.

1. These oils are obtained, by pressure, from certain vegetables, as the olive, the almond, linseed, &c.

2. As thus obtained, they are generally found combined with mucilage.

3. They do not combine with water, or with alcohol.

4. They unite with alcalis, and form soap.

5. Their properties are changed by boiling with metallic oxyds, those of lead for example. The mucilage unites with the oxyd, and the oil is rendered drying, and fit for the use of the painter.

6. VOLATILE OR ESSENTIAL OILS.

1. These oils have a penetrating smell; and an acid taste.

2. They are volatilized by a gentle heat.

3. They are soluble in alcohol.

4. They do not unite with water. With the intervention of a little sugar, however, they are combinable, in small proportion, with water.

5. When nitric acid is poured upon these oils, especially if it has been previously mixed with one fifth or one sixth of sulphuric acid, the mixture bursts out into a violent flame. This experiment requires caution, as the inflamed oil is apt to be scattered about.

6. Several of them detonate, when rubbed with oxygenated muriate of potash, and take fire when poured into oxygenated muriatic gas.

7. Essential oils are thickened by long exposure to air.

Camphor resembles the essential oils in many properties, but is not inflamed by nitric acid, which converts it into an acid distinguished by peculiar properties, and termed the camphoric acid.

7. RESINS.

Resins are the inspissated juices of certain plants, and are obtained, generally, by wounding their bark. Gum copal, or lac may be taken as an example.

1. They are dry, brittle, and inflammable.

2. They dissolve readily in alcohol, and essential oils, but not in water. From their solution in alcohol, they are precipitated by water.

3. They are the basis of cements and varnishes, and are chiefly used in medicine.

Gum resins are resins mixed with extractive matter, and are soluble partly in alcohol, and partly in water.

8. FARINA OR FECULA.

Common starch may be taken, as an example of farina. It will be found to have the following qualities.

1. It is not soluble in water, unless when heated to 160°; and if the temperature be raised to 180°, the solution coagulates.

2. Like sugar, it is converted, by the action of the nitric acid, into oxalic acid.

3. When distilled alone, it yields an acid, termed the pyromucous. This has been lately shewn to be identical with vinegar.

4. Farina forms a considerable part of wheat and other flour, and of the potatoe. It may be obtained separate by washing with water.

5. It becomes sour, when exposed in a moist state to the air.

9. GLUTEN.

1. Gluten may be obtained from wheat flour, by kneading it into dough with water, and washing off, from this, all the farina by repeated affusions of water, working it at the same time with the fingers.

2. It is elastic, and when drawn out, recovers itself something like the elastic gum. When strongly heated it shrinks, and if distilled in a retort, unlike other vegetable substances, it yields ammonia.

3. When exposed moist to the atmosphere, it does not turn sour, but putrefies like animal matter.
4 It is soluble in pure alcalis, and precipitable by acids.

10. ELASTIC GUM OR CAOUTCHOUC.

1. This substance is inflammable.
2. It is insoluble in water.
3. It is imperfectly dissolved by spirit of turpentine.
4. Its only solvent is ether; and, when employed for this purpose, the ether should be previously washed. This may be done by shaking it in a bottle, half filled with water, and half with ether. The bottle is next to be held inverted, and the water, which is the heaviest, suffered to escape. In this way, about half the ether is lost; and the remainder is considerably stronger than before. This solution may be so applied, as to form hollow tubes.

11. THE WOODY FIBRE.

1. This forms the basis of all wood, and is more abundant in proportion as the wood is harder.
2. It is insoluble in water.
3. When exposed to heat it affords a peculiar acid, called the pyroligneous, which has been lately proved identical with the acetous. In the retort, a black substance remains, which is charcoal.

12. COLOURING MATTER.

The colouring matter exists in vegetables, combind with various other principles; and according to the nature of the substance with which it is combined, it is soluble by different menstrua. It has an affinity for alumine and for oxyd of tin, in consequence of which these solutions precipitate infusions of the colouring principle in water.

1. To a decoction of madder in water, add a solution of sulphate of alumine. The alumine will combine with the colouring matter, and will form a coloured precipitate, or lake.

2. To the same decoction add a little of the nitro-muriate of tin. The oxyd of tin will detach the colouring matter, and will form an insoluble precipitate.

3. Similar experiments may be made on an infusion of cochineal, which, though an animal production, owes its colouring matter, remotely, to a vegetable.

4. On this principle, of its attraction for colouring matter, depends the use of alum in dying, its basis serving as an intermedium between the cloth and the colouring principle.

WAX.

1. Wax is readily fusible, and inflammable.

2. Yellow wax is bleached by oxygenated muriatic acid.

3. Wax is soluble in alkalis.

RESULTS OF THE DECOMPOSITION OF VEGETABLES.

Vinous fermentation.——The phenomena and result of this process should be accurately examined; which may be done with the aid of an apparatus, similar to that described by Lavoisier's Elements, part 3.

The properties of alcohol may be exhibited by those of the spirit of wine, generally found in the shops. Or the spirit may be converted into alcohol, by adding to it dry carbonate of potash, as long as this is rendered moist by the spirit, and afterwards distilling off the alcohol with a very gentle heat.

1. Alcohol is considerably lighter than water.

2. It unites chemically with water, and caloric is evolved during the combination. A contraction of bulk, also, ensues. Hence a pint of water, and a pint of alcohol, after admixture, and when perfectly cold, are found to occupy a less bulk than two pints.

3. It is inflammable. During its combustion carbonic acid is generated, and a quantity of water exceeding in weight the original weight of the alcohol. An ingenious apparatus proving this, is figured in Lavoisier's Elements, plate IX. fig. 5.

4. Alcohol is the best solvent of resins, and essential oils.

5. By distillation with such acids, as readily give up their oxygen, alcohol is changed into ether. Thus equal parts of sulphuric acid and of alcohol, mixed together very cautiously, by adding small portions of acid repeatedly to the alcohol, give, on distillation, the liquor termed ether. It may be formed, also, by means of the nitric or oxygenated muriatic acids.

ETHER.

1. Ether is extremely light; its specific gravity being even considerably less than that of alcohol.

2. It is not miscible with water; and, when these two fluids are shaken together, the ether, on standing, always rises to the surface.

3. It is extremely volatile. A few drops evaporate almost instantly from the palm of the hand.

4. During its evaporation, a considerable degree of cold is produced. This may be shewn by moistening, repeatedly, the bulb of a thermometer with ether, and exposing it to the air. See also Art. II. No. 12.

5. Ether, at the temperature of 104°, exists in the state of a gas. This may be shewn by filling a jar with water of this temperature, and inverting it in a vessel of the same. Then, introduce a little ether, by means of a small glass tube, closed at one end. The ether will rise to the top of the jar, and, in its ascent, will be changed into gas.

6. Ether is changed into a gas, by diminishing the weight of the atmosphere. Into a glass tube about six inches long, and half an inch diameter, put a tea spoonful of ether, and fill up the tube with water. Then, pressing the thumb on the open end of the tube, place it, inverted, in a jar of water. Let the whole be set under the receiver of an air pump, and the air exhausted. The ether will be changed into gas, which will expel the water entirely from the tube. On re-admitting the air into the receiver, the gas is again condensed into a liquid form.

7. The gas, produced by the volatilization of ether, is inflammable. Fill a small and very strong vial with oxygen gas, and let fall into it a drop of ether. On contact with the flame of a candle, a loud explosion will take place.

ACETOUS ACID.

1. Common vinegar, purified by distillation, may be taken as an example of acetous acid.

2. The acetous acid may be concentrated, by exposure to cold, which congeals the water sooner than the real acid, and affords a mean of separating it.

3. Acetous acid unites with alkalis, earths, and metallic oxyds.

A. When potash, saturated with this acid, is evaporated to dryness, the salt assumes a black colour. On being re-dissolved, however, and again evaporated, the salt is obtained white, and, when fused and suffered to cool, affords the acetite of potash.

This salt strongly attracts moisture from the air, and is very soluble in water. When exposed to a pretty strong heat, it is decomposed ; carbonic acid and carbonated hydrogen gasses come over; and in the retort there remains a mixture of carbon with carbonate of potash.

When this salt is distilled, with half its weight of sulphuric acid, the vegetable acid is expelled in a very concentrated form, and is then termed

ACETIC ACID.

1. This acid has a very strong taste, and a most pungent smell.

2. It is very volatile; and is inflammable when heated, taking fire on the approach of a lighted paper, and burning like alcohol.

3. It unites with alcalis, and the solutions, when evaporated, do not become black. Hence it is probable that the change of acetous into acetie acid depends in great measure on the separation of carbon.

4. This acid may be obtained from the acetite of copper by distillation per se.

5. The acetie acid, in the temperature of 38° of Faht., congeals or becomes glacial; and again liquefies at 59°.

6. When distilled with alcohol it affords an ether, termed acetic ether.

The acetous acid may be, also, combined with oxyds of lead and of copper. Lead corroded into a white oxyd, or rather carbonate, by the fumes of vinegar, forms cerusse or white lead, which, when dissolved in distilled vinegar, and crystallized, constitutes the acetite or sugar of lead. This salt is not decomposed, without the addition of sulphuric acid. Copper, corroded in a similar manner, affords verdigris, which when dissolved in distilled vinegar, affords a crystallizable salt, called acetate of copper. From this the acetic acid may be separated by distillation per se.

ART. XXIX. ANIMAL SUBSTANCES.

1. ANIMAL JELLY.

Animal jelly may be extracted from most of the soft parts of animals, and even from bones, by long continued boiling. It forms the basis of soups, broth, &c. and imparts to these their nutritious properties.

It is readily soluble in warm water; and congeals, when cold, into a cohesive substance, which may again be dissolved by water. It becomes sour, when exposed to the influence of the air. When evaporated to dryness, it forms portable soup, glue, isinglass, &c.

2. ANIMAL ALBUMEN.

The white of an egg may be employed, in exhibiting the qualities of animal albumen.

A. Albumen is insoluble in water, even at the boiling temperature.

B. It is soluble in pure alcalis, and is precipitated again by the addition of acids.

C. It is coagulated, by the temperature of 160°, into a solid cohesive mass; and also, by acids, oxyds, and alcohol. The coagulum, thus produced, is only soluble in alkalis, and during the solution ammonia is evolved.

D. On exposure to air, it passes to the putrefactive state.

E. When exposed to a gentle heat, in a retort, with diluted nitric acid, azotic gas is disengaged, which proceeds not from the acid, but from the animal matter.

GLUTEN, OR ANIMAL FIBRE.

Gluten forms the basis of the muscular or fleshy parts of animals, and remains, combined with albumen, when all the soluble parts have been washed away by water. It may, also, be obtained from coagulated blood, by laying this on a linen strainer, and pouring on water, till a white fibrous matter alone remains.

1. Gluten is insoluble in water, except by the long continued heat of a papin's digester.

2. It is soluble in acids, and in pure alkalis.

3. With diluted nitric acid, it yields much more azotic gas than any other animal substance.

4. It differs from albumen, in being coagulated by the mere contact of air, and by a temperature of 120°; and in being insoluble in cold liquid ammonia. Its structure, also, is fibrous; whereas that of albumen is smooth and homogeneous.

ANIMAL OIL.

Animal oil differs from the vegetable oils, in being generally solid at the temperature of the atmosphere, but is similar to them in its other properties. Among animal oils, may be ranked butter, tallow, lard, suet, spermaceti, &c. They all contain a peculiar acid, called the sebacic acid. This may be obtained, by adding to the oil, when liquefied by heat, finely powdered quicklime; collecting the sebat of lime; and distilling it with sulphuric acid.

A singular instance of the production of animal oil from the lean or muscular part of animals, is presented by the conversion of muscle into a substance strongly resembling spermaceti. To effect this conversion, it is only necessary, to confine the fleshy part of an animal, in a box with several holes in it, under the surface of a running stream. When thus confined, the change takes place spontaneously in the course of a few months. But it may be accomplished, much sooner, by digesting animal muscle in strong nitric acid, and washing off the acid by water, as soon as the change has ensued. The spermaceti, thus obtained, may be bleached, by exposure to the oxygenated muriatic acid gas.

ANIMAL ACIDS.

Of these, I shall mention none except the prussic acid, as being the only one likely to be the subject of experiment.

The prussic acid is formed in animal matters, when exposed to a high temperature. Let blood be evaporated to dryness, and let the dried blood be mixed with an equal weight of carbonate of potash, and the mixture be exposed to heat in a crucible, two thirds only of which are filled. The crucible is to have a cover applied, and the heat must be kept up till the flame ceases to proceed from the materials. By this operation, the prussic acid is formed, and combines with the potash. The prussiate of potash is next to be washed off, by repeated affusions of water; and mixed with a solution of sulphates of iron and alumine. The precipitate, thus formed, when washed with muriatic acid will assume a beautiful blue colour, which is owing to a combination of prussic acid with oxyd of iron. This prussiate of iron has the properties already described, page 102, No. 5.

The prussic acid may be obtained, in a separate state, by the process, described in Chaptal's Elements, Vol. II.

PART II.

DIRECTIONS FOR EXAMINING MINERAL WATERS, AND MINERAL BODIES IN GENERAL.

THE complete and accurate analysis of mineral waters, and of mineral bodies in general, is one of the most difficult subjects of chemical manipulation; and requires a very extensive acquaintance with the properties and habitudes of a numerous class of substances. Long and attentive study of the science is, therefore, essential to qualify any one for undertaking exact and minute determinations of the proportion of the component parts of bodies. Such minuteness, however, is scarcely ever required, in the experiments that are subservient to the ordinary purposes of life; a general knowledge of the composition of bodies being sufficient to assist in directing the most useful applications of them. I shall not attempt, therefore, to lay down rules for accurate analysis; but shall only describe such experiments, as are suited to afford an insight into the kind, but not to decide the exact proportion, of the constituent principles of natural waters, and of mineral substances in general.

SECT. I. EXAMINATION OF MINERAL WATERS.

Water is never presented by nature in a state of complete purity. Even when collected as it descends in the form of rain, chemical tests detect in it a minute proportion of foreign ingredients. And when it has been absorbed by the earth; has traversed its different strata; and is returned to us by springs, it is found to have acquired various impregnations. The readiest method of judging of the contents of natural waters, is by applying what are termed tests or re-agents; i. e. substances, which, on being added to a water, exhibit, by the phenomena they produce, the nature of the saline or other ingredients. For example, if, on adding infusion of litmus to any water, its colour is changed to red, we infer, that the water contains an uncombined acid: If this change ensues, even after the water has been boiled, we judge that the acid is a fixed and not a volatile one: And if, on adding the muriated barytes, a precipitate falls down, we safely conclude that the peculiar acid, present in the water, is, either entirely or in part, the sulphuric acid. I shall first enumerate the tests, generally employed in examining waters, and describe their application; and, afterwards, indicate by what particular tests the substances, generally found in waters, may be detected.

I. INFUSION OF LITMUS—SYRUP OF VIOLETS, &c.

As the infusion of litmus is apt to spoil by keeping, I include in the chest some solid litmus. The infusion is prepared by steeping this substance, first bruised in a mortar, and tied up in a thin rag, in distilled water, which extracts its blue colour.

If the colour of the infusion tends too much to purple, it may be amended by a drop or two of solution of pure ammonia; but of this, no more must be added than is barely sufficient, lest the delicacy of the test should be impaired.

The syrup of violets is not easily obtained pure. When it can be procured genuine, it is an excellent test of acids, and may be employed in the same manner as the infusion of litmus.

Paper stained with the juice of the march violet, or with that of radishes, answers a similar purpose. In staining paper for the purposes of a test, it must be used unsized; or if sized, it must previously be washed with warm water; because the alum, which enters into the composition of the size, will otherwise change the vegetable colour to red.

In the Philosophical Magazine, Vol. I. p. 180, may be found some recipes for other test liquors, invented by Mr. Watt.

Infusion of litmus is a test of most uncombined acids.

(1) If the water, under examination, reddens the unboiled, but not the boiled water; or if the red colour, occasioned by adding the infusion to a recent water, does not return to blue on boiling, we may infer that the acid is a volatile one, and most probably the carbonic acid. Sulphurated hydrogen gas, dissolved in water, also reddens litmus, but not after boiling.

(2) To ascertain whether the change be produced by carbonic acid, or sulphurated hydrogen, when experiment shews that the reddening cause is volatile, add a little lime water. This, if carbonic acid be present, will occasion a precipitate, which will dissolve, with effervescence, on adding a little muriatic acid. Sulphurated hydrogen may, also, be contained in the same water, which will be ascertained by the tests hereafter to be described.

(3) Paper tinged with litmus is, also, reddened by the presence of carbonic acid, but regains its blue colour on drying. The mineral and fixed acids redden it permanently. That these acids, however, may produce their effect, it is necessary that they should be present in a sufficient proportion. (See Kirwan on Mineral Waters, p. 40.)

II. INFUSION OF LITMUS REDDENED BY VINEGAR—SPIRITUOUS TINCTURE OF BRAZIL WOOD—TINCTURE OF TURMERIC—AND PAPER STAINED WITH EACH OF THESE THREE SUBSTANCES.—SYRUP OF VIOLETS.

All these different tests have one and the same object.

(1) Infusion of litmus reddened by vinegar, or litmus paper reddened by vinegar, has its blue colour restored by pure alcalis and pure earths, and by carbonated alcalis and earths.

(2) Turmeric paper and tincture are changed to a reddish brown by alcalis, whether pure or carbonated, and by pure earths, but not by carbonated earths.

(3) The red infusion of brazil wood, and paper stained with it, become blue by alcalis and earths, and even by the latter when dissolved by an excess of carbonic acid. In the last mentioned case, however, the change will either cease to appear, or be much less remarkable, when the water has been boiled.

(4) Syrup of violets when pure is, by the same causes, termed green; as is also paper stained with the juice of the violet or with radishes.

III. TINCTURE OF GALLS.

Tincture of galls is the test generally employed for discovering iron, with all the combinations of which it produces a black tinge, more or less intense according to the quantity. By applying this test before and after evaporation or boiling, we may know whether the iron be held in solution by carbonic acid, or a fixed acid; for

(1) If it produce its effect before the application

of heat and not afterwards, carbonic acid is the solvent.

(2) If after as well as before, a mineral acid is the solvent.

(3) If by the boiling a yellowish powder be precipitated, and yet galls continue to strike the water black afterwards, the iron, as often happens, is dissolved both by carbonic acid and by a fixed acid.

IV. SULPHURIC ACID.

(1) Sulphuric acid discovers, by a slight effervescence, the presence of carbonic acid, whether uncombined, or united with alcalis or earths.

(2) If lime be present, whether pure or uncombined, the addition of sulphuric acid occasions, after a few days, a white precipitate.

(3) Barytes is precipitated, instantly, in the form of a white powder.

(4) Nitrous and muriatic salts, on adding sulphuric acid and applying heat, are decomposed; and if a stopper moistened with solution of pure ammonia be held over the vessel, white clouds will appear. For distinguishing whether nitric or muriatic acid be the cause of this appearance, rules will be given hereafter.

V. NITRIC AND NITROUS ACIDS.

These acids, if they occasion effervescence, give the same indications as the sulphuric. The nitrous acid has been recommended, as a test distinguishing between hepatic waters that contain sulphuret of potash, and those that contain only sulphurated hydrogen gas. In the former case a precipitate ensues on adding nitrous acid, and a very fœtid smell arises: In the latter a slight cloudiness only appears, and the smell of the water becomes less disagreeable.

VI. OXALIC ACID, AND OXALATES.

This acid is a most delicate test of lime, which it separates from all its combinations.

(1) If a water, which is precipitated by oxalic acid, become milky on adding a watery solution of carbonic acid, we may infer that pure lime (or barytes, which has never yet been found pure in waters) is present.

(2) If the oxalic acid occasion a precipitate, before but not after boiling, the lime is dissolved by an excess of carbonic acid;

(3) If after boiling, by a fixed acid. A considerable excess of any of the mineral acids, however, prevents the oxalic acid from occasioning a precipitate, even though lime be present, because some acids decompose the oxalic, and others, dissolving the oxalate of lime, prevent it from appearing. (Vid. Kirwan on Waters, p. 88.)

The oxalate of ammonia, or of potash, (which may easily be formed by saturating their respective carbonates with a solution of oxalic acid) are not liable to the above objection; and are preferable, as re-agents, to the uncombined acid.

VII. PURE ALKALIS, AND CARBONATED ALKALIS.

(1) The pure fixed alkalis precipitate all earths, and metals, whether dissolved by volatile or fixed menstrua; but only in certain states of dilution; for example, sulphate of alumine may be present in water, in the proportion of 4 grs. to 500, without being discovered by pure fixed alcalis. As the alkalis precipitate so many substances, it is evident,

that they cannot afford, any very precise information, when employed as re-agents. From the colour of the precipitate, as it approaches to a pure white, or recedes from it, an experienced eye will judge, that the precipitated earth contains less or more of metallic admixture.

(2) Pure fixed alcalis, also, decompose all salts with basis of ammonia, which becomes evident by its smell, and also by the white fumes it exhibits with the vapour of muriatic acid.

(3) Carbonates of potash and soda have similar effects.

(4) Pure ammonia precipitates all earthy and metallic salts. Besides this property, it, also, imparts a deep blue colour to any liquid that contains copper in a state of solution.

(5) Carbonate of ammonia has the same properties, except that it does not precipitate magnesia from its combinations. Hence, to ascertain whether this earth be present in any solution, add the carbonate of ammonia, till no further precipitation ensues; filtre the liquor; and then add pure ammonia. If any precipitation now occurs, we may infer the presence of magnesia.

VIII. Lime-water.

As any quantity of lime-water, that can be included in a chemical chest, would very soon be expended, it will be necessary for the experimenter to prepare it himself, which may be done according to the process described in page 81.

(1) Lime-water is applied to the purposes of a test chiefly for detecting carbonic acid. Let any liquor, supposed to contain this acid, be mixed with an equal bulk of lime-water. If carbonic acid be present, either free or combined, a precipitate will

immediately appear, which, on adding a few drops of muriatic acid, will again be dissolved with effervescence.

(2) Lime-water will also shew the presence of corrosive sublimate, by a brick dust coloured sediment. If arsenic be contained in a liquid, lime-water, when added, will occasion a precipitate, consisting of lime and arsenic, which is very difficultly soluble in water. This precipitate, when mixed up with oil and laid on hot coals, yields the well known garlic smell of arsenic.

IX. PURE BARYTES, AND ITS SOLUTION IN WATER.

(1) A solution of pure barytes is even more effectual than lime-water in detecting the presence of carbonic acid, and is much more portable and convenient, since from the crystals of this earth, which are also included in the chest, the barytic solution may at any time be immediately prepared. In discovering fixed air, the solution of barytes is used similarly to lime-water, and if this acid be present, gives, in like manner, a precipitate, soluble with effervesence in dilute muriatic acid.

(2) The barytic solution is also, a most sensible test of sulphuric acid and its combinations, which it indicates by a precipitate, not soluble in muriatic acid.——Pure strontites has similar virtues as a test.

X. METALS.

(1) Of the metals, silver and mercury are tests of the presence of sulphurets, and of sulphurated hydrogen gas. If a little quicksilver be put into a bottle, containing water impregnated with either of these substances, its surface soon acquires a black

film, and, on shaking, a blackish powder separates from it. Silver is immediately tarnished by the same cause.

(2) The metals may be used, also, as tests of each other on the principle of elective affinity. Thus, for example, a polished iron plate, immersed in a solution of sulphate of copper, soon acquires a coat of this metal; and the same in other similar examples.

XI. SULPHATE OF IRON.

This is the only one of the sulphates, except that of silver, applicable to the purposes of a test. When used with this view, it is generally employed for ascertaining the presence of oxygenous gas, of which a natural water may contain a small quantity.

A water, suspected to contain this gas, may be mixed with a little recently dissolved sulphate of iron, and kept corked up. If an oxyd of iron be precipitated, the water may be inferred to contain oxygenous gas.

XII. SULPHATE, NITRATE, AND ACETITE OF SILVER.

These solutions are all, in some measure, applicable to the same purpose.

(1) They are peculiarly adapted to the discovery of muriatic acid, and of muriates. For the silver, quitting the nitric acid, combines with the muriatic, and forms a flakey precipitate, which, at first, is white, but, on exposure to the sun's light, acquires a bluish colour. A precipitation, however, may arise from other causes, which it may be proper to state.

(2) The solutions of silver in acids are precipitated by carbonated alcalis and earths. The agency of these may be prevented by previously adding a few

drops of the same acid, in which the silver is dissolved.

(3) The nitrate and acetite of silver are decomposed by the sulphuric and sulphureous acids ; but this may be prevented by adding, previously, a few drops of nitrate or acetite of barytes, and, after allowing the precipitate to subside, the clear liquor may be decanted, and the solution of silver be added. Should a precipitation now take place, the presence of muriatic acid, or some one of its combinations, may be suspected.

(4) The solutions of silver are, also, precipitated by sulphurated hydrogen and by sulphurets ; but the precipitate is then reddish, or brown, or black ; or it may be at first white, and afterwards becomes speedily brown or black. It is soluble in dilute nitrous acid, which is not the case, if occasioned by muriatic or sulphuric acid.

(5) The solutions of silver are precipitated by extractive matter ; but in this case, also, the precipitate is discoloured, and is soluble in nitrous acid.

XIII. NITRATE AND ACETITE OF LEAD.

(1) Acetite of lead, the most eligible of these two tests, is precipitated by sulphuric and muriatic acids, but as of both these we have much better indicators, I do not enlarge on its application to this purpose.

(2) The acetite is also a test of sulphurated hydrogen and of sulphurets of alcalis, which occasion a black precipitate ; and if a paper, on which characters are traced with a solution of acetite of lead, be held over a portion of water containing sulphurated hydrogen, they are soon rendered visible.

(3) The acetite of lead is employed in the dis-

covery of uncombined boracic acid, a very rare ingredient of waters. To ascertain whether this be present, some cautions are necessary. (a) The uncombined alkalis and earths (if any be suspected) must be saturated with acetic or acetous acid. (b) The sulphates must be decomposed by acetite of barytes, and the muriates by acetite of silver. The filtered liquor, if boracic acid be contained in it, will give a precipitate soluble in nitric acid of the specific gravity of 1. 3.

XIV. NITRATE OF MERCURY PREPARED WITH AND WITHOUT HEAT.

This solution, differently prepared, is sometimes employed as a test. But, since other tests answer the same purposes more effectually, I have not thought proper to include the nitrate of mercury in the chest. For the same reason, also, oxygenated muriate of mercury is omitted.

XV. MURIATE, NITRATE, AND ACETITE OF BARYTES.

(1) These solutions are all most delicate tests of sulphuric acid, and its combinations, with which they give a white precipitate, insoluble in dilute muriatic acid. They are decomposed, however, by carbonates of alcali; but the precipitate, occasioned by these, is soluble in dilute muriatic or nitric acids, with effervescence.

(2) Phosphoric salts occasion a precipitate, also, which is soluble in muriatic acid, without effervescence.

XVI. PRUSSIATES OF POTASH, AND OF LIME.

Of these two, the prussiate of potash is the most eligible. When pure, it does not speedily assume a blue colour on the addition of an acid, nor does it *immediately* precipitate muriated barytes.

Prussiate of potash is a very sensible test of iron, with whose solutions in acids, it produces a prussian blue precipitate, in consequence of a double elective affinity. To render its effect more certain, however, it may be proper to add, previously, to any water suspected to contain iron, a little muriatic acid, with a view to the saturation of uncombined alcalis or earths, which, if present, prevent the detection of very minute quantites of iron.

(1) If a water, after boiling and filtration, does not afford a blue precipitate, on the addition of prussiate of potash, the solvent of the iron may be inferred to be a volatile one, and probably the carbonic acid.

(2) Should the precipitation ensue in the boiled water, the solvent is a fixed acid, the nature of which must be ascertained by other tests.

XVII. SOLUTION OF SOAP IN ALCOHOL.

This solution may be employed to ascertain the comparative hardness of waters. With distilled water it may be mixed, without any change ensuing; but if added to a hard water, it produces a milkiness, more or less considerable, as the water is less pure; and from the degree of this milkiness, an experienced eye will derive a tolerable indication of the quality of the water. This effect is owing to the alcali quitting the oil, whenever there is present in a water any substance, for which the alcali has a stronger affinity than it has for oil. Thus all uncombined acids, and all earthy and metallic salts decompose soap; and occasion that property in waters which is termed hardness.

XVIII. ALCOHOL.

Alcohol, when mixed with any water, in the proportion of about an equal bulk, precipitates all the salts, which it is incapable of dissolving. (See Kirwan on Waters, p. 263.)

XIX. SULPHURET OF AMMONIA.

This and other sulphurets, as well as water saturated with sulphurated hydrogen, may be employed in detecting lead and arsenic, with the former of which they give a black, and with the latter a yellowish, precipitate. As lead and arsenic, however, are never found in natural waters I shall reserve, for another occasion, what I have to say of the application of these tests.

SUBSTANCES THAT MAY BE EXPECTED IN MINERAL WATERS; AND THE MEANS OF DETECTING THEM.

ACIDS IN GENERAL. Infusion of litmus—Syrup of violets, I.

ACID BORACIC. Acetite of lead, XIII. 3.

ACID CARBONIC. Infusion of litmus, I. 1. 2.

ACID MURIATIC. Nitrate and acetite of silver, XII.

ACID NITRIC. Sulphuric acid, IV. 4.

ACID PHOSPHORIC. Solutions of barytes, XV. 2.

ACID SULPHUREOUS. By its smell—and destroying the colour of litmus, and of infusion of red roses.

Acid Sulphuric. Solution of pure barytes, IX. Barytic salts, XV. Acetite of lead, XII.

Alcalis in general. Vegetable colours, II.

Ammonia, by its smell and tests, II.

Barytes and its compounds, by sulphuric acid, IV.

Carbonates in general. Effervesce on adding acids.

Earths dissolved by Carbonic Acid. By a precipitation on boiling—by pure alcalis, VII.

Iron dissolved by Carbonic Acid. Tincture of galls, III. 1. Prussiate of potash, XVI. 1.

———— by Sulphuric Acid. Same tests, III. 3. XVI. 2.

Lime in a pure State. Water saturated with carbonic acid. Blowing air from the lungs. Oxalic acid, VI.

—— dissolved by Carbonic Acid. Precipitation on boiling—Caustic alkalis, VII. Oxalic acid, VI.

Magnesia dissolved by Carbonic Acid. Precipitation on boiling—the precipitate soluble in dilute sulphuric acid.

Muriates of Alcalis. Solutions of silver, XII.

——— of Lime. Solutions of silver, XII. and oxalic acid, VI.

Sulphates in general. Barytic solutions, IX. and XV.—Acetite of lead, XII.

Sulphate of Alumine. Barytic solutions, IX. and XV.—A precipitate by carbonate of ammonia not soluble in acetous acid, but soluble in pure fixed alkalis by boiling.

SULPHATE OF LIME. Barytic solutions IX. and XV.—Oxalic acid, VI.—A precipitate by alkalis not soluble in dilute sulphuric acid.

SULPHURETS OF ALCALIS. Polished metals, X. Smell on adding sulphuric or muriatic acid.—Nitrous acid, V.

SULPHURATED HYDROGEN GAS. Infusion of litmus, I. Polished metals, X. Acetite of lead, XIII. 2.

* * *

The reader, who may wish for rules for the complete and accurate analysis of mineral waters, will find in almost every elementary work, a chapter allotted to this subject. He may, also, consult Bergman's Physical and Chemical Essays, Vol. I. Essay 2d. and Kirwan's Essay on the Analysis of Mineral Waters, London, 1799. As this manual, however, may sometimes be employed as a travelling companion, and may attend the chemist where more bulky works cannot be had, it may be proper to state, briefly, the mode of analyzing waters by the more certain, but still not unobjectionable, mode of evaporation.

The vessels, employed for evaporation, should be of such materials, as are not likely to be acted on by the contents of the water. I prefer those of unglazed biscuit ware, made by Messrs. Wedgwoods; but as their surface is not perfectly smooth, and the dry mass may adhere so strongly as not to be entirely scraped off, the water, when reduced to about one tenth or less, may be transferred, with any deposit that may have taken place, into a smaller vessel of glass. Here, let it be evaporated to dryness.

A. The dry mass, when collected and accurately weighed, is to be put into a bottle, and alcohol poured on it, to the depth of an inch. After having stood a few hours, and been occasionally shaken, pour the whole on a filtre, wash it with a little more alcohol; and dry and weigh the remainder.

B. To the undissolved residue, add eight times its weight of cold distilled water; shake the mixture frequently; and, after some time, filtre, ascertaining the loss of weight.

C. Boil the residuum for a quarter of an hour, in some what more than 500 times its weight of water, and afterwards filtre.

D. The residue, which must be dried and weighed, is no longer soluble in water or alcohol. If it has a brown colour, denoting the presence of iron, let it be moistened with water, and exposed to the sun's rays for some weeks.

I. The solution in alcohol (A) may contain one or all of the following salts—muriates of lime, magnesia, or barytes, or nitrates of the same earths. Sometimes, also, the alcohol may take up a sulphate of iron, in which the metal is highly oxydated; as will appear from its reddish brown colour.

1. In order to discover the quality and quantity of the ingredients, evaporate to dryness, add above half its weight of strong sulphuric acid, and apply the heat. The muriatic or nitric acid will be expelled; and will be known by the colour of their fumes, the former being white, and the latter orange coloured. 2. To ascertain whether lime or magnesia be the basis, let the heat be continued till no more fumes arise; and let it then be raised, to expel the excess of sulphuric acid. To the dry mass add twice its weight of distilled water. This will take up the sulphate of magnesia, and leave the sulphate of lime. The two sulphates may be separately decomposed by

boiling with three or four times their weight o carbonate of potash. The carbonates of lime and magnesia, thus obtained, may be separately dissolved in muriatic acid and evaporated. The weight of the dry salts will inform us, how much of each the alcohol had taken up.

The presence of barytes, which is very rarely to be expected, may be known by a precipitation ensuing, on adding sulphuric acid to a portion of the alcoholic solution, which has been diluted with 50 or 60 times its bulk of water.

II. The watery solution (B) may contain a variety of salts; the accurate separation of which, from each other, is a problem of considerable difficulty.

1. The analysis of this solution may be attempted by crystallization. For this purpose, let one half be evaporated by a very gentle heat, not exceeding 80° or 90°. Should any crystals appear on the surface of the solution while hot, in the form of a pellicle, let them be separated and dried on bibulous paper. These are muriate of soda or common salt. The remaining solution, on cooling very gradually, will, perhaps, afford crystals distinguishable by their form and other qualities. When a variety of salts, however, are contained in the same solution, it is extremely difficult to obtain them sufficiently distinct to ascertain their kind.

2. The nature of the saline contents must, therefore, be examined by tests or re-agents.

The presence of an uncombined alkali will be discovered by the stained papers (p. 130), and of acids by the tests (p. 128). The vegetable alcali or potash may be distinguished from the mineral or soda, by saturation with sulphuric acid, and evaporation to dryness; the sulphate of soda being much more soluble than that of potash; or by supersaturation with the tartarous acid, which gives a soluble salt with soda but not with potash.

If neutral salts be present in the solution, we have to ascertain both the nature of the acid and of the basis. This may be done by attention to the rules already given for the application of tests, which it is unnecessary to repeat in this place.

III. The solution by boiling water contains scarcely any thing besides sulphate of lime.

IV. The residuum (D) is to be digested in distilled vinegar, which takes up magnesia and lime, but leaves undissolved alumine and highly oxydated iron. Evaporate the solution to dryness. If it contain acetite of lime only, a substance will be obtained, which does not attract moisture from the air; if magnesia be present, the mass will deliquiate. To separate the lime from the magnesia proceed as in I.

The residue, insoluble in acetous acid, may contain alumine, silex, and iron. The two first may be dissolved by muriatic acid, from which the iron may be precipitated first by prussiate of potash, and the alumine afterwards by a fixed alcali.

SECT. II. EXAMINATION OF MINERALS.

The chemical analysis of minerals is attended even with greater difficulties, than that of natural waters. It would, therefore, be a vain attempt to comprehend, in a concise manual, rules sufficiently minute for the accurate separation of their component principles. On the present occasion, I mean only to offer a few general directions for attaining such a knowledge of the composition of mineral bodies, as may enable the chemical student to refer them to their proper place in a mineral arrangement; and to judge whether or not they may admit of application to the uses of common life.

The great variety of mineral bodies, which nature presents in the composition of this globe, have been classed by late writers under a few general divisions. They may be arranged under four heads. 1st. Earths. 2dly. Salts. 3dly. Inflammable fossils—and 4thly. Metals, and their Ores.

EARTHS. The formation of such a definition of earths, as would apply exactly to the bodies defined, and to no others, is attended with considerable difficulty, and indeed has never yet been effected. It would lead me into too long a discussion, to comment, in this place, on the definitions that have been generally offered, and to state the grounds of objection to each of them. Sensible, therefore, that I am unable to present an unexceptionable character of earthy bodies, I shall select such an one, as may be sufficient for the less accurate purpose of general distinction.

"The term earth," says Mr. Kirwan, "denotes a tasteless, inodorous, dry, brittle, uninflammable substance, whose specific gravity does not exceed 4.9. (i. e. which is never five times heavier than water), and which gives no tinge to borax in fusion." After stating some exceptions to this definition, afforded by the strong taste of certain earths, and the solubility of others, he adds. "Since, however, a line must be drawn between salts and earths, I think it should begin where solution is scarce perceptible; salts terminating, and earths, in strictness, commencing, where the weight of the water, requisite for the solution, exceeds that of the solvend, 1000 times. But, not to depart too widely from the commonly received import of words that are in constant use, substances, that require 100 times their weight of water to dissolve them, and have the other sensible properties of earths, may be so styled in a loose and popular sense."

The simple, or primitive earths, are those which cannot be resolved into more remote principles. Such are lime, argill, magnesia, &c.

The compound earths are composed of two or more primitive earths, united chemically together. Sometimes, the union of an earth with an acid constitutes what is vulgarly called an earth, as in the examples of sulphate of lime, fluate of lime, &c.

SALTS. Under this head, Mr. Kirwan arranges "all those substances, that require less than 200 times their weight of water to dissolve them." This description, though by no means so amply characteristic of the class of salts, as to serve for an exact definition, is sufficient for our present purpose.

"By INFLAMMABLE FOSSILS," the same author observes, "are to be understood all those, of mineral origin, whose principal character is inflammability, a criterion, which excludes the diamond and metallic substances, though, also, susceptible of combustion."

METALLIC SUBSTANCES are so well characterized by external properties, as not to require any definition. "Those, on which nature has bestowed their proper metallic appearance, or which are alloyed only with other metals or semi-metals, are called *native* metals. But those that are distinguished, as they commonly are in mines, by combination with some other unmetallic substances, are said to be mineralized. The substance that sets them in that state is called a mineralizer, and the compound of both are ore." Thus, in the most common ore of copper, this metal is found oxydated, and the oxyd combined with sulphur. The copper may be said to be mineralized by oxygen and sulphur, and the compound of the three bodies is called an ore of copper.

METHOD OF EXAMINING A MINERAL, THE COMPOSITION OF WHICH IS UNKNOWN.

A mineral substance presented to our examination, without any previous knowledge of its composition, should first be referred to one of the above four classes, in order that we may attain a general knowledge of its nature, before proceeding to analyze it minutely.

I. To ascertain whether the unknown mineral contains saline matter, let 100 grains or any other determinate quantity, in the state of fine powder, be put into a bottle, and shaken up repeatedly with 30 times its weight of water, of the temperature of 120 or 130°. After having stood an hour or two, pour the contents of the bottle on a filtering paper, previously weighed, and placed on a funnel. When the water has drained off, dry the powder on the filtre, in a heat of about 212°; and, when dry, let the whole be accurately weighed. If the weight be considerably less than the joint weight of the powder before digestion and the filtering paper, we may infer that some salt has been dissolved, and the decrease of weight will indicate its quantity.

In certain cases, it may be adviseable to use repeated portions of boiling water, when the salt, suspected to be present, is difficult of solution.

Should the mineral, under examination, be proved, by the foregoing experiment, to contain much salt, the kind and proportion must next be determined, by rules which will hereafter be laid down.

II. The second class, viz. earthy bodies, are distinguished by their insolubility in water; by their freedom from taste; by their uninflammability; and by their specific gravity never reaching 5. If, therefore, a mineral be insoluble in water, when tried in the forgoing manner; if it be not consumed either wholly or in considerable part by keeping it, for some time, on a red hot iron; we may conclude that it is neither a salt nor an inflammable body.

III. The only remaining class, with which it can be confounded, are ores of metals, from many of which it may be distinguished, merely by poising it in the hand, the ores of metals being always heavier than earths. Or if a doubt should still remain, it may be weighed hydrostatically. The mode of doing this it may be proper to describe; but the principle, on which the practice is founded, cannot with propriety be explained here. Let the mineral be suspended by a piece of fine hair, silk, or thread, from the scale of a balance, and weighed in the air. Suppose it to weigh 250 grains. Let it next, (still suspended to the balance) be immersed in a glass of water of the temperature of 60°. The scale containing the weight will now preponderate. Add, therefore, to the scale from which the mineral hangs, as many grain weights as are necessary to restore the equilibrium. Suppose that 50 grains are necessary: Then, the specific gravity may be learnt by dividing the weight in air by the weight lost in water. Thus in the foregoing case, $250 \div 50 = 5$; or a substance, which should lose weight in water according to the above proportion, would be five times heavier than water. It must, therefore, contain some metal, though probably in no great quantity. Any mineral, which, when weighed in the above manner, proves to be 5, 6, 7, or more times heavier than water, may, therefore, be inferred to contain a metal, and may be referred to the class of ores.

IV. Inflammable substances are distinguished by their burning away, either entirely or in considerable part, on a red hot iron; and by their detonating, when mixed with powdered nitre, and thrown into a red hot crucible. Certain ores of metals, however, which contain a considerable proportion of inflammable matter, answer to this test—but may be distinguished from purely inflammable substances, by their greater specific gravity.

I shall now proceed to offer a few general rules, for the more accurate examination of substances of each of the above classes; without, however, pretending to comprehend, in this manual, a code of directions sufficiently minute, to enable any one to perform a complete analysis.

I. EXAMINATION OF SALTS.

1. A solution of salt obtained in the foregoing manner (see page 147) may be slowly evaporated, and left to cool gradually. When cold, crystals will probably appear, which a chemist, acquainted with the form of salts, will easily recognize. But as several different salts may be present in the same solution, and may not crystallize, in a sufficiently distinct shape, it may be necessary to have recourse to the evidence of tests.

2. Let the salt, in the first place, be referred to one of the following orders.

(a) *Acids, or salts with excess of acid.* These are known by their effect on blue vegetable colours. The particular species of acid may be discovered by the tests described, page 139 and 140.

(b) *Alcalis.* These are characterized by their effect on vegetable colours, and by the other properties enumerated, page 39.

(c) *Salts with metallic bases.* These afford a very copious precipitate, when mixed with a solution of prussiate of potash. To ascertain the species of metal, precipitate the whole by prussiate of potash; calcine the precipitate; and proceed according to the rules, which will hereafter be given, for separating metals from each other.

(d) *Salts with earthy bases.* If a solution of salt, in which prussiate of potash occasions no precipitation, afford a precipitate on adding pure or carbonated potash, we may infer, that a compound of an acid, with some one of the earths, is present in the solution. Or if, after prussiate of potash has ceased to throw down a sediment, the above mentioned alcali precipitates a further portion, we may infer that both earthy and metallic salts are contained in the solution. In the first case, add the alcaline solution, and when it has ceased to produce any effect, let the sediment subside; decant the supernatant liquor; and wash and dry the precipitate. The earths may be examined, according to the rules that will be given in the following article. In the second case, prussiate of potash must be added, as long as it precipitates any thing; and the liquor must be decanted from the sediment, which is to be washed with distilled water, adding the washings to what has been poured off. The decanted solution must next be mixed with the alcaline one, and the precipitated earths reserved for experiment. By this last process, earths and metals may be separated from each other.

E. *Neutral salts with alcaline bases.* These salts are not precipitated either by prussiate or carbonate of potash. It may happen, however, that salts of this class may be contained in a solution, along with metallic or earthy ones. In this case, the analysis becomes difficult; because the alcali, that is added to precipitate the two last, renders it difficult to ascertain, whether the neutral salts are owing to this addition, or were originally present. I am not aware of any method of obviating this difficulty, except the following. Let the metals be precipitated by prussiate of ammonia; and the earths by carbonate of ammonia in a temperature of 180° or upwards, in order to ensure the decomposition of magnesian salts, which this carbonate does not effect in the cold. Separate the liquor by filtration, and boil it to dryness. Then expose the dry mass to such a heat as is sufficient to expel the ammoniacal salts. Those, with basis of fixed alkali, will remain fixed. By this process, indeed, it will be impossible to ascertain whether ammoniacal salts were originally present ; but this may be learned by adding, to the salt under examination, before its solution in water, some pure potash, which, if ammonia be contained in the salt, will produce its peculiar smell. The vegetable and mineral alcalis may be distinguished by adding to the solution, a little tartarous acid, which precipitates the former but not the latter.

Having ascertained the basis of the salt, the acid will easily be discriminated. Muriated barytes will indicate sulphuric acid ; nitrate of silver the muriatic ; and salts containing nitric acid may be known by a detonation ensuing on projecting them, mixed with powdered charcoal, into a red hot crucible.

II. EXAMINATION OF EARTHS AND STONES.

When a mineral, the composition of which we are desirous to discover, resists the action of water, and possesses characters that rank it among earthy bodies, the next object of enquiry is the nature of the earths, that enter into its composition ; in other words, how many of the simple earths, and which of them, it may contain. Of these earths, viz. silex, alumine, magnesia, lime, strontites, and barytes, one or more, and sometimes all, may be expected in the composition of stones, besides a small proportion of metals, to which the colour of the stone is owing. In general, however, it is not usual to find more than four of the simple earths in one mineral.

The newly discovered earths, jargonia, glucine, &c. occur very rarely.

A stone, which is intended for chemical examination, should be finely powdered; and care should be taken that the mortar is of harder materials than the stone; otherwise, it will be liable to abrasion, and uncertainty will be occasioned in the result of the process. For soft stones, a mortar of Wedgwood's ware is sufficient; but for very hard ones, one of agate or hard steel is required; and the stone should be weighed both before and after pulverization, that the addition, if any, may be ascertained and allowed for. When a stone is extremely difficult to reduce to powder, it may sometimes be necessary to make it red hot, and, while in this state, to plunge it into cold water. By this treatment, it becomes brittle, and is afterwards easily pulverized.

The chemical agents, employed in the analysis of stones, should be of the greatest possible purity. To obtain them in this state, directions have been given in the former part of this work.

In treating of the analysis of stones, it may be proper to divide them, 1st. into such as are soluble, either wholly or in part, and with effervescence, in nitric or muriatic acids, diluted with five or six parts of water; and 2dly. into such as do not dissolve in these acids.

1. *Earths or stones, soluble, with effervescence, in diluted nitric or sulphuric acids.*

A. If it be found, on trial, that the mineral, under examination, effervesces with either of these acids, let a given weight, finely powdered, be digested with one of them diluted in the above proportion, in a gentle heat, for two or three hours. Ascertain the loss of weight, in the manner pointed out, page 147, and filtre the solution, reserving the insoluble portion.

B. The solution, when effected, may contain lime, magnesia, alumine, barytes, or strontites. To ascertain the presence of the two last, dilute an aliquot part of the solution with 20 times its bulk of water; and add a little sulphuric acid, or, in preference, solution of sulphate of soda. Should a white precipitate fall down, we may infer the presence of barytes, of strontites, or of both.

C. To ascertain which of these earths, (viz. barytes or strontites) is present; or, if both are contained in the solution, to separate them from each other, add sulphate of soda, till the precipitate ceases; decant the supernatant liquid; wash the sediment on a filtre; and dry it. Then digest it with four times its weight of pure carbonate of potash, and a sufficient quantity of water, in a gentle heat, during two or three hours. A double exchange of principles will ensue, and we shall obtain a carbonate of barytes or strontites, or a mixture of both. Pour, on these, nitric acid, of the specific gravity 1.4, diluted with an equal weight of distilled water. This will dissolve the strontites, but not the barytes. To determine whether any strontites has been take up by the acid, evaporate the solution to dryness, and dissolve the dry mass in alcohol. This alcoholic solution, if it contain nitrate of strontites, will burn with a deep blood red flame.

Barytes and strontites may, also, be separated from each other, in the following manner. To a saturated solution of the two earths in an acid, add prussiate of potash, which, if pure, will occasion no immediate precipitation; but after some time, small and insoluble crystals will form on the surface of the jar. These are the prussiated barytes, which may be changed into the carbonate by a red heat, continued with the access of air, till the black colour disappears. The strontites may be afterwards separated from the solution by carbonate of potash.

A third method of separating strontites from barytes is founded on the stronger affinity of barytes, than of the former earth, for acids. Hence, if the two earths be present in the same solution, add a solution of pure barytes (see page 90) till the precipitation ceases. The barytes will seize the acid, and will throw down the strontites. The strontitic solution, in this case, should have no excess of acid, which would prevent the action of the barytic earth.

D. The solution (B), after the addition of sulphate of soda, may contain lime, magnesia, alumine, and some metallic oxyds. To separate the oxyds, add prussiate of potash, till its effect ceases, and filtre the solution, reserving the precipitate for future experiments.

E. When lime, magnesia, and alumine are contained in the same solution, proceed as follows.

(a) Precipitate the solution, previously made hot, by carbonate of potash; wash the precipitate well, and dry it. It will consist of carbonates of lime, magnesia, and alumine. (b) The alumine may be separated, by digestion with a solution of pure potash, which will dissolve the alumine, but not the other earths. (c) To this solution of alumine, add diluted sulphuric acid, till the precipitate ceases; decant the supernatant liquor; wash the precipitate well with distilled water, and dry it. Then expose it to a low red heat, in a crucible, and weigh it, which will give the proportion of alumine.

F. Magnesia and lime, may be separated, by the following process. Evaporate the solution in nitric or muriatic acid to dryness. Weigh the dry mass, and pour on it, in a glass evaporating dish,* more than its own weight of strong sulphuric acid. Apply a sand heat, till the acid ceases to rise, and then raise the heat, so as to expel the excess of sulphuric acid. Weigh the dry mass, and digest it in twice its weight of cold distilled water. This will dissolve the sulphate of magnesia, and will leave the sulphate of lime, which must be put on a filtre, washed with a little more water, and dried in a low red heat. To estimate the quantity of lime, deduct from the weight of the sulphate, 59 per cent.

The magnesia is next to be precipitated, from the sulphate, by carbonate of potash, in a heat approaching 212°; and the precipitate, after being well washed, must be dried, and calcined for an hour. Its weight, after calcination, will give the quantity of magnesia contained in the stone.

G. If magnesia and alumine only be contained in a solution (the absence of lime being indicated by the non-appearance of a precipitate, on adding oxalate of ammonia), the two earths may be separated by adding, to the cold solution, the carbonate of ammonia. This will separate the alumine, which may be collected, washed, and dried. The magnesia, remaining in solution, may be precipitated by carbonate of potash; heat being applied, to expel the excess of carbonic acid.

H. The insoluble residue (A) may contain alumine, silex, and oxyds of metals, so highly charged with oxygen, as to resist the action of nitric and muriatic acids.

(a) Add concentrated sulphuric acid, and evaporated to dryness, in the vessel decribed, in the note

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* The bottom of a broken florence flask answers this purpose extremely well, and bears, without breaking, the heat necessary to expel the sulphuric acid.

beneath. On the dry mass pour a fresh portion of the acid; boil again to dryness; and let this be done, repeatedly, three or four times. By this operation, the alumine will be converted into a neutral sulphate of alumine, which will be rendered easily soluble in warm water, by adding a slight excess of acid. Let the sulphate of alumine be washed off, and the insoluble part be collected and dried. The alumine may be precipitated, by carbonate of potash; washed, dried, and ignited; and its weight ascertained.

(b) The oxyds (generally of iron only) may be separated from the silex, in the following manner. Let the insoluble part (a) be heated in a crucible with a little wax. This will render the oxyds soluble in diluted sulphuric acid; and the silex will be left pure and white. Let it be washed; ignited; and its weight ascertained.

II. *Stones insoluble in diluted nitric and muriatic acids.*

These stones must be reduced to powder, observing the cautions given in page 152.

I. Let 100 grains, or any other determinate quantity, be mixed with three times their weight of pure and dry potash. Put the whole into a crucible of silver or platina, and add a little water. The crucible, covered with a lid, must then be gradually heated; and as the materials swell and would boil over, they are to be stirred, constantly, with a rod of silver or platina. When the moisture is dissipated, and the mass has become quite dry, raise the heat, as far as can be done without melting the crucible, if of silver; and continue the heat, during half an hour or an hour.

The phenomena, that occur during this operation, indicate, in some degree, the nature of the mineral under examination. If the mixture undergo a perfectly liquid fusion, we may presume that the stone contains much siliceous earth; if it remain pasty and opaque, the other earths are to be suspected; and, lastly, if it has the form of a dry powder, the bulk of which has considerably increased, it is a sign of the predominance of alumine.

If the fused mass has a dark green, or brownish colour, the presence of oxyd of iron is announced; a bright green indicates manganese, especially if the colour be imparted to water; and a yellowish green the oxyd of chrome.

K. The crucible, being removed from the fire, is to be well cleaned on the outside; and set, with its contents, in a porcelain or glass vessel, filled with hot water, which is to be stirred, and renewed occasionally, till the whole mass is detached. The water dissolves a considerable part of the compound of alumine and silex with potash, and even the whole, if added in sufficient quantity.

L. To the solution (K), and the mass that has resisted solution, in the same vessel, add muriatic acid. The first portions of acid will throw down a flocculent sediment, which consists of the earths that were held dissolved by the alkali. Then, an effervescence ensues; and a precipitate occurs, which is no sooner formed than it is dissolved. Lastly, the portion, that resisted the action of water, is taken up, silently if it contains alumine, and with effervescence if it be calcareous earth.

M. From the phenomena, attending the action of muriatic acid, some indications may be derived. If the solution assume a purplish red colour, it is a sign of oxyd of manganese; an orange red shews iron; and a gold yellow colour betokens chrome. Freedom from colour proves that the stone contains no metallic ingredients.

N. When the solution is complete, it is to be evaporated to dryness in a glass vessel; but if any thing resist solution, it must be heated as before (I.) with potash. When the liquor approaches to dryness, it assumes the form of a jelly, and must then be diligently stirred till quite dry.

O. (a) Let the dry mass be digested in a gentle heat, with three or four pints or even more of distilled water; and filtered. (b) Wash what remains on the filtre, repeatedly; till the washing cease to precipitate the nitrate of silver; and add the washings to the filtred liquor. (c) Let the residue on the filtre be dried, and ignited in a crucible. Its weight shews the quantity of silex. If pure, it should be perfectly white; but if it have any colour, an admixture of some metallic oxyd is indicated. From this, it may be purified by digestion in muriatic acid; and may again be washed, ignited, and weighed.

P. The solution (O), which, owing to the addition of the washings will have considerable bulk, is next to be evaporated, till less than a pint remains; carbonate of potash must then be added; and the liquor must be heated during a few minutes. Let the precipitate, occasioned by the alcali, subside; decant the liquor from above it; and wash the sediment, repeatedly, with warm water. Let it then be put on a filtre and dried.

Q. The dried powder may contain alumine, lime, magnesia, barytes, or strontites; besides metallic oxyds; which may be separated from each other by the rules already given.

R. It may be proper to examine the solution (P) after the addition of carbonate of potash; in order to discover, whether any and what acid, was contained in the stone.

(a) For this purpose, let the excess of alcali be neutralized by muriatic acid; and the liquor filtered.

(b) Add, to a little of this liquor, a solution of muriated barytes. Should a copious precipitate ensue, which is insoluble in dilute muriatic acid, the presence of sulphuric acid is detected. And if much barytes, strontites, or lime, has been found in the precipitate Q, we may infer the presence of a sulphate of one of these three earths.

(c) If, on mixing the liquid (a) with the solution of muriated barytes, a precipitate ensues, which is soluble in muriatic acid, the phosphoric acid may be known to be present; and if lime be, also, found, the phosphate of lime is indicated.

(d) To a portion of the liquor (a) add a solution of muriate of lime, till the precipitate, if any, ceases. Collect this precipitate, wash it, dry it; and pour on it a little sulphuric acid. Should acid fumes arise, the fluoric acid may be suspected. To ascertain its presence decisively, distil a portion of the precipitate with half its weight of sulphuric acid. The fluoric acid will be known by its effects on the retort, and by the properties described, page 86.

S. The method of separating, from each other, the metallic oxyds, usually found as the colouring ingredients of stones, remains to be accomplished.

(a) Let the precipitate, by the prussiate of potash (D) be exposed to a red heat; by which the prussic acid will be decomposed. The oxyds, thus obtained, if insoluble in dilute nitric or muriatic acid, will be rendered so by again calcining them with the addition of a little wax or oil.

(b) Or the process may be varied by omitting the precipitation by prussiate of potash, and proceeding as directed, E. page 154.

The oxyds will remain mixed with the magnesia and lime; and after the addition of sulphuric acid, will be held in solution by that acid, along with magnesia only.

In both cases, the same method of proceeding may be adopted, such variation only being necessary, as is occasioned by the presence of magnesia in the latter.

(c) To the solution (a or b), containing several metallic oxyds dissolved by an acid, add a solution of crystallized carbonate of potash, as long as any precipitation ensues. This will separate the oxyds of iron, chrome, and nickel; but the oxyd of manganese, and the magnesia, if any be present, will remain dissolved.

(d) Magnesia, and oxyd of manganese, may be separated, by adding to their solution (c) the hydro-sulphuret of potash (see p. 59, F.), which will throw down the manganese, but not the magnesia. The precipitated manganese must be calcined with the access of air; and weighed. The magnesia may afterwards be separated by solution of pure potash; and when precipitated, must be washed, dried, and calcined.

(e) The oxyd of chrome may be separated, from those of iron and nickel, by repeatedly boiling the three, to dryness, with nitric acid. This will acidify the chrome, and will render it soluble in pure potash, which does not take up the other oxyds. From this combination with potash, the chromic oxyd may be detached, by adding muriatic acid, and evaporating the liquor, till it assumes a green colour. Then, on adding a solution of pure potash, the oxyd of chrome will fall down, because the quantity of oxygen, required for its acidification, has been separated by the muriatic acid.

(f) The oxyds of iron and nickel are next to be dissolved in muriatic acid; and to the solution, pure liquid ammonia is to be added, till there is an evident excess of it. The oxyd of iron will be precipitated; and must be dried and weighed. The oxyd of nickel remains dissolved by the excess of ammonia, to which it imparts a blue colour. It may be separated by evaporating the solution to dryness, and dissolving the salt.

The analysis of the stone is now completed, and its accuracy may be judged, by the correspondence of the weight of the component parts, with that of the stone, originally submitted to experiment.

It may be 'proper to observe, that certain stones, which are not soluble in diluted nitric and muriatic acids, may be decomposed by an easier process than that decribed A. Among these, are the compounds of barytes, strontites, and lime, with acids, chiefly with the sulphuric, fluoric, and phosphoric. The sulphates of barytes, strontites, and lime; the fluate of lime; and the phosphate of lime, are all found native in the earth, and, except the last, are all insoluble in the above mentioned acids. They may be known generally by their external characters. The compounds of barytes and strontites have a specific gravity greater than that of other earths, but inferior to that of metallic ones. They have, frequently, a regular or crystallized form; are more or less transparent; have some lustre; and their hardness is such as does not prevent their yielding to the knife. The combinations of lime, with the above mentioned acids, are distinguished by similar characters, except that they are much less heavy. To the minerologist, the outward form and characters of these stones are sufficient indications of their composition.

Instead of the fusion with alcali, an easier process may be recommended. Let the mineral, under examination, be reduced to powder, and be digested, in nearly a boiling heat, during one or two hours, with three or four times its weight of carbonate of potash, and a sufficient quantity of distilled water. The acid, united with the earth, will quit it, and pass to the potash; while the carbonic acid will leave the alcali, and combine with the earth. We shall obtain, therefore, a compound of the acid of the stone with potash, which will remain in solution, while the carbonated earths will form an insoluble precipitate. The solution may be assayed, to discover the nature of the acid, according to the formula I; and the earths may be separated from each other by the processes B, &c.

T. In the foregoing rules for analysis, I have omitted the mode of detecting and separating *glucine;* because this earth is of very rare occurrence. When alumine and glucine are present in a mineral, they may be separated, from the precipitate (E.a.) by pure potash, which dissolves both these earths. A sufficient quantity of acid is then to be added to saturate the alcali; and carbonate of ammonia is to be poured in, till a considerable excess of this carbonate is manifested by the smell. The alumine is thus separated; but the glucine, being soluble in the carbonate of ammonia, remains dissolved, and may be precipitated by boiling the solution.

U. The presence of potash (which has lately been discovered in some stones) may be detected, by boiling the powdered mineral, repeatedly, to dryness, with strong sulphuric acid. Wash the dry mass with water; add a little excess of acid; and evaporate the solution to a smaller bulk. If crystals of alum should appear, it is a decisive proof of potash, because this salt can never be obtained in a crystallized form, without the addition of the vegetable alcali.

But, since a mineral may contain potash, and little or no alumine, in which case no crystals of alum will appear, it may be necessary, in the latter case, to add a little alumine, along with the sulphuric acid. Or the stone may be so hard as to resist the action of sulphuric acid; and it will then be necessary to fuse it, (in the manner directed I) with soda, which has also a solvent power over alumine and silex. The fused mass is to be dissolved in water; and supersaturated with sulphuric acid. Evaporate to dryness; re-dissolve in water; and filtre, to separate the silex. Evaporate the solution, which will first afford crystals of sulphate of soda, and afterwards of sulphate of alumine, should this alcali be contained in the mineral.

The potash, contained in sulphate of alumine, may be separated from the earth, by adding a solution of pure barytes, as long as any precipitation is produced. The alumine and sulphate of barytes will fall down together, and the potash will remain in solution. Its presence may be known by the tests, p. 143. II. 2.

V. Soda may be detected in a mineral, by the following experiments. Let the powdered stone be treated with sulphuric acid, as in U; wash off the solution, and add pure ammonia, till the precipitation ceases. Then filtre; evaporate the solution to dryness; and raise the heat so as to expel the sulphate of ammonia. The sulphate of soda will remain, and may be known by the characters, page 56.

III. ANALYSIS OF INFLAMMABLE FOSSILS.

The exact analysis of inflammable fossils is seldom necessary in directing the most beneficial application of them. It may be proper however to offer a few general rules for judging of their purity.

1. SULPHUR. Sulphur should be entirely volatilized, by distillation in a glass retort. If any thing remain fixed, it must be considered as an impurity, and may be examined by the preceding rules.

Sulphur, also, should be totally dissolved by boiling with solution of pure potash, and may be separated from its impurities by this alcali.

2. COALS.

1. The proportion of bituminous matter in coal may be learnt by distillation in an earthen retort, and collecting the product.

2. The proportion of earthy or metallic ingredients may be found, by burning the coal, with access of air, on a red hot iron. What remains unconsumed must be considered as an impurity, and may be analyzed by the foregoing rules.

3. The proportion of carbon may be ascertained, by observing the quantity of nitrate of potash, which a given weight of the coal is capable of decomposing. For this purpose, let 500 grains or more of perfectly pure nitre, be melted in a crucible, and when red hot, let the coal to be examined, reduced to a coarse powder, be projected on the nitre, by small portions at once, not exceeding one or two grains. Immediately, when the flame occasioned by one projection has ceased, let another be made; and so on till the effect ceases. The proportion of carbon in the coal is directly proportionate to the quantity required to alcalize the nitre. Thus since 12.709 of carbon are required to alcalize 100 of nitre, it will be easy to deduce the quantity of carbon in a given weight of coal, from the quantity of nitre, which it is capable of decomposing. This method, however, is liable to several objections, which its inventor, Mr. Kirwan, seems fully aware of. See his Elements of Mineralogy, Vol. II. p. 514.

PLUMBAGO, OR BLACK LEAD, is another inflammable substance, which it may sometimes be highly useful to be able to identify, and to judge of its purity.—When projected on red hot nitre, it should detonate; and on dissolving the decomposed nitre, an oxyd of iron should remain, amounting to one tenth the weight of the plumbago. Any mineral, therefore, that answers to these characters; and leaves a shining trace on paper, like that of the black lead pencils, is plumbago.

IV. ANALYSIS OF METALLIC ORES.

The class of metals comprehends so great a number of individuals, that it is almost impossible to offer a comprehensive formula for the analysis of ores. Yet some general directions are absolutely necessary, to enable the naturalist to judge of the composition of bodies of this class.

The ores of metals may be analyzed in two modes, in the humid and the dry way. The first is effected with the aid of acids and of other liquid agents; and may often be accomplished by persons who are prevented, by the want of furnaces and other necessary apparatus, from attempting the second.

It is hardly possible to employ a solvent capable of taking up all the metals. Thus, the nitric acid does not act on gold or platina; and the nitro-muriatic, which dissolves these metals, has no solvent action on silver. It will be necessary therefore to vary the solvent, according to the nature of the ore under examination.

FOR ORES OF GOLD AND PLATINA, the nitro-muriatic acid is the most proper solvent. A given weight of the ore may be digested with this acid, as long as it extracts any thing. The solution may be evaporated to dryness, in order to expel the excess of acid; and dissolved in water. The addition of a solution of tin in muriatic acid will shew the presence of gold, by a purple precipitate; and platina will be indicated by a precipitate, on adding a solution of muriate of ammonia. When gold and platina are both contained in the same solution, they may be separated from each other, by the last mentioned solution, which throws down the platina but not the gold. In this way platina may be detached, also, from other metals.

When gold is contained in a solution, along with several other metals, it may be separated from most of them, by adding a dilute solution of sulphate of iron. The only metals, which this salt precipitates, are gold, silver and mercury.

For extracting SILVER from its ores, the nitric acid is the most proper solvent. The silver may be precipitated by muriate of soda (common salt). Every hundred parts of the precipitate contain 75 of silver. But as lead may be present in the solution; and this metal is, also, precipitated by muriate of soda, it may be proper to immerse in the solution (which should not have any excess of acid) a polished plate of copper. This will precipitate the silver, if present, in a metallic form. The muriate of silver is also soluble in liquid ammonia, which that of lead is not.

COPPER ORES may be analyzed by boiling them with five times their weight of concentrated sulphuric acid, till a dry mass is obtained, from which water will extract the sulphate of copper. This salt is to be decomposed by a polished plate of iron, immersed in a dilute solution of it. The copper will be precipitated in a metallic state, and may be scraped off, and weighed.

If silver be suspected along with copper, nitrous acid must be employed as the solvent; and a plate of polished copper will detect the silver.

IRON ORES may be dissolved in dilute muriatic acid, or, if too highly oxydated to be dissolved by this acid, they must be previously mixed with one eighth their weight of powdered charcoal, and calcined in a crucible for one hour. The iron is thus rendered soluble.

The solution must then be diluted with 10 or 12 times its quantity of water, previously well boiled, to expel the air, and must be preserved in a well stopped glass bottle, for six or eight days. The phosphate of iron will, within that time, be precipitated, if any be present, and the liquor must be decanted off.

The solution may contain the oxyds of iron, manganese, and zinc. It may be precipitated by carbonate of soda, which will separate them all. The oxyd of zinc will be taken up, by a solution of pure ammonia; distilled vinegar will take up the manganese; and will leave the oxyd of iron. From the weight of this, after ignition, during quarter of an hour, 28 per cent. may be deducted. The remainder shews the quantity of iron.

TIN ORES. No successful mode of analyzing these, in the humid way, has hitherto been discovered. The presence of tin in an ore is indicated by a purple precipitate, on mixing its solution in muriatic acid, with one of gold in nitro-muriatic acid.

LEAD ORES may be analyzed by solution in nitric acid, diluted with an equal weight of water. The sulphur, if any, will remain undissolved. Let the solution be precipitated by carbonate of soda. If any silver be present, it will be taken up by pure liquid ammonia. Wash off the excess of ammonia by distilled water; and add concentrated sulphuric acid, applying heat, so that the muriatic acid may be wholly expelled. Weigh the sulphate of lead, and after deducting 70 per cent. the remainder shews the quantity of lead.

MERCURY may be detected in ores that are supposed to contain it, by distillation in an earthen retort with half their weight of iron filings or lime. The mercury, if any be present, will rise, and be condensed in the receiver.

ORES OF ZINC may be digested with the nitric acid, and the part that is dissolved, boiled to dryness;

again dissolved in the acid, and again evaporated. By this means the iron, if any be present, will be rendered insoluble in dilute nitric acid, which will take up the oxyd of zinc. To this solution, add pure liquid ammonia in excess, which will separate the lead, and iron if any should have been dissolved; and the excess of alkali will retain the oxyd of zinc. This may be separated by the addition of an acid.

ANTIMONIAL ORES. Dissolve a given weight, in three or four parts of muriatic and one of nitric acid. This will take up the antimony, and leave the sulphur, if any. On dilution with water, the oxyd antimony is precipitated, and the iron and mercury remain dissolved. Lead may be detected by sulphuric acid.

ORES OF ARSENIC may be digested with nitro-muriatic acid, composed of one part nitrous, and one and a half, or two, of muriatic. Evaporate the solution to one fourth; and add water, which will precipitate the arsenic. The iron may afterwards be separated by ammonia.

ORES OF BISMUTH are also assayed, by digestion in nitric acid, moderately diluted. The addition of water precipitates the oxyd, and if not wholly separated at first, evaporate the solution; after which a further addition of water will precipitate the remainder.

ORES OF COBALT may be dissolved in nitro-muriatic acid. Then add carbonate of potash, which, at first, separates iron and arsenic. Filtre, and add a further quantity of the carbonate, when a greyish red precipitate will fall down, which is oxyd of cobalt. The iron and arsenic may be separated by heat, which volatilizes the arsenic. Cobalt is, also, ascertained, if the solution of an ore in muriatic acid give a sympathetic ink; see p. 112.

ORES OF NICKEL. Dissolve them in nitric acid; and add to the solution pure ammonia, in such proportion that the alcali may be considerably in excess. This will precipitate other metals, and will retain the oxyd of nickel in solution, which may be obtained by evaporation to dryness, and heating the dry mass, till the nitrate of ammonia has sublimed.

ORES OF MANGANESE. The earths, and several of the metals, contained in this ore, may first be separated by diluted nitric acid, which does not act on highly oxydated manganese. The ore may afterwards be digested with strong muriatic acid, which will take up the oxyd of manganese. Oxygenated muriatic acid will arise, if a gentle heat be applied, and may be known by its peculiar smell, and by its discharging the colour of wet litmus paper, exposed to the fumes. From muriatic acid, the manganese is precipitated by carbonate of soda, in the form of a white oxyd, which becomes black when heated in a crucible. Ores, suspected to contain manganese, may also be distilled per se, or with sulphuric acid, when oxygenous gas will be obtained. Oxyd of manganese may be separated from oxyd of iron, by solution of pure potash, which takes up the former but not the latter.

Ores of manganese may, also, be distinguished, by the colour they impart to borax, when exposed together to the blow pipe. See p. 111.

ORES OF URANITE. These may be dissolved in dilute nitric acid, which takes up the uranitic oxyd, and leaves that of iron ; or in dilute sulphuric acid, which makes the same election. Or if any iron has got into the solution, it may be precipitated by zinc. Then add caustic potash, which throws down the oxyds of zinc and uranium. The former may be separated by digestion in pure ammonia, which leaves, undissolved, the oxyd of uranite. This, when dissolved by dilute sulphuric acid, affords, on evaporation, crystals of a lemon yellow colour.

If copper be present, it will be dissolved, along with the zinc, by the ammonia. If lead, it will form with sulphuric acid a salt much less soluble than the sulphate of uranite, and which, on evaporation, will, therefore, separate first.

ORES OF TUNGSTEN. For these, the most proper treatment seems to be digestion in nitro-muriatic acid, which takes up the earths, and other metals. The tungsten remains, in the form of a yellow oxyd, distinguishable, by its becoming white, on the addition of liquid ammonia, from the oxyd of uranite. To reduce this oxyd to tungstenite, mix it with an equal weight of dried blood; heat the mixture to redness; press it into another crucible, which should be nearly full; and apply a violent heat, for an hour at least.

ORES OF MOLYBDENA. Repeated distillation to dryness, with nitric acid, converts the oxyd into an acid; which is insoluble in nitric acid, and may be thus separated from other metals except iron, from which it may dissolved by sulphuric or muriatic acids. The solution in sulphuric acid is blue when cold, but colourless when heated. That in muriatic acid is only blue, when the acid is heated and concentrated.

ANALYSIS OF ORES IN THE DRY WAY.

To analyze ores in the dry way, a method which affords the most satisfactory evidence of their composition, and should always precede the working of large and extensive strata, a more complicated apparatus is required. An assaying furnace, with muffles, crucibles, &c., are absolutely necessary; but as these may be found described in most elementary books, I shall omit the detail of them in this place.

The reduction of an ore requires, frequently, previous roasting to expel the sulphur, and other volatile ingredients. Or this may be effected, by mixing the powdered ore with nitre, and projecting the mixture into a crucible. The sulphate of potash thus formed, may be washed off; and the oxyd must be reserved for subsequent experiments.

As many of the metals retain their oxygen so forcibly, that the application of heat is incapable of expelling it, the addition of inflammable matter becomes expedient. And to enable the reduced particles of metal to agglutinate and form a collected mass, instead of scattered grains, which would otherwise happen, some fusible ingredient must be added, through which, when in fusion, the reduced metal may descend, and be collected at the bottom of the crucible. Substances, that answer both these purposes, are called *fluxes*. The alcaline and earthy part of fluxes serve, also, another end, viz. that of combining with any acid, which may be attached to a metal, and which would prevent its reduction if not separated.

The ores of different metals, and different ores of the same metal, require different fluxes. To offer rules, however, for each individual case, would occupy too much room in this work. I shall, therefore, only state a few of these fluxes that are most generally applicable.

The black flux, (described page 108 note), is a very good one. Two parts of muriate of soda, previously dried in a crucible, one part of powdered lime, one part of fluate of lime, and half a part of charcoal: Or four hundred parts of calcined borax, forty of lime, and fifty of charcoal: Or two parts of pounded glass, one of borax, and half a part of charcoal, are all well adapted to the purpose of fluxes. The ore, after being roasted, if necessary, is to be well mixed with three or four times its weight of the flux, and put into a crucible, with a little powdered charcoal over the surface. A cover must be luted on; and the crucible exposed to the necessary heat in a wind furnace. Ores of iron, as being difficultly reduced, require a very intense fire. Those of silver and lead are metallized by a lower heat.

The volatile metals, as mercury, zinc, and arsenic, it is obvious, ought not to be treated in the above manner, and require to be distilled with inflammable matters, in an earthen retort.

For minute instructions respecting the analysis of every species of ore, both in the humid and dry ways, I refer to the second volume of Mr. Kirwan's Mineralogy.

PART III.

APPLICATION OF CHEMICAL TESTS AND REAGENTS TO VARIOUS USEFUL PURPOSES.

SECT. I.

METHOD OF DETECTING POISONS.

WHEN sudden death is suspected to have been occasioned by the administration of poisons, either wilfully or by accident, the testimony of the physician is occasionally required, to confirm or invalidate this suspicion. He may, also, be sometimes called upon to ascertain the cause of the noxious effects, arising from the presence of poisonous substances in articles of diet; and it may, therefore, serve an important purpose, to point out, concisely, the simplest and most practicable modes of obtaining, by experiment, the necessary information.

The only poisons, however, that can be clearly and decisively detected by chemical means, are those of the mineral kingdom. Arsenic and corrosive sublimate are most likely to be exhibited, with the view of producing death; and lead and copper may be introduced, undesignedly, in several ways, into our food and drink. The continued operation of the two last may often, unsuspected, produce effects less sudden and violent, but not less baneful to health and life, than the more active poisons;

and their operation generally involves, in the pernicious consequences, a greater number of sufferers.

1. METHOD OF DISCOVERING ARSENIC.

When the cause of sudden death is believed, from the symptoms preceding it, to be the administration of arsenic, the contents of the stomach must be attentively examined. To effect this, let a ligature be made at each orifice; the stomach removed entirely from the body; and its whole contents washed out into an earthen or glass vessel. The arsenic on account of its greater specific gravity, will settle to the bottom, and may be obtained separate, by washing off the other substances by repeated affusions of cold water. These washings should not be thrown away, till the presence of arsenic has been clearly ascertained. It may be expected at the bottom of the vessel in the form of a white powder, which must be carefully collected; dried on a filtre; and submitted to experiment.

A. Boil a small portion of the powder, with a few ounces of distilled water, in a clean florence flask, and filtre the solution.

B. To this solution, add a portion of water saturated with sulphurated hydrogen gas (see page 59). If arsenic be present, a golden yellow sediment will fall down, which will appear sooner, if a few drops of acetic acid be added.

C. A similar effect is produced, by the addition of sulphuret of ammonia.

D. To a little of the solution A, add a single drop of a weak solution of carbonate of potash, and afterwards a few drops of a solution of sulphate of copper. The presence of arenic will be manifested by a yellowish green precipitate.

E. The sediments, produced by any of the foregoing experiments, may be collected, dried, and laid on red hot charcoal. A smell of sulphur will first arise, and will be followed by that of garlic.

F. But the most decisive mode of determining the presence of arsenic is, by reducing it to a metallic state, in which its characters are clear and unequivocal. For this purpose, let a portion of the white sediment, collected from the contents of the stomach, be mixed with three times its weight of black flux, see page 108, or, if this cannot be procured, with two parts of dry carbonate of potash (the salt of tartar of the shops) and one of powdered charcoal. Procure a tube eight or nine inches long, and one sixth of an inch in diameter, of thin glass, sealed hermetically at one end. Coat the closed end with clay for about an inch, and let the coating dry. Then put into the tube the mixture of the powder and its flux, and if any should adhere to the inner surface, let it be wiped off by a feather, so that the inner surface of the upper part of the tube may be quite clean. Stop the end of the tube loosely with a little paper, and heat the coated end only, on a chafing dish of red hot coals, taking care to avoid breathing the fumes. The arsenic, if present, will rise to the upper part of the tube, on the inner surface of which it will form a thin brilliant coating. Break the tube, and scrape off the reduced metal. Lay a little on a heated iron, when if it be arsenic, a dense smoke will arise, and a strong smell of garlic will be perceived. The arsenic may be further identified, by putting a small quantity between two polished plates of copper; binding these tightly together by iron wire; and exposing them to heat. If the included substance be arsenic, a white stain will be left on the copper.

G. It may be proper to observe that neither the stain on copper, nor the odour of garlic is produced, by the white oxyd, when heated, without the addition of some inflammable ingredient. The absence of arsenic must not, therefore, be inferred, if no smell is occasioned by laying the white powder on a heated iron.

The late celebrated Dr. Black ascertained, that all the necessary experiments, for the detection of arsenic, may be made on a single grain of the white oxyd; this small quantity having produced, when heated in a tube with its proper flux, as much of the metal, as clearly established its presence.

If the quantity of arsenic, in the stomach, should be so small, which is not very probable, as to occasion death, and yet to remain suspended in the washings, the whole contents, and the water employed to wash them, must be filtered, and the clear liquor assayed for arsenic by the tests B, C, D, and E.

2. DISCOVERY OF CORROSIVE SUBLIMATE.

Corrosive sublimate (the oxygenated muriate of mercury), next to arsenic, is the most virulent of the metallic poisons. It may be collected by treating the contents of the stomach in the manner already described; But as it is more soluble than arsenic, viz. in about 19 times its weight of water; no more water must be employed than is barely sufficient, and the washings must be carefully preserved for examination.

If a powder should be collected by this operation, which proves on examination, not to be arsenic, it may be known to be corrosive sublimate by the following characters.

A. Expose a small quantity of it, without any admixture, to heat, in a coated glass tube, as directed in the treatment of arsenic. Corrosive sublimate will be ascertained by its rising to the top of the tube, and lining the inner surface, in the form of a shining white crust.

B. Dissolve another portion in distilled water; and it may be proper to observe how much of the salt the water is capable of taking up.

C. To the watery solution, add a little lime water. A precipitate of an orange yellow colour will instantly appear.

D. To another portion of the solution, add a single drop of a dilute solution of carbonate of potash (salt of tartar). A white precipitate will appear; but on a still further addition of alcali, an orange coloured sediment will be formed.

E. The carbonate of soda has similar effects.

F. Sulphurated water throws down a dark coloured sediment, which, when dried and strongly heated, is wholly volatilized, without any odour of garlic.

The only mineral poison, of great virulence, that has not been mentioned, and which, from its being little known to act as such, it is very improbable we should meet with, is the carbonate of barytes. This, in the country, where it is found, is employed as a poison for rats, and there can be no doubt would be equally destructive to human life. It may be discovered, by dissolving it in muriatic acid, and by the insolubility of the precipitate, which this solution yields, on adding sulphuric acid (see page 92). Barytic salts will be contained in the water employed to wash the contents of the stomach, and will be detected, on adding sulphuric acid, by a copious precipitate.

3. METHOD OF DETECTING COPPER OR LEAD.

Copper and lead sometimes gain admission into articles of food, in consequence of the employment of kitchen utensils of these materials.

If copper be suspected in any liquor, its presence will be ascertained by adding a solution of pure ammonia, which will strike a beautiful blue colour. If the solution be very dilute, it may be concentrated by evaporation; and if the liquor contain a considerable excess of acid, like that used to preserve pickles, as much of the alcali must be added, as is more than sufficient to saturate the acid.

Lead is occasionally found, in sufficient quantity to be injurious to health, in water that has been kept in leaden vessels, and sometimes even in pump water, in consequence of the metal being used in the construction of the pump. Acetite of lead has, also, been known to be fraudulently added to bad wines, with the view of concealing their defects.

Lead may be discovered by adding, to a portion of the suspected water, about half its bulk of water impregnated with sulphurated hydrogen gas. If lead be present, it will be manifested by a dark brown or blackish tinge. This test is so delicate, that water, condensed by the leaden worm of a still-tub, is sensibly affected by it. It is, also, detected by a similar effect ensuing, on the addition of sulphurets of ammonia or potash.

For discovering the presence of lead in wines, a test invented by Dr. Hahnemann, and known by the title of Hahnemann's wine test, may be employed. This test is prepared by putting together, into a small vial, sixteen grains of the sulphuret of lime, prepared in the dry way (see page 81), and twenty grains of acidulous tartrite of potash (cream of tartar). The vial is to be filled with water; well corked; and occasionally shaken for the space of ten minutes. When the powder has subsided; decant the clear liquor; and preserve it in a well stopped bottle for use. The liquor, when fresh prepared, discovers lead by a dark coloured precipitate. A further proof of the presence of lead in wines is the occurrence of a precipitate, on adding the sulphate of soda.

SECT. II. RULES FOR ASCERTAINING THE PURITY OF CHEMICAL PREPARATIONS EMPLOYED FOR THE PURPOSES OF MEDICINE, AND FOR OTHER USES.

1. *Sulphuric acid—Acidum Vitriolicum of the London Pharmacopœia.—Oil of Vitriol.*

The specific gravity of sulphuric acid should be 1850. It should remain perfectly transparent, when diluted with distilled water. If a sediment should occur, on dilution, it is a proof of the presence of sulphate of lead or lime.

Iron will be detected in sulphuric acid, by saturating a diluted portion of it with pure carbonate of soda, and adding prussiate of potash, which will manifest the presence of iron by a prussian blue precipitate. Copper may be discovered, by pouring, into a similar saturated solution, pure solution of ammonia; and lead may be detected by the sulphuret of ammonia. The latter metal, however, is generally precipitated, on dilution, in combination with sulphuric acid.

Sulphate of potash or of soda may be found, by saturating the diluted acid with ammonia, evaporating to dryness, and applying a pretty strong heat. The sulphate of ammonia will escape; and that of potash or of soda will remain, and may be distinguished by its solubility and other charaters. (See page 56.

2. *Nitric and Nitrous Acids—Acidum Nitrosum, Pharm. Lond. Aquafortis.*

The nitric acid should be perfectly colourless and as limpid as water. It should be preserved in a dark place; to prevent its conversion into the nitr*ous* kind.

These acids are most likely to be adulterated with sulphuric and muriatic acids. The sulphuric acid may be discovered by adding to a portion of the acid, largely diluted, nitrated or muriated barytes, which occasion, with sulphuric acid, a white and insoluble precipitate. The muriatic acid may be ascertained by nitrate of silver, which affords a sediment, at first white, but which becomes coloured, by exposure to the direct light of the sun. Both these acids, however, may be present at once; and, in this case, it will be necessary to add a solution of nitrate of barytes, as long as any precipitate falls, which will separate the sulphuric acid. Let the sediment subside; decant the clear liquor; and add the nitrate of silver. If a precipitate appear, muriatic acid may be inferred to be present also.

These acids should have the specific gravity of 1550.

3. *Muriatic Acid—Acidum Muriaticum, P. L. Spirit of Salt.*

This acid generally contains iron, which may be known by its yellow colour, the pure acid being perfectly colourless. It my also be detected by the same mode, as was recommended in examining sulphuric acid.

Sulphuric acid is discoverable by a precipitation, on adding the muriate of barytes.

The specific gravity of this acid should be 1170.

4. *Acetic Acid—Acidum Acetosum, P. L. Radical or concentrated Vinegar.*

This acid is often contaminated by sulphureous and sulphuric acid. The first may be known by drawing a little of the vapour into the lungs, when if the acid be pure, no unpleasant sensation will be felt; but, if sulphureous acid be contained in the acetic, it will not fail to be discovered in this mode. The sulphuric acid is detected by muriated barytes: Copper by super-saturation with pure ammonia: And lead by sulphuret of ammonia.

The specific gravity of this acid should be 1050 at least.

5. *Acetous Acid.—Acetum Distillatum, P. L. Distilled Vinegar.*

If vinegar be distilled in copper vessels, it can hardly fail being contaminated by that metal; and if a leaden worm be used, for its condensation, some portion of lead will certainly be dissolved. The former metal will appear, on adding an excess of solution of ammonia; and lead will be detected by the sulphurated ammonia, or by water saturated with sulphurated hydrogen.

It is not unusual, in order to increase the acid taste of vinegar, to add sulphuric acid. This acid may be immediately discovered, by solutions of barytes, which, when vinegar has been thus adulterated, throw down a white precipitate.

6. *Boracic acid—Sedative Salt of Homberg.*

Genuine boracic acid should totally dissolve in five times its weight of boiling alcohol; and the solution, when set on fire, should emit a green flame. The best boracic acid forms small hexangular scaley crystals, of a shining silvery white colour. Its specific gravity is 1480.

7. *Tartarous Acid.*

This acid often contains sulphuric acid, to discover which, let a portion be dissolved in water, and a solution of acetite of lead be added. A precipitate will appear, which, if the acid be pure, is entirely re-dissolved by a few drops of pure nitric acid, or by a little pure acetic acid. If any portion remain undissolved, sulphuric acid is the cause. Muriate of barytes, also, when the acid is adulterated with sulphuric acid, but not otherwise, gives a precipitate insoluble by an excess of muriatic acid.

8. *Acid of Amber.*

Acid of amber is adulterated, sometimes with sulphuric acid and its combinations; sometimes with tartarous acid; and at others with muriate of ammonia.

Sulphuric acid is detected by solutions of barytes; tartareous acid by carbonate of potash, which forms a difficultly soluble tartrite; and muriate of ammonia by nitrate of silver, which discovers the acid, and by a solution of pure potash, which excites a strong smell of ammonia.

Pure acid of amber is a crystalline white salt; of an acid taste; soluble in twenty-four parts of cold and eight of hot water; and is volatilized when laid on red hot iron, without leaving any ashes or other residue.

9. *Acid of Benzoin—Flores Benzoes, P. L.*

This acid is not very liable to adulteration. The best has a brilliant white colour, and a peculiarly grateful smell. It is soluble in a large quantity of boiling water or alcohol; and leaves no residue, when placed on a heated iron.

10. *Carbonate of Potash.—Kali Preparatum, P. L.*

The salt of tartar of the shops generally contains sulphate and muriate of potash, and siliceous and calcareous earths. It should dissolve entirely, if pure, in twice its weight of cold water; and any thing, that remain undissolved, may be regarded as an impurity. Sometimes one fourth of foreign admixtures may thus be detected, the greater part of which is sulphate of potash. To ascertain the nature of the adulteration, dissolve a portion in pure and diluted nitric acid. The siliceous earth only will remain undissolved. Add, to one portion of the solution, nitrate of barytes. This will detect sulphate of potash by a copious precipitate. To another portion add nitrate of silver, which will discover muriatic salts; and to a third oxalate of ammonia, which will detect calcareous earth.

The solution of carbonate of potash (Aqua Kali, P. L.) may be examined in a similar manner.

11. *Solution of pure Potash—Aqua Kali Puri, P. L.*

This may be assayed for sulphuric and muriatic salts by saturation with nitric acid, and by the tests, recommended in speaking of carbonate of potash. A perfectly pure solution of potash should remain transparent, on the addition of barytic water. If a precipitate should ensue, which dissolves, with effervescence, in dilute muriatic acid, it is owing to the presence of carbonic acid; if the precipitate is not soluble, it indicates sulphuric acid. A redundancy of carbonic acid is, also, shewn by an effervescence on adding diluted sulphuric acid; and an excess of lime, by a white precipitate, on blowing air, from the lungs, through the solution, by means of a tobacco pipe.

This solution should be of such a stsength, as that an exact wine pint may weigh 18 ounces troy.

12. *Carbonate of Soda—Natron Preparatum, P. L.*

Carbonate of soda is scarcely ever found free from muriate and sulphate of soda. These may be discovered by adding, to a little of the carbonate saturated with pure nitric acid, first nitrate of barytes, to detect sulphuric acid; and afterwards nitrate of silver, to ascertain the presence of muriatic acid. Carbonate of potash will be shewn by a precipitate ensuing, on the addition of tartarous acid to a strong solution of the alcali; for this acid forms a difficultly soluble salt with potash, but not with soda.

13. *Solution of Carbonate of Ammonia— Aqua Ammonia, P. L.*

This should have the specific gravity of 1150; should effervesce on the addition of acids; and should afford a strong coagulum, on adding alcohol.

14. *Carbonate of Ammonia—Ammonia Preparata, P. L.*

This salt should be entirely volatilized by heat. If any thing remain, when it is laid on a heated iron, carbonate of potash or of lime may be suspected; and these impurities are most likely to be present, if the carbonate of ammonia be purchased in the form of a powder. It should therefore always be bought in solid lumps. Sulphuric and muriatic salts, lime, and iron may be discovered by adding to the alcali, saturated with nitric acid, the appropriate tests, already often mentioned.

15. *Solution of Pure Ammonia in Water—Aqua Ammoniæ Puræ, P. L.—Strong Spirit of Sal Ammoniac.*

The volatile alkali, in its purest state, exists as a gas, condensible by water; and its solution in water is the only form, under which it is applicable to useful purposes. This solution should contain nothing besides the volatile alcali; the alcali should be perfectly free from carbonic acid; and should be combined with water, in the greatest possible proportion. The presence of other salts may be discovered, by saturating a portion of the solution with pure nitric acid, and adding the tests for sulphuric and muriatic acids. Carbonic acid is shewn by a precipitation, on mixing the solution with one of muriate of lime; for this earthy salt is not precipitated by pure ammonia. The only mode of determining the strength of the solution, is by taking its specific gravity, which, at 60°, of Faht., should be as 905, or thereabouts, to 1000.

16. *Spirit of Hartshorn.—Liquor Volatilis Cornu Cervi, P. L.*

This may be counterfeited by mixing the aqua ammoniæ puræ with the distilled spirit of hartshorn, in order to increase the pungency of its smell, and to enable it to bear an addition of water. The fraud is detected by adding alcohol to the sophisticated spirit; for if no considerable coagulation ensues, the adulteration is proved. It may also be discovered by the usual effervescence not ensuing with acids. The solution should have the specific gravity of 1500.

17. *Sulphate of Soda—Natron Vitriolatum, P. L.* *Glauber's Salt.*

This salt ought not to contain an excess of either acid or alkali, both of which may be detected by the vegetable infusions page 128. Nor should it be mixed with earthy or metallic salts; the former of which are detected by carbonate, and the latter by prussiate of potash. Muriate of soda is discovered, by adding nitrate of barytes, till the precipitate ceases; and afterwards nitrate of silver. Sulphate of potash is discovered by its more sparing solubility. The sulphate of soda, however, being itself one of the cheapest salts, there is little risk of its being intentionally sophisticated.

18. *Sulphate of Potash—Kali Vitriolatum, P. L.* *Vitriolated Tartar.*

The purity of this salt may be ascertained by the same means, as that of the former one. The little value of this salt renders it pretty secure from wilful adulteration.

19. *Nitrate of Potash—Nitrum Purificatum, P. L.* *Nitre or Salt Petre.*

Nitrate of potash, is, with great difficulty, freed entirely from muriate of soda; and a small portion of the latter, except for nice chemical purposes, is an admixture of little importance. To discover muriate of soda, a solution of nitrate of silver must be added, as long as any sediment is produced. The precipitate, washed and dried, must be weighed. Every hundred grains will denote 42½ of muriate of soda.

Sulphate of potash or of soda may be discovered by nitrate or muriate of barytes.

20. *Muriate of Soda—Common Salt.*

Common salt is scarcely ever found free from salts with earthy bases, chiefly muriate of magnesia and lime, which are contained in the lime, and adhere to the crystals. The earths may be precipitated by carbonate of soda; and the precipitated lime and magnesia may be separated from each other by the rules given, page 154.

21. *Muriate of Ammonia—Ammonia Muriata, P. L. Sal Ammoniac.*

The salt ought to be entirely volatilized by a low heat, when laid on a heated iron. It sometimes contains sulphate of ammonia, however, which, being also volatile, cannot be thus detected. To ascertain the presence of the latter salt, add the muriate or nitrate of barytes, which will indicate the sulphate, by a copious and insoluble precipitate.

22. *Acetite of Potash—Kali Acetatum, P. L.*

Genuine acetite of potash is perfectly soluble in four times its weight of alcohol, and is thus separable from other salts, that are insoluble in alcohol. The tartrite of pôtash (soluble tartar) is the adulteration most likely to be employed. This may be discovered by adding a solution of tartarous acid, which, if the suspected salt be present, will occasion a copious precipitate. The tartrite is also detected by its forming a precipitate, with acetite of lead or muriate of barytes, soluble in acetic or muriatic acid; and sulphates, by a precipitate with the same agents, insoluble in acids.

23. *Neutral Tartrite of Potash.—Kali Tartarizatum, P. L.—Soluble Tartar.*

This salt should afford a very copious precipitate on adding tartarous acid. The only salt, likely to be mixed with it, is sulphate of soda, which may be detected by a precipitate with muriated barytes, insoluble in diluted muriatic acid.

24. *Acidulous Tartrite of Potash—Tartarum Purificatum.—Cream of Tartar.*

The only substance, with which this salt is likely to be adulterated, is sulphate of potash. To determine whether this be present, pour on about half an ounce of the powdered crystals, two or three ounce measures of distilled water; shake the mixture frequently; and let it stand one or two hours. The sulphate of potash, being more soluble than the tartrite will be taken up; and may be known by the bitter taste of the solution, and by a precipitate, on adding muriate of barytes, which will be insoluble in muriatic acid.

25. *Compound Tartrite of Soda and Potash.—Natron Tartarizatum, P. L.—Rochelle or Seignette's Salt.*

Sulphate of soda, the only salt, with which this may be expected to be adulterated, is discovered by adding to a solution of Rochelle salt, the acetite of lead or muriate of barytes.—The former, if the sulphate be present, affords a precipitate, insoluble in acetous acid; and the latter one, insoluble in muriatic acid.

26. *Sulphate of Magnesia.—Magnesia Vitriolata, P. L.—Epsom Salt.*

This salt is very likely to be adulterated with sulphate of soda, or Glauber's salt, which may be made to resemble the magnesian salt in appearance, by stirring it briskly at the moment it is about to crystallize. The fraud may be discovered, very readily, if the salt consist entirely of the sulphate of soda, because no precipitation will ensue on adding carbonate of potash. If only a part of the salt be sulphate of soda, detection is not so easy; but may still be accomplished. For since 100 parts of pure sulphate of magnesia give between 30 and 40, of the dry carbonate, when completely decomposed by carbonate of potash; if the salt under examination, affords a considerably less proportion, its sophistication may be fairly inferred: Or, to discover the sulphate of soda, precipitate all the magnesia by pure ammonia, with the aid of heat. Decant the clear liquor from the precipitate; filtre it; and after evaporation to dryness, apply such a heat as will volatilize the sulphate of ammonia, when that of soda will remain fixed.

Muriate of magnesia or of lime may be detected, by the salt becoming moist when exposed to the air; and by a precipitation with nitrated silver, after nitrate of barytes has separated all the sulphuric acid and magnesia. Alum is discoverable by oxalic acid.

27. *Sulphate of Alumine.—Alum.*

Perfectly pure alum should contain neither iron nor copper. The former is manifested by adding prussiate of potash; and the latter by an excess of pure ammonia.

28. *Borate of Soda.—Borax.*

Borate of soda, if adulterated at all, will probably be so, with alum or fused muriate of soda. To discover these, borax must be dissolved in water, and its excess of alkali be saturated with nitric acid. Nitrate of barytes, added to this saturated solution, will detect the sulphuric salt, and nitrate of silver the muriate of soda.

29. *Sulphate of Iron—Ferrum Vitriolatum, P. L. Green Vitriol.*

If this salt should contain copper, which is the only admixture likely to be found in it, pure ammonia, added till a precipitation ceases, will afford a blue liquor. Any copper, that may chance to be present, may be separated, and the salt purified, by immersing, in a solution of it, a clear polished plate of iron.

30. *Tartarized Antimony.—Antimonium Tartarizatum, P. L.—Emetic Tartar.*

A solution of this salt should afford, with acetite of lead, a precipitate perfectly soluble in dilute nitric acid. A few drops of the sulphuret of ammonia, also, should immediately precipitate a gold coloured sulphuret of antimony.

31. *Oxygenated Muriate of Mercury.—Hydragyrus Muriatus, P. L.—Corrosive Sublimate.*

If there be any reason to suspect arsenic in this salt, the fraud may be discovered as follows.

Dissolve a small quantity of the sublimate in distilled water ; add a solution of carbonate of ammonia, till the precipitate ceases; and filtre the solution. If on the addition of a few drops of ammoniated copper,* to this solution a precipitate of a yellowish green colour is produced, the sublimate contains arsenic.

32. *Muriate of Mercury.—Calomel, P. L.*

Calomel should be completely saturated with mercury. This may be ascertained by boiling, for a few minutes, one part of calomel with $\frac{1}{32}$d part of muriate of ammonia (sal ammoniac) in 10 parts of distilled water. When carbonate of potash is added to the filtered solution, no precipitation will ensue, if the calomel be pure. This preparation, when rubbed in an earthen mortar with pure ammonia, should become intensely black, and should exhibit nothing of an orange hue.

33. *Mercury or Quicksilver.—Hydrargyrus, P. L.*

Scarcely any substance is so liable to adulteration as mercury, owing to the property which it possesses, of dissolving completely some of the baser metals. This union is so strong, that they even rise along with the quicksilver, when distilled. The impurity of mercury is generally indicated by its dull aspect ; by its tarnishing, and become covering with a coat of oxyd, on long exposure to the air ; by its adhesion to the surface of glass ; and when shaken with water in a bottle by the formation of a

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* Prepared by digesting a little verdegris in the solution of pure ammonia.

black powder. Lead and tin are frequent impurities; and the mercury becomes capable of taking up more of these, if zinc or bismuth be previously added. In order to discover lead, the mercury may be agitated with a little water, in order to oxydate that metal. Pour off the water, and digest the mercury with a little acetous acid. This will dissolve the oxyd of lead, which will be indicated by a blackish precipitate with sulphurated water. Or, to this acetous solution, add a little sulphate of soda, which will precipitate a sulphate of lead, containing, when dry, 72 per cent. of metal. If only a very minute quantity of lead be present, in a large quantity of metal, it may be detected by solution in nitric acid, and the addition of sulphurated water. A dark brown precipitate will ensue, and will subside, if allowed to stand a few days. One part of lead may thus be separated from 15263 parts of mercury.* Bismuth is detected by pouring a nitric solution, prepared without heat, into distilled water; a white precipitate will appear, if this metal be present. Tin is manifested, in like manner, by a weak solution of nitro-muriate of gold, which throws down a purple sediment; and zinc by exposing the metal to heat.

34. *Red-oxyd of Mercury—Hydrargyrus Calcinatus, P. L.*

This substance is rarely found adulterated, as it would be difficult to find a substance well suited to this purpose. If well prepared, it may be totally volatilized by heat.

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* See Mr. Accum's valuable papers, on the detection of adulterations, in Nicholson's Journal.

35. *Red Oxyd of Mercury by Nitric Acid—Hydrargyrus Nitratus Ruber, P. L.—Red Precipitate.*

This is very liable to adulteration with minium or red lead. The fraud may be discovered by digesting it in acetic acid, and adding to the solution sulphurated water, or sulphuret of ammonia. It should, also, be totally volatilized by heat.

36. *White Oxyd of Mercury.—Calx Hydrargyri Alba, P. L.—White Precipitate.*

White lead is the most probable adulteration of this substance, and chalk may, also, be occasionally mixed with it. The oxyd of lead may be discovered as in the last article; and chalk, by adding, to the dilute solution, a little oxalic acid.

37. *Red Sulphurated Oxyd of Mercury.—Hydrargyrus Sulphuratus Ruber, P. L.——Factitious Cinnabar.*

This substance is frequently adulterated with red lead, which may be detected by the foregoing rules.—Chalk and dragon's blood are also sometimes mixed with it. The chalk is discovered by an effervescence on adding acetic acid, and by pouring oxalic acid into the acetous solution. Dragon's blood will be left unvolatilized, when the sulphuret is exposed to heat; and may be detected by its giving a colour to alcohol, when the cinnabar is digested with it.

38. *Black Sulphurated Oxyd of Mercury—Hydrargyrus cum Sulphure, P. L.—Ethiops Mineral.*

The mercury and sulphur, in this preparation, should be so intimately combined, that no globules of the metal can be discovered by a magnifier; and that, when rubbed on gold, no white stain may be communicated. The admixture of ivory black may be detected, by its not being wholly volatilized by heat; or by boiling with alcali to extract the sulphur, and afterwards exposing the residuum to heat, which ought entirely to evaporate.

39. *Yellow Oxyd of Mercury.—Hydrargyrus Vitriolatus, P. L.—Turbith Mineral.*

This preparation should be wholly evaporable; and when digested with distilled water, the water ought not to take up any sulphuric acid, which will be discovered by muriate of barytes.

40. *Fused Nitrate of Silver—Argentum Nitratum, P. L.—Lunar Caustic.*

The most probable admixture, with this substance, is nitrate of copper, derived from the employment of an impure silver. In moderate proportion, this is of little importance. It may be ascertained by solution in water, and adding an excess of pure ammonia, which will detect copper by a deep blue colour.

41. *White Oxyd of Zinc.—Zincum Calcinatum, P. L.—Flowers of Zinc.*

Oxyd of zinc may be adulterated with chalk, which is discoverable by an effervescence with acetous acid, and by the precipitation of this solution with oxalic acid. Lead is detected by adding, to the acetous solution, sulphurated water, or sulphuret of ammonia. Arsenic, to which the activity of this medicine has been sometimes ascribed, is detected, also, by sulphurated water, added to the acetous solution, but in this case the precipitate has a yellow colour; and when laid on red hot charcoal, gives first a smell of a sulphur, and afterwards of arsenic.

42. *White Oxyd of Lead.—Cerussa, P.L.—White Lead.*

This is frequently sophisticated with chalk, the presence of which may be detected by cold acetous acid, and by adding to this solution oxalic acid. Carbonate of barytes is detected by sulphate of soda added to the same solution, very largely diluted with distilled water; and sulphate of barytes, or sulphate of lead, by the insolubility of the cerusse in distilled vinegar.

43. *Acetite of Lead.—Cerussa Acetata, P. L.—Sugar of Lead.*

If the acetite of lead should be adulterated with acetite of lime or of barytes, the former may be detected by adding, to a dilute solution, the oxalic acid; and the latter by sulphuric acid, added to a solution very largely diluted with water. Acetite of lead ought to dissolve entirely in water; and any thing that resists solution may be regarded as an impurity.

44. *Green Oxyd of Copper.—Verdegris.*

This oxyd is scarcely ever found pure, being mixed with pieces of copper, grape stalks, and other impurities. The amount of this admixture of insoluble substances may be ascertained, by boiling a portion of verdegris, with 12 or 14 times its weight of distilled vinegar; allowing the undissolved part to settle; and ascertaining its weight. Sulphate of copper may be detected, by boiling the verdegris with water, and evaporating the solution. Crystals of acetite of copper will first separate; and, when the solution has been further concentrated, the sulphate of copper will crystallize. Or it may be discovered, by adding, to the watery solution, muriate of barytes, which will throw down a very abundant precipitate. Tartrite of copper, another adulteration sometimes met with, is discovered by dissolving a little of the verdegris in acetous acid, and adding acetite or muriate of barytes, which will afford with the tartarous acid a precipitate, soluble in muriatic acid.

45. *Crystallized Acetite of Copper.—Distilled or Crystallized Verdegris.*

This is prepared by dissolving the common verdegris in distilled vinegar, and crystallizing the solution. These crystals should dissolve entirely in six times their weight of boiling water; and the solution should give no precipitation with solutions of barytes; for, if these solutions throw down a precipitate, sulphate of copper is indicated. This impurity may be discovered, by evaporating the solution very low, and separating the crystals of acetite of copper. Further evaporation and cooling will crystallize the sulphate, if any be present.

46. *Carbonate of Magnesia.—Magnesia Alba, P. L.*

Carbonate of magnesia is most liable to adulteration with chalk; and as lime forms with sulphuric acid a very insoluble salt, and magnesia one very readily dissolved, this acid may be employed in detecting the fraud. To a suspected portion of magnesia, add a little sulphuric acid, diluted with

8 or 10 times its weight of water. If the magnesia should entirely be taken up, and the solution should remain transparent, it may be pronounced pure; but not otherwise. Another mode of discovering the deception is as follows. Saturate a portion of the suspected magnesia with muriatic acid; and add a solution of carbonate of ammonia. If any lime be present, it will form an insoluble precipitate, but the magnesia will remain in solution.

47. *Pure Magnesia.—Magnesia Usta, P. L.—Calcined Magnesia.*

Calcined magnesia may be assayed by the same tests as the carbonate. It ought not to effervesce at all with dilute sulphuric acid; and, if the earth and acid be put together into one scale of a balance, no diminution of weight should ensue on mixing them together. It should be perfectly free from taste, and when digested with distilled water, the filtered liquor should manifest no property of lime water. Calcined magnesia, however, is very seldom so pure as to be totally dissolved by diluted sulphuric acid; for a small insoluble residue generally remains, consisting chiefly of siliceous earth, derived from the alcali. The solution in sulphuric acid, when largely diluted, ought not to afford any precipitation with oxalate of ammonia.

48. *Spirit of Wine; Alcohol*; *and Æthers.*

The only decisive mode of ascertaining the purity of spirit of wine and of ethers, is by determining their specific gravity. Highly rectified alcohol should have the specific gravity of 829 to 1000. Common spirit of wine 837. Sulphuric ether 739. The spiritus ætheris vitriolicus, P. L., or sweet spirit of vitriol, about 750—and nitric ether, the spiritus etheris nitrosus, or sweet spirit of nitre, 908. The ethers ought not to redden the colour of litmus; nor ought those, formed from sulphuric acid, to give any precipitation with solutions of barytes.

49. *Essential or Volatile Oils.*

As essential oils constitute only a very small proportion of the vegetables, from which they are obtained, and bear generally a very high price, there is a considerable temptation to adulterate them. They are found sophisticated, either with cheaper volatile oils, with fixed oils, or with spirit of wine. The fixed oils are discovered, by distillation with a very gentle heat, which elevates the essential oils, and leaves the fixed ones. These last may, also, be detected by moistening a little writing paper with the suspected oil, and holding it before the fire. If the oil be entirely essential, no stain will remain on the paper. Alcohol, also, detects the fixed oils, because it only dissolves the essential ones; and the mixture becomes milky. The presence of cheaper essential oils is discovered by the smell. Alcohol, a cheaper liquid than some of the most costly oils, is discovered by adding water, which, if alcohol be present, occasions a milkiness.

SECT. III. USE OF CHEMICAL RE-AGENTS TO CERTAIN ARTISTS AND MANUFACTURERS.

To point out all the beneficial applications of chemical substances to the purposes of the arts, would require a distinct and very extensive treatise. In this place, I have no further view than to describe the mode of detecting adulterations in certain articles of commerce, the strength and purity of which are essential to the success of chemical processes.

1. *Mode of detecting the Adulteration of Pot-ashes, Pearl-ashes, and Barilla.*

Few objects of commerce are sophisticated to a greater extent than the alcalis, to the great loss and injury of the bleacher, the dyer, the glass-maker, the soap-boiler, and of all other artists, who are in the habit of employing these substances. In the first part of this work (see page 47) I have already given rules for discovering such adulterations; and to what has been said, I apprehend it is only necessary to add the directions of Mr. Kirwan, intended to effect the same end, but differing in the mode. They are transcribed from his paper, entitled " Experiments on the Alcaline Substances used in Bleaching;"—see Transactions of the Irish Academy for 1789.

" To discover whether any quantity of fixed alkali worth attention exists in any saline compound, dissolve one ounce of it in boiling water, and into this solution let fall a drop of a solution of sublimate corrosive; this will be converted into a brick colour, if an alkali be present, or into a brick colour mixed with yellow, if the substance tried contains lime.

" But the substances used by bleachers being always impregnated with an alkali, the above trial is in general superfluous, except for the purpose of detecting lime. The quantity of alkali is therefore what they should chiefly be solicitous to determine, and for this purpose:

" 1st. Procure a quantity of alum, suppose one pound, reduce it to powder, wash it with cold water, and then put it into a tea-pot, pouring on it three or four times its weight of boiling water.

" 2dly. Weigh an ounce of the ash or alkaline substance to be tried, powder it, and put it into a florence flask with one pound of pure water (common water boiled for a quarter of an hour, and afterwards filtered through paper, will answer) if the substance to be examined be of the nature of barilla, or potash; or half a pound of water if it contain but little earthy matter, as pearl-ash; let them boil for a quarter of an hour: when cool let the solution be filtered into another florence flask.

" 3dly. This being done, gradually pour the solution of alum hot into the alkaline solution also heated; a precipitation will immediately appear; shake them well together, and let the effervescence, if any, cease before more of the aluminous solution be added; continue the addition of the alum until the mixed liquor, when clear, turns syrup of violets, or paper tinged blue by raddishes, or by litmus, red; then pour the liquor and precipitate on a paper filter placed in a glass funnel. The precipitated earth will remain on the filter; pour on this a pound or more of hot water gradually, until it passes tasteless; take up the filter, and let the earth dry on it until they separate easily. Then put the earth into a cup of Staffordshire ware, place it on hot sand, and dry the earth until it ceases to stick to glass or iron; then pound it, and reduce it to powder in the cup with a glass pestle, and keep it a quarter of an hour in a heat of from 470° to 500°.

" 4thly. The earth being thus dried, throw it into a florence flask, and weigh it; then put about one ounce of spirit of salt into another flask, and place this in the same scale as the earth, and counterbalance both in the opposite scale: this being done, pour the spirit of salt gradually into the flask that contains the earth; and when all effervescence is over (if there be any) blow into the flask, and observe what weight must be added to the scale containing the flasks, to restore the equilibrium; subtract this weight from that of the earth, the remainder is a weight exactly *proportioned* to the weight of mere alkali of that particular species which is contained in one ounce of the substance examined; all beside is superfluous matter.

"I have said that alkalies of the *same species* may thus be directly compared, because alkalies of *different* species cannot but require the intervention of another proportion; and the reason is, because *equal* quantities of alkalies of different species precipitate *unequal* quantites of earth of alum. Thus 100 parts by weight of mere *vegetable* alkali, precipitate 78 of earth of alum; but 100 parts of *mineral* alkali precipitate 170, 8 parts of that earth. Therefore the precipitation of 78 parts of earth of alum by vegetable alkali, denotes as much of this as the precipitation of 170,8 of that earth by the mineral alkali denotes of the mineral alkali. Hence the quantities of alkali in all the different species of pot-ashes, pearl-ashes, weed or wood-ashes, may be immediately compared by the above test, as they all contain the vegetable alkali; and the different kinds of kelp or kelps manufactured in different places, and the different sorts of barilla, may thus be compared, because they all contain the mineral alkali. But kelps and pot-ashes, as they contain different sorts of alkali, can only be compared together by means of the proportion above indicated."

2. *Mode of detecting the Adulteration of Manganese.*

In the section on drugs, instructions may be found for discovering impurities in several chemical preparations, employed by the artist, as cerusse or white lead; red lead; verdegris, &c. No rules however, have been given for examining manganese, which is a substance that varies much in quality, and is often sophisticated; as the bleachers experience, to their no small disappointment and loss.

The principal defect of manganese arises from the admixture of chalk, which is not always an intentional adulteration; but is sometimes found united with it, as it occurs in the earth. When to this impure manganese, mixed with muriate of soda (see page 71), the sulphuric acid is added, the materials effervesce and swell considerably; and a large proportion passes into the receiver, in consequence of which the bleaching liquor is totally spoiled. This misfortune, has, to my knowledge, frequently happened; and can only be prevented by so slow and cautious an addition of the acid, as is nearly inconsistent with the business of an extensive bleaching work. The presence of carbonate of lime may be discovered in manganese, by pouring, on a portion of this substance, nitric acid diluted with 8 or 10 parts of water. If the manganese be good, no effervescence will ensue; nor will the acid dissolve any thing; but if carbonate of lime be present, it will be taken up by the acid. To the solution, add a sufficient quantity of carbonate of potash to precipitate the lime; wash the sediment with water; and dry it. Its weight will shew, how much chalk the manganese under examination contained.

Another adulteration of manganese, that may, perhaps, be sometimes practised, is the addition of some ores of iron. This impurity is less easily discovered. But if the iron be in such a state of oxydation as to be soluble in muriatic acid, the following process may discover it. Dissolve a portion, with the assistance of heat, in concentrated muriatic acid; dilute the solution largely with distilled water; and add a solution of crystallized carbonate of potash. The manganese will remain suspended by the excess of carbonic acid, on mixing the two solutions; but the iron will be precipitated in the state of a coloured oxyd.

SECT. IV. APPLICATION OF CHEMICAL TESTS TO THE USES OF THE FARMER AND COUNTRY GENTLEMAN.

The benefits that might be derived, from the union of chemical skill with extensive observation of agricultural, facts are, perhaps, incalculable. At present, however, the state of knowledge, among farmers, is not such, as to enable them to reap much advantage from chemical experiments: And the chemist, has, himself, scarcely ever opportunities of applying his knowledge to practical purposes, in this way. It may, perhaps, however, be of use to offer a few brief directions for the analysis of marls, lime-stones, &c.; and, on this occasion, I shall owe much of my information, as in various other parts of this work, to the writings of Mr. Kirwan, whose pamphlet on philosophical agriculture, I strongly recommend to general perusal.*

1. LIME.

It is impossible to lay down any general rules respecting the fitness of lime for the purposes of agriculture, because much must depend on the pecu-

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* It is entitled "The Manures most advantageously applicable to the various sorts of soils; and the causes of their beneficial effects in each particular instance; by R. Kirwan, Esq. London 1796."

liarities of soil, exposure, and other circumstances. Hence a species of lime may be extremely well adapted for one kind of land, and not for another. All that can be accomplished by chemical means, is to ascertain the degree of purity of the lime, and to infer, from this, to what kind of soil it is best adapted. Thus a lime, which contains much argillaceous earth, is better adapted, than a purer one, to dry and gravelly soils; and stiff clayey lands require a lime as free as possible from the argillaceous ingredient.

To determine the purity of lime, let a given weight be dissolved in diluted muriatic acid. Let a little excess of acid be added, that no portion may remain undissolved, owing to the deficiency of the solvent. Dilute with distilled water; let the insoluble part, if any, subside; and the clear liquor be decanted. Wash the sediment with further portions of water; and pour it upon a filtre previously weighed. Dry the filtre, and ascertain its increase of weight, which will indicate how much insoluble matter, the quantity of lime, submitted to experiment, contained. It is easy to judge, by the external qualities of the insoluble portion, whether argillaceous earth abounds in its composition.

There is one earth, however, lately found in several lime-stones, which is highly injurious to the vegetation of plants, and is not discoverable by the foregoing process, being, equally with lime, soluble in muriatic acid. This earth is magnesia, which, by direct experiments, has been ascertained to be extremely noxious to plants. Mr. Tennant, the gentleman to whom we owe this fact, was informed that in the neighbourhood of Doncaster, two kinds of lime were employed, one of which, it was necessary to use sparingly, and to spread very evenly; for it was said that a large proportion, instead of increasing, diminished the fertility of the soil, and that whenever a heap of it was left in one spot, all fertility was prevented for many years. Fifty or sixty bushels, on an acre, were considered to be as much as could be used with advantage. The other sort of lime, which was obtained from a village near Ferrybridge, though considerably dearer, from the distant carriage, was more frequently employed on account of its superior utility. A large quantity was never found to be injurious; and the spots, which were covered with it, instead of being rendered barren, became remarkably fertile. On examining the composition of these two species of lime, the fertilizing one proved to consist entirely of calcareous earth; and the noxious one of three parts lime and two magnesia.

The presence of magnesia in lime proved, on further investigation, to be a very common occurrence. The magnesian lime-stone appears to extend for 30 or 40 miles, from a little south-west of Worksop, in Nottinghamshire, to near Ferrybridge in Yorkshire; and it has also been found at Breedon and Matlock in Derbyshire.

The magnesian lime-stone, according to Mr. Tennant, may easily be distinguished, from that which is purely calcareous, by the slowness of its solution in acids, which is so considerable, that even the softest kind of the former is much longer in dissolving than marble. It has, also, frequently a crystallized structure, and sometimes, though not always, small black dots may be seen dispersed through it. In the countries, where this lime-stone is found, the lime is generally distinguished, from its effects in agriculture, by the farmers, as *hot* lime, in opposition to the purely calcareous, which they term *mild*.

To ascertain, by chemical means, the composition of a lime or lime-stone, suspected to contain magnesia, the following is the easiest, though not the most accurate process. Procure a florence flask; clean it well from oil by a little soap lees, or salt of tartar and quicklime mixed; and break it off, about the middle of the body, by setting fire to a string tied round it, and moistened with oil of turpentine. Into the bottom part of this flask, put 100 grains of the lime or lime-stone; and pour on it, by degrees, half an ounce of strong sulphuric acid. On each affusion of acid a violent effervescence will ensue; when this ceases, stir the acid and lime together with a small glass tube or rod, and place the flask in an iron pan filled with sand. Set it over the fire, and continue the heat till the mass is quite dry. Scrape off the dry mass; weigh it; and put it into a wine glass, which may be filled up with water. Stir the mixture, and when it has stood half an hour; pour the whole on a filtering paper, placed on a funnel, and previously weighed. Wash the insoluble part with water, as it lies on the filtre; and add the washings to the filtered liquor. To this liquor add a solution of half an ounce of salt of tartar in water; when, if magnesia be present, a very copious white sediment will ensue; if lime only, merely a slight milkiness. In the former case, heat the liquor, by setting it in a tea cup, near the fire; let the sediment subside; pour off the clear liquor, which may be thrown away; and wash the white powder repeatedly with warm water. Then pour it on a filtre of paper, the weight of which is known; dry it; and weigh. The result, if the lime-stone has been submitted to experiment, shews how much carbonate of magnesia was contained in the original stone; or, deducting 60 per cent., how much pure magnesia 100 parts of the lime-stone contained. If the burnt lime has been used, deduct from the weight of the precipitate 60 per cent; and the remainder will give the weight of the magnesia in each 100 grains of the burnt lime.

2. ANALYSIS OF MARLS.

The ingredient of marls, on which their fitness for agricultural purposes depends, is the carbonate of lime. It is owing to the presence of this earth, that marls effervesce on the addition of acids, which is one of their distinguishing characters. In ascertaining whether an effervescence takes place, let the marl be put into a glass partly filled with water, which will expel a portion of air contained mechanically in the marl; and thus obviate one source of fallacy. When the marl is throughly penetrated by the water, add a little muriatic acid or spirit of salt. If a discharge of air should ensue, the marly nature of the earth is sufficiently established.

To find the composition of a marl, pour a few ounces of diluted muriatic acid into a florence flask; place them in a scale; and let them be balanced. Then reduce a few ounces of dry marl into powder; and let this powder be carefully and gradually thrown into the flask, until, after repeated additions, no further effervescence is perceived. Let the remainder of the powdered marl be weighed; by which the quantity projected will be known. Let the balance be then restored. The difference of weight, between the quantity projected, and that requisite to restore the balance, will shew the weight of air lost during effervescence. If the loss amount to 13 per cent. of the quantity of marl projected, or from 13 to 32 per cent. the marl assayed is calcareous marl, or marl rich in calcareous earth.

Clayey marls, or those in which the argillaceous ingredient prevails, lose only 8 or 10 per cent. of their weight, by this treatment; and sandy marls about the same proportion. The presence of much argillaceous earth may be judged, by drying the marl, after being washed with spirit of salt, when it will harden and form a brick.

To determine, with still greater precision, the quantity of calcareous earth in a marl, let the solution in muriatic acid be filtered and mixed with a solution of carbonate of potash, till no further precipitation appears. Let the sediment subside; wash it well with water; lay it on a filtre, previously weighed; and dry it. The weight of the dry mass will shew how much carbonate of lime the quantity of marl, submitted to experiment, contained.

3. ANALYSIS OF SOILS.

The following rules, for determining the composition of a soil, are copied from the interesting tract of Mr. Kirwan already referred to.

" 1mo. In dry weather, when the soil is not over moist nor dry, let a surface of 16 square inches be cut through to the depth of 8 inches; this may be effected by a right angled spade, formed for this particular purpose. Of the parallelopiped thus dug up, the two inches next the surface should be cut off to get rid of the grass, and the greater part of the roots; we shall then have a solid 6 inches long, and 16 square at the end = 96 cubic inches. Let this be weighed *; its weight will serve to find the specific gravity of the soil; for if 96 cubic inches weigh *n* pounds, 1728 (a cubic foot) should weigh *x* pounds, and *x* divided by 75,954 will express by

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* Troy weights are generally more exactly made than avoirdupois, and therefore should be preferred. A cubic foot of pure water, weighs 75,945 troy, very nearly, or 62,5 avoirdupois pounds, at the temperature 62°.

the quotient the specific gravity of the soil. To render this and the subsequent operations more intelligible, I shall illustrate each by an example: Suppose the 96 cubic inches to weigh 6,66 pounds, then 1728 cubic inches should weigh

$$120 \text{ lb. and } \frac{120}{75,954} = 1,579.$$

" 2°. The earth being weighed, is next to be broken down and freed from all stony substances above the size of a pippin, and the remainder well mixed together, to render the whole as homogeneous as possible; then weigh the stones that were picked out, and find the proportion belonging to each pound of the residuary earth; call this the *stoney supplement*, and denote it by *S*. Thus if the stones weigh 1lb.= 12 oz. the remainder, or mere earth, must weigh 5,66 lb; and if to 5,66 lb. there belong 12 ozs. of stone, to 1 lb. must belong 2,12014 ozs. or 2ozs. 57,66 grs.= 1017,66 grs. This then is the stoney supplement of each succeeding pound=S.

" 3°. Of the earth thus freed from stoney matter, take 1lb.—*S*. (that is the above case 1lb.—2 oz. $57\frac{2}{3}$ grs.) heat it nearly to redness in a flat vessel, often stirring it for half an hour, and weigh it again when cold. Its loss of weight will indicate the quantity of water contained in 1lb. of the soil. Note this loss, and call it the *watery supplement*=*W*. Suppose it in this case 100 grains.

" 4°. Take another pound of the above mass freed from stones, deducting the stoney and watery supplements; that is, 1lb.—S—W, or in the above case 1lb.—2 ozs. $57\frac{2}{3}$ grs. for stone, and—100 grs. for water: consequently 1lb.—2 ozs. $157\frac{2}{3}$ grs. reduce it to powder: boil it in four times its weight of distilled water for half an hour; when cool, pour it off, first into a coarse linen filtre to catch the fibrous particles of roots, and then through paper, to catch the finer clayey particles diffused through it: set by the clear water, add what remains on the filtre to the boiled mass: if it be insipid, as I suppose it to be, then weigh the fibrous matter, and call it the *fibrous supplement*=F. Suppose it in the example in hand to weigh 10 grs.

"5°. Take two other pounds of the mass freed from stoney matter, No. II. substracting from them the weight of the stoney, watery, and fibrous substances already found; that is, 2lb.—2S—2W—2F; pour twice their weight of warm distilled water on them, and let them stand twenty-four hours or longer; that is, until the water has acquired a colour, then pour it off and add more water as long as it changes colour; afterwards filtre the coloured water and evaporate it to a pint, or half a pint; set it in a cool place for three days, then take out the saline matter, if any be found, and set it by.

"6°. Examine the liquor out of which the salts have been taken; if it does not effervesce with the marine acid, evaporate it to dryness, and weigh the residuum; if it does effervesce with acids, saturate it with the vitriolic or marine, and evaporate it to one fourth of the whole: when cool, take out the saline residuum, evaporate the remainder to dryness, and weigh it: this gives the coaly matter, which may be tried by projecting it on melted nitre, with which it will deflagrate. The half of this coaly matter call the *coaly supplement* of 1lb. I shall suppose it to amount to 12 grs. and denote it by C.

7°. The filtred water, No. IV. is next to be gently evaporated to nearly one pint, and then suffered to rest for three days in a cool place, that it may deposit its saline contents, if it contains any; and these being taken out, the remainder must be evaporated nearly to dryness, and its saline and other contents examined. How this should be done, I shall not mention, the methods being too various, tedious, and of too little consequence; few falts occur except gypsum, which is easily distinguished. The water may be examined as to its saline contents when it is evaporated to a pint; if any salts be found, call them the *saline supplement*, and denote them by *S*. I shall suppose them here =4 grains.

" 8°. We now return to the boiled earthy residuum, No. IV. which we shall suppose fully freed from its saline matter, as, if it be not, it may easily be rendered so, by adding more hot water: let it then be dried as in No. III. is mentioned. Of this earthy matter thus dried, weigh off one ounce, deducting one-twelfth part of each of the supplements *S.W.F.C.* and *S*; that is, in this

$$\text{case}\frac{1017,66}{12}=84,4054\frac{100}{12}=8,333\dagger\frac{10}{12}$$

$$=8,333\dagger\frac{12}{12}=1\dagger\frac{4}{12}=0,3333=95\text{ grs.}$$

in all — then 480 — 95 = 385 grains will remain, and represent the mere earthy matter in an ounce of the soil.

" 9°. Let this remainder be gradually thrown into a florence flask, holding one and an half as much spirit of nitre as the earth weighs, and also diluted with its own weight of water (the acids employed should be freed from all contamination of the vitriolic acid); the next day the flask with its contents being again weighed, the difference between the weights of the ingredients and the weights now found, will express the quantity of air that escaped during the solution. Thus in the above case, the earth weighing 385 grains, the acid 577,5 grains, and the water 577,5 grains, in all 1540 grains, the weight after solution should also be 1540, if nothing escaped; but if the soil contains calcareous matter, a loss will always be found after solution. Let us suppose it to amount to 60 grains.

" The weight of air that escaped, furnishes us with one method of estimating the quantity of calcareous matter contained in the earth essayed; for mild calx generally contains 40 per cent. of air; then if 40 parts air indicate 100 of calcareous matter, 60 parts air will indicate 150*.

" 10°. The solution is then to be carefully poured off, and the undissolved mass washed and shaken in distilled water; the whole thrown on a filtre, and washed as long as the water that passes through has any taste. The contents of this water should be precipitated by a solution of mild mineral alkali: this precipitate also being washed and dried in a heat below redness, should then be weighed. Thus we have another method of finding the weight of the calcareous matter.

" 11°. The undissolved mass is next to be dried in the heat already mentioned, and the difference between its weight and the weight of the whole earthy mass before solution should be noted, as it furnishes a third method of discovering the weight of the calcareous matter of which it is now deprived. Supposing this to amount to 150 grains, the weight of the undissolved residuum should in the above case be 383—150=235 grains.

" 12°. Reduce the dried mass into the finest powder, throw it into a florence flask or glass retort,

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* I take no account of magnesia, as in agriculture I believe it of little importance.

and pour on it three times its weight of pure oil of vitriol, digest in a strong sand heat, and at last raise the heat so as to make the acid boil; afterwards let it evaporate nearly to dryness: when cold, pour on it gradually six or eight times its weight of distilled water, and, after some hours, pour off the solution on a filtre; the filtre should previously be weighed, and its edges soaked in melted tallow[*]; the substance found on the filtre being weighed (substracting the weight of the filtre) gives the quantity of silicious matter; and this weight substracted from that of the dried mass, gives that of the argill. In this case I will suppose the silicious mass to weigh 140 grains, then the argillaceous should weigh 95 grains.

“ Then the composition of one pound of the soil is as follows.

Stony matter		1017,66
Water		100
Fibres of roots		10
Soluble coal		12
Saline matter		4
Silex	140 × 12 =	1680
Argill	95 × 12 =	1140
Mild calx	150 × 12 =	1800
		5763,66[†]

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[*] An ingenious contrivance of Dr. Black.

[†] An error of 3,66 grains for decimals omitted in substractions.

And in centesimal proportion			
	Stony matter	18	
	Fine silicious	29	
			47
	Argill		22
	Mild calx		31
			100

Its retentive power is 82,25: hence I should judge it to be unfertile in this climate, unless situated on a declivity, with an unimpeded fall. It may be called a *clayey loam.*

Mr. Young discovered a remarkable circumstance attendant on fertile soils: he found that equal weights of different soils, being dried and reduced to powder, afforded quantites of air by distillation somewhat corresponding to the ratios of their values. This air was a mixture of fixed and inflammable airs, both proceeding, most probably, from the decomposition of water by the coaly matter in the soil. The distillation should be made from a retort glazed on the outside. He found an ounce of dry soil, value five shillings, produced, ten ounce measures;

Of value of from	5 to 12s.	produced	28 oz.
	12 — 20		42
above	20		66

This appears to be a good method of estimating the proportion of coaly matter in soils that are in full heart; that is, not exhausted, and freed from roots, &c. Another mark of the goodness of a soil is the length of the roots of wheat growing in it; for these are an inverse proportion to each other, as, if the land be poor, the wheat will extend its roots to a great distance in quest of food; whereas, if it be rich, they will not extend above five or six inches: but of these and some other empyrical marks, I shall say no more, as they do not tell us the defects of the soils.

SECT. V. MISCELLANEOUS USES OF CHEMICAL RE-AGENTS.

1. *Removal of Ink Stains.* The stains of ink on cloth, paper, or wood, may be removed by almost all acids; but those acids are to be preferred, which are least likely to injure the texture of the stained substance. The muriatic acid, diluted with 5 or 6 times its weight of water, may be applied to the spot; and after a minute or two, may be washed off; repeating its application as often as may be found necessary. But the vegetable acids are attended with less risk, and are equally effectual. A solution of the oxalic, citric, or tartarous acids in water, may be applied to the most delicate fabrics, without any danger of injuring them; and the same solutions discharge, from paper, written but not printed ink. Hence they may be employed in cleaning books, which have been defaced by writing on the margin, without impairing the text.

2. *Iron Stains.* These may be occasioned either by ink stains, which, on the application of soap, are changed into iron stains, or by the direct contact of rusted iron. They may be removed by diluted muriatic acid, or by one of the vegetable acids already mentioned. When suffered to remain long on cloth, they become extremely difficult to take out, because the iron, by repeated moistening with water, and exposure to the air, acquires such an addition of oxygen, as renders it insoluble in acids. I have found, however, that even these spots may be discharged, by applying first a solution of an alkaline sulphuret; which must be well washed from the cloth; and afterwards, a liquid acid. The

sulphuret, in this case, extracts part of the oxygen from the iron; and renders it soluble in dilute acids.

3. *Fruit and Wine Stains.* These are best removed by a watery solution of the oxygenated muriatic acid, (see p. 72) or by that of oxygenated muriate of potash or lime, to which a little sulphuric acid has been added. The stained spot may be steeped in one of these solutions, till it is discharged; but the solution can only be applied with safety to white goods; because the uncombined oxygenated acid discharges all printed and dyed colours. A convenient mode of applying the oxygenated acid, easily practicable by persons, who have not the apparatus for saturating water with the gas, is as follows. Put about a table spoonful of muriatic acid (spirit of salt) into a tea cup, and add to it about a tea spoonful of powdered manganese. Then set this cup in a larger one filled with hot water. Moisten the stained spot with water, and expose it to the fumes that arise from the tea cup. If the exposure be continued a sufficient length of time, the stain will disappear.

4. *Spots of Grease* may be removed by a diluted solution of pure potash; but this must be cautiously applied, to prevent injury to the cloth. Stains of *white wax*, which sometimes fall upon the cloaths from wax candles, are removable by spirit of turpentine or sulphuric ether. The marks of *white paint* may also be discharged by the last mentioned agents.

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