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Dialogues in Chemistry,

INTENDED FOR

THE INSTRUCTION AND ENTERTAINMENT

OF

YOUNG PEOPLE:

IN WHICH

THE FIRST PRINCIPLES OF THAT SCIENCE ARE FULLY EXPLAINED.

TO WHICH ARE ADDED,

QUESTIONS AND OTHER EXERCISES

FOR THE

EXAMINATION OF PUPILS.

BY THE REV. J. JOYCE,

Author of Scientific Dialogues, Dialogues on the Microscope, &c.

FROM THE THIRD LONDON EDITION, CORRECTED AND VERY MUCH ENLARGED; WITH AN ACCOUNT OF ALL THE LATE DISCOVERIES, AND ADDITIONAL NOTES BY

AN AMERICAN PROFESSOR OF CHEMISTRY.

IN TWO VOLUMES.

VOL. I.

NEW-YORK:

PUBLISHED BY JAMES EASTBURN AND CO.

AT THE LITERARY ROOMS, BROADWAY.

Clayton & Kingsland, Printers.

1818.

TO

SIR HUMPHREY DAVY, F. R. S. &c. &c.

THE

LEARNED AND ELOQUENT

PROFESSOR OF CHEMISTRY

AT

THE ROYAL INSTITUTION,

THESE VOLUMES,

INTENDED AS AN EASY AND FAMILIAR INTRODUCTION TO

HIS ADMIRABLE LECTURES, AND TO THE

SCIENCE IN GENERAL,

ARE

MOST RESPECTFULLY INSCRIBED,

BY

THE AUTHOR.

March 25, 1807.

Having said thus much of myself, I will now say a few words of my Book; the plan and method of which will be found very similar to those which I adopted and pursued in the SCIENTIFIC DIALOGUES, and which have been sanctioned by the most decided public approbation. I have, however, rendered these Volumes more practical, and better adapted to the purposes both of the Preceptor and Pupil, by subjoining at the end of each volume a Series of Questions and other Exercises, suited to the several Conversations.* By the aid of these the Tutor will be able to examine his Pupil, and know how far

* The Author has now published, at the express desire of many persons engaged in the important business of education, a small work, entitled, "A Companion to the Scientific Dialogues, or the Tutor's Assistant and Pupil's Manual in Natural and Experimental Philosophy," by which the SCIENTIFIC DIALOGUES are in every respect adapted to ease the labour of the Preceptor, and to facilitate the progress of *the Student, who has not* the advantage of an in- *r in these Sciences.*

he has studied, and how far he understands the subject given him for consideration.

The Exercises will, I trust, be found of still greater importance to those who study these Volumes by themselves, and who have not the advantage of a Tutor's instructions. Such will not fail to see, that the mode for them to pursue is, after they have studied one Conversation, to examine themselves by the Questions adapted to it; and, on a succeeding day, to take the Questions only, and write in their own words the best answers they can devise, and then compare them with the book. Here the *festina lente* is earnestly recommended: not to go to a second Conversation till the first is well understood and fully digested.

No person, in connexion with chemical reading, ought to omit an opportunity, if it present itself, of attending a Course of Lectures, which always *includes a variety* of illustrative and *instructive experiments*. It is, however

CONTENTS OF VOL. I.

CONVERSATION I.

INTRODUCTION.

Of the Elements, or Simple Bodies.

TUTOR—CHARLES—JAMES.

CHARLES. As you are going, sir, to show us experiments in Chemistry, may I ask if this subject is connected with Natural Philosophy?

Tutor. In some respects the studies are inseparable. Thus, in the third and fourth volumes of the "Scientific Dialogues,"* we have demonstrated the weight, pressure, and motion of fluids in general, considering more particularly the several properties of *water* and *air*: now, by Chemistry, we shall be able to show you of what these fluids, which are so common as scarcely to claim your notice, are compounded.

James. I thought *air* and *water*, as well as *earth* and *fire*, had been simple and uncompounded bodies. I am sure, I have often heard them called the first elements of things.

* A *work by the* same author, in six small volumes, *which has passed through* many editions.

Tutor. This is an error of very early date: it was taught by Pythagoras, and I believe before his time, for truth; but modern discoveries have shown, in the clearest manner, that even the air, which you breathe, is compounded of two other, and perhaps simple *gases.*

Charles. What do you mean by gases?

Tutor. Formerly there was but one species of air known, namely, the atmospheric; but, since the discovery of several other kinds, chemists call all the permanently elastic aeriform fluids by the general name of gases; thus we have oxygen gas, hydrogen gas, azotic gas, and many others, with which I hope you will shortly be acquainted.

James. Do you call the common air atmospheric gas?

Tutor. In general chemists do not alter that name, but call it *the air*, leaving the term gas to be applied to the factitious airs.

James. Have these gases the same properties as the atmospheric air?

Tutor. Yes; they are transparent, elastic, ponderous, invisible, and not condensable into a liquid or solid state, by any degree of cold hitherto known.

Charles. Are there no substances, which may be called elements?

Tutor. As the elements of things, or, to speak more properly, *simple bodies,* are those which cannot be separated into others more simple, nor reproduced by artificial means; it would, perhaps, be presumption to assert, that we are acquainted with any such. The pure part of the atmospheric air, for instance, which we call oxygen gas, has never yet been decompounded; but, until it can be asserted that it is incapable of decomposition, it would be rash to affirm certainly, that even this is a simple body.

Charles. Perhaps future inquiries, and experiments, may demonstrate the existence of many more simple substances than those which were so called by the ancient philosophers.

Tutor. It is probable, also, that, as the science of Chemistry advances to perfection, many of those substances, which are supposed even now to be simple bodies, may be found capable of decomposition; and every discovery of this kind will make men of science less tenacious of their own theories, and less positive in deciding absolutely whether they have come to the knowledge of a single body, that is not made up of others more simple. At any rate, the term "elements" should be considered as denoting the last term of the analysis, according to the present state of knowledge.

James. Is the term *element* used as synonymous with *undecompounded* body?

Tutor. It is; and the improvements taking place in the methods of investigating natural bodies are constantly changing the opinions of chemists, with respect to their nature, as simple or *compound.*

James. How many of these simple bodies do chemists now enumerate ?

Tutor. It is not easy to say. Sir Humphrey Davy says, there is no reason to suppose, that any real *indestructible principle* has been yet discovered. Matter, he says, may ultimately be found to be the same in essence, differing only in the arrangement of its particles ; or two or three simple substances may produce all the varieties of compound bodies.

The following is a list of the simple bodies, given by Dr. Thompson, in his work on Chemistry, a few years since. He divides them into two classes : First, those which can be confined in proper vessels, and exhibited in a separate state ; these he calls *confinable* bodies. Secondly, those that cannot be confined by vessels, and which cannot be exhibited in a separate state ; these are denominated *unconfinable* bodies.

TABLE OF SIMPLE SUBSTANCES.

I. CONFINABLE BODIES.

Oxygen.	Hydrogen.
Sulphur.	Azote, or Nitrogen.
Phosphorus.	Muriatic Acid.
Carbon, or Diamond.	

METALS.

Gold.	Cobalt.
Platinum.	Manganese.
Silver.	Tungsten.
Mercury.	Bismuth.

Copper.	Antimony.
Iron.	Molybdenum.
Tin.	Uranium.
Lead.	Titanium.
Nickel.	Chromium.
Zinc.	Columbium.
Tellurium.	Tantalium, and perhaps others.
Arsenic.	

ALKALIES.

Potass.	Soda.

EARTHS.

Barytes.	Yttria.
Strontian.	Glucina.
Lime.	Zirconia.
Magnesia.	Silica.
Alumina.	

II. UNCONFINABLE BODIES.

Light.	Electricity.
Caloric.	Magnetism.

Charles. Have any of these been decomposed since ?

Tutor. Yes, they have, and other substances have been added, that were at that time not known; so that a different classification has since been made out. Thus, potass and soda, which, by Dr. Thompson, were given as simple bodies, are now found to consist of metallic substances, called *potassium* and *sodium*, united with *oxygen.*

James. Are the alkalies, then, no longer be ranked with simple bodies?

Tutor. They are not: they are compound of metals and oxygen. The same may be sa of the earths, as lime, magnesia, &c.

Charles. Of what are these compounded?

Tutor. They are composed of metallic su stances, named, by Sir Humphrey Davy, *calciu* and *magnium*, and oxygen. Independently, ther fore, of the unconfinable or imponderable bodi *light*, *caloric*, and *electricity*, (for we have nothi to do with *magnetism* in Chemistry,) we have classification, which places *oxygen* at the top, account of its great importance as an agent Chemistry.

James. Is oxygen then a simple body?

Tutor. At present it has not been decomp sed; and, therefore, it may be considered such. This arrangement is as follows:—

NEW ARRANGEMENT OF

SIMPLE SUBSTANCES.

I. Oxygen.

II. Bodies capable of uniting with oxygen, nd forming, with it, various compounds:

1. Hydrogen, with oxygen, forms Water.

2. Bodies forming, with oxygen, Acids.

Nitrogen, with oxygen, forms	nitric acid.
Sulphur	sulphuric acid.
Phosphorus	phosphoric acid.
Carbon	carbonic acid.
Boracium	boracic acid.
(a) Fluorium	fluoric acid.
(a) Muriatum	muriatic acid.

3. Metallic bodies forming Alkalies.

Potassium, with oxygen, forms	potass.
Sodium	soda.
Ammonium	ammonia.

4. Metallic bodies forming Earths.

Calcium, with oxygen, forms	lime.
Magnium	magnesia.
Barium	barytes.
Strontium	strontites.
Silicum	silex.
Alumium	alumina.

Yttrium	yttria.
Glucium	glucina.
Zirconium	zirconia.

5. METALS naturally metallic, or which yield their oxygen to carbon, or heat, alone.

(1.) *Malleable Metals.*

Gold.	Mercury.	Lead.
Platina.	Tin.	Nickel.
Palladium.	Copper.	Zinc.
Silver.	Iron.	

(2.) *Brittle Metals.*

Arsenic.	Cobalt.	Uranium.
Bismuth.	Tungsten.	Columbium.
Antimony.	Molybdenum.	Iridium.
Manganese.	Titanium.	Osmium.
Tellurium.	Chrome.	Rhodium.

Charles. Is it from simple bodies that other substances are compounded?

Tutor. Certainly: what takes place in the combustion of a piece of wood, or coal?

Charles. It gives out light and heat.

Tutor. Then light and heat, or, as chemists say, light and caloric, enter into the combination of wood and coal; and these may be extricated, or set free, from them, if they are raised to a certain degree of temperature. (*a*) Again: lead is a simple body; but common red lead, which chemists call oxide of lead, is compounded of *lead and oxygen*, and these may be separated *from one another*, by a proper degree of heat, *James.* Will all the simple substances combine and form compounds?

Tutor. Certainly; and from these, combined in different ways, an indefinite number of substances are produced.

Charles. Among the simple substances, I see carbon, or diamond; are they the same thing? I thought by carbon was meant charcoal.

Tutor. It has been proved, as we shall show hereafter, that the diamond is pure carbon, and that charcoal is an oxide of carbon, that is, a combination of carbon and oxygen.(*a*)

This glass contains half an ounce of Epsom salt (sulphate of magnesia) dissolved in water; I pour into it some solution of carbonate of soda, which is likewise very clear.

James. The mixture is quite white.

Tutor. A powder will, in a short time, subside, which is carbonate of magnesia; the fluid above it, though transparent, contains sulphate of soda.

Charles. How is that known?

Tutor. I will draw it off, and evaporate it over a slow but clear fire, till a skin rises on its surface, and, when it becomes cool, it will crystallize; the crystals are sulphate of soda, or Glauber's salt. Here then is a complete decomposition; the sulphuric acid, which was united to the magnesia, combines with the soda, and the carbonic acid, which was united to the soda, is now combined to the magnesia. By the analysis, I find, that *Epsom salt* is a compound of sulphuric acid and magnesia; and, from the new substance, it appears, that Glauber's salt is a compound of sulphuric acid and soda. (*a*)

James. Is not an expensive apparatus necessary to perform chemical experiments?

Tutor. The most important and luminous facts in this science may be exhibited with the aid of Florence flasks, common phials, and a few wine or ale glasses. But, in conducting your experiments, I shall recommend a strict attention *to order and* neatness. Let every phial and jar have a label, denoting the substance it contains; and, where it is convenient, let the same experiment be diversified by using different substances, or different proportions of the same substance.

Charles. Shall we be able to repeat the experiments ourselves?

Tutor. You will, if you have attained to habits of caution and accuracy; but, without these qualities, you ought not to meddle with the mineral acids, a very small portion of which, dropped on your clothes, would burn them into holes.

James. How does it appear, that Chemistry is of so much importance in the arts of life?

Tutor. This I might demonstrate in a thousand instances, but I will mention only one, by way of illustration. By an attentive examination of vegetable substances, it is known, that some abound with resin, some with gum, some contain sweet juices, from which sugar is produced, and others contain astringent, or bitter, or acid matter. In some, we find oils of different kinds; and, in others, colouring materials, which can be transferred to wool, linen, &c.; and many contain substances, which have medical efficacy. Now all these are extracted or prepared by chemical operations, which may, therefore, be considered as the foundation of a great variety of useful arts.

Charles. I see, then, that the business of dying cloth, and making sugar, depends on Chemistry.

Tutor. So also do bleaching, glass-makin the working of metals, printing, &c.

James. How does printing make one of tl number ?

Tutor. In ascertaining the best materials f making the types, or letters, and in investigatii the most proper substances, and in due propo tions, for the ink. Agriculture, gardening, tl arts of cookery and of making wine, beer, ai other fermented liquors ; the knowledge of pha macy and medicine, all depend on the principl of Chemistry.

This science, however, not only supplies m ny of our wants, comforts, and luxuries ; but excites a laudable curiosity, which characteriz the minds of those young persons, who are of scientific turn ; and it is admirably calculated serve as an instructive, rational, and almost pe petual fund of amusement.

[Chemistry is not a science of parade. It ; fords occupation and infinite variety. It deman no bodily strength. It can be pursued in retir ment. There is no danger of its inflaming tl imagination, because the mind is intent upon r alities. The knowledge that is acquired is e act, and the pleasure of the pursuit is a sufficie reward for the labour.—*Maria Edgeworth's L ters to Literary Ladies.*]

CONVERSATION III.

Of the Attraction of Aggregation.

TUTOR. I must now desire your attention, while I endeavour familiarly to illustrate the several sorts of attraction, or affinity, which are noticed by chemists.

James. Do the words attraction and affinity mean the same thing?

Tutor. *Attraction* is the term commonly used by writers in natural philosophy; but *affinity* is that which is more appropriate to Chemistry. However, they both are used indiscriminately by the best authors on this subject.

Attraction, or affinity of *aggregation*, is that which takes place between parts of the same substance, or between bodies of the same kind. Thus the parts of an iron bar adhere by the attraction of aggregation. When two or more drops of water, or two globules of mercury, unite in one larger body, it is by aggregation. Two pieces of lead, melted together in a crucible, form a uniform mass, the particles of which are held together by the attraction of *aggregation.*

Charles. In what does this differ from attraction of cohesion?

Tutor. They are frequently used for one another; but accuracy of definition would require, perhaps, that attraction of cohesion should be only used when it is merely superficial, as between the surfaces of marble, lead, &c.

The *aggregate* is, in fact, a coherent body, and must be distinguished from a *heap:* for though a *heap*, as of wheat, sand, &c. consists of parts all of a similar nature, yet those parts have no cohesion with each other.

The *aggregate* and the *heap* must be distinguished from a mixture, as is the case of gunpowder, before it is formed into grains, and which consists of a mixture of charcoal, sulphur, and nitre.

James. I shall, from these instances, know how to distinguish between an *aggregate*, a *heap*, and a *mixture.*

Tutor. I wish you also to bear in mind the several kinds of aggregation, *viz.* (1.) the *solid*, as is exhibited in wood, metal, sulphur, &c.; (2.) the *soft*, as in glue, meat, jellies, &c.; (3.) the *liquid*, as in water, oil, mercury, &c.; and (4.) the *aeriform*, as in air, and all the gases.

Charles. Will not water, in its several states, exhibit the solid aggregation, as in ice, the fluid in water, and the aeriform in a state of vapour, *or steam?*

Tutor. *It will;* and, according to M. Fourroy and others, ice will, when exposed to a mperature of 32°, assume a *soft* state.

James. Wax and tallow will also exhibit the lid, the soft, and the fluid states.

Tutor. They will: and the aeriform too; r, by a stronger heat, they may be made to fly f in a state of vapour. Metals may, in the me manner, be caused to pass through these veral states of aggregation.

Charles. Is not this kind of attraction easily estroyed.

Tutor. Every effort, that tends to separate e particles of bodies, tends also to destroy the traction of aggregation; such as grinding, cutng, filing, pounding, &c. In all these cases, e force applied must be more than equal to the rce of attraction. If the aggregation of a body diminished, it exhibits a greater surface.

James. Yes; a lump of sugar, or salt, when roken into bits, will present more surface than did when whole.

Tutor. By this means the energy of chemical gents is increased: thus, fluate of lime (Derbyire spar) is scarcely affected by sulphuric acid the lump; but let it be first ground into power, and a rapid decomposition takes place, as ou shall see.

Charles. What is the vapour that escapes?

Tutor. It is called fluoric acid: the spar is a mpound of this acid and lime; hence it is lled "fluate of lime," and, in the decomposition, the sulphuric acid combines with the lime forming what is called a sulphate of lime.

James. May we estimate the force of thi kind of attraction by the power required to over come it ?

Tutor. Yes, you may ; hence the difficult of cutting marble, flint, and the diamond ; henc also the different degrees of exertion required t separate the several kinds of timber.

James. Is there any method of measuring th force of this kind of attraction ?

Tutor. There is : thus, if rods of meta glass, wood, whalebone, &c., of the same thick ness, be suspended in a perpendicular directio and weights be attached to the lower extremit of each, till the rods are broken, then the weigh required to break them is the measure of th attraction. It has been found, for instance, tha to separate the parts of beech, and ash, and oal requires twice as much force as is necessary i the case of common fir, or deal. In some case the attraction of aggregation is overcome b heat.

Charles. Different degrees of heat are, imagine, required to overcome the differe kinds of aggregation.

Tutor. You are right ; a small degree of he will reduce some bodies from the solid to th soft state ; a greater heat is required to brir them to the fluid state, and a still greater to re *duce* them to the state of vapour. The sam may be said of glass, metals, and in short, perhaps, of every body in nature.

James. Is that the reason why *hot* liquids dissolve solid substances, as salt, sooner than *cold?*

Tutor. It does not only dissolve them quicker, but in much larger quantities; when, however, the liquor cools, part of the salt falls to the bottom of the vessel, in regular crystals. Try the experiment with common salt and boiling water, which will afford an instance of *crystallization.*

Ex. Take half an ounce of Glauber's salt, which has been dried over a fire, let it be well pulverized, and dissolved in an ounce or more of boiling water: when cold, the original crystals will be seen in the fluid, notwithstanding the salt was reduced to powder.

CONVERSATION IV.

Of the Attraction of Composition, or Chemical Affinity.

TUTOR. *Attraction of composition* is that power, by means of which the particles of bodies attract each other so intimately as to produce a uniform whole, that cannot be separated by any mechanical efforts, and the characteristic properties of which are often different, and sometimes quite contrary to those of the constituent parts.

Charles. Will you give us an example to illustrate this definition ?

Tutor. I will. Sand and salt, exposed to a strong heat, combine by this law of attraction, and make glass. In this state it is a uniform whole, which no mechanical efforts can again separate into sand and salt ; and the properties of glass are not only different from those of sand and salt, but in many respects contrary to them.

James. True: glass is transparent, at least some sorts of it; but that cannot be said of sand, or salt.

Tutor. Glass is insipid to the tongue, but the salt, that enters into the composition, has a very acrid taste.

I will put a small quantity of mercury and sulphur into a crucible, an ounce of each, and stir them together over a fire till the sulphur is completely melted, when I will pour the mixture on a piece of glass, or marble, previously greased and warmed. Now the substance, obtained from this composition, is called *sulphuret of mercury*, and has, as you see, neither the colour, nor brilliancy, nor inflammability, nor volatility of either of its component parts.

Charles. As the mercury cannot be separated from the sulphur by any mechanical means, do you, on that account, say, that they are chemically united?

Tutor. Yes: the union of salt and water; of alcohol and camphor; of sulphuric acid and alumina; of nitric acid and potass; of silver and gold, or of any of the metals, &c., is formed by this same law.

James. What is alcohol?

Tutor. It is pure spirit; and, when mixed with an equal quantity of water, it is sold in the shops as *spirit of wine.* But I will show you more experiments, in order to fix this definition in your memory. You know the acrid burning nature of sulphuric acid, and quick lime?

Charles. Yes, I know they will, ei them, destroy my clothes, and injure wl they happen to fall on.

Tutor. Well, I will mix a small qua each together; now the pungent and co nature of both is destroyed; and the sù produced by this chemical union is called *of Paris*, or *gypsum*, or, more properly phate of lime."

Put a dessert-spoonful of the tincture of ı bage into a wine-glass of water, mix thei and put half of it into another glass. Adı of the glasses a few drops of sulphuric aı the *blue* colour will be changed to a fin son; to the other add an alkali, as a solı potass, and the blue will be changed into Now reverse the experiment, and drop ı ly down the sides of the glass, in which th is, a few drops of sulphuric acid, and thı crimson colour at the bottom, purple in tl dle, and green at the top. To the other g some alkali, and you see the colours are in

James. How is the tincture of cabbage

Tutor. By infusing red-cabbage leave: tilled water. The infusion of violets wo swer the same purpose, and is obtained same way.

Here is a piece of muriate of ammonia (: moniac) and some unslacked lime. W try if they have any smell?

Charles. Very little, if any.

›r. Pound them together in the marble : ; but do not keep your head over the : while you do it.

rles. The scent is so pungent, I cannot ıear it.

es. It is a perfect smelling-bottle; did ıt equal parts of each substance?

›r. I did; that is the best proportion; 'the compound be quickly put into a bottle, glass stopple, it will serve as a smelling-for a considerable length of time.

rles. In this case, two bodies without by chemical affinity, have produced a com-substance, that yields a most pungent scent.

›r. In this phial is water impregnated with ıia, or, what will do as well, common spi-hartshorn and water; in the other is con-ted muriatic acid; smell them both, but › near.

es. That caution is almost useless, as I : bring them near my nose.

›r. I will mix a little of each in a glass.

es. The smell is completely gône, and lour changed; so that two very pungent , by chemical union, produce a third sub-without smell.

›r. Let it stand a little, and it will under-ther change in its colour.

a *saturated* solution of muriate of lime, I , gradually, concentrated sulphuric acid, e *two fluids* will produce a solid compound.

Charles. The disengaged vapour is very pungent to the smell.

Tutor. This vapour, when collected, is called muriatic acid gas. Here two fluids have, by chemical action, formed a solid. You observe, also, that a great deal of heat is disengaged?

James. Yes, the glass is very hot. With two solid substances can you produce a fluid?

Tutor. I can: a solid composed of mercury and bismuth, and another composed of lead and mercury, being well rubbed together in a mortar, quickly become fluid. Again, equal parts of crystallized nitrate of ammonia, and sulphate of soda (Glauber's salt) rubbed together, will produce a fluid.

Two malleable and ductile metals form a brittle alloy. Iron and tin will bear the hammer, and may be drawn into wires; but, being mixed together by fusion, the compound substance is very brittle, and will easily break by the blow of a hammer.

Charles. What do you mean by the word *saturated*, which you used a few minutes ago?

Tutor. When a substance, which has an affinity to another substance, is mixed with as much of it as it can hold in combination, then the former substance is said to be *saturated*, or the mixture is said to have attained the *point of saturation.* In the instance above referred to, the muriatic acid is combined with as much lime as *it will hold.* When you have dissolved as much

' sugar in water as it will contain, the water
to be *saturated* with salt, or sugar.
ιes. Is it only a certain quantity of a solid
nce that can be dissolved in a fluid?
or. Certainly: and, if you attempt to add
by raising the temperature, that is, by
g the fluid, it will, as it grows cold, fall
bottom in a solid form.
rles. I remember I was to take some
ne morning, and dissolved them in warm
the preceding evening, and, to my astonish-
when I was going to drink the dose off, I
the salts at the bottom, in the same shape
en I first put them into the water.
or. But not in the same quantity: for
ater had *taken up*, or *held in solution*, a
nd, having attained the point of saturation,
st fell down, and assumed their former
lline shape.
es. Would the same thing happen in a
e of common salt, or sugar?
or. It would; but, when water is satura-
th sugar, it will take up salt; and, when
ted with salt, it will still hold a certain
ty of sugar in solution.
e an ounce of Glauber's salt, and dissolve
ttle more than double its weight of boiling
; pour it hot into a phial, and cork it up.
cold, the crystals will not fall down, though
ater is much more than saturated; but,
tant the cork is removed, crystallization
gin and continue.

This principle of attraction of compositio so important in Chemistry, that it has been us to divide it into several distinct heads: to-da have only illustrated the definition, which I you to commit to your memory, and to-morr we shall resume the subject.

CONVERSATION V.

Of the General Laws of the ATTRACTION OF COMPOSITION, *or Chemical Affinity.*

LAW I.

TUTOR. "Attraction of composition cannot act but between bodies of different natures."

Here are soda and sulphuric acid, which are both highly acrid substances, but of a very different nature; by chemical affinity they will combine, and we get, instead of the original substances, a compound called "sulphate of soda," which is the Glauber's salt. The union is ve complete, for the salt produced is readily solved, and the solution is quite clear.

Charles. I understand this: because th traction, which takes place between bodie the same kind, as in the instance of two dr of quicksilver, or two drops of water. pieces of wax, &c., does not change the body, but only increases it *therefore the* attraction of aggre

Tutor. This law is so invariable, that the at-
raction is never stronger than when the bodies
etween which it acts are, in nature, the most
ssentially different from one another. No sub-
tances are more completely opposite to each
ther than *acids* and *alkalies;* yet they form the
nost perfect union: thus common vinegar will
eadily unite with spirits of hartshorn; so will
cetous acid (which is highly concentrated vine-
ar) with pure volatile alkali; and mineral or
egetable alkali with any of the mineral acids.

James. What do you mean by the word *con-
entrated?*

Tutor. Vinegar consists of an acid and water;
he acid is said to be concentrated, when it is se-
arated from the water; and, in proportion as the
cid is free from water, it is said to be more or
ess concentrated. Thus acetous acid may be
btained from vinegar, and alcohol from brandy;
ither by distillation, or by exposing the vinegar
nd spirit to severe frost; for the water will be
rozen, and the acid and alcohol will be found in
he middle of the ice.

LAW II.

Tutor. "The attraction of composition acts
nly between the minutest particles of bodies."

If a piece of sulphur be put into alcohol, there
ill be no action; but if the sulphur be first
ounded very fine, a union will take place.—
is experiment is not very easy, but I will show

it you. Put some pounded sulphur into a retort A; (Plate II, fig. 11) suspend within it a bottle B, containing alcohol; and, when the whole is covered with another glass C, and the joinings well luted, then heat the apparatus by means of the furnace F. The sulphur is sublimed; that is, it will rise up in very small particles, and unite with the small particles of alcohol, which are also driven off by the heat; and the two bodies, thus united, will fall into the matrass X. I will pour out the liquor.

Charles. It is slightly coloured: but how am I to know that the sulphur is dissolved in the alcohol?

Tutor. Pour a small quantity of the liquor into a wine-glass, and add some distilled water to it.

James. The sulphur is fallen down in its original state.

Tutor. You cannot wish for a stronger proof, that the two bodies united in the operation; and it is equally clear, that it was necessary, that the two substances should be first reduced into very small parts, before the union could be formed.

Charles. The same thing will happen with camphor and spirit of wine. The spirit of wine will dissolve the camphor, and the fluid be very clear. If to some of this, in a wine-glass, I pour a little water, the camphor will be separated from the spirit, and fall to the bottom in fine flakes. (*a*)

Tutor. In these cases, the small particles of sulphur and camphor united with the spirit; nor could the combination of the sulphur and spirit have been completed, had not the particles been exceedingly minute; but alcohol will readily dissolve the camphor, when in lumps.

LAW III.

Tutor. "This attraction may take place between several bodies."

It frequently happens, that various separate bodies, presented to each other in a fluid state, unite and form a single mass, which possesses all the properties of a perfect compound. Some salts consist of three different substances: common alum, for instance, is formed of sulphuric acid, alumina, and potass, or soda.

Two, three, or more metals may be fused together, so as to produce compounds; the properties of which are widely different from those of the constituent parts.

Experiment 1. Melt eight parts of bismuth, five of lead, and three of tin together. The fusibility of the mixture is so altered, that a spoon or other vessel made of it will melt in boiling water.

Ex. 2. If lead, tin, bismuth, and mercury be combined by fusion, in the proportions of 2, 3, 5, and 1, the compound produced melts at a heat even less than that of boiling water.

Ex. 3. A composition of lead, zinc, and bismuth, in equal parts, may be kept in fusion upon a paper held over the flame of a candle or lamp.

LAW IV.

Tutor. "In order that bodies may unite chemically, one of them must be in a fluid state."

Sugar, or salt, cannot be united with ice, but most readily with water. In glass-making likewise, if one of the substances, which enters into the composition, be not rendered fluid, by an increase of heat, no action could take place among them.

Charles. Is it the heat in the furnace that melts the alkali?

Tutor. It is: the sand afterwards melts, and the compound is glass. There are numerous cases in which an increase of temperature is essentially necessary to determine bodies to unite. Mercury, for instance, will not combine with sulphur, unless heat be applied; then they unite readily.(*a*)

LAW V.

Tutor. "When two or more bodies are united by this affinity, their temperature suffers a change at the instant of union."

James. I perceived this when you mixed the acids and alkalies together; for, although both were in a cold state, yet, when brought into contact with one another, a considerable heat was occasioned.

Tutor. What happened then is the result, in a greater or less degree, in all cases where there is a chemical union.

Experiment 1. Mix equal parts of concentrated sulphuric acid and alcohol together, and, in a few minutes, the mixture becomes so hot as to render the vessel almost insupportable to the hands.

Ex. 2. If four parts, by weight, of common sulphuric acid, and one part of water, be mixed, each at the temperature of 50°, the compound immediately acquires a temperature much higher than that of boiling water.

Charles. Is this the reason why a violent heat is perceived in the slacking of lime?

Tutor. It is. All dense acids, ammonia, and alcohol, when mixed with water, have the property of raising its temperature considerably: the same is the case when alkalies are introduced into concentrated acids.

The temperature is not always raised by chemical attraction; it is sometimes lowered.

Experiment 1. If muriate of ammonia be dissolved in water, and a thermometer be plunged into it, the mercury will fall.

Ex. 2. If an ounce and a half of muriate of ammonia, and an equal quantity of nitrate of potass (common nitre) be first reduced separately to fine powder, then blended together, and afterwards mixed gradually with four ounces of water at 50°, a degree of cold will be produced sufficient to sink the thermometer to 36°. Another of the same quantity of salts, will cool it ›elow the freezing point.

ɪ. Will not a more considerable effect uced if ice, just melted, be used instead ıon water ?

. Certainly ; and still greater if snow is e of : but this subject we shall hereafter

CONVERSATION VI.

Of the General Laws of the Attraction of Composition, or Chemical Affinity, continued.

LAW VI.

TUTOR. "Bodies, between which the attraction of composition takes place, acquire qualities different from those which the compounding bodies had before." This may be verified in *taste*, *smell*, *colour*, &c.

Sulphate of potass, Epsom salts, is an example: as a compound it is bitter, and a purgative; but the constituent parts, namely, the sulphuric acid and the potass, have neither of these properties.

Muriate of ammonia (sal-ammoniac) has no *smell*, but it is compounded of muriatic acid and ammonia.

Charles. These, indeed, have both very powerful and pungent scents.

tor. Take a little sulphuret of potass, and
en it with a few drops of water.

nes. It emits a very fetid odour.

'or. But it is formed of sulphur and potass,
ı, taken separately, are without smell. The
happens with regard to *colour*. How dif-
: is the red oxide of lead (red lead) from
ad of which it is formed.

ırles. Is that powder, which we call red
made of the metal of that name?

or. It is lead united with oxygen gas,(*a*)
ı will see hereafter. Again! what can be
different in colour than the green oxide of
r (green vitriol) and the copper of which
ɔrmed. Cobalt, also, which is of a gray
·, when combined with oxygen becomes of
blue.

ill mention another very striking instance;
grains of oxygenated muriatic acid, or a few
of pure mercury, may be taken in water
ıt producing any bad effect; but if these
ıbstances are so combined as to form oxyge-
mercurial muriate, they become, in that
a most dreadful poison, which is known
the name of *corrosive sublimate.*

this principle bodies frequently change
'orm: thus *muriatic acid gas*, and *alkaline*
hen combined, form crystals of *ammoniacal*
te.

o fluids will produce a solid, as sulphuric
nd a solution of potass. Or mix some ni-

trate of lime with a solution of potass, and you have a complete jelly-like solid.

James. Is not the solid substance the potass, that was dissolved in one of the fluids?

Tutor. Yes, it is. I proceed now to

LAW VII.

"The energy of chemical affinity, acting between various bodies, is different in different substances."

James. Pray explain what you mean by this law.

Tutor. You will learn, by a thousand experiments, that, when two substances, of different kinds, are combined, and unite into one whole, if a third body be presented, which has an attraction to one of the constituent parts of the compound, superior to that attraction by which they were held together, the two bodies, between which the strongest attraction prevails, will combine, and the other will be disengaged.

Experiment. Here is a little muriate of barytes, to which I will add a few drops of sulphuric acid; and now observe the change.

Charles. Those two clear fluids have formed one very similar in appearance to cream. Of what does the muriate of barytes consist?

Tutor. It is formed of pure barytes and muriatic acid.

Charles. Was there an attraction between those substances?

Tutor. There was: but the barytes has a still stronger attraction for the sulphuric acid than it has for the muriatic, and therefore leaves the latter to join the former.

James. Then they unite with a force equal to the difference of attractions that the barytes has for the two acids.

Tutor. Right: if the attraction of the barytes to the muriatic acid be 9, and to the sulphuric it be 12, then the union of the sulphuric acid to the barytes will be with a force equal to 3.

Experiment 1. To a solution of chalk, in nitric acid, add a solution of potass, and the chalk will re-assume its original form.

Ex. 2. Into a solution of gold, pour some sulphuric ether, shake it well, and let it remain at rest; the ether will deprive the solution of all its gold.

Charles. Has the acid, in which the gold was dissolved, a greater attraction for the ether than for the gold?

Tutor. Certainly, or this second union could not have taken place.

Ex. 3. On the same principle, quicksilver dissolved in nitric acid will be made to re-appear by an addition of a thin piece of *copper*.

James. Do you call the fluid now a solution of copper in nitric acid?

Tutor. It is nothing else; for the mercury has fallen to the bottom. As nitric acid has a still stronger attraction for iron than for copper, immerse a thin slip of iron in this solution, which will be dissolved, the copper precipitated, and the fluid is now a solution of iron in nitric acid.—In the same manner, a piece of zinc will precipitate the iron: and ammonia will join the acid and throw down the zinc, when the solution will be *nitrate of ammonia*. If to this solution of nitrate of ammonia, some lime-water be added, the ammonia will be disengaged, as may be known by the pungent odour, and the solution will be *nitrate of lime*. Lastly, add some oxalic acid to the solution of nitrate of lime; the lime will join the oxalic acid, and the nitric acid will remain.

Charles. From these several experiments I clearly perceive, that different bodies have different degrees of affinity for one and the same substance.(*a*)

LAW VIII.

Tutor. "Chemical affinity is capable of uniting bodies in definite or indefinite proportions."

Experiment. If water and alcohol be mixed in any proportion, a chemical combination ensues. The compound has always a specific gravity different from the mean specific gravity of the fluids combined. Its bulk is likewise not the arithmetical mean of the fluids in a separate state.

James. I remember you told us before,* that a pint of alcohol and a pint of water, mixed together, would not make exactly two pints of the compound.

* *See Scientific Dialogues*, vol. iii, p. 175, 176.

Tutor. This is a proof that the two fluids have entered into chemical combination. The same is the case when liquid acids and water, or acids and alcohol, are combined.

Chemical affinity, then, unites some bodies in any proportion whatever; their combination is, therefore, said to be unlimited.

Charles. Do you mean, that the proportions of the two substances, as the water and alcohol, may be varied indefinitely?

Tutor. I do. In other cases, however, chemical affinity is capable of combining two or more substances to a certain extent only.

Experiment. Take sulphuric acid, and drop into it a solution of alkali, as soda; examine the mixture after every addition of alkali. For a considerable time it will exhibit the properties of an acid; that is, it will convert vegetable blue colours into red, and it will have a sour taste. But there is a point where the combination ends; and, if more soda be added, the mixture will gradually acquire alkaline properties.

James. Will it then change vegetable blues into green, and possess an alkaline taste?

Tutor. It will: and these properties will become stronger, the greater the quantity of soda is added.

Experiment. Drop, gradually, carbonate of lime into muriatic acid, and you will see that an effervescence takes place, for the muriatic acid and lime *unite*, and the carbonic acid flies off. *But you may go on* adding the lime, till it pro-

ıce no further effervescence, and the lime falls
the bottom.

Charles. There ceases, then, to be any further
ıemical union. Does this experiment explain
ıe reason why water can dissolve only a certain
ıantity of sugar or salt?

Tutor. Yes, it does; and also why alcohol can
ıly dissolve a certain quantity of camphor; and,
ter it has dissolved this quantity, if more be
ldded, it will fall to the bottom.(*a*)

CONVERSATION VII.

Of Chemical Affinity.

CHARLES. I do not think we quite comprehend the subject of chemical affinity; will you illustrate it still farther?

Tutor. I will, though there should be some risk of repetition. When two substances unite, in consequence of their mutual attraction, they are said to combine by virtue of simple chemical affinity. Here is some muriate of soda, that is, a combination of muriatic acid and soda, formed by single affinity.

James. Do you mean, that these substances have an attraction for each other?

Tutor. I do; but nitric acid has a stronger attraction for the soda than the muriatic acid. I will pour into the muriate of soda some nitric acid; the muriatic acid is disengaged, and the nitric acid combines with the soda.

Charles. Is this new combination nitrate of soda?

Tutor. It is. Now I will add to this some sulphuric acid, which has a still stronger attraction for the soda than the nitric acid; the consequence of which will be, that the nitric acid will be expelled, and a sulphate of soda will be formed of the sulphuric acid and soda.

James. Was it owing to chemical affinity, that the muriate of soda was first formed, and then that the nitrate, and afterwards the sulphate of soda were combined?

Tutor. It was; for each of the acids has an affinity for soda, but the muriatic acid has the least or weakest attraction for it, the nitric the next stronger, and the sulphuric the strongest. In almost all chemical books, there are what are called tables of affinity.

Charles. Yes, I have seen them, but do not understand their structure or use.

Tutor. I will make the matter clear by a short specimen, which exhibits some of the affinities of the alkalies, sulphuric acid, and nitric acid.

Potass, Soda, Ammonia.	Sulphuric Acid.	Nitric Acid.
Sulphuric acid.	Barytes.	Potass.
Nitric acid.	Strontian.	Soda.
Muriatic acid.	Potass.	Barytes.
Sebacic acid.	Soda.	Strontian.
Fluoric acid.	Lime.	Lime.
Phosphoric acid.	Magnesia.	Magnesia.
Oxalic acid.	Ammonia.	Ammonia
Tartarous acid, &c.	Alumina, &c.	Alumina, &c.

James. Does the first column point out the affinities that the several acids have for the substances above it, *viz.* potass, soda, and ammonia?

Tutor. It does; and the acids are so arranged as to show the order of their attraction for them.

Charles. Has the sulphuric acid the strongest affinity for soda, and the tartarous the least?

Tutor. Just so: the same thing happens with regard to the second and third columns. Barytes has the strongest affinity for sulphuric acid; the next in order is the earth called strontian, then potass, and last in order is alumina.

For nitric acid, potass has the strongest affinity, and, among the substances enumerated, alumina has the weakest.

James. I do not see the application of these tables to practical purposes.

Tutor. In the column over which *soda* stands, the several acids, as I have said, exhibit a series of the affinities of soda, decreasing in strength downwards, so that the combination of soda, with any of the acids, may be decomposed by the other acids, that precede this substance, but not by those which follow it; the same thing applies to potass and ammonia.

Charles. I understand, by the experiment just now performed, that the muriate of soda can be decomposed by the sulphuric and nitric acids, because they range above the muriatic acid, but not by the sebacic and others, which, being below, have affinities less strong for soda than the muriatic acid.

Tutor. That is right: it is also evident, that sulphate of soda cannot bè decomposed by any of the acids; whereas, a tartrate of soda may undergo decomposition by all or any of the seven acids above it. Look to the next column; how can I decompose the sulphate of potass?

James. Either by means of strontian or barytes, and the potass will be disengaged. Upon what principle are the tables of affinities formed?

Tutor. Upon this, *viz*. that a given quantity of acid will take up a greater quantity of one base than of another, in proportion to the force of its affinity for the base; thus, in the instance of *sulphuric acid*, it has been ascertained, that 100 parts, by weight, take 200 parts of barytes to *saturate* it; but the same quantity of acid will be saturated by 70 parts of lime only.

Charles. Do you mean, that 100 ounces, or grains, of sulphuric acid, will hold in solution 200 ounces or grains of barytes, and only 70 of lime?

Tutor. I do: and it should seem, that the quantity of base required to saturate a given quantity of pure acid, is a true expression of the force of affinity between the acid and the base. It appears, from Mr. Kirwan's experiments, that 100 parts of sulphuric acid will hold in solution

Barytes.	Strontian.	Potass.	Soda.	Lime.	Magnesia.	Ammonia.
200 :	138 :	121 :	78 :	70 :	58 :	26

and 100 parts of nitric acid will hold in solution

178 :	*116* :	117 :	73 :	55 :	47 :	40

By referring to the column over which sulphuric acid stands, you will find, that the substances arrange in the order of the figures just transcribed.—See table, page 42.

James. Do you say that the affinity of barytes for the sulphuric acid is to that of potass as 200 to 121, and so of the rest?

Tutor. That would undoubtedly be the law, provided the tables were formed with strict accuracy, and the experiment made with pure substances. Such tables would give likewise, at first sight, the real nature and proportions of compounds: thus we should know, that sulphate of barytes was a compound of 100 parts of sulphuric acid, and 200 of lime; sulphate of soda, of 100 parts of acid, and 78 of soda. I hope you now understand the nature of simple affinity, or the affinity which simple substances have for each other?

Charles. I think we do. Pray what is compound affinity?

Tutor. The action of two compound substances, by which they mutually decompose each other. I will give you an instance, from the foregoing table, page 42. In this glass is a solution of sulphate of ammonia: now, if I pour into it nitric acid, there is no decomposition, because you see, by the table, that the sulphuric acid has a greater affinity for ammonia than the nitric acid.

James. By the same rule, the sulphate of ammonia cannot be decomposed by any of the acids, because the sulphuric stands the highest in order.

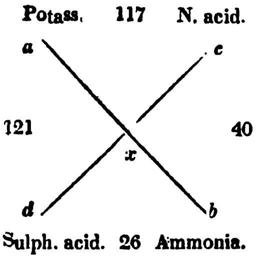
Tutor. You are right. In the third column you see, that potass stands highest under nitric acid, and ammonia almost the last. I therefore add to the sulphate of ammonia a solution of the nitrate of potass.

Charles. Now there is an evident decomposition going forward.

Tutor. The sulphuric acid of the sulphate of ammonia attracts the potass of the nitrate of potass; for potass stands higher in the table than ammonia, and has therefore a greater affinity for it: at the same time, the ammonia unites with the nitric acid.

James. Are the new compounds *sulphate of potass* and *nitrate of ammonia?*

Tutor. They are: this kind of attraction has been explained or expressed by Dr. Black, and other chemists, in the following manner. By the table, page 44, the attraction of sulphuric acid for potass and ammonia is as 121 and 26, and of the nitric acid for the same substances is as 117 and 40. Now it is evident, if the cross bars *a b* and *c d* be moveable about the point *x*, and are drawn by the contending forces of 121 + 40 and 117 + 26, *that the former,* being equal to 161, must overcome *the latter force,* which is equal only to 143,



l would shut the bars together ; that is, *a* will nbine with *d*, and *c* with *b*.

Charles. The potass combines with the sulphu- acid, and the nitric acid with the ammonia.

Tutor. They do, and this is a proper illus- tion of compound affinity. Here, by mixing phate of ammonia and nitrate of potass, we re a double decomposition, which gives, as ults, the sulphate of potass and nitrate of monia.

James. Is this double decomposition of any ctical importance?

Tutor. Yes, there are substances highly use- in the arts, that cannot be formed in any er way. Acetate of alumina, used in calico- nting, cannot be made by mixing acetic acid l alumina: but, by mixing sulphate of alumina h acetate of lead, the decomposition will take ce, and the acetate of alumina is formed.

Take another instance or two to illustrate this uble decomposition. Highly concentrated ni- c acid has no action upon iron, but, if a little ter be added, a violent action instantly takes ce.

Charles. How is this accounted for ?

Tutor. The particles of the acid in its pure te, have a greater affinity for each other than the iron ; but by lowering the acid with wa- , the union between the oxygen and azote, of ich the nitric acid is composed, will be weak- ed, part of the oxygen combines with the iron, l *nitrous gas* is disengaged and flies off.

In this glass I have a solution of nitrate of silver, to which I will add a solution of muriate of lime; two new substances will be formed, nitrate of lime, and muriate of silver; the latter, being insoluble in water, will be precipitated in a solid form.

James. Is the white substance the muriate of silver?

Tutor. It is. You will find tables of chemical affinities in almost every work, and, from the little that I have explained, you will readily understand their uses, and the practical advantages to be derived from them. I beg you will look to Dr. Henry's table, No. VI. of the Appendix, page 530, seventh edition, 1815.

Charles. In that work there is a different kind of diagram, explanatory of chemical affinity, which I do not comprehend.

Tutor. Diagrams of that kind were invented by Bergman, as a sort of register of any experiments in affinity.

James. What should a complete register of an experiment express?

Tutor. It should show (1.) the *result;* (2.) the *menstruum*, such as water, alcohol, &c.; (3.) the *temperature* of the substances when the experiment is made; (4.) the state of the new combinations, whether they are precipitated from the menstruum, or remain dissolved, or are sublimed.

Charles. Can all these things be expressed *a mere figure?*

James. What is the origin of the term *menstruum?*

Tutor. In answer to the last question, the word is derived from *mensis*, a *month;* because the alchemists, in making experiments, used to continue each substance in solution a whole month; hence the fluid was called menstruum.

I will now proceed to show how an experiment is to be registered by means of a diagram, and how the several circumstances just referred to, may, by this means, be concisely expressed.

Here is a solution of muriate of potass, at the temperature of 60°; I am desirous of ascertaining whether it can be decomposed by soda; upon trial, I find no change takes place; which is thus expressed:—

$$\begin{array}{c}\text{Muriate}\\ \text{of}\\ \text{Potass.}\end{array}\left\{\begin{array}{lll}\text{Muriatic acid.} & & \text{Soda.}\\ & & \text{water } 60^\circ.\\ \text{Potass.} & & \end{array}\right.$$

Charles. The substance to be decomposed is muriate of potass, placed on the outside of a bracket; and within the bracket I see are the component parts, *viz.* muriatic acid and potass. What does "water 60°" mean?

Tutor. It points out, that water is the menstruum; and the 60° shows at what temperature it is. The soda is placed opposite one of the simple substances, and, as no change is effected by the soda, the diagram is left imperfect. I will give you another figure, rather more complete.

	Muriate of Potass.
Muriate of Soda.	Mur. ac. Potass.
	water 212°.
	Soda.

James. Here the menstruum is boiling water. Is potass presented to a solution of muriate of soda in boiling water ?

Tutor. It is : a decomposition takes place, muriate of potass is formed, and soda is set free from the muriatic acid.

Charles. What do the straight lines above and below denote ?

Tutor. They are straight, to denote that both substances remain in solution. Here are some other examples.

	Sulphate of Strontian.		Nitrate of Potass.
Sulphate of Magnesia.	Sulph. a. Stron.	Carbonate of Potass.	Potass. Nitric a.
	water 60°.		water 60°.
	Magnesia.		Carb. a.

James. In the first of these examples I see that strontian decomposes the sulphate of magnesia, and that sulphate of strontian is formed ; in the second, the carbonate of potass is decomposed by nitric acid, and a nitrate of potass is formed. What do the lines mean ?

Tutor. In the first example, the bracket above *and the line below* point downwards, to show that both the sulphate of strontian and the mag-nesia are precipitated. In the second, the uppe *straight* line shows, that the nitrate of potass i held in solution, and the lower line pointing up-wards denotes, that the carbonic acid goes off i the form of gas. Take two other examples.

	Sulphate of Soda.		Muriate of Lime.
Sulphate of Magnesia.	Sulph. a. Soda. / water 60°. / Magnesia.	Muriate of Ammonia	Mur. a. Lime. / Fire. / Ammonia.

Charles. I understand these examples: i the first, the sulphate of soda is held in solution and the magnesia precipitated; in the second the muriate of lime is precipitated, and the am-monia goes off in gas. What does the wor *fire* mean?

Tutor. It shows that the experiment is con-ducted by heat; that is, that the muriate c ammonia and lime are heated together, to pro-duce the decomposition. Now, I think yo will comprehend the diagram given in Dr. Hen-ry's Work,* which is nearly this,

	Acetite of Zinc.		
Sulphate of Zinc.	Zinc.	Acetous a.	Acetite of Lead.
	Sulph. a.	Lead.	
	Sulphate of Lead.		

* *See vol. i, p. 64,* seventh edition, 1815.

James. Yes: the original compounds are the sulphate of zinc and acetate of lead; these being mixed, the lead goes over to the sulphuric acid, and the zinc passes to the acetous acid, the sulphate of lead is precipitated, because the bracket points downwards, but the acetate of zinc is held in solution, because the point of the bracket turns upwards.

CONVERSATION VIII.

Of Heat.

'UTOR. You understand what is meant by action ?

'harles. It is that principle by which bodies eavour to approach one another ; thus, two :es of cork, swimming on a basin of water, e, by the law of attraction, a tendency to- ds one another, or to the sides of the basin, ording as they are situated ; and two drops of cury, placed near one another, will run to- ier, and form one large drop.*

ames. By this principle, also, the planets e a tendency to the sun, and would fall to it, he mutual attraction of the bodies were not nced by another invisible power.†

'utor. The natural effect of attraction is to der bodies solid and compact. The princi- agent employed to counteract this is *fire*, or t. This is called, by chemists, *caloric*, and

* *Scientific* Dialogues, vol. i, p. 28.
† *Scientific* Dialogues, vol. i and ii.

is found to exist in all bodies whatever, in a greater or lesser degree.

Charles. Is there, then, a general law, which tends to bring bodies, or the parts of bodies together, and another, which tends to remove them from each other?

Tutor. There are; and upon these apparently opposite principles the consistence of all bodies depends.

James. That is, as the one or the other prevails, a body is more or less compact and solid.

Tutor. True; when the attraction prevails, bodies are in a solid state; when the heat, or caloric, is most powerful, they are in a state of gas; and the liquid form is, perhaps, the mean state, or the point of equilibrium between the two. Water, in what we call its usual state, is in a liquid form; when part of its heat is taken away, it assumes the character of ice, and when more heat is added, it flies off in the shape of steam.

Charles. Are all substances capable of existing in these several states?

Tutor. All bodies in nature are either solid or liquid, or in a state of aeriform gas, or vapour, according to the degree of heat to which they are exposed. To a person who never lived out of the Torrid Zone, nor conversed with those who had, it would seem scarcely credible, that water should become solid, or ice; to us, however, the phenomenon is common enough. Mercury also may be made solid, by taking away a certain quantity of its caloric. On the other hand, by the application of high degrees of heat, there is, perhaps, not a substance in nature so hard and solid, that may not be converted into an aeriform state :—and, therefore, it has been inferred by Lavoisier, that all bodies are capable of existing in these several states.(*a*)

James. You speak of taking away the heat of bodies—does heat exist in all substances ? Mercury, to the touch, seems to possess no heat ; it always feels cold.

Tutor. Hot and cold are comparative terms : when I come out of the hot bath, the air in the room gives me the sensation of cold ; but, if you were to come out of the garden into the same room, the air of it would give you the sensation of heat, and you would wonder why I complained of cold. Take two basins of water, one pretty hot and the other cold, and keep one hand in each a few minutes ; then plunge them both in a third vessel of water, moderately warm.

Charles. I have tried this ; and to the hand taken from the cold water this will be hot, but to the other it will give the sensation of chilliness.

Tutor. In general, every body appears hot or warm on being touched, which is at a higher temperature than the hand ; and every body, which is less heated than the hand, and draws heat from it, on being touched, appears cold.

James. What is cold ?

Tutor. *Coldness* is only the absence or *rather the deficiency* of heat ; and, according to

Dr. Black, it is the state the most proper to mat ter; the state which it would assume, were i left to itself, and not affected by some externa cause.

Charles. What is heat?

Tutor. Heat, or caloric, is plainly somethin either superadded to common matter, or it cause some alteration of it from its common state; an it exists in two states, *viz.* in *combination* and a *liberty.*

James. I do not understand these terms.

Tutor. Caloric, in combination, forms a con stituent part of all bodies; in this state it is no sensible to our organs; but it is probably owin to this that the particles of bodies do not touch each other. When it becomes sensible to ou feelings, or can be indicated by the thermometer it is then denominated free caloric.

Charles. When the thermometer rises, doe it show that free caloric is entering into the su rounding bodies?

Tutor. Certainly it does: and the thermomet itself, which is one of these bodies, receives share, in proportion to its mass, and to the ca city which it possesses for containing caloric.

James. Is there caloric in combination the coals and wood that are in the grate?

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James. I now understand what is meant by free and combined caloric. The heat was in the wood and the coals before the light was applied to them, but by the application of the candle it was set at liberty.

Tutor. You are right; we will resume the subject to-morrow. In the mean time, remember that caloric exists in every body, and in every place with which we are acquainted. It combines most readily with every species and particle of matter. On this subject, Dr. Black has given the following as a general law:—"Whenever a body changes its state, it either combines with or is separated from caloric."

CONVERSATION IX.

Of Heat.

JAMES. I do not comprehend what *caloric*

Tutor. Perhaps you may never know what is, but from its effects. It has been defined impenetrable fluid, highly elastic, and so subt that its gravity has not been yet ascertained.

Charles. If it be a substance, it must neve theless have gravity.

Tutor. Certainly; according to the definiti formerly given to matter;* and means may her after be found to ascertain its gravity; but present we know it is diffused through, and co bined with all bodies; nor can it be entirely s parated from any of them.

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Tutor. It cannot: and chemists, in reasoni upon bodies, take no notice of the caloric them, but consider it as essential to their e *istence.*

* Scientific Dialogues, vol. i, p. 10.

Charles. You can increase or diminish the quantity of caloric in bodies, though it is not possible either to take it wholly away from any, or obtain it by itself.

Tutor. True: for in taking away caloric from a body, we do but change its place, by taking it from one and giving it to another body. Thus, if I have a pint or a pound of water, at 90°, I can diminish the quantity of caloric immediately, by mixing it with water of a less temperature; if, for instance, I add to it a pound of water at 50°, the mean heat of the whole will be 70°; 20° having been in this case subtracted from the one quantity and added to the other.

James. The water, if ever so hot, will cool of itself.

Tutor. That is, the caloric will fly off from the water, and unite with the surrounding air, or other adjacent bodies; for there is a tendency in caloric to fly off from any hotter body to those in its vicinity that are cooler. Heat is thus brought into a state of equilibrium.

Charles. How is this known?

Tutor. By the thermometer it is found, that all bodies, communicating freely with each other, acquire in a greater or less time the same degree of temperature.

James. Are the different bodies in a room in which there is no fire, and to which the sun has no access, all of the same temperature? I am sure they *do not* appear so to the touch. The *green cloth seems* much warmer than the tabl on which it lies, and the table is less cold than the marble slab: how, therefore, do these facts, which cannot, I think, be denied, be made to accord with the theory of this universal equilibrium, with regard to heat?

Tutor. The difficulty which you feel, depends partly on your own sensations, and partly upon the nature of the substances to which you refer, some of which are better conductors of heat than others. If you try the cloth, the table, and the slab, under the circumstances which you have described, by the thermometer, you will find they are all of the same temperature.

Charles. Is the thermometer, then, as its name imports, a true measure of the heat of bodies?

Tutor. Of the *temperature*, or degree of heat it is, but not of the quantity of caloric which they contain; because, in bodies of different kinds, the quantities of absolute heat may be unequal, though the temperatures be the same.

Experiment. Let a piece of iron, and another of wood, be heated in an oven till they both exhibit the same degree of temperature by the thermometer. To the hand, the iron will feel the hotter body; that is, the iron will communicate more heat to the hand, and will continue longer to communicate heat, before it assumes the temperature of the hand, than the wood will do.

James. Do you infer from this, that the iron *contains the greater* quantity of caloric, although, by the thermometer, it did not appear to be at a higher degree of temperature than the wood?

Tutor. Certainly: because it could not give out what it did not possess. Again, let the iron and wood be both immerged in snow till the temperature of both is reduced to 32°; that is, to the temperature of the snow. The iron now will feel the colder body of the two to the hand, and will continue a longer time to feel cold before it becomes of the same temperature with the hand. In other words, it seems to require a greater quantity of caloric than the wood, because it is at an equal temperature with the hand.

Charles. Perhaps this may depend on the quantity of matter contained in each substance; and that, as there is more matter in the iron than in the wood, more caloric is required in the former than in the latter, to bring them to the same temperature.

Tutor. This is a natural supposition, but experiments prove, that it is not well founded; Dr. Black says, and no one understood the subject better than he did, that the proportions are widely different from this. He found, that quicksilver, which is fourteen times heavier than water, was warmed by a fire much faster than water; and it cooled faster too, when they were both exposed to the same current of air.

James. Is that the reason why quicksilver was preferred, of all other fluids, for the construction of thermometers?

Tutor. *It probably* was: and Dr. Black, from this circumstance, inferred, that the ca city of different bodies for heat can only known from actual experiment.

Charles. What do you mean by the w *capacity* in this connexion ?

Tutor. The meaning is pretty nearly t same as when the term is applied to vessel in these, the capacity is greatest, in that whi will contain the most ; so it is with regard caloric ; that substance is said to have the gre est capacity for it, that contains the most to brought to a given degree of temperature, measured by the thermometer.

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Charles. If that be the case, it is certai that iron, which is longer in heating and co ing, must have a greater capacity for caloric th wood, because it receives or throws it out fast, but is longer in coming to the same degr of temperature.

Tutor. The *second* inference is, that *the celerity with which caloric or heat is communicated from hotter bodies to colder ones is nearly proportional to the difference of their temperature.*

Charles. Do you mean, that the heat is taken away fastest at first, and more and more slowly afterwards?

Tutor. Yes, I do; and the reason is obvious —because the air, becoming every moment warmer, while it cools the hot body, is less fit to take away the rest of its heat.

James. This can be the case only when the air is stagnant; if the hot body be exposed to a current of wind, it may lose equal quantities of heat in equal times.

Tutor. True; and this observation will enable you to understand why, in frosty weather, if the air is calm, we do not experience cold so much as when there is wind.

Charles. I have frequently thought a windy day colder than a calm one, though the thermometer has been several degrees higher in the former than the latter.

Tutor. In calm weather, our clothes, and the air entangled in them, receive heat from our bodies, which is accumulated to a certain degree. But in windy weather this heat is prevented from accumulating; the cold air, by its rapid succession, cooling our clothes faster, and carrying away the warm air that was entangled in them.

is found to exist in all bodies whatever, in a greater or lesser degree.

Charles. Is there, then, a general law, which tends to bring bodies, or the parts of bodies together, and another, which tends to remove them from each other?

Tutor. There are; and upon these apparently opposite principles the consistence of all bodies depends.

James. That is, as the one or the other prevails, a body is more or less compact and solid.

Tutor. True; when the attraction prevails, bodies are in a solid state; when the heat, or caloric, is most powerful, they are in a state of gas; and the liquid form is, perhaps, the mean state, or the point of equilibrium between the two. Water, in what we call its usual state, is in a liquid form; when part of its heat is taken away, it assumes the character of ice, and when more heat is added, it flies off in the shape of steam.

Charles. Are all substances capable of existing in these several states?

Tutor. All bodies in nature are either solid or liquid, or in a state of aeriform gas, or vapour, according to the degree of heat to which they are exposed. To a person who never lived out of the Torrid Zone, nor conversed with those who had, it would seem scarcely credible, that *water* should become solid, or ice; to us, however, the phenomenon is common enough. *Mercury* also may be made solid, by taking away a certain quantity of its caloric. On the other hand, by the application of high degrees of heat, there is, perhaps, not a substance in nature so hard and solid, that may not be converted into an aeriform state :—and, therefore, it has been inferred by Lavoisier, that all bodies are capable of existing in these several states.(*a*)

James. You speak of taking away the heat of bodies—does heat exist in all substances ? Mercury, to the touch, seems to possess no heat ; it always feels cold.

Tutor. Hot and cold are comparative terms : when I come out of the hot bath, the air in the room gives me the sensation of cold ; but, if you were to come out of the garden into the same room, the air of it would give you the sensation of heat, and you would wonder why I complained of cold. Take two basins of water, one pretty hot and the other cold, and keep one hand in each a few minutes ; then plunge them both in a third vessel of water, moderately warm.

Charles. I have tried this ; and to the hand taken from the cold water this will be hot, but to the other it will give the sensation of chilliness.

Tutor. In general, every body appears hot or warm on being touched, which is at a higher temperature than the hand ; and every body, which is less heated than the hand, and draws heat from it, on being touched, appears cold.

James. What is cold ?

Tutor. *Coldness* is only the absence or *rather the deficiency* of heat ; and, according to

Dr. Black, it is the state the most proper to matter; the state which it would assume, were it left to itself, and not affected by some external cause.

Charles. What is heat?

Tutor. Heat, or caloric, is plainly something either superadded to common matter, or it causes some alteration of it from its common state; and it exists in two states, *viz.* in *combination* and at *liberty.*

James. I do not understand these terms.

Tutor. Caloric, in combination, forms a constituent part of all bodies; in this state it is not sensible to our organs; but it is probably owing to this that the particles of bodies do not touch each other. When it becomes sensible to our feelings, or can be indicated by the thermometer, it is then denominated free caloric.

Charles. When the thermometer rises, does it show that free caloric is entering into the surrounding bodies?

Tutor. Certainly it does: and the thermometer itself, which is one of these bodies, receives its share, in proportion to its mass, and to the capacity which it possesses for containing caloric.

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Tutor. The meaning is pretty nearly the same as when the term is applied to vessels; in these, the capacity is greatest, in that which will contain the most; so it is with regard to caloric; that substance is said to have the greatest capacity for it, that contains the most to be brought to a given degree of temperature, as measured by the thermometer.

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Charles. If that be the case, it is certain, that iron, which is longer in heating and cooling, must have a greater capacity for caloric than wood, because it receives or throws it out as fast, but is longer in coming to the same degree of temperature.

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James. Is not the thermometer affected the wind?

Tutor. In general, not at all. The mercu of a thermometer, suspended in a large roo did not fall in the least when a stream of air w directed against the bulb: but, if that air h been directed against you and me, we shou have felt colder certainly.

Charles. Then the air is not made cold by agitation?

Tutor. It is not. A piece of ice suspend in the air of a warm room, and blown upon bellows, instead of being kept more cool, as o bodies would, and preserved the longer from b ing totally melted, would be melted faster th when the air is allowed to be quiet around it.

Charles. From this account of the matter see the reason why we are in danger of taki cold, by being exposed to a current air, wh we are very warm from exercise.

Tutor. I hope, then, you will in future pr by this knowledge. The third inference *that the celerity with which caloric is communic ed from hotter bodies to colder ones is proporti able to the extent of contact, and the closeness communication between the bodies.*

James. That is the reason why the water broad and shallow kettles, called *conjurors*, w boil so soon. Because the extent of surface so great, in comparison of others that cont equal quantities of water.

Tutor. For the same reason in large works, as founderies and breweries, the fire is made to extend round the coppers, &c. in which the materials are put to be melted, or heated.

By this principle is explained the cause why bodies that are spongy are longer in heating than those which are more dense.

Charles. Our short poker in the nursery, when kept in the fire a few minutes, cannot be held in the hand without burning it, but a piece of stick, much shorter than this, I could hold easily by one end while the other is burning away in the fire. Is that because the wood is more porous than the iron ?

Tutor. It is. You see also why our clothes, made of wool, are so well adapted to keep us warm in cold weather.

James. Yes, because the heat of our bodies is a good while in making its escape through such porous and spongy substances.

Tutor. In very cold countries, the inhabitants are not only wrapped in furs in the day, but they cover themselves by night with feather beds.

Charles. Do not these things add warmth to the body ?

Tutor. No : they only preserve the heat of it from escaping. As a proof of this, the very same things, as flannel and furs, are used to keep ice cool. The best way to preserve a lump of ice from *melting*, in a warm room, would be to *wrap it up in several* foldings of flannel.

James. Is it for a similar reason, that the ground is never very much affected by frost, if the snow upon it is pretty deep?

Tutor. Yes: nothing can be more spongy and soft than snow, in its natural state, and nothing preserves vegetables and corn better, in long and severe frosts. In cold climates, the wool and hair of the wild animals is much increased against the winter, to preserve them from the severity of the season. The same thing happens, though in a less degree, with tame animals, as the horse, cow, &c.

Charles. The earth must, however, be cooled down to the freezing point; because snow can never be preserved at a higher temperature than this.

Tutor. True: but this is a great degree of heat, compared with the cold in the high northern climates. In many parts of Lapland the thermometer frequently falls 32 degrees below the freezing point: which is just as much colder than simple frost as frost is colder than the usual warmth of our summer weather. In some parts of Siberia, the cold has been so severe as to freeze the mercury in the thermometer, or at least 72(*a*) degrees below the freezing point.

CONVERSATION X.

Of the Action of Heat upon Bodies.

TUTOR. You know that heat, or caloric, expands bodies ?

Charles. Yes : I remember the experiments on the pyrometer,* which showed this very clearly.

James. But those experiments related only to solid substances.

Tutor. They did ; bodies, however, are expanded *least* in the *solid* state ; *more* in a *liquid* state ; and *most* of all in an *aeriform* state. Here is a tube about twelve inches long, and only one third of an inch in diameter ; I will fill it up to this mark, about eleven inches, with cold water : and then plunge it into boiling water, and you will see, after a few minutes, that the water in the tube has risen above the mark.

Charles. The expansion of air, too, is very manifest by tying up a small quantity of it in a bladder, and bringing the bladder near the fire.

* *See Scientific Dialogues*, vol. iv, p. 230.

Tutor. In certain fluids, as quicksilver, linseed oil, and alcohol, the expansions, within certain limits, are proportional to the quantities of heat communicated to them.

James. Do you mean, that the quantity of heat, required to raise the mercury in the thermometer four degrees, is double that which is required to raise it two degrees, four times that required to raise it one degree, and so in proportion?

Tutor. I do: and upon this principle, mercury, oil, and alcohol, have been, and are still used in the construction of thermometers.

James. You said there were limits to the regularity of these expansions.

Tutor. Yes: these are near the points of congelation and evaporation, and then they cannot be depended on as thermometers.

Charles. If fluids expand by heat, and contract by cold, what made the pipe belonging to the cistern burst in the frost?

Tutor. That is a proper question; it leads to the mention of some objections to the general rule. Water contracts, till it has sunk to within 8 degrees of the freezing point; and then, strange as it may appear, it expands; and this expansion is the cause of the bursting of vessels, in which water or other fluids are suffered to freeze.

Charles. How is this expansion accounted for?

Tutor. The difficulty is resolved by the laws of crystallization, which cause the particles to unite, so as to give the solid mass a certain peculiar configuration. The same thing happens to cast iron, which expands as it cools.

James. Do not Mr. Wedgewood's thermometers* form an exception to this rule, for in them the clay contracts by heat.

Tutor. It seems so at first ; but the contraction of the clay probably arises from the expulsion of the moisture from it, and not from the action of heat on the particles themselves.(*a*)

Charles. Does heat change the form of bodies ?

Tutor. Yes : as we have seen, it converts solids into liquids, and liquids into vapours, or into permanently elastic fluids. The liquid and vaporous forms of bodies are brought about in the same way with the expansion of solids, being only higher degrees of it.

James. Is it not the same with regard to the aeriform state ?

Tutor. No : in that case, the particles appear to be thrown into certain spheres, in which they are fixed by some other force than that of heat. These they do not quit by any degree of cold that has been produced.

Charles. I am not sure that I understand what is meant by *latent* heat.

Tutor. Every body, which passes from the solid to the liquid state, absorbs a portion of heat, which, *though it exists* in a state of combination,

* *Scientific Dialogues*, vol. iv, p. 223.

is not sensible to the thermometer, and is, therefore, called *latent* or concealed heat.

Experiment 1. If a pound of water, at 32°, be mixed with an equal quantity of the same fluid, at 172°, the temperature of the mixture will be 102°, which is the arithmetical mean of the two temperatures, because $\frac{32° + 172}{2} = 102$

James. Here a quantity of heat, that raised the thermometer 70°, passed from the warm water into the cold, by which the temperature of the latter was increased 70°.

Tutor. If a pound of ice, at 32°, be mixed with an equal quantity of water, at 172°, the temperature of the mixture will be still 32° only.

Charles. Has the hot water no other effect than that of dissolving the ice ?

Tutor. No : whence it follows that 140° of heat or caloric are absorbed, which produce no change in the thermometer.

Experiment 1. The mercury of a thermometer, plunged into a vessel filled with pounded ice, will immediately descend to 32°. If, then, the vessel be immersed in boiling water, the mercury will not rise during the whole time that the ice is liquefying.

Ex. 2. Dr. Black found that a lump of ice, suspended in a warm room, took upwards of five hours to liquefy ; during which time, a stream of cold air continued to flow from it. He says, that if the caloric, which was communicated to

ead of having been absorbed, had been
/ed in making the ice sensibly hotter, its
·ature, at the end of the time, would have
ed that of red hot iron.

es. Is heat, then, the cause of fluidity ?

r. It is: ice and snow require large por-
f it to bring them into a state of fluidity.

les. Is that the reason why ice and snow
long in melting, after a change of wea-
om a severe frost ?

r. When a thaw succeeds to frost, the
nd ice are very soon brought up to 32°,
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s. This seems to be a very fortunate cir-
nce; since, as it is, we often have floods
e breaking up of a frost, though the snow
o gradually.

r. It is, indeed: for in some countries,
the snow lies very thick on the ground, if
ting were instantaneous, the torrents and
ions would be absolutely irresistible;
ould carry every thing away in their

les. Is it the slowness with which ice is
hat enables confectioners and others to
n ice-houses so long ?

Tutor. Yes: it begins to melt, perhaps, imi
diately, but, as the building is exposed as li
as possible to the external air, and is either
der ground or in a shady place, and covered
a thick covering of thatch, the heat penetr
very slowly; and there are always drain
carry off the water that runs from it.

James. They have double doors; one at
distance of several feet or yards within anotl

Tutor. This is in order that the person
fetches away the ice may go in and shut
outer door before he opens that which is
the ice. By this precaution, a very small
tion of the external air gains access to the in
part of the ice-house; and thus ice is
during the whole summer. For the same
son, snow on the tops of lofty mountains co
ues in a melting state through the summer,
melting so slowly, that the whole season is in
ficient for its complete liquefaction.

Charles. Instead of the ice absorbing the
loric, may it not be dispersed?

Tutor. Take a piece in your hand:—wh
the consequence?

Charles. It makes my hand very cold.

Tutor. That is, it absorbs, or draws the c
ric very rapidly from you. I have suspen
on the beam, a lump of ice by a string, h
your hand just under it.

Charles. A stream of cold air seems to desc
from the ice.

Tutor. The air in contact with the ice is ived partly of its caloric, and, on that account, becomes heavier than the warmer air in the om, and falls downwards. Its place is imme- itely supplied by other portions of warmer air, ich, in their turn, lose their caloric and de- end. Thus, there is a constant flow of warm r to the sides of the ice, and a descent of the me in a cold state, from the lower part of the ass; during which operation the ice must ne- ssarily receive a great quantity of caloric.

James. If I understand you, the only effect oduced by this caloric is to change the ice in- water, without making it sensibly warmer than e ice was before.

Tutor. Right: the caloric changes the ice at ° to water at 32°; it must itself, therefore, absorbed or concealed within the water. To w more effectually the absorption of caloric he ice, Dr. Black suspended equal quantities e and water, at the same temperature, in vessels of the same size and shape, in a , the heat of the air of which was 47°. At nd of half an hour, the temperature of the had risen 7 degrees; but, in ten hours and some of the ice was left in the middle of her glass undissolved; but the water near les of the glass had also gained 8 degrees of

les. That is, in one case, the 7 degrees ned in half an hour, and in the other, 8 in 21 *half* hours.

Yes: and the doctor adds, that the

whole quantity of caloric received by t
glass, must have been $21+7^{\circ}=147^{\circ}$; v
no part of this caloric appeared in the ice
except 3 degrees, the remaining 139 ha
absorbed by the ice in melting, and we
cealed in the water into which it was cl

CONVERSATION XI.

Of the Action of Heat on Bodies.

CHARLES. Is the caloric, of which we conversed yesterday, separated from the liquids when they return to a solid state?

Tutor. Yes, as the following experiment will prove: if a pound of water, at 32°, be quickly mixed with an equal quantity of ice, at 4°, about one fifth part of the water will be frozen, and the temperature of the mixture will be 32°. Here the ice is raised from 4° to 32°; therefore by the congelation of one fifth of a pound of water, a quantity of caloric is given out from the water, sufficient to raise a pound of ice 28°.

Charles. Do bodies, by passing from the fluid to the aeriform, absorb heat?

Tutor. They do; which is again given out when they recover their liquid state, as the following experiments will prove:—

Experiment 1. If a vessel of water be placed on the fire, it will, in a few minutes, reach the *boiling point*; but it will take a considerable time before all the water is reduced to a state of vapour.

Ex. 2. A vessel, containing a few ounces of water, was exposed to such a heat as made it boil in four minutes, but it took twenty minutes, wholly to go off in the shape of steam and vapour. The heat was equally great during the whole time; consequently, four times as much caloric was necessary to bring the water into a state of vapour, as was required to make it boil; But this extra quantity of caloric was neither sensible in the water, the vessel, or the vapour; it was undoubtedly absorbed in the steam.

Charles. You mentioned the "*boiling point*;" is the heat of boiling water always the same?

Tutor. No: it is liable to some variations, on account of the state of the atmosphere. When the barometer stands at 30.4, water, when it boils, will be found hotter than it is to-day, when it stands only at 28.8.

James. What is the reason of this?

Tutor. It depends on the pressure of the atmosphere: hot water, much below the boiling heat, will boil in vacuo, as you saw in the experiment on the air-pump; as the pressure is increased, it requires a greater degree of heat before it boils.

Charles. Then the heat of the water will be greater under a greater pressure.

Tutor. Yes: but the moment the extra pressure is taken away, the extra heat will fly off in *vapour*. *Water*, in Papin's Digester, may be

ot enough to melt lead ; but the instant the
ɛmoved, it sinks down to the heat of boiling
and all the caloric above this goes off in
.
ottle closely corked, was raised several
s above the boiling point, but the instant
opened, a small portion of it went off in
, and the rest sunk to the boiling point.
's. From these experiments, it is clear
dies, by passing from the fluid state to the
m, absorb heat.
r. Water, or wine, or other liquids, in
nates are put into porous vessels ; then
'd in wet cloths, and exposed to the sun,
urrent of warm air, for the purpose of
them.
les. How is that accounted for ?
r. The water in the cloths evaporating,
ing into vapour, absorbs the heat from the
and whatever it may contain. For the
'ason, the mercury of a thermometer, ta-
: of water, and hung in the air, always de-
the evaporation of the moisture carries
ie caloric. The same thing happens to
iometer, placed under the receiver of an
ip ; in this case, the caloric is carried off
expansion of common air into that which
: rare.
's. I have seen the wet linen hanging on
es in the garden, frozen at a time when
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Tutor. Yes: but the moment the extra pressure is taken away, the extra heat will fly off in vapour. Water, in Papin's Digester, may be le hot enough to melt lead ; but the instant the s removed, it sinks down to the heat of boiling er, and all the caloric above this goes off in our.

bottle closely corked, was raised several rees above the boiling point, but the instant as opened, a small portion of it went off in our, and the rest sunk to the boiling point.

ames. From these experiments, it is clear bodies, by passing from the fluid state to the form, absorb heat.

utor. Water, or wine, or other liquids, in climates are put into porous vessels ; then pped in wet cloths, and exposed to the sun, a current of warm air, for the purpose of ling them.

harles. How is that accounted for ?

utor. The water in the cloths evaporating, assing into vapour, absorbs the heat from the le and whatever it may contain. For the e reason, the mercury of a thermometer, taout of water, and hung in the air, always deds, the evaporation of the moisture carries y the caloric. The same thing happens to ermometer, placed under the receiver of an pump ; in this case, the caloric is carried off he expansion of common air into that which ore rare.

ames. I have seen the wet linen hanging on lines in the garden, frozen at a time when mercury in the thermometer was much above freezing point.

Tutor. Though the temperature of the air was not so low as the freezing point, yet if you had tried the linen itself, you would have found that this was cooled to 32°, which was occasioned by a brisk air causing the water in the linen to evaporate, and carry off the caloric with it.

This will account for the cold produced by perspiration, without which workmen employed in glass-houses and iron-founderies could not exist; the heat of those places is much higher than that of the human body, but the extra caloric is caried off by perspiration or evaporation.

Charles. Is that the reason why medicines are used in fevers to create or promote perspiration?

Tutor. Yes, these are prescribed as one of the means to carry off the extra caloric, and to bring the body to its usual temperature.

James. Is the steam of boiling water of the same temperature with the water from which it proceeds?

Tutor. Yes, it is: if a thermometer be admitted through the lid of a vessel in which water is boiling, but so as not to touch the water, the mercury will rise to 212°, which is precisely the temperature of the water beneath. The water is, however, receiving continually new accessions of heat, which of course exists in the steam in a state of chemical union. Experiments have been made on this subject, which show that a pound of water in a state of steam, contains more *caloric than a* pound of boiling water, in the pro*portion of full* $4\frac{1}{2}$ to 1.

Charles. I believe the principle of absorption of caloric, during the liquefaction of bodies, has been applied to produce cold.

Tutor. Yes: a solution of equal parts of muriate of ammonia (sal-ammoniac) and nitrate of potass (nitre) make a very convenient mixture, that will freeze water and cream in the height of summer.

James. Are ices, that come to table, made in this way?

Tutor. Yes: the cream or other fluids are put in tin or copper moulds, and placed in some of the cooling mixtures till they become solid. [See the next page.]

Charles. Is this cold produced by the conversion of the solid salts into fluids?

Tutor. Yes: as the liquefaction of ice absorbs heat from surrounding bodies, so does the liquefaction of salts in this and other instances.

James. Are there other compositions besides that mentioned which produce similar effects?

Tutor. Yes: by mixing, very quickly, four parts of muriate of ammonia reduced to powder, with three parts of light, dry, and fresh snow, the mercury will fall 70° or 80° below the freezing point. I will insert a table of some mixtures, which may be used in freezing any fluids.

TABLE
OF
FREEZING MIXTURES.

Mixtures.	*Thermometer sinks.*
Muriate of ammonia 5 parts Nitrate of potass .... 5 Water 16	From 50° to 10°.
Sulphate of soda ...... 8 parts Muriatic acid 5	From 50° to 0°.
Snow or pounded ice 2 parts Muriate of soda 1	From 0° to — 5°.
Snow or pounded ice 1 part Muriate of soda .... 5 Mur. of ammonia & Nitrate of potass 5	From — 5° to — 18°.
Snow or pounded ice 12 parts Muriate of soda .... 5 *Nitrate of ammonia* 5	From — 18° to — 25°.

Charles. Do you first cool the mercury from 50° to 0°, and then, when it stands at 0°, put the thermometer in the next mixture to bring it to – 5, and then to – 18, and last from – 18 to – 25?

Tutor. That is the method made use of to get the greatest degree of cold. Equal parts of muriate of lime and fresh fallen snow has produced the greatest degree of cold known, *viz.* – 73.

James. It was, I suppose, cooled down first?

Tutor. A spirit thermometer was used, which was cooled down to – 40, before the main experiment was made. By means of 13lbs. of muriate of lime, and an equal weight of snow, 56lbs. of mercury was reduced from a liquid to a solid state, by Messrs. Pepys and Allen.

Charles. A good deal of precaution in mixing the materials is, I suppose, necessary?

Tutor. On a small scale 2 or 3lbs. of the muriate of lime is sufficient for the purpose. The mercury should be put into a very thin glass retort, which is to be immersed in a mixture of the muriate, and snow; and when this has produced the greatest cold, another mixture is to be prepared. The second, or at most the third mixture, will scarcely ever fail to congeal the mercury.

In all attempts to produce cold, the salts must be reduced to powder; the vessel in which the mixture is made should be very thin, and only large enough *to contain* it; and the experiment *must be made* as quickly as possible, taking care to stir the mixture with a glass or rod during the operation. The subject BUSTION we shall discuss hereafter.

CONVERSATION XII.

Of the Apparatus used in Chemistry.

TOR. I will now explain the nature and rties of some of the apparatus, which we nake use of in our experiments on this sub- This vessel (Plate 1, Fig. 1) is a retort; ɪsed for distilling a small quantity of any nce.

ɪes. What is it made of?

or. This is made of baked clay, but *glass* s are very useful in Chemistry: they are ɔmetimes made of *iron.* Fig. 2 is called a :ted retort; from the circumstance of its made with the small neck or tube *x*, ;h which the materials may be introduced the experiment is going on, as in Fig. 3. ubstance to be distilled is put in at *a;* and, istils, it passes over to the receiver B, which d to the retort at *b.*

rles. Distillation cannot, I suppose, be per- d without heat: how is that applied to a :etort?

ɪr. *The* best means is by an Argand's lamp, or any other of a similar construction. Fig. 4 is the representation of what is called a pneumatic apparatus, such a one as is used in the Lectures at the Royal Institution. A M is a large tin vessel neatly japanned, nearly filled with water; *s* is a shelf, so placed as to be about an inch under the water, having several holes bored through it. B is a glass receiver, which may be filled with water, and then placed on the shelf with its open part downwards; the water, you know, will not run out.

James. Certainly: the pressure of the atmosphere on the water, in the vessel A M, will sustain the water in the jar, provided it be not elevated above its surface.*

Tutor. In the retort C is some water; while in its present position, I light the lamp E. What will be the result?

Charles. The water will boil, and be converted into steam, which must pass along C *c*.

Tutor. The end of C *c* is brought under a hole in the shelf over which the jar B stands.

James. Then steam being so much lighter than water, it will ascend through it to the top of B, and force out a part of the water that is in the jar.

Tutor. I withdraw the lamp, and you see the part *a* B of the jar is filled with steam.

Charles. But, as the apparatus cools, the water in the jar ascends again.

* *Scientific* Dialogues, vol. iii.

or. It does: and the jar will, in a short
be as full as it was before. I will take away
etort C *c*, and put in its place B, Fig. 2,
contains a few ounces of black oxyde of
nese, and some sulphuric acid, diluted with
The heat from the lamp will drive off
riform fluid, which chemists call oxygen
t has, you see, displaced all the water of
r B *a*.

es. Will that be absorbed again, as the
was?

or. No: being what is denominated a per-
tly elastic fluid, it will remain as it is, and
r may be slided carefully off from the shelf
plate, or other vessel, containing water
h to cover its edge: and in this state it may
noved to any other place, and may be pre-
l for future experiments.

rles. Are the wires *x*, *y*, *z*, moveable?

or. Yes, they are: and, by means of the
s *v*, *v*, *v*, they may be fastened to any part.
are of different sizes, to sustain smaller and
retorts; if *x* is wanted, then *y* and *z* can
ned round out of the way, so that it may
ught to any distance from the lamp.

es. You said the oxygen gas might be re-
l for experiments: how do you transfer it
he jar to any other vessel?

or. Suppose I wish to fill a common glass
, or tumbler, with the gas in the jar: I first
vith the water in the trough A M, and place
he shelf; then bring the mouth of the jar

under the holes of the shelf; and, by depressing the top of it, the mouth of the jar will be elevated, and the gas escape and rise up through the hole over which the goblet or other glass vessel was placed, and will fill it by displacing the water.

Charles. Are you not liable to lose some of the gas by this operation?

Tutor. When once you have acquired a little dexterity in managing the business, there is little risk to be apprehended; and then, indeed, you will have no need to take the precaution of placing the vessel, to be filled with gas, on the shelf; but, by holding both that and the jar under water, the gas is readily transferred from one vessel to another.

James. How would you get it into a narrow mouth vessel, as a common phial?

Tutor. In that case, a glass funnel, as A, Fig. 5, is useful; the phial must be filled with water, and holding its mouth downwards, still under water, introduce the funnel, and then transfer the gas from the jar, through the funnel into the phial.

Charles. Then it may be corked and carried any where, I suppose?

Tutor. True. Dr. Ingenhouz, who discovered the method of burning iron wire in oxygen gas, used always to carry about with him a phial filled with gas, to amuse his friends with the experiment.

James. I should like to see how that is done.

Tutor. I take a piece of very fine iron wire, twisted into a spiral form, as A C, Fig. 6; one of its extremities, A, is fixed into a cork, adapted to the phial, and to the other extremity is put a small piece of tinder; a morsel of phosphorus would be better; then I light the tinder, and introduce it into the phial already filled with oxygen gas. You will see the iron burns with more brilliancy than you ever saw any other body, however combustible, in common air.

Charles. The sparks that fly off resemble those that fly from a cat and wheel, as we call it, in fire works.

Tutor. They do; and you will find them in the shape of little globules of iron at the bottom of the phial.

James. Is not its nature changed?

Tutor. Yes: it is now an oxyde of iron; that is, iron combined with oxygen.

Charles. This is a beautiful experiment: I should not have supposed that iron would burn.

Tutor. There are few of the metals that may not, by means of Chemistry, be made to burn. Thus, in our experiments on Galvanism, we saw gold and silver leaf burn with as much brilliancy as the iron in this.*

James. What is the tube G for, in Fig. 4?

Tutor. It is intended to receive gases that are to be exploded by means of Galvanism, or the electric spark. It is a strong glass tube, closed

* Scientific Dialogues, vol. vi.

at the upper end, and having a scale marked upon it. Near the closed end are two wires, *o*, *p*, which almost touch. They are cemented into the glass, in such a manner that no air can escape through the holes. The tube is first filled with water, and then the gases are to be introduced in the usual way. The space between the wires *o* and *p* is to be made a part of the electric circuit, by fastening chains connected with a Leyden phial, or battery, to the hooks *o* and *p*: the spark will pass through the space between the wires, and explode the gases. Instruments of this kind are called exploding tubes.

Charles. What are the gases that will inflame by this method?

Tutor. They are the oxygen and hydrogen gases, mixed in certain proportions, as we shall show when we come to treat of the composition of water.

James. Is it necessary to have the pneumatic apparatus made of tin, or iron?

Tutor. No: a common small washing-tub, with a shelf placed in it, will answer the same end; it should be 12 or 14 inches deep, in order to fill the glass receivers conveniently. There are some gases which are absorbed by water; in experiments with these, mercury must be used instead of water.

Charles. Do you fill the trough with quicksilver?

Tutor. The expense of mercury is too great to be used in this manner: a smaller trough is accordingly used, such as in Fig. 7, Plate II, this is usually made of wood, or stone; the cavity B, and groove, are filled with the fluid metal, and so also is the receiving vessel; Fig. 8 is a section of this trough, supposed to be cut through the middle, and from this we learn the method of placing the glass receiver *x* and the retort B.

James. The experiments that require a mercurial apparatus, seem to be done on a smaller scale.

Tutor. They are, to avoid the great expense of the metal. A, Fig. 9, is called a matrass, which may be placed in a sand-bath; B is an alembic, fitted to the head of the matrass. The heated liquid, that flies off in vapour, is condensed in B, and falls into a groove round its inside, and runs from it, by the tube C, into the receiver D.

Charles. What do you mean by a sand-bath?

Tutor. It is a vessel containing a quantity of sand, and so placed over a charcoal fire, or furnace, as to be capable of being raised to any degree of heat. The sand will communicate a more equal and regular heat to glass or earthen vessels, than can be obtained when exposed to the fire itself.

James. What does Fig. 10 represent?

Tutor. A phial, with a bent tube fitted into it: which, by the bend at *x*, will hang on the side of any tub, or other vessel, as Fig. 4, and the bended part, *z*, will come under one of the holes in the shelf. Or the jar B, in Fig. 4, may be brought into such a position to the edge of the shelf, that the part z may be introduced under it. This will supersede the necessity of having the shelf pierced with holes.

CONVERSATION XIII.

Of Oxygen—Oxygen Gas.

HARLES. You have mentioned oxygen gas, what is oxygen itself?

utor. It is one of the most important agents ature; there is scarcely a single process, r natural or artificial, in which oxygen has share; but it is known only in combination other bodies. It is absorbed by some combble bodies, and converts them into acids. hur, for instance, burnt in oxygen gas, forms huric acid; phosphorus, by the same pro- yields phosphoric acid; and charcoal will what is denominated carbonic acid gas, so d from possessing real acid properties, gh in a state of gas.

mes. By what means are these operations ormed?

utor. Let the receiver A R (Fig. 12) be fill- ith oxygen gas; and upon the small stand F piece of phosphorus; if this be inflamed, by ns of a hot iron wire introduced through the ury, or by a burning glass, G, it exhibits as brilliant a combustion as can be imagined; th gas disappears, and a concrete substance is foun on the inner surface of the glass receiver, whic is phosphoric acid.

Charles. Does the phosphorus unite with th oxygen of the gas?

Tutor. It does, and the caloric escapes; fo oxygen gas is composed of oxygen and caloric and, being decomposed, the former unites wi the phosphorus, and the latter escapes.

Oxygen is necessary for combustion; it unite itself always in bodies that burn, increasing thei weight and changing their properties.

James. Does the phosphoric acid weigh mo than the phosphorus did previously to the com bustion?

Tutor. It does, and the rule holds universally When oxygen combines with metallic substan ces, the results are oxydes, which have los their metallic properties, but which are alway heavier than the metals were from which the are formed. The combination of oxygen wit any body, is called *oxygenation.*

Charles. As you cannot get the oxygen b itself, are there any other means of procurin oxygen gas than from the manganese, as yo showed us yesterday?

Tutor. It may be obtained from many substan ces. If I put pure oxygenated muriate of pota into the retort, as in Fig. 4, and apply the hea of the lamp, the salt will melt, and the gas be e l in abundance, and collected in the jar

It may be had also from the red oxyde of mercury and from red lead, in the same manner; and from nitrate of potass; (common nitre;) but from all these it is obtained by a considerable degree of heat.

James. Did Dr. Ingenhouz, who, you say, was in the habit of frequently exhibiting the experiment of the burning of iron, obtain the gas by any of these means?

Tutor. It was summer time when I saw him; and he was able to get as much as he pleased, without any of the apparatus which I have described. Oxygen gas of great purity, may be obtained from the green leaves of plants. Fill a large bell glass, such as A, Fig. 12, with water, and introduce under it some fresh cabbage leaves; (*a*) and let the glass so filled, and inverted also in water, be exposed to the rays of the sun; gas will escape, and ascend to the top of the receiver, from whence it may be transferred to any other vessel.

Charles. Is it necessary to have the direct rays of the sun; will not light do?

Tutor. Though light is a great chemical agent, yet it will not of itself answer any good purpose in this case. The apparatus must be exposed to the direct rays of the sun; and, in proportion to the brilliancy of the day, and the vigour of the plant, you will obtain a greater quantity of gas. In very bright days, about the middle of summer, a considerable portion of oxygen gas may be obtained by this method.

James. Can you show us any other e
ment like the combustion of the iron wire

Tutor. A very fine watch spring may b
in the same manner ; and, if it be first w
and likewise the gas, which is used in the
tion, it will be found that the result, or the
of iron, will weigh nearly as much as the
and the gas together.

Here are some very fine turnings of z
the form of a ball ; this I will hang to a p
wire, and insert a morsel of phosphoru
which, being lighted, I introduce into a
oxygen gas.

Charles. The ball burns with a beautif
flame, surrounded by a whitish one.

Tutor. The zinc unites to the oxygen
gas, while the caloric and light escape ; a
result is an oxyde of zinc.

This bladder is filled with oxygen gas ;
a stop cock, to prevent its escape. On a
piece of ignited charcoal I have thrown
iron filings, which, in the common air,
no particular appearance. But, when I pu
into oxygen gas, or cause a current of t
to pass over them from the bladder, th
burn with great brilliancy. The filings o
copper, or antimony, would have answ
well.

James. Candles would, I suppose, bu
a great degree of brightness in this k
gas.

Tutor. You shall see: here is an

ır filled with it; if I let this lighted taper, which have fixed on a wire for convenience, with ıe wick bent upwards, down into the jar, you ill see with what splendour it burns. If I blow out, and immerse it again, while the snuff is ed hot, it instantly takes fire. If a piece of the ark of charcoal be fastened to the wire and gnited, and then immersed in the gas, it will ırow out extremely brilliant sparks. All combustible bodies whatever burn in oxygen gas ith increased splendour.

Charles. If I understand the subject discussed -day and yesterday, oxygen gas is composed of certain something, never yet seen by itself, ılled oxygen and caloric.

Tutor. It is: and the name *oxygen*, a Greek ırd, denoting the cause of acidity, is given to because it is considered as that cause.

James. Yes: I remember sulphur and phosırus united to oxygen gave acids as results.

Tutor. And, according to the quantity of gen absorbed, the acids are stronger or ker.

ıe other properties of oxygen gas are, that ıot absorbed by water: it is rather heavier common air; and, during every combustion gen gas, the gas suffers a considerable dion.

bodies, by combustion in oxygen gas, acn addition to their weight.

CONVERSATION XIV.

Of Oxygen, and its Compounds.

CHARLES. Are there different degr oxygenation?

Tutor. Yes; chemists reckon four suc grees:—the first degree forms oxydes; t cond forms weak acids; the third, strong and those of the fourth degree are call peroxygenated acids. There are likewis ferent kinds of oxydes, which assume di colours, according to the quantity of oxyg bibed. This I wish you carefully to reme

James. How are these changes express

Tutor. I will give you a short table, v though confined to a few instances, will p in possession of the whole theory for all.

TABLE

OF DIFFERENT DEGREES OF

OXYGENATION.

aloric,	forms oxygen gas.	
ydrogen,	—— water.	
arbon,	—— carbonic acid gas.	
Degrees of Oxygenation.		
ulphur,	1. forms oxyde of sulphur.	
	2. —— sulphurous acid.	
	3. —— sulphuric acid.	
lercury,	1. —— black oxyde	of Mercury.(*a*)
	2. —— yellow oxyde	
	3 —— red oxyde	

arles. What is the oxyde of sulphur?

tor. If sulphur be kept melted, in an open l, it becomes soft like wax, by means of the en, which it imbibes from the air during ı; it is, therefore, a compound of sulphur small portion of oxygen, and is called the of sulphur.

nes. Is sulphur*ous* acid formed by the of a large portion of oxygen with the sul- ?

tor. It is: and sulphur*ic* acid is that which strongest, or that in which there is the st portion of oxygen combined.

arles. Do the terminations *ous* and *ic* de- always the smaller and greater degrees of nation?

Tutor. They do, whenever they are used: thus, we say,

Oxyde of phosphorus,
Phosphor*ous* acid,
Phosphor*ic* acid.

The oxyde is phosphorus changed a little by exposure to the air, at a low temperature.

James. Are not the terminations *ous* and *ic* applicable in all cases?

Tutor. No: for all substances do not admit of similar degrees of oxygenation; thus, we have,

Oxyde of carbon (charcoal)
and
Carbonic acid;

but no carbon*ous* acid.

James. Does carbon then admit of two degrees of oxygenation only?

Tutor. It does. Again, we have

Muriatic acid,
Oxymuriatic acid,
and
Hyperoxymuriatic acid.

In this case, we have no degree so low as an oxyde, nor any which can be denominated muriat*ous*. In some instances, only one degree of oxygenation is admitted, as in the fluoric acid and boracic acid.

Charles. Does the same principle hold with regard to the metals?

Tutor. Yes: the black, the yellow, and the red oxydes, denote the different degrees of oxygenation ; the black being the least, and the red the greatest.

James. Are the colours the same in the oxydes of all metals ?

Tutor. No : in lead we have the gray, the yellow, and the red. In bismuth there are but two, namely, the gray and white oxydes : in cobalt and nickel only one ; but arsenic admits of three degrees of oxygenation, *viz.*

1. Gray oxyde of arsenic,
2. White oxyde of arsenic,
3. Arsenic acid.

Thus you understand that oxygen is capable of combining with a great many substances, precisely as salt, or sugar, will combine with water : its properties are, (1.) that it is absolutely necessary to combustion, and to the existence of animal life, without which, neither the one nor the other can exist a single moment.

James. If so essential, where is the great reservoir to supply all that is wanted ?

Tutor. The air which we breathe contains, in every 100 parts, about 22 of oxygen gas, by means of which combustion and animal life are maintained ; if a mouse, for instance, be confined under a receiver filled with common air, it will live only till it has absorbed all the oxygen from it ; a candle also will burn till the oxygen is exhausted, but no longer.

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In this case, we have no degree so low as an oxyde, nor any which can be denominated muriat*ous*. In some instances, only one degree of oxygenation is admitted, as in the fluoric acid and boracic acid.

Charles. Does the same principle hold with regard to the metals?

Tutor. Yes: the black, the yellow, and the red oxydes, denote the different degrees of

oxygenation; the black being the least, and th
red the greatest.

James. Are the colours the same in th
oxydes of all metals?

Tutor. No: in lead we have the gray, the
yellow, and the red. In bismuth there are but
two, namely, the gray and white oxydes: in co-
balt and nickel only one; but arsenic admits of
three degrees of oxygenation, *viz.*

1. Gray oxyde of arsenic,
2. White oxyde of arsenic,
3. Arsenic acid.

Thus you understand that oxygen is capable of combining with a great many substances, precisely as salt, or sugar, will combine with water: its properties are, (1.) that it is absolutely necessary to combustion, and to the existence of animal life, without which, neither the one nor the other can exist a single moment.

James. If so essential, where is the great reservoir to supply all that is wanted?

Tutor. The air which we breathe contains, in ery 100 parts, about 22 of oxygen gas, by ans of which combustion and animal life are intained; if a mouse, for instance, be confin- under a receiver filled with common air, it live only till it has absorbed all the oxygen it; a candle also will burn till the oxygen xhausted, but no longer.

arles. Is there no fear of exhausting the *sphere itself in* process of time?

or. That might be the case, if there were

no natural means adapted to create new supplies of it; but these seem perfectly adequate to all our wants. As the cabbage-plants under the glass receiver gave out oxygen gas when exposed to the sun's rays, so we may be sure that there is, in every bright day, a perpetual distillation of oxygen gas, from, or by means of the vegetable creation.

Charles. Does this process, which is so important in itself, only go on in the light of the sun?

Tutor. Though the organs of all vegetables pour forth streams of oxygen gas during the presence of the sun's rays, yet it is ascertained, beyond all doubt, that at night they emit a gas of a contrary and very noxious quality.* But to proceed: water is a compound substance, as we shall hereafter show, of oxygen and hydrogen; every decomposition of that fluid, of which there may be numerous instances that we know nothing of, must afford new supplies of oxygen.

* The effect of light on vegetation is well known to every practical gardener. Many flowers follow the course of the sun; and plants that grow in houses, or other confined situations, press towards the light; whereas, plants that grow in the shade, or are suffered to remain in darkness, are pale, and almost colourless. To blanch their lettuces, cabbages, &c. gardeners tie up the leaves, to guard them from the light. The greater the light to which plants are exposed, the brighter the colour which they acquire. Vegetables are not only indebted to the sun's rays for their colour, but for their taste and odour also; hence, the hot climates are the native countries of perfumes, highly flavoured fruits, and aromatic resins.

James. In appearance, this gas does not seem t all different from common air.

Tutor. True ; and this brings us to its other roperties ; (2.) it is colourless and invisible, lastic, and capable of great degrees of expanion and compression.

Charles. You said it was heavier than atmospheric air ?

Tutor. It is, in the proportion of 34 or 35 to 1 ; that is, when a hundred cubic inches of ommon air weigh 31 grains, the same quantity f oxygen gas will weigh 34 or 35 grains.

You will remember, also, that oxygen gas is eculiarly characterized by these two properes :—First, that of supporting animal life by espiration ; and, secondly, that of supporting ombustion.

The nature of combustion will be considered a few days.

CONVERSATION XV.

Of Azote, or Nitrogen.

TUTOR. The next substance I wish you to be acquainted with is azote, or, as it is called by some chemists, nitrogen; because this, like oxygen, enters into the composition of the atmospheric air.

James. Is nitrogen a simple or elementary substance?

Tutor. It has long been suspected to be a compound; and, as the result of numerous experiments, it is supposed to be compounded of oxygen and an unknown base; in the proportion of about 55 of oxygen to 45 of base.

Charles. Is nitrogen, like oxygen, to be known only in combination with other substances?

Tutor. Just so: combined with caloric, it is azotic or nitrogen gas; it is found in combination with all animal and vegetable bodies,(*a*) in nitric acid, and in ammonia. It is incapable of supporting animal life, or combustion.

s. Would an animal die in azotic gas im-
ly ?

r. Yes, a mouse, or a bird, that would
hours in a vessel of oxygen gas, and some
ven in a vessel of common air, will die
ment it is plunged into azotic gas. A
taper will, as you shall see, in similar
tances, be instantly extinguished. But
re of this and oxygen gas produces at-
ric air.

les. In what proportions?

r. About 78 parts of azotic gas, and 22
gen gas, make 100 parts of atmospheric
ese numbers are near the truth, but not
ely accurate, because, besides these gases,
re also in the atmosphere small portions
rogen gas and carbonic acid gas.

s. Is azotic gas heavier than common

r. No, it is somewhat lighter; it is,
er, elastic, and capable of condensation
tation.

les. Can you imitate the common air, by
together the oxygen and azotic gases?

r. Most readily. You have seen with
plendour a taper burnt in the former,
w instantaneously it was extinguished in
ter; now I will mix in this jar, at present
water, three measures of azotic gas and
oxygen gas, and the taper will burn in it
es *in the* air of the room, and a person
eathe in it without any risk.

James. How is azotic gas produced artificially?

Tutor. There are several ways.

(1.) Under this bell-glass (such as A, Fig. 12,) which is full of atmospheric air, and standing in water, I introduce some sulphuret of potass, which, in a few days, will absorb all the oxygen and leave the azotic gas perfectly pure.

Charles. Has the sulphuret of potass a strong attraction for oxygen?

Tutor. It has, and thus it separates it from the atmospheric air: during the experiment, the sulphur, by combining with the oxygen, is converted into sulphuric acid, which unites to the potass, forming with it a sulphate of potass.

(2.) Instead of the sulphuret of potass, equal weights of sulphur and iron filings, made into a paste, will answer the same purpose. The air in the bell-glass will gradually diminish, as the ascent of the water will prove, till only about three fourths remain, which is pure azotic gas.

(3.) Any kind of muscular flesh, cut in small pieces, and put in a retort, with some diluted nitric acid, will, by the application of heat, produce azotic gas, which may be preserved by means of the pneumatic apparatus, Fig. 4.

James. Why do animal substances yield this gas?

Tutor. It is found that they are composed of *azote, carbon,* hydrogen, and oxygen, and, by *the addition of* the nitric acid, the azote is set at *liberty.*—*See vol.* ii.

harles. Do these different substances decom-
: the air in which they are confined ?

utor. They do, by absorbing the oxygen leaving the azotic gas pure.

is found, that the air bladders of the com- carp contain azotic gas: if, therefore, these ders are broken, under inverted glasses d with water, the gas is easily collected in ll quantities.

TABLE

OF DIFFERENT COMBINATIONS OF

AZOTE.

ote bined ith	Caloric		forms azotic gas.
	Oxygen,	1.	—— the base of atmospheric air.
		2.	—— nitrous oxyde.
		3.	—— nitrous gas.
		4.	—— nitric acid.
	Hydrogen . . .		—— ammonia.

ames. I see there are four different combi- ons of azote with oxygen, are these regulated he quantity of oxygen absorbed ?

'utor. They are; in a certain proportion, of 22 parts oxygen gas to 78 of azotic gas, atmospheric air is formed; when more gen enters into combination, we have nitrous de; with a still greater proportion, we get ous gas; and, when more oxygen is absorb- we have the nitric acid.

'he best *method* of distinguishing azotic gas *i other gases,* which resemble it in general operties, is, that it produces no change in the ·getable colours; and when agitated with lime ater, it does not render it milky.

Charles. Has it been ascertained whether nirogen is a compound?

Tutor. From some experiments by Mr. Miers, it would follow, that nitrogen is composed of oxygen and hydrogen with less oxygen than exists in water. But their accuracy has been doubted.

The experiments of Sir Humphrey Davy, on the presumption of nitrogen being an oxyde, have not been attended with success. Hence, says Dr. Henry, the general tenor of these inquiries lends no strength to the opinion that nitrogen is a compound body.

CONVERSATION XVI.

Of Hydrogen.

JTOR. The nex tsubject is *hydrogen*, which, have hinted before, is one of the constituent ciples of water; and on that account it has ame. It possesses so great an affinity for ca-, that it cannot be procured but in a state of oination; and, united to caloric, it forms hy-en gas.

arles. Was not hydrogen gas formerly called nmable air?

tor. It was; and it is one of the most abun- principles in nature; for, besides making t the one sixth or one seventh of all the water exists, it is one of the ingredients of bitu-s, oils, ardent spirits, ether, and, indeed, of e component parts of animal and vegetable es; it is one of the bases of ammonia, as ave seen, (p. 141,) and of various compound s, as we shall see hereafter.

mes. What are the chief properties of hy-en gas?

tor. It is, like the others, invisible and elastic; but it is full twelve times lighter than atmospheric air.

Charles. Its great levity, I believe, renders it proper for balloons.

Tutor. It is used for that purpose; because the lighter fluid always ascends in those that are heavier; and therefore, if the balloon and the gas, which it contains, be lighter than an equal bulk of common air, it will ascend till it arrives at that height where an equal bulk of air shall just equal the weight of the balloon.

Hydrogen gas has a disagreeable smell, and is unfit for the purposes of animal life and combustion.

James. Will it kill any one, like azotic gas?

Tutor. Not so soon, but it would in a few minutes effectually destroy life. It is often found in mines and coal-pits, and, unless means are taken to ventilate them, no one can, without the most imminent risk, venture down.

Charles. Why was it called inflammable air, if it will not support combustion?

Tutor. On account, probably, of its readily taking fire, when it comes in contact with atmospheric air. Fill a small jar, or common phial, with hydrogen gas, and, holding its mouth downwards, bring the gas into contact with the flame of a candle; the air will take fire, and burn silently, with a blueish flame. The ignes fatui are supposed to proceed from inflammable air, *which abounds in* marshy grounds, set on fire by *the electric fluid.*

James. Is it owing to its being united with the tmosphere that it burns?

Tutor. Entirely so; for, if I introduce hydroen gas into this bell, Fig. 12, filled with merury, and place some tinder and phosphorus in ie little saucer F, and then apply to the phoshorus a bent iron wire, heated in the fire, hich may easily be introduced through the iercury, the phosphorus will melt, but without ıy inflammation.

Charles. Why did you make use of mercury ıstead of water in this experiment?

Tutor. Because the iron wire would have been ompletely cooled in passing through water, and endered unfit for igniting the phosphorus.

James. Will hydrogen gas burn in contact ith oxygen gas?

Tutor. It will explode with great violence. ere is a very thick phial; I introduce into it ne part of hydrogen and two of common air; ıd, when they are thoroughly mixed, (which is asily done by agitating them with the little wair that was remaining in the phial,) I will sudenly bring the mouth of the bottle to the candle.

James. It has made a report like a pistol.

Tutor. I will now introduce two parts of hyogen gas and one of oxygen, and then set fire it as before.

Charles. The explosion is much more violent v.

Tutor. *A mixture* of these two gases has been led *detonating air.* If I tie a piece of tobaccopipe to this bladder, which I have filled with hydrogen gas, and with it blow up soap bubbles, they will ascend rapidly to the ceiling; but, if, during their ascent, I apply to them a lighted taper, they will burn without noise. If now the experiment be made with a mixture of the hydrogen and oxygen gases, there will be a strong detonation.

James. Would a bird or mouse die in it?

Tutor. Yes, it would be thrown into convulsions, and in a few seconds expire. Attempts have been made to breathe it; when it was diluted with common air, it was effected without injury; but pure hydrogen gas no one was, probably, ever able to inspire for a minute together.

Charles. How is hydrogen gas obtained?

Tutor. It may be extracted by means of heat, from all bodies of which it is a constituent part; but the purest is that which is gained by a decomposition of water. I take sulphuric acid, diluted with five or six times its weight of water, and pour it upon iron filings in a retort; an effervescence takes place, and the gas, which escapes, is hydrogen gas. By the application of heat to the retort, the gas will be produced more abundantly.(*a*)

Charles. Does that gas proceed from the iron filings?

Tutor. No: it is obtained by the decomposition of water; by means of the metal and the *sulphuric acid;* the water itself, which, as we *shall prove hereafter*, is a combination of oxygen and hydrogen, is decomposed; the oxygen unites with the iron, and the hydrogen gas escapes.

James. What is the cause of the noise which accompanies this kind of experiments?

Tutor. It is owing to the quick motion excited in the mixture by means of the air bubbles suddenly disengaged, and breaking at the surface of the fluid.

James. Is this gas obtained in a state of nature?

Tutor. It may, in hot summer weather, be obtained in considerable quantities from all ponds, and other stagnant waters, by the following method. Fill a wide mouthed bottle with water (a common decanter, with a funnel, will answer the same end,) and keep it inverted in the pond; then stir the mud at the bottom of the water, just under the bottle, so as to permit the bubbles of air which proceed from the mud to enter he bottle. This air will be found to be hydroen gas.(*a*) In hot climates, if the mud at the ottom of the pond be well agitated, and, immeately after, a lighted candle be brought near the rface of the water, the hydrogen gas will take e, and the flame will spread over the whole rface of the water.

alling stars, and other meteors, it is suppose produced from hydrogen gas, inflamed by lectric fluid.

arles. Does the gas obtained in this way ed *from the* water or the mud?

Tutor. It is generally supposed, that hydrogen gas always proceeds from water, in consequence of a decomposition. We know, that water is easily decomposed by heat, if iron be present.

James. How is that?

Tutor. The oxygen of the water combines with iron, at a red heat, so as to convert it into an oxyde, and the caloric unites with hydrogen, and forms hydrogen gas.

Charles. The hydrogen gas, which is produced in nature, being so much lighter than common air, must be continually ascending into the higher regions of the atmosphere.

Tutor. It must; and, in its passage, it may, by means of the electric fluid, combine with the oxygen of the atmosphere, and produce water, which falls in the shape of rain.

I will put iron filings into this jar, Fig. 13, having two tubulures; to one is adjusted a very small glass tube, *z*, and through the other, with a glass funnel, Fig. 5, I pour diluted sulphuric acid, and then put the stopper in. The gas i instantly disengaged, and will escape through *z* to this I apply a lighted taper.

James. It has taken fire, and continues burn with a fine blue flame.

Tutor. It is called the philosophical cand and will burn as long as any gas comes over.

Charles. Has this gas been applied to *useful purpose?*

Tutor. Artificial fireworks may be constr ed by filling bladders with it, and connecting them with jets, tubes, &c. bent in different directions, and formed into various figures, pierced with all sorts of holes. The gas, which is forced through these holes by pressing the bladders, will, when inflamed, exhibit many curious phenomena, without noise or smoke.

James. You have said hydrogen gas has a very unpleasant smell; upon what fact do you state this?

Tutor. This may be known in many different ways, especially wherever there is a sudden decomposition of water. If you suddenly dash some water into a very fierce fire, the water will be decomposed; the oxygen will unite with the coal, and the hydrogen be given out to the great annoyance of by-standers.

Charles. As hydrogen gas is so much lighter than several other gases, it will, I suppose, rise the surface of any other gas with which it may ance to come in contact?

Tutor. This observation leads me to mention ery curious property of hydrogen gas, which possesses in common with all other aeriform ies, *viz.* a tendency to diffuse itself through other elastic fluid with which it may be in act.

u know, that spirit of wine may, if properly duced on a vessel of water, be kept from g, and so of other nonelastic fluids of differpecific gravities. But this is not the case lastic fluids, or gases, which readily penetrate each ; the fact, with respect to hydrogen and oxygen gases, may be proved by a very simple experiment.

Provide two glass ounce phials, and a tube open at both ends, about ten inches long and a twentieth of an inch bore. At each end, the tube is to be passed through a perforated cork adapted to the necks of both bottles. Fill one of them with oxygen gas, and the other with hydrogen gas ; place the former on a table with the mouth upwards, and into this insert the tube secured by its cork. Then, holding the hydrogen phial with its mouth downwards, fit it upon the cork at the top of the tube. The two bottles, thus connected, are to be suffered to remain in this perpendicular position. After standing some hours, it will be found, that the two gases have united, and that hydrogen gas, fourteen times lighter than the oxygen, has descended through the tube from the upper to the lower phial, and the oxygen has equally ascended contrary to its natural gravity, which may be known by bringing a lighted taper to the mouth of each phial, when there will be an explosion in each, which proves there must have been a union of the two gases,

CONVERSATION XVII.

Of Sulphur and its Compounds.

TUTOR. Sulphur is a very important sub-
stance in Chemistry, and it is one of those which
have never yet been decomposed.

James. Then it may be denominated a simple
ody. Is it not the same thing as is commonly
lled brimstone ?

Tutor. It is, as I have before told you; and
attracted the attention of mankind at a very
ly period; it was used by the ancients in me-
ine, and its fumes have, for more than two
usand years, been employed in bleaching
l.

arles. Are there not two kinds, one in
rolls and the other in powder ?

tor. It is known in both these states, but
are rendered so by artificial processes. In
e, sulphur is found in a state of combination
nineral, vegetable, or even animal matters.
ts *in many* mineral waters, but it is found
reatest abundance in volcanic countries.

James. In what state is it obtained?

Tutor. Frequently in a state of great purity, solid or in loose powder, either detached, or in veins of the earth. In some parts of Italy it is deposited as a crust, on stones contiguous to the volcanoes.

Charles. Does sulphur dissolve in water?

Tutor. No: but in oils, and in alcohol, it is soluble; it may be dissolved also in hydrogen gas.

James. Does it not readily combine with the different metals?

Tutor. It does, and in that state it forms what were formerly denominated pyrites, but, according to the modern Chemistry, these are called sulphurets. Thus sulphur united to iron is martial pyrites, or sulphuret of iron.

Charles. Are all the sulphurets combinations of sulphur with different metals?

Tutor. No: sulphur combines with alkalies and earths, as well as with metals, and the compounds are sulphurets. Thus we have sulphurets of soda, of potass, of barytes, &c., as well as metallic sulphurets. When these last are found in a state of nature, the sulphur is extracted by exposing them to the heat of a furnace. The sulphur, when melted, is received in water.

James. How is it formed into rolls?

Tutor. It is again melted, and poured into wooden moulds.

Charles. What do they mean by flowers of sulphur?

Tutor. It is that substance which is used in medicine, and which is formed by sublimation. To obtain this, sulphur is heated to the temperature of 170° Fahrenheit, when it rises up in the form of a fine powder, which may be collected in a proper vessel, or, on a large scale, in close rooms made for the purpose.

James. How do they make the sulphur casts of antique gems?

Tutor. If sulphur be kept melted in an open vessel, it becomes thick and viscid. If, in this state, it is poured into a basin of water, it will be found of a reddish colour, and as soft as wax; and then it is employed in taking off impressions from seals and medals. In this form it is called the oxyde of sulphur.

James. But the casts that I have seen are not soft.

Tutor. By exposure to the air they become hard and brittle again.

When sulphur is heated to the temperature of 560° in the open air, it takes fire spontaneously, and burns with a pale blue flame, and emits a great quantity of fumes. If these fumes be collected, they are found to consist of sulphuric acid, which will be described hereafter.

TABLE

OF THE COMBINATIONS OF SULPHUR.

Sulphur combined with

Oxygen, forms	1. Oxyde of sulphur.	
	2. Sulphurous acid.	
	3. Sulphuric acid.	
Metals, Alkalies, or Earths,	form Sulphurets.	

Charles. Here are three different combinations of oxygen with sulphur.

Tutor. The first is an oxyde, formed with a small portion of oxygen in union with the sulphur. With a larger portion of oxygen we get a weak acid: and, by a combination of the two substances, in which there is the greatest proportion of oxygen, we get a very strong acid, called sulphuric acid.

James. Pray what is *liver of sulphur?*

Tutor. It takes its name from its colour, which is similar to that of brown liver; and it is formed of potass, or soda and sulphur in equal parts: it is now denominated an alkaline sulphuret.

Charles. Is heat necessary in uniting these two substances?

Tutor. The operation must be performed by fire, in a crucible.

James. Sulphur is, I believe, very inflammable.

Tutor. It is; and when set fire to in oxyge
s, it burns with a most beautiful and brilliar
ght;(*a*) during the combustion, it unites with
e oxygen, and forms an incombustible sub-
ance, *viz.* sulphuric acid.

Charles. What is the cause of some bodies
ing so much more combustible than others?

Tutor. It is owing to the great affinity that
ey have for oxygen; of this kind is phosphorus.
ence sulphuric acid, being already saturated
ith oxygen, can have no affinity for it, and is
cordingly incombustible.

James. Of what use is sulphur?

Tutor. It is of great importance in medicine,
it is found capable, in a short time, of impreg-
ting every part of the body; it is used in
aching and in dying, and it makes a very large
portion of gunpowder; one of its most com-
n, but not least useful properties, is that
's combustibility, by which, with the help of
nder-box, light is almost instantaneously pro-
d.

arles. Where is sulphur chiefly found?

tor. Volcanic sulphur is found at Vesu-
Etna, Iceland, and in some of the West-
Islands. But that which has not a volcanic
is met with in Spain, Poland, Switzerland,
, and Italy, as well as in Asia and America.

grains of phosphorus; this I will inflame by means of the burning glass G.

Charles. It burns with great splendour; and, as it burns, the mercury rises higher and higher in the glass.

Tutor. The phosphorus, at a certain temperature, combines with the oxygen and forms phosphoric acid, which covers the inside of the jar with white flakes, and occupies much less space than the gas.

This experiment may be exhibited on a larger scale: A B, Fig. 18, is a glass balloon having a large aperture; and to this is fitted a plate E F, in which are cemented tubes *x* and *y*, with stop cocks *a a*. Before the plate is fixed on, the supporter *z* and the small cup *c* are introduced, and in the latter are some grains of phosphorus. The tube *x* is now to be connected with an air-pump, and the balloon to be exhausted of air as much as possible; then, with the tube *y*, oxygen gas is to be admitted.

James. How will you inflame the phosphorus?

Tutor. By means of a burning glass and the rays of the sun, as before. The combustion will be very rapid, accompanied with a strong degree of heat.

Charles. Are the white flakes about the glass phosphoric acid?

Tutor. They are; and, if the experiment be conducted with accuracy, the weights of the phosphorus and the oxygen gas should be taken, and it will be found that they are precisely equa the weight of the acid obtained.

TABLE

OF THE COMBINATIONS OF PHOSPHORUS.

Phosphorus combined with

Oxygen, forms	1. Oxyde of phosphorus. 2. Phosphorous acid. 3. Phosphoric acid.
Hydrogen, Azote, Carbon, Sulphur, Metals, Earths,	forms Phosphurets.

James. The phosphorus sold in chemists' shops is in long slender rolls ; how is it moulded into that shape ?

Tutor. Phosphorus is easily fused ; and in hat state it is put into small tubes, which give form. With one of these little rolls, I can rite on any plain surface, as the wall of a room, on paper, &c. In the dark, the letters will pear luminous.

Charles. How will you handle it to write h ?

Tutor. That is a proper question, for the mth of the fingers will soon inflame it ; to rent this, I will put a roll of phosphorus in a , or in a pencil case, and then it is easil man I shall, however, always have a basi. er at hand, in case it should take fire by the neat of the atmosphere.

James. I should like to surprise Emma with a sight of some phosphoric writing.

Tutor. Let me urge it upon you never to alarm any one in the night, by such exhibitions, because frights of this kind may be attended with fatal consequences.

Charles. How do you account for the luminous appearance of the writing?

Tutor. It is caused by the great affinity which phosphorus has for oxygen, which renders it combustible at a very moderate temperature. It will inflame also by friction.

Experiment. I will fold a few grains in this piece of brown paper, and then rub it against the table.

James. The paper is soon on fire.

Tutor. A few grains rubbed in a mortar with iron filings take fire immediately.

Charles. How does friction cause the combustion?

Tutor. It raises the temperature of the phosphorus, which then attracts the oxygen from the atmosphere more rapidly, and, at the same time, the light and caloric are set free.

James. I have seen phosphoric bottles, with which a light is easily kindled.

Tutor. These are made sometimes of phos- *rus only,* sometimes with phosphorus and *, and sometimes* with phosphorus and sulhur, in the proportion of eight parts of the former to one of the latter. This last is so inflammable, that a grain or two taken out of the phial with match, and rubbed on a cork, instantly inflames.

CONVERSATION XIX.

Of Carbon.

…OR. The next subject under consi… bon, or the diamond.

I thought carbon had been an… charcoal, but surely charcoal and… nnot mean the same thing?

Tutor. Carbon and charcoal are frequ… used as synonymous terms, but improperl… since, as we shall show, charcoal is a comp… of pure carbon and oxygen; that is, charc… an oxyde of carbon. (*a*)

James. What are we to understand by… bon?

Tutor. It is a simple substance; and, in its… state, is known only in the diamond, and th… fore the definition of the diamond will an… for that of carbon also.

Charles. Is the diamond a combustible… stance?

Tutor. It is; this Sir Isaac Newton co… *tured to be the case,* from its power of re… …s; *and in the* year 1694 it was proved h, by experiments made by some philoso-rs at Florence.

ames. How did they burn it?

'utor. They exposed a small diamond to the t of a large burning glass; it first became dull tarnished, lost part of its weight, and at last vas entirely dissipated, without the smallest duum. Since that, diamonds have been con-ied by the heat of a furnace, and, in the year 1, Macquer, a celebrated chemist, observed diamond swell up and burn with a sensible ie. Many other experiments have tended rove, beyond dispute, that the diamond is ibustible and volatile.

harles. I do not yet see how the diamond carbon are the same.

'utor. M. Lavoisier, in the year 1772, en-voured to ascertain the product of a diamond nt in oxygen gas; and he found, that the quan-of diamond consumed was in exact propor-to the quantity of oxygen gas absorbed.

ames. During the combustion, did the dia-id combine with the oxygen gas?

'utor. It did; and the product was found to arbonic acid gas; and this, as we shall here-r see, is a compound of carbon and oxygen.

harles. The inference then seems to be ir, that the diamond and carbon are the same. how can charcoal be reckoned a compound iamond, or carbon and oxygen?

Tutor. By one set of experiments, 100 parts of carbonic acid gas were found to contain.

17.88 parts of diamond, and
82.12 —— of oxygen.

100.00

By another set of experiments, 100 parts of carbonic acid gas were found to be composed of

28 parts of charcoal,
72 —— of oxygen.

100

If, therefore, we take away the 72 parts of oxygen, which is common in both series of experiments, there will be left 17.88 parts of diamond, and 10.12 parts of oxygen, equal to 28 parts of charcoal. Do you comprehend now the difference between carbon and charcoal?

Charles. Carbon, or diamond, is a simple elementary substance, but charcoal is a compound of carbon and oxygen.(*a*)

Tutor. The diamond is that substance in a state of purity to which chemists now assign the name of carbon; and charcoal, which is a compound of carbon and oxygen, is denominated the oxyde of carbon.

Since 28 parts of charcoal contain
17.88 parts of carbon,
and 10.12 —— of oxygen,

28.00,

you tell me what proportions of these sub- ;ces make up 100 parts of charcoal?
imes. Yes, readily, by two statements in Rule of Three, which will stand thus: as

28 : 17.88 : : 100 : 63.857, &c.
28 : 10.12 : : 100 : 36.142, &c.

hat, in 100 parts of charcoal, there are
63.85 parts of diamond, or pure carbon,
36.15 of oxygen nearly, = 100.

harles. Does carbon unite with other sub- ces besides oxygen?

'*utor.* Yes, with a number of bodies; and compounds so formed are called *carburets.* ıs, a combination of carbon and sulphur is a ›uret of sulphur. Black-lead, also, or, as it ften called, plumbago, is a carburet of iron, posed of nine parts of carbon and one of ı.

harles. Do you mean the black-lead of ch the crucibles are made that bear the heat vell?

utor. Yes: a moderate heat has no effect n it; but, exposed to a very strong heat, in ›pen vessel, it burns all away slowly, except ut one tenth, which is an oxyde of iron.

ames. Is the difficulty of combustion owing he iron?

utor. No, to the carbon, which is supposed ›e nearly pure, and, on that account, it re- es, like the diamond, a very high degree of erature *to produce* any effect upon it.

Charles. In what respect is charcoal, that consumes away to a white powder, with a very moderate degree of heat, like these substances?

Tutor. Well made charcoal, provided all air and moisture be excluded, will endure, without injury, the most violent heat that can be applied.

James. Does it undergo no change by heat?

Tutor. It is rendered harder and more brilliant. This substance is possessed of many curious properties, among which is this, that it is not liable to decay with age.

Charles. Is that the reason why carpenters and others char, or burn, the ends of posts before they fix them in the ground?

Tutor. It is: this property was known to the ancients. It is believed, that planks and other wood properly charred will never be affected with the *dry rot.* Charcoal is used to purify a great variety of substances. Cloths, which have become musty, lose their odour, if newly made charcoal be wrapped up in them. It will take away the taint from meat that is injured by being kept too long, provided it be boiled with it. Reduced to powder, it is thought to be an excellent preservative for the teeth and gums.(*a*)

James. How is charcoal made?

Tutor. A piece of wood put into a crucible, and covered well with sand, and then put into a strong fire some time, will be converted into a black shining substance, without taste or smell; and in that state it is pure charcoal.

harles. The common method of burning rcoal in piles, in the open air, cannot then : it in the pure state.

utor. You are right: but it may be rendered y being reduced to powder, and well washed ı pure water, and then dried, by means of a ng heat, in a close vessel.

ames. I think I have seen the smith put rcoal to his iron in the fire, when he wanted arden it.

utor. Yes, the carbon of it combines with ı, and renders it hard, or, in fact, converts it steel. The diamond does the same, which nother proof that carbon and the diamond ıess the same properties, or are the same g.

arles. Was the experiment ever made with liamond?

tor. Yes: M. Morveau, a celebrated French ıist, enclosed a diamond in a very small ble of pure iron, and exposed it, completely ed up in a common crucible, to a sufficient the diamond disappeared, and the iron nverted into steel. By a nice calculation, ıeen ascertained, that steel contains about tieth of its weight of carbon.

her property of charcoal is, that it ab- oisture, and, when dry, attracts greedily

iment 1. Fill a jar with common air, or of gas, and place it over dry mercury. e a piece of red hot charcoal from the fire, and plunge it in the mercury; and cold, pass it under the glass containing gas out bringing it into contact with the atmos a considerable diminution of the gas wil fected.

Ex. 2. If charcoal thus made to absorb gas, be brought into contact with hydrog water is generated. Charcoal resists the faction of animal substances, and is a ver conductor of heat.

Ex. 3. Charcoal destroys the taste, the and colour of many vegetable substances. mon vinegar, by being boiled on charcoal, dered perfectly limpid. Rum and other spirits lose their flavour and colour by m tion with powdered charcoal. The col litmus, indigo, and other pigments suspen water is destroyed by charcoal.

Ex. 4. Charcoal is a bad conductor of ca hence powdered charcoal may be advantag employed to surround substances required kept cool in a warm atmosphere; and also t fine the caloric of heated bodies.

CONVERSATION XX.

Of Combustion.

OR. Having, in some former Conversa-
ntered so much at large into the subject
, we shall now proceed to consider the
of *combustion*, which is closely connected

es. What do you mean by combustion.?
. Here are a well burnt brick, and a
f wood: what will be the consequence if
em both in the fire?
. The brick will become red hot, but
d will burn away, giving out, at the same
ght and heat.
. The term *combustion* is applied to the
of the wood, but not to the heating of the
Combustion is always attended with a
gement of light and heat.
es. The brick, after it has been made as
ossible, may be taken out of the fire, and
ool and become as it was before, but the
ll be consumed.

Tutor. You are right with regard to the brick: the wood, however, is not *consumed*, but merely decomposed, part of which has gone off in the shape of smoke, part in the form of some particular gas, and part remains, as you know, in the ashes.

James. Then, with regard to this subject, there are two sorts of bodies, those that will burn, and those that will not burn.

Tutor. Yes: these are distinguished as *combustibles* and *incombustibles*; and *combustion* denotes a total change in the nature of combustible bodies, accompanied by caloric and light.

Charles. Is the combustible body, in all cases, decomposed?

Tutor. It is: in the operation of combustion there are, as you will perceive by a moment's reflection, two things to be accounted for: 1, The change which the combustible body undergoes; and, 2, The emission of light and caloric. Now, in conformity with the principle already explained in the Conversations on Affinity, these are effected by the double decomposition.

James. A double decomposition requires that there should be at least two compound substances. The wood, I can easily believe, is one, but where is the other?

Tutor. No body will burn, or, in other words, combustion cannot take place, without the presence of air.

Charles. The air, we know, is a compound of oxygen and azote; and, therefore, we have ıow the two compounds for effecting this doubl lecomposition.

James. But combustion takes place most briliantly in the presence of oxygen only, which is simple body, how is that explained ?

Tutor. In both cases, it is the oxygen gas ony that is employed in combustion ; and, as far s combustion is concerned, this gas is a compound, consisting of a certain *base* and *caloric.*

Charles. There are combustible bodies also, s sulphur, that are simple.

Tutor. Yet these even are considered, in this heory, as composed of a certain *base* and *light.* n combustion, therefore, the base of the oxygen as combines with the base of the combustible, nd forms a new substance : while, at the same me, the caloric of the oxygen gas unites with e light of the combustible, and the compound es off in the shape of fire.

James. Can you illustrate this by a diagram, th any particular body, as you did in the innces of chemical affinity ?

Tutor. Yes : we will take sulphur as an mple ; the double decomposition may be wn in this manner :—

Sulphuric acid.

ulphur. { Base. — Oxygen. } Oxygen gas.
{ Light. — Caloric. }

Fire.

Here the base of the sulphur combines with the oxygen of the gas, forming with it a compound, called sulphuric acid: but the combination of light and caloric gives the compound fire, which escapes.

Charles. This is certainly a very beautiful theory, if it is true: but how is it proved that light exists in the combustible body in a state of combination; may it not proceed from the oxygen gas?

Tutor. The reasons assigned by Dr. Thomson, and others, in defence of this theory, appear to me satisfactory; they are these: 1. The quantity of light, which appears during combustion, depends on the combustible body. *Phosphorus*, as you have seen, emits a vast quantity, *charcoal* a smaller, and *hydrogen* the smallest of the three.

James. Perhaps, during the combustion of phosphorus, a greater quantity of oxygen enters into the combination than in the other cases, which may account for the most light.

Tutor. No, the reverse is the case: the quantity of oxygen, which combines with the combustible body during these processes, is greatest in those instances where the light is smallest. 2. The colour of the light certainly depends, in every instance, upon the combustible that burns, which would scarcely happen unless light were separated from it. 3. Vegetables made to grow in the dark, do not produce combustible substances; *light*, therefore, seems necessary to the very existence of combustible bodies. D you understand now this theory?

Charles. I think I do. Oxygen gas, which i necessary to the process, is composed of oxyge and caloric; and the combustible body consists of some particular substance called the base and light. In every case of combustion, the base of the combustible unites with the oxygen, forming with it a new substance; while the light of the combustible combines with the caloric of the oxygen gas, and goes off in the form of fire.—See the diagram, p. 135.

Tutor. That is just: now we advance another step. Dr. Thomson divides all bodies in nature, as far as combustion is concerned, into three classes, which he denominates *supporters*, *combustibles*, and *incombustibles.*

James. We understand what is meant by the wo latter terms, but how do you define the ther, *supporters?*

Tutor. They are substances that are not, of emselves, capable of undergoing combustion, t are necessary to the process.

Charles. Is oxygen gas a supporter?

Tutor. It is the only simple supporter that is wn; when incombustible bodies are united n oxygen, they also become supporters.

ames. I always thought that oxygen gas was mbustible.

tor. No; it does not itself burn, but assists e combustion of other bodies; and, during process, it combines with the combustible body, and may, by proper methods, be again obtained from it.

Charles. Do you reckon the common air among the supporters of combustion?

Tutor. Yes: the azote is, of itself, neither a supporter nor combustible; but, being united to the oxygen, the compound becomes a supporter. The same thing occurs with regard to the muriatic acid gas; of itself it is incombustible, but, when combined with oxygen, it becomes a supporter of combustion.

James. Then there are some incombustibles, as well as combustibles, that are capable of being combined with oxygen?

Tutor. Yes; the two just mentioned, *viz.* azote and muriatic acid, but no others. These, however, combine in several proportions. This circumstance distinguishes simple incombustibles from the simple combustibles: the former are incapable of burning, for, during their combination with oxygen, there is neither light nor heat given out.

Charles. You said oxygen was the only simple supporter, pray what are the compound supporters?

Tutor. There are six; and these are formed from the union of oxygen with azote and muriatic acid in different proportions.

James. Then oxygen is the principle common to all these substances?

Tutor. Yes: to oxygen they are wholly indebted for the property that makes them support ers. The supporters of combustion are thus arranged:—

- **Supporters of Combustion.**
  - **Simple.**
    - Oxygen gas.
  - **Compound.**
    - Air. / Nitrous oxyde. / Nitric oxyde. / Nitric acid. — Composed of azote and oxygen.
    - Oxymuriatic acid. / Hyperoxymuriatic acid, or Chlorine. — Composed of muriatic acid and oxygen.

Charles. Among the compounds of azote and oxygen, does the *air* contain the least portion of oxygen, and the *nitric acid* the most?

Tutor. Just so: combustibles are divided into three kinds; the simple, the compound, and oxydes. The simple combustibles are hydrogen, sulphur, phosphorus, carbon, and the metals, of which, the first four have been already described.

James. Are the compound combustibles formed of these?

Tutor. They are: and most of them are denominated by terms ending in *uret*, as sulph*urets*, *ph*osph*urets*, carb*urets*, &c.; as the sulphuret, or phosphuret, or carburet of iron, &c. The oxydes are combustible, as being composed of combustible substances, or their compounds, with oxygen

Charles. Are not the compound combustibles very numerous ?

Tutor. Yes, they are : and they constitute the greater part of animal and vegetable substances. • You are not now to be told, that, in every combustion, the oxygen of the supporter always unites with the combustible, and forms a new substance.

James. It does, and a very different one too.

Tutor. The general term for these substances is that of *product.* Every product is always either *water*, an *acid*, or a *metallic oxyde.*(*a*) Can you, from what you know and have seen, give me an instance of each of these combinations ?

Charles. Yes : water is a *product* formed from the combustion of hydrogen and oxygen ; sulphuric acid is a *product* obtained from the combustion of sulphur in oxygen gas ; and the oxyde of iron, we saw, was a *product* resulting from the combustion of iron wire in oxygen gas.

James. I have only one difficulty on the subject ; you have treated some substances as compounds to-day, which you described, a few days ago, as simple bodies, such as sulphur.

Tutor. Simple substances denote, in Chemistry, those bodies that cannot be decompounded, in opposition to others that may. A sulphuret of iron may be decomposed, and the iron and the sulphur separated ; but sulphur cannot be decomposed so as to get the base by itself ; if it *gives out light*, it combines, at the same time, *with oxygen,* forming thereby an oxyde, or an cid. Therefore sulphur may be considered as simple substance, (although, if the modern theo-y of combustion be true, it is compounded of a ase and *light*,) because the base cannot be ob-ained by itself.

The following facts I recommend you to com-nit to your memory as axioms :

1. Combustion cannot take place without the resence of oxygen.

2. In every combustion there is an absorption f oxygen.(*a*)

3. In the products of combustion there is al-ays an augmentation of weight, equal to the uantity of oxygen absorbed.

4. In every instance of combustion, light and eat are disengaged.

CONVERSATION XXI.

Of Carbonic Acid Gas.

TUTOR. We now proceed to carbonic a
gas, which is diffused abundantly in nature. I
found in a state of gas, and also in combinat
with a great variety of bodies.

Charles. What are its chief properties?

Tutor. It will not support combustion nor a
mal life.

James. Will it extinguish flame?

Tutor. Yes, instantly; and it would be f
to any large animal that should be plunged int

Charles. Why do you limit the operatior
large animals?

Tutor. Because there are insects, for
stance, that seem to require, for the continua
of their existence, but very small portions of

James. Where is this gas found?

Tutor. In the lower parts of mines, caver
tombs, &c.; and, on account of its suffocat
and destructive property, it was called the cho
damp. There is a cavern near Naples, *viz.*
Del Cane, that has long been famous for the

ction of large quantities of this gas. A dog iven into this cavern would immediately die.

James. Would it not kill a human being also?

Tutor. Not if he stood upright: because, s gas being heavier than common air, in the oportion of 1½ to 1, it falls to the bottom, and erefore the upper part of the cavern is, in genal, quite free from the gas, while the lower rt is completely full of it; of course, if a dog d man go into the place, to the former it will destruction, but the latter will experience no d effects from it.

Charles. I suppose this gas, like the others, y easily be transferred from one vessel to other?

Tutor. Yes, and even in a much readier man-r: owing to its great weight, it may actually poured out of any vessel like water. Here jar containing some carbonic acid gas: if I it up, the gas will flow out precisely in the way, though perhaps not quite so fast, as if re filled with water.

mes. How can I know that? it appears to npty.

or. I told you this gas will extinguish I will therefore pour what is in this aply empty bottle upon a lighted candle.

les. It has extinguished it. This proves gas must be heavier than common air, it descends like any other body, that is lly heavier than air.

James. How did you procure the gas th was in the jar ?

Tutor. Besides being found in a natural state it may be obtained from a great variety of sub stances, as from marble, chalk, lime-stone, &c. that with which you saw me make the experi ment was got from marble.

James. By what means ?

Tutor. I put some pounded marble into a r tort, and then poured on it sulphuric acid, (luted with about six times its weight of wate an effervescence immediately took place and t gas was disengaged, which I collected by mea of the pneumatic apparatus.

Charles. Of what does marble consist ?

Tutor. Of lime and carbonic acid gas ; i formed of these ingredients, and, by presenti to it sulphuric acid, for which lime has a strong affinity than for carbonic acid, it unites with t sulphuric acid and lets the carbonic acid gas cape.

James. What do you call that substance nc which consists of the sulphuric acid and lime

Tutor. It is called sulphate of lime.

Charles. What do you mean by *sulphate ?*

Tutor. It is a term introduced into Chem try to denote a substance called a neutral s that is formed by the sulphuric acid with cert bases ; thus, sulphate of soda is a combination soda and the sulphuric acid ; this is also cal *Glauber's salts.* Sulphate of potass, called a

:d tartar, is produced by the combination
ıric acid and potass.

. As marble consists of lime and car-
id gas, and as you obtain the latter by
ıg sulphuric acid to the lime, how would
:eed if you wanted the lime by itself?

. It is obtained by great heat, which
ımpose the marble and drive off the gas.

:s. Is this the way it is got in the com-
:-kilns?

. It is: but, in general, chalk, or lime-
used instead of marble. The best lime
'hich is the most free from the carbonic
This gas is formed also during fer-
n; and, on account of its great weight,
ies the empty space of the vessel in
ıe fermenting process is going on.

. If I bring a lighted wax taper close to
ıce of a large brewing tun, while the beer
nting, will the flame be extinguished?

. It will, and the smoke remaining in
rill then render its surface visible, which,
:ing, may be thrown in waves.

:s. Is this gas used for any practical
ı?

. It is found to be a slight acid, with
ater may be impregnated; it may then
ı internally, and it is found very benefi-
any medical cases. Thus you find, that
: thing, which is fatal to life in a state of
r be of great advantage to the constitu-
n combined with water, or other liquids.

It is the same with plants; in a state of gas it is highly injurious, but applied to them, when combined with water, it proves highly nutritive.

Charles. How is this explained?

Tutor. Where there is water, the carbonic acid gas is probably decomposed; the carbon unites with the vegetable or animal substance, becoming a component part of it, while the oxygen is disengaged.

James. With what other liquids is this gas found in union?

Tutor In bottled beer, cider, and many wines it is found in abundance: in these it has been usual to denominate it fixed air, but it is, in truth, the carbonic acid gas that gives them that brisk taste which renders them so pleasant.

Experiment 1. Here are three glass tubes, each about nine inches long, and an inch and a half in diameter; the first is filled with the common air of the room, the second contains carbonic acid gas, and the third oxygen gas.

Charles. To appearance they are all the same.

Tutor. This lighted taper will show the difference; in the first it burns as usual; I will put it in the second, and it is instantly extinguished, but the wick remains red hot; in this state, I thrust it quickly into the oxygen gas, by which it is kindled again, and it burns with great splendour.

James. This indeed proves, in a very striking manner, how much fitter oxygen gas is for the purposes of combustion than common air, and how speedily carbonic acid gas extinguishes light.

Tutor. By this property of carbonic acid gas, it may be ascertained whether wells, or mines, or vaults may be entered with safety. Where a candle will not burn, animal life cannot long exist.

Ex. 2. I will fill this jar with carbonic acid gas, and let it stand a few hours; you will then see, that the water has absorbed the greater part or the whole of the gas. Water may, indeed, by pressure, be made to absorb nearly three times its own bulk of gas. In this state the water will exhibit acid properties.

Charles. What are those?

Tutor. A piece of blue paper stained with litmus, being dipped into the water, will be changed to red.

Ex. 3. This decanter contains lime-water, that is, a solution of lime in water; you see it is perfectly transparent. I will introduce into it a stream of carbonic acid gas.

James. It has already a milky appearance; its transparency is entirely lost.

Tutor. The acid of the gas has an affinity for and combines with the lime, forming with it a carbonate of lime, which in time will be precipitated to the bottom of the bottle. A similar effect will be produced with the solutions of barytes, or *strontian*.

This acid is capable of combining with the earths, alkalies, and metals, and forming with them carbonates.

Charles. What effect does it produce on them by this combination?

Tutor. It renders some of the most acrid and destructive substances in nature perfectly mild, and even salutary. Pure quick-lime will burn every thing which it touches; but, saturated with carbonic acid gas, it is calcareous earth, or chalk. Soda and potass are very corrosive substances, but, combined with carbonic acid, they become substances highly prized in pharmacy and for domestic uses.

James. How do you procure carbonic acid gas for experiments?

Tutor. Into a common gas bottle, as represented in Fig. 10, put some powdered or grossly bruised marble; and pour on it sulphuric acid, diluted with five or six times its weight of water. The gas will be produced, which should be received over mercury, unless it is to be used immediately, when it may be collected over water.

The following properties of carbonic acid gas will be worth your committing to your memory:

1. It extinguishes flame and is fatal to animals.
2. It is much heavier than common air.
3. It is absorbed by water, and water, impregnated with it, may be freed from the gas *by boiling,* or by means of the air-pump, or by *-ing.*

4. Carbonic acid gas, when combined with water, reddens vegetable blue colours.

5. Carbonic acid gas precipitates lime combined with water; of course it is an excellent test to discover the presence of lime whenever it is suspected.

6. Carbonic acid gas is generated in several cases of combustion, and in the respiration of animals.

7. Carbonic acid gas retards the putrefaction of animal substances, and it exerts powerful effects on living vegetables.(*a*)

CONVERSATION XXII.

Of Atmospheric Air—Nitrous Gas—Eudiometers.

TUTOR. Having described the principal kinds of gases which come under the consideration of chemists, I shall proceed to a chemical examination of the common atmospheric air. This is found chiefly to consist of a combination of oxygen and azotic gases.

James. Was it not formerly considered as an elementary substance?

Tutor. Yes, it was: but the discoveries made in Chemistry have overturned that opinion, and many others, which were for several centuries regarded as sacred.

Charles. Is it known what the proportions are which go to the formation of the atmosphere?

Tutor. From the most accurate experiments it appears, that in 100 parts of atmospheric air, there are 22 of oxygen gas, and 78 of azotic gas. These probably exist in a state of chemical union.

imes. Is there not always some moisture air?

utor. Water undoubtedly always exists i atmosphere, and so does carbonic acid gas frequently hydrogen gas; but these proba exist only by mechanical mixture, and not hemical union.

iarles. I do not comprehend how you can rate these several parts from one another.

utor. You know, that carbonic acid gas has eat attraction for lime; here is some lime-r, that is, a solution of lime in water.

imes. It is as clear as water; I should have ght it had been nothing else.

utor. Your sense of taste or of smell would undeceive you; I take a glass full of it, and it in the room a few hours, and I shall find ered with a crust, or little whitish skin, is the lime in the water, combined with rbonic acid gas that was in the air.

rles. Then the lime has a stronger affini-he carbonic acid than for the water.

r. It has, and therefore it leaves the o unite with the carbon; and that sub-as we have already seen, would be called te of lime.

. By placing any quantity of air over er, will the lime imbibe all the carbonic from the air?

It will completely, if the lime-water cient *quantities*, and the water and air l *together*, so that the lime may have access to every part of the air; thus you see how the carbonic acid gas is separated from the rest.

Charles. Can you as readily get rid of the oxygen?

Tutor. Yes: by inflaming sulphur or phosphorus in a portion of the atmospheric air, these substances have so great an attraction for the oxygen, that they will combine with and form an acid, and leave the remainder of the air pure azotic gas.

James. Is there much carbonic acid gas in the atmosphere?

Tutor. There is rarely more than the one hundredth part of the whole, and frequently not even so much as that; but the atmosphere is seldom without it; even on the tops of the highest mountains it is found to exist in very small quantities.

Charles. May we then infer, that the common air, which we breathe, consists of oxygen gas, azotic gas, and carbonic acid gas?

Tutor. Yes: as, however, there is but a very small proportion of the latter, chemists, in speaking of the atmosphere, generally calculate upon the oxygen and azotic gases only; and of these, in every 100 parts of common air there are, as we have said, about 22 of oxygen gas, and 78 of azotic gas.

James. Does not the proportion vary under different circumstances?

Tutor. Yes, they do: and, as the salubrity

the air that we breathe depends on the quan-
y of oxygen gas contained in it,(*a*) various
ethods have been invented to ascertain the
irity of the atmosphere.

Charles. Are there any instruments for this
irpose ?

Tutor. There are ; they are called *Eudiome-
rs*, on account of their being employed to mea-
ire the purity of a given portion of air : this
ads us to exhibit another kind of gas, called ni-
ous gas.

James. How is that obtained ?

Tutor. It may be collected in the pneumatic
paratus (Fig. 4.) I put a few pieces of copper
a small retort c, and on them I pour some
uted nitric acid ; and in a short time the ni-
us gas is produced.

Charles. What are the properties of this gas ?

Tutor. Like the others it is colourless ; it
no sensible taste, is neither acid nor alkaline ;
nnot be respired ; many combustible bodies
ot burn in it ; but the combustion of others
be supported by it, as phosphorus, when
luced in a state of inflammation, and many
e pyrophori take fire in it spontaneously.
ts most important property is the greedy
tion that it has for the oxygen gas in atmos-
air ; on this principle eudiometers are
l.

es. As the nitrous gas attracts the oxy-
to *itself, does* it actually diminish the
be air from which the oxygen gas is taken?

Tutor. It does; and, therefore, in proportion to this diminution is the salubrity of the air estimated. In this tube, A B (Fig. 14,) I have introduced a certain quantity of the air in the room, which occupies the space A *a*; I will now throw up an equal quantity of nitrous gas, and observe what happens.

James. A red smoke, or vapour, is produced.

Charles. And the two airs together do not occupy so large a space as they occupied separately; the water is now at *b*, though the air at first kept it down to *a*, and therefore the quantity of that, in addition to the nitrous gas, should have sunk the water to x.

Tutor. The red vapours are caused by the union of the nitrous gas with the oxygen gas.

James. Does the nitrous gas decompose the atmospheric air?

Tutor. Yes: it takes the oxygen gas from the azotic, and with it forms nitrous acid; but, as the experiment is made over water, the acid is absorbed by the water.

Charles. Is the remaining gas in the tube azotic gas only?

Tutor. It is: the experiment will be more striking, if, instead of atmospheric air, I make use of pure oxygen, for then I may throw up three measures of nitrous gas without sensibly increasing the bulk of the gas first in the tube.

James. I felt the tube very warm while the *red vapour* was produced.

Tutor. By decomposing the atmospheric air, e caloric escaped, which before was employed, a latent state, in holding the gases in solution.

Charles. Is there any other method of exhibiting the comparative purity of different gases ?

Tutor. Yes, several : take two tubes, each few inches long, such as that in Fig. 14. Fill e one with atmospherical air, the other with ygen gas ; invert them in separate cups of a lution of sulphuret of potass. The sulphuret ill gradually ascend in the tube containing comon air, till only about four fifths of the original ill remain.

James. Will it ascend higher in the other ?

Tutor. Yes : if the oxygen gas be very pure, will absorb nearly the whole.

Charles. Has the sulphuret of potass the property of imbibing oxygen ?

Tutor. It has, and therefore it acts only on e atmospheric air as long as any oxygen is comined with it ; of course, it is a good substance ascertain the comparative purity of different inds of air.

James. May not other substances, that aborb oxygen, be applied to the same purpose ?

Tutor. Certainly : phosphorus, for instance, hen exposed to the air, absorbs all the oxygen, nd is converted into phosphorous acid ; this ibstance has been applied as a eudiometer, by xposing to its action a portion of air : and, when e absorption of air has ceased, the remainder measured.

James. Does the diminution in
quantity of oxygen gas which it conta

Tutor. It does. Sir Humphrey
posed, as a good eudiometer, a saturat
of green sulphate of muriate of iron,
ed with nitrous gas.

Charles. How is it used?

Tutor. A small glass tube gradu
with the air to be examined, is to
into the nitrous solution, and agitate
The oxygen is absorbed in a few m
the diminution shows the degree of pu
air to be examined.

Another eudiometer consists of a s
z, Fig. 25; into the neck of which is
fitted a small tube, *a b*, which contain
a cubic inch, and is divided into 100 e
The liquid used with this instrument
boiling a mixture of quick-lime and
water, and filtering the solution.

James. In what way is this instrum

Tutor. The bottle is filled with
and the tube, containing the air to be
is next put in its place: by inverting
ment the air ascends, and is brought i
with the liquid.

Charles. Is the oxygen of it absorl

Tutor. It is, so that the whole oc
space than it did before; I therefo
ply the vacuum, open the stopper a
water, and the water rushes in; the
again renewed, another absorption t

proceed, till there is no farther diminu-
ıe amount of which is measured by the
the tube.

:. Is there foünd to be any great varia-
ith regard to the general purity of the
ere in different places ?

. No :(*a*) the air in Egypt, in France,
›urgh, and some sent from the coast of
has been examined with the greatest
/, and it is found that the proportions of
'edients are always the same, or very
o, *viz.* 22 parts of oxygen gas to 78 of
as, that is, in bulk ; for in weight there
very 100 parts, 26 of oxygen gas to 74
gas.

:s. Since oxygen goes to the support of
and is abstracted from the atmosphere,
think that, instead of the proportions
ıg always the same, they must be per-
fluctuating.

. The breathing of animals, combus-
a thousand other operations, are con-
bstracting the oxygen from the atmos-
nd decomposing it ; but azotic gas, be-
:r than either oxygen gas or the atmos-
air, ascends after the decomposition, and
bly, in the upper regions, by some un-
rocess, reconverted into atmospherical

CONVERSATION XXIII.

'arbonated or Carburetted Hydrogen Gas; of hosphorated Hydrogen Gas; of the Gaseous xyde of Azote.

UTOR. We shall now proceed to enume- some other of the gases, which, though of consequence in Chemistry, require to be ced; the first of these is *light carbonated* or *uretted hydrogen gas.*

imes. Is this a modification only of hydrogen ?

'utor. It is: but its specific gravity is much ter than that of hydrogen gas; it burns with eper and denser coloured flame.

harles. How is it obtained?

'utor. From marshes and ditches, on the sur- of stagnant and putrid waters, and in almost ry situation in which putrid animal and ve- *ble matters* are accumulated. It is also pro- *l by the* decomposition of wood.

James. Do you mean by burning?

Tutor. Yes: the flame of burning wood is the inflamed carbonated hydrogen gas, set free by the application of heat to these bodies.

Charles. Is it not very like hydrogen gas?

Tutor. It is: it may be obtained in the same way, and may be burned as that is burned also.

When common pit-coal is distilled in close vessels, a vast quantity of inflammable air is evolved, which burns with a fine yellowish white flame, and yields the most brilliant light, approaching to the light of a candle burning in oxygen gas.—For a more particular account of this light, now known by the name of gas lights, see Appendix to vol. ii.

James. Why is it called *light*, since it is of a greater specific gravity than hydrogen gas.

Tutor. In opposition to another gas, called the *heavy carbonated hydrogen gas*, which is obtained artificially, and contains a larger quantity of carbon in solution than the former.

Charles. Are there any other combinations of hydrogen gas?

Tutor. Yes; there is the sulphuretted hydrogen gas, and the phosphuretted hydrogen gas: the former is hydrogen gas combined with sulphur, and the latter is the same gas combined with phosphorus.

Charles. Are these easily obtained?

Tutor. The sulphuretted gas may be obtained by *melting together*, in a crucible, equal parts of *iron filings* and sulphur; the mass is then to be reduced to a powder, and introduced into the vessel z (Fig. 16) with two mouths, D and C, one of which has a stopper, A, and the other the bent tube, B, accurately ground to fit the mouths C and D. When the powder has been put into the phial, the bent tube is to be placed in D, and the other end introduced through the trough of water into the jar F.

James. Will the gas fly off without any additional heat?(a)

Tutor. Yes, it will. It was formerly called *hepatic gas*; it is unfit for respiration and combustion, but when inflamed in contact with atmospheric air, or hydrogen gas, it burns with a reddish blue flame, and deposits sulphur. It has also another curious property belonging to it, by which the hands, if plunged into it, will continue luminous for some minutes after they are withdrawn.

Charles. Is the phosphorated hydrogen gas of the same nature?

Tutor. This is the most combustible substance in nature; it takes fire immediately upon contact with the atmospheric air; and, when mixed with oxygen gas, or with oxygenated muriatic gas, it burns with great violence.—When bubbles of it are suffered to pass through water, they take fire in succession, as they reach the surface of the fluid.

James. This must be a curious kind of gas; pray how is it obtained?

tor. There is some risk attending the pro- and therefore you should not make the ex- ient without proper assistance. In a small t, put one part of phosphorus and ten of ntrated solution of potass: make the mix- boil, and the gas may be received over mer- as in Fig. 8, or over water, as in Fig. 4.

rles. Is it the phosphorus that burns so intly?

'or. In this process there is a decomposi- f the water; the oxygen of which unites to f the phosphorus, forming phosphoric acid, i unites to the potass, and forms phosphate tass. The hydrogen of the water dissolves er part of the phosphorus, and is converted he phosphuretted hydrogen gas.

nes. Is any of this gas formed in nature?

'or. The air, which burns at the surface rtain springs, and the ignis fatuus, com- called the Jack-a-Lantern, consist of this huretted hydrogen gas.(*a*)

ien three measures of sulphuric acid and f alcohol are mixed together in a retort ixture becomes very hot, assumes a brown ick colour, and becomes of a thick con- ce: when made to boil by the heat of a gas in large quantities is disengaged, which een denominated *olefiant* gas. When this mixed with oxygen gas, and burnt in close ls, by means of electricity, it detonates, ie *products* of this combustion are water *rbonic acid*; hence, the component parts

Charles. Are there no other gases besides these?

Tutor. Yes, there are many other gases, which will be described in our future conversations, as connected with particular objects; thus, muriatic acid gas will be described when we come to speak of the muriatic acid; and so of the rest.

CONVERSATION XIV.

Of the Decomposition of Water.

JAMES. You told us, a few days since, that :er was composed of hydrogen and oxygen ; you show us how it is done by actual experi- nt ?

tutor. Till within these last forty years, wa- was esteemed an elementary principle, and one of the most interesting facts in the new nistry, to be able first to decompose water, then, secondly, to form it anew from its iples, the hydrogen and oxygen gases.

rles. It does seem strange, that such a nce as water should be compounded of two of air only.

r. I will first show you how it is decom- here is a glass tube, A B, Fig. 19, about in diameter, which I place across the fur- with a very small inclination from A to he extremity A, I lute on a glass retort, ning a certain quantity of distilled water ; e other is to be luted the worm W, the *of which* leads to the bottle Z, having two openings; one connected with the worm, and in the other opening is fixed a bent tube, *a*, intended to carry off any elastic fluids that may escape into the bottle. Two fires are now to be lighted; the one in the furnace X sufficient to keep the glass tube red hot, and the other in the smaller furnace or crucible F, to keep the water in the retort boiling.

Charles. Then the water will pass in the form of steam, from the retort through the glass tube into the worm, where it will be again condensed, and flow out into the bottle *z*, as water.

James. This is simple distillation; but it was distilled water made use of.

Tutor. And, if the experiment be done carefully, the same quantity of water will be found in Z, as was put into R; so that, in this operation, it is proved, that mere heat effects no change on the water.

I will now repeat the experiment as before; but first I will put some grains of charcoal in the tube A B, through which the steam must pass in its way to the worm. When the water is completely carried off from R, the charcoal in the tube will be found to have disappeared.

Charles. Has the steam driven it into the worm?

Tutor. It will be found to have vanished entirely during the operation, and a considerable quantity of gas has escaped through the tube *a*. Let us now weigh the water in Z. There is not so much in this as was put into the retort R.

ı. Then there is a loss, in this experi-
ıf water, and the charcoal also, which
t differ from the last.

'es. But some gas has been obtained in its

•. Upon examination it will be found, that ds of gas have escaped, and that these are ılt of new combinations made with the nd charcoal, that have disappeared; one : gases is carbonic acid gas, formed from rcoal and the oxygen of the water; and ɛr is a very light kind of gas, of a differ- ıre, and, as will be shown, is pure hydro-

•

s. How much charcoal was used?

•. Twenty-eight grains; and the quanti- ater lost was 85.7 grains.

les. If the gas had been collected, would been equal to the weight of these two ces?

r. It would: in figures the experiment nd thus:—

	Grs.	
al,	=28	
lost,	=85.7=	{ 72 oxygen gas, and 13.7 hydrogen gas.
	113.7	

144 cubical inches of carbonic acid gas collected	Gr. =100
380 inches of light gas, capable of combustion	=13.7
	113.7

A hundred grains of carbonic acid gas, therefore, consist of 28 grains of charcoal, and of 72 grains of oxygen gas, which it derived from the 85.7 grains of water.

James. I see also, that the 85.7 grains of water consist of 72 grains of oxygen gas, and 13.7 grains of that lighter gas capable of being burnt; because, as there is nothing lost in the experiment, the whole may thus be accounted for: a quantity of gas is obtained, which is exactly equal in weight to the charcoal and water that disappeared.

Tutor. I will repeat the experiment exactly as before; but, instead of charcoal, let us make use of some very thin shavings of iron, rolled up in the spiral form. Here is now a quantity of gas, which I have collected.

Charles. Is the iron dissipated, as the charcoal was?

Tutor. So far from it, that it has increased in weight; but then there is water lost; the quantity found in the bottle Z weighs 100 grains less than that, which was put into the retort R.

James. Has the iron gained these 100 grains?

Tutor. Not entirely: it has gained 85 grains, and the gas collected weighs 15 grains.

Charles. The iron is a good deal changed since it was put into the tube. It is very like what was burnt in oxygen gas.

Tutor. It is, indeed, a true oxyde of iron; that is, iron combined with the oxygen of the water; and the gas collected is hydrogen gas.

James. Does it follow then, that 100 parts of water are composed of 85 parts of oxygen gas and 15 of hydrogen gas?

Tutor. Certainly; for the increased weight of the iron, which is wholly owing to the oxygen, and the gas collected, are equal to the weight of the water lost.

These experiments, which were first made by M. Lavoisier with the greatest accuracy, and which have been repeated by many other chemists, prove, that water is composed of oxygen and hydrogen. When we next meet, I will show you how he produced water by the reunion of these two substances.

CONVERSATION XXV.

Of the Composition of Water.

TUTOR. M. Lavoisier was not satisfied with the analysis of water only, to prove that it was composed of the two gases referred to yesterday; he inferred, that, if water be a compound of hydrogen and oxygen, in the proportions of 15 and 85, it ought to follow, that, by reuniting them in the same proportions, the result would be water.

James. The difficulty would be in bringing them into a state of combination; if mixing them together in the same vessel would answer, that might easily be done.

Tutor. They are both combustible substances, and therefore he had only to bring them together and inflame them, by means of the electric spark.

Charles. How was it effected ?

Tutor. He took a large glass vessel, such as A (Fig. 20), which held three or four gallons. Round the mouth he cemented the plate of copper B C, having above it a cylinder of the metal pierced with holes, to receive three tubes, each of which, as you see, is furnished with a stop cock. By means of the tube H *h*, the air is exhausted from the vessel A.

James. Is the extremity *h* made to fit into an air-pump ?

Tutor. It is ; and, by that means, the air is easily exhausted from the glass vessel, previously to the admission of the proposed gases. The tube Z communicates, by M, with a reservoir of oxygen gas ; and the tube Y, with an exceedingly small aperture, communicates, by N, with another reservoir of hydrogen gas. There is also a glass tube inserted, and cemented in the plate B C, through which a metal wire G L, passes, having at its extremity L, a little ball ; from this to the extremity X the electric spark is to pass to inflame the hydrogen gas.

Things being thus prepared, and the glass vessel A exhausted of common air, it is filled with oxygen gas, by opening the stop cock *a*. The hydrogen gas is to be pressed in, and, as it enters, it is set fire to by the electric spark. The combustion can in this way be kept on as long as we please, by supplying a fresh quantity of the two gases ; and, as the experiment goes on, a quantity of water is collected on the sides of the vessel A, and trickles down in drops to the bottom.

Charles. Does not the inflammation of hydrogen and oxygen gases produce a very violent explosion ?

Tutor. When mixed together in certain proportions, and in an open vessel, they do; but here the hydrogen is introduced very gradually, and is inflamed immediately, at the very extremity of the tube; so that it burns in a similar manner to the combustion of hydrogen gas when in contact only with the atmosphere.—See experiment, p. 145.

James. Then the experiment may be conducted without any danger?

Tutor. It may. Dr. Thompson thus describes the fact:—If the explosion be made in a close vessel, there is found, provided the gas be pure, a quantity of water, exactly equal in weight to the quantity of the gases consumed.

Charles. The conclusion then is, that the water thus obtained must be composed of these gases; for it clearly did not exist in the vessel; and it is equally evident that nothing but the gases were introduced to it.

Tutor. Are you satisfied, from the experiments of to-day, and those of yesterday, that water is composed of oxygen and hydrogen?

James. There seems no reason to doubt it.

Tutor. Remember also, that the combustion of hydrogen is nothing but the act of its combination with oxygen, and that water is formed as a result; if two parts in bulk of hydrogen gas are mixed with six of common air the mixture explodes, and, after the explosion, the mixture is reduced from 8 parts to 5. The whole of the *hydrogen gas is* consumed, and also the oxyge-

ous part of the common air, and a quantity of wa-
er is formed equal in weight to these bodies.

Charles. In this experiment, then, the diminu-
on will be in proportion to the purity of the
ises employed ?

Tutor. It will ; and, as we have seen that
e atmospherical air is in almost all cases the
me, the experiment now under consideration
fords a test of the purity of hydrogen gas. If the
r parts of common air, and the two of hydro-
n gas, be reduced by inflammation to five, the
drogen is considered as pure ; but if only to
r, it must contain some foreign matter.

James. Pray why are the tubes *z* and *y* (Fig.
) enlarged about the parts N and M ?

Tutor. It is necessary that the gases used
ould not only be very pure, but they must be
veyed also to the glass vessel in a very dry
e ; and, therefore, in the swelled parts of the
s there are placed some salts capable of at-
ing or imbibing moisture, such as acetate of
s, muriate of lime, &c.

arles. Do the gases, by passing over these
leave their moisture behind them ?

or. The salts are only coarsely pounded,
t the gases pass freely between the frag-
and are thus freed from every particle of
re. I will now give you, in figures, the
of the grand experiment made on this sub-

CONVERSATION XXVI.

Of the Alkalies—Potass, Soda, and Ammonia.

TUTOR. There are three alkalies, two of which are denominated fixed alkalies, and the other is called volatile alkali.

James. What is meant by the word alkali?

Tutor. It was originally applied to a substance obtained from the plant *kali*, which, being burnt, the ashes are to be washed in water, and, if the water be then evaporated to dryness, a white salt-like substance remains; this is called alkali.

Charles. Is it obtained from nothing else?

Tutor. Yes: by burning any kind of green wood or seaweeds, alkali may be hád; but the alkalies differ in some of their properties, according to the substance from which they are procured.

James. What are the properties belonging to all the alkalies?

Tutor. 1. They change vegetable blue colours to green. 2. They have an acrid and peculiar taste. 3. They render oils and fat miscible with

4. They are soluble in water ; and, 5. are capable of combining with the acids.
: three alkalies are potass, soda, and am- ; the first two are called fixed alkalies, e last volatile.

rles. Why are potass and soda denominat- :d ?

or. Because they require a red heat to ize them ; whereas the ammonia assumes ous form, and is dissipated with a moderate : of heat.

es. From what is potass obtained ?

or. If wood be burnt to ashes, and these washed with water, and the liquid filtrated ıen evaporated, the substance which re- is potass, which was long distinguished by me of vegetable alkali.

rles. What are the properties by which ıbstance is known ?

or. It is a brittle white substance ; its s very acrid, and so corrosive, that it is y surgeons as a caustic to destroy useless cences, and to open abscesses. It has so an affinity for water, that one part of wa- ll dissolve two parts of potass, and the so- is transparent, but almost of the consist- f oil.

es. Is this the same substance as is sold shops as potash ?

or. I am describing a substance in a state *ity, whereas* the potash of the shops is *inated with* many other things. By heat, *Tutor.* It agrees with potass in its taste, smell, and action upon animal bodies, it has also a strong affinity for water, but does not liquefy, like potass, by being exposed to the air; it merely effloresces, or falls into powder.

Charles. You said, that the alkalies rendered oils and fat miscible with water; what are the compounds thus formed called?

Tutor. Soap; the combination of potass with oil or fat, forms *soft* soap; and the union of soda with the same substances produces *hard* soap.

James. Does potass, being so much stronger than soda, make the soft soap more powerful than the hard?

Tutor. It does: and on that account it is used in washing wools, woollen cloths, &c. In medical cases it is also used.

Charles. Soap is of different colours, as the white, the yellow, and the mottled.

Tutor. The *white* is made of very choice tallow; in the *mottled* soap is dispersed a solution of sulphate of iron, or black oxyde of manganese, which produces the colour: in *yellow* soap there is a mixture of resin with the tallow.

James. I should like to be able to make soap.

Tutor. Soap is an article subject to the excise duty, which will prevent us from manufacturing more than a very small quantity.

Experiment. Take one part of slaked lime, and two of carbonate of soda; boil them in *twelve parts* of water for half an hour; then filter and evaporate the solution till its specific

r is such, that an ounce phial will contain
ce and three drams of the fluid. To one
'this fluid add two of olive oil, and let
e well beat together, and in a few days
ll have a white hard soap.
ı, like potass, corrodes woollen cloth ; and,
olutions be sufficiently strong, they will re-
: to the form of jelly.
es. What is the use of this jelly ?
r. It has been used in France as soap.
: acids decompose soap, and separate the
art from the alkaline.
les. How do you make the experiment ?
r. In one of these glasses is a solution
in water ; in the other a solution in alco-

es. They are both very clear.
r. I will drop a little acid in them ; they
v turbid, and the oil is separated.
solution of soap in alcohol is used as a
ascertain the comparative hardness of
; with pure distilled water it may be mix-
ıout effecting any change ; but if the solu-
poured into hard water it produces a milki-

les. What is the cause of hardness in
?
r. Various waters obtained from springs
nbined with metallic salts, or earths, which
: occasion of the hardness ; these decom-
ap, because they have a stronger affinity
alkali than the oil has.

James. Is *soft* water that which is free from these salts?

Tutor. It is: and this dissolves soap very completely.

Charles. What do you mean by ammonia, or volatile alkali?

Tutor. It is distinguished from the fixed alkalies by a very sharp penetrating smell, and by its great volatility.

James. Is it a liquid?

Tutor. In its purest form it subsists in a state of gas; and then it is called ammoniacal gas; it is transparent and colourless; it is acrid and corrosive, but not so strong as the fixed alkalies, nor will it, like them, corrode animal bodies. When combined with water, it is called liquid ammonia.

Charles. Is not spirit of hartshorn liquid ammonia?

Tutor. It is: but what is generally sold under that name is weak in comparison of the real liquid ammonia.

James. How is pure ammonia obtained?

Tutor. From a mixture of three parts of quick-lime, and one of muriate of ammonia in powder, put into a retort, and the heat of a lamp applied to it; the muriatic acid of the ammonia combines with the lime, and the gas is driven off, which must be received over mercury.

Charles. Would water absorb it?

Tutor. Yes, very rapidly, and in great quan-

ꝫs. If a piece of ice is brought into conta
h this gas, it melts and absorbs the ammoni
ile the temperature is diminished.

'ames. When combined with water, is th
ıperature of the water diminished?

Tutor. It is: water is capable of absorbing
l condensing more than one third of its
ight of ammoniacal gas.

Charles. Is the specific gravity of the water
reased by it?

Tutor. No, it is diminished by about a tenth
t. In this state it is usually called ammonia,
the term almost always means a liquid so-
ion of ammonia in water. When heated to
temperature of 130°, the ammonia flies off
he shape of gas; when cooled down to 46°,
ystallizes; and, when suddenly cooled down
still lower, it assumes the appearance of
 jelly, with scarcely any smell.

mes. Does ammonia combine with sulphur?

tor. It does, in a state of vapour, and forms
ɔgenated sulphuret of ammonia.

rles. How is it obtained?

or. By distilling a mixture of five parts
-ammoniac, five parts of sulphur, and six
ick-lime. Ammonia combines also with
ıriatic acid gas; and the two gases form
id salt *muriate of ammonia.*

s. That is sal-ammoniac; it is strange,
gases only should form such a solid.

. True; but it is not the only instance
many. Ammoniacal gas unites over

mercury with carbonic acid gas, and the result is a crystallization of carbonate of ammonia, in silky fibres, or fine powder.

Charles. Has ammonia any effect on the metals?

Tutor. It has on some few of them: it possesses also the property of reducing metallic oxydes to the form of metals again.

James. How is this accounted for?

Tutor. Ammonia is a compound of hydrogen and nitrogen, or azote: the hydrogen unites with the oxygen of the metal, and forms water, while the azote escapes in the shape of gas.

Charles. What other properties belong to the ammoniacal gas besides the smell?

Tutor. It extinguishes flame; and is fatal to animal life. Before the flame of a wax taper is put out by immersion in this gas it is enlarged, by the addition of another, of a pale yellow colour, which descends from the mouth of the jar to the bottom; it is easily decomposed by the electric and Galvanic sparks.

Ammonia is produced during the decomposition of animal and vegetable substances, and is generated by the union of the hydrogen and azote contained in them.

CONVERSATION XXVII.

Of the Decomposition of the Alkalies.

[T]UTOR. The alkalies were considered, till hin these few years, as simple bodies, though ras suspected they would hereafter be proved e compounds.

[J]ames. Do you refer to all three?

[T]utor. No: ammonia, at an early period of umatic Chemistry, was ascertained to consist nitrogen and hydrogen; and hence it was gined, that the other two, *viz.* potass and a, would be found to possess the same con- ution.

[C]harles. Has the conjecture been confirmed?

[T]utor. No: by the application of Galvanism hem it has been discovered, that they consist netallic bases united to oxygen.

[J]ames. By whom was the discovery made?

[T]utor. Sir Humphrey Davy, led by the law, ch he had discovered, to regulate the decom- itions produced by Galvanism, submitted the *fixed alkalies* to the action of this power.—

He effected their decomposition, and demonstrated, as we have observed, that they consist of metallic bases combined with oxygen.

Charles. How was the experiment made?

Tutor. The chief difficulty in subjecting potass to electrical action is, that, in a perfectly dry state, it is a complete non-conductor of electricity; but when moistened, by merely breathing upon it, it readily undergoes fusion and decomposition, on the application of strong electrical powers.—See Scientific Dialogues, vol. vi.

James. Was the alkali placed in the electrical circuit?

Tutor. It was: a piece of potass of sixty or seventy grains may be placed on an insulated plate of platina, and may be connected with the opposite end of a powerful Galvanic battery; and, on establishing the connexion, the potass will fuse at both places where it is in contact with the platina. An effervescence will be seen at the upper surface, arising from the escape of the oxygen gas. At the lower, or negative surface, small bubbles will appear, having a high metallic surface, something like quicksilver. Some of these globules burn with an explosion, and bright flame; others become tarnished, and are protected by a white film from farther change. Pure soda gives similar results.

Charles. Are they obtained by the same means?

Tutor. The decomposition of soda requires a eater intensity of action. The quantity of soda ed upon should not exceed fifteen or twenty ains; and the distance between the platina faces must be reduced, perhaps to the sixnth part of an inch.

James. Are the properties of the metallic stances obtained from the two alkalies the ne?

Tutor. Not exactly so: the metal from the la does not, like that of the potass, continue id at the temperature of the atmosphere; but peedily becomes solid, and bears a considera- resemblance to silver. When the power of Galvanic, or Voltaic battery is very much in- eased, globules of the metal fly off with great locity through the air, in a state of vivid com- stion, producing jets of fire.

Charles. Are these metals easily preserved?

Tutor. To keep them from oxidation, it is cessary to immerse them almost instantly in re naphtha, a fluid that will hereafter be de- ibed.

James. When an oxidation takes place is the tal reduced to the alkali again?

Tutor. If the globules of the metals obtained m either alkali are exposed to the action of the over mercury, an absorption of oxygen takes ice, and a crust of pure alkali is formed on the rface, which defends the interior from farther ange. If heat be applied to the globules thus nfined, *a rapid* combustion ensues, attended h *a brilliant* white flame. The globules are found, after the experiment, converted into a white substance, which is the specific alkali, according as potass or soda has been formed. In this process oxygen is absorbed, and the weight of the alkali produced is found to exceed that of the globules consumed.

When either of these metallic substances is thrown into water a rapid disengagement of hydrogen gas takes place: and the oxygen of the water, uniting with the globules, brings back the alkali.

Charles. The description of these experiments seems to render the nature of the two fixed alkalies very clear.

Tutor. Nothing can be more satisfactory than the evidence furnished by these experiments, which have been repeated a thousand times, and by the ablest chemists. It is to be observed, that, by the powerful agency of the opposite electricities, each alkali is resolved into oxygen and a peculiar base. This base, like other combustible bodies, is repelled by positively electrified surfaces, and attracted by negative ones. Again, by uniting with oxygen, these bases are converted into alkalies, either slowly, and at the ordinary temperatures; or with heat and light, if their temperatures are raised. Hence the evidence is complete, both by analysis and synthesis, that each of the fixed alkalies is a compound of *oxygen with* a peculiar basis.

James. Are we then to range the bases of the *fixed alkalies* among the metals?

Tutor. Yes : with these they agree in opacity, lustre, malleability, conducting powers of heat and electricity ; and in their qualities of chemical combination.

Charles. You have said nothing about their specific gravities.

Tutor. In this there is a vast difference between all the old and the newly-discovered metals : they are both much lighter than water, although the lightest of all the old metals is four or five times heavier than that fluid. This, however, ought not to put them out of that rank, because there is as much difference between tellurium and platina, as there is between the base of soda and tellurium ; so that tellurium may be considered as forming a kind of link between the old metals and the bases of the alkalies.

James. What names are given to these two metallic substances ?

Tutor. Sir Humphrey Davy named the base of potass, POTASSIUM ; and that of soda he called SODIUM ; and these names have obtained a universal acceptation.

Charles. Is there any other means of obtaining these metals besides by large Galvanic batteries ?

Tutor. Yes, merely by the intervention of chemical affinities. This method, which affords larger quantities of metal, though not of so pure a nature, consists in bringing the alkalies *into contact* with intensely heated iron, his temperature, attracts oxygen more ıan the bases of the alkalies retain it.

Can you describe the experiment?

The apparatus used for obtaining pot- ffers but little from that already de- which is commonly employed in the de- ion of water by means of iron. ısists of a common gun-barrel, curved and ut at one end, into which the alkali is put, ean iron turnings; the tube is then placed rnace, and the strongest heat applied, by of double blast bellows. The iron seizes the oxygen of the alkali, and the metallic ium is thus obtained.

arles. Can you enumerate the chief pro- es of potassium?

utor. At the temperature of 60° it exists in ll globules, so much like mercury, that no dif- ence can be discovered by the eye between minute globules of each metal. At this tem- rature the metal is only imperfectly fluid, but 150° its fluidity is perfect. At the tempera- re of 50° it becomes a soft and malleable solid, the lustre of silver; reduced to the freezing oint it is brittle, and exhibits, when broken, a rystallized texture, which, in a microscope, seems composed of beautiful facets of a perfect whiteness and high metallic splendour.

Potassium is a perfect conductor of electricity and of heat. Its specific gravity is to that of wa- ter as about 6 or 7 to 10. It is capable of oxida- *tion.*

›n of potassium on water is attended
lowing circumstances :—
›ught into contact with water it de-
ıe water with great violence : an
ıs explosion is produced, with vehe-
; and a solution of pure potass is the
e hydrogen gas, which is disengaged,
dissolve a portion of potassium ; for,
into the air, it forms a white ring
radually enlarging as it ascends, like
ıretted hydrogen gas. Each grain of
etaches more than a cubic inch of hy-

ıle of potassium be placed on ice, it
rns with a bright flame ; and a deep
le in the ice, filled with the fluid,
ınd to be a solution of potass.
uction of alkali, by the action of wa-
sium, is well exhibited by dropping a
the metal upon moistened paper,
›een tinged with turmeric. At the
n the globule comes into contact with
t burns, and moves rapidly as if it
ıted and in search of moisture, leav-
it a deep reddish brown trace, and
the paper exactly like dry caustic

rown into the liquid mineral acids the
ss inflames, and burns on the surface.
atic acid gas it burns vividly with
llations, and muriate of potass is gene-

Potassium readily combines with the simple ›mbustibles. With mercury it gives some ›ry curious results. The combination is rapid, ›d it is effected by merely bringing them into ›ntact at the temperature of the atmosphere. ›he amalgam, which consists of about seventy ›rts of mercury and one of potassium, is soft ›d malleable ; but, by increasing the proportion ' potassium, the solidity and brittleness of the ›mpound are increased.

Potassium reduces all the metallic oxydes ›hen heated with them ; and, in consequence of ›is property, it decomposes and corrodes glass: ›tass is generated with the oxygen taken from ›e metal, which dissolves the glass.

Potassium consists of about eighty-six parts of the ›etallic base and fourteen of oxygen : but ›fferent chemists have given different propor- ›ons.

James. The properties, which you have de- ›ribed as belonging to potassium, are very cu- ›ous ; does sodium possess similar qualities?

Tutor. Sodium agrees, in many of its proper- ›es, with the potassium, and exerts on several ›odies a precisely similar action, excepting that ›e results are compounds of soda instead of pot- ›s. The difference, that subsists between the ›vo, may be thus briefly described :—

1. Sodium, at the common temperature, ex- ›ts in a solid form. It has the general appear- ›nce of silver, and is exceedingly malleable. ›hen pressed by a platina blade, with a small

e, it spreads into thin leaves; several glo s may, by strong pressure, be forced into ; so that the property of welding, which ngs to iron, at a very strong heat only, is essed by this substance at common temperatures.

It is specifically lighter than water, in the ortion of about 93 to 100. It is much less le than potassium.

When sodium is exposed to the atmose, it immediately tarnishes; and, by des, becomes covered with a white crust of

It combines with oxygen slowly, and withany luminous appearance, at all common eratures. When heated, the combination nes rapid, but still without light. When to a red heat, it produces flame, and forth bright sparks, exhibiting a beautiect.

When thrown into water, it produces a viffervescence and a loud hissing noise; it es with the oxygen of the water to form and hydrogen gas is evolved. When into hot water it produces a violent efferve, and a loud hissing noise; and, in this ew scintillations are generally observed rface of the fluid.

ium is susceptible of different degrees on: it unites with oxygen to form soda portion of about seventy-seven of meto twenty-three of oxygen.

Charles. Since the two fixed alkalies are found to consist of a metallic base and oxygen, is it admitted that the volatile alkali is a compound of nitrogen and hydrogen?

Tutor. No: it is now pretty generally admitted, that it contains oxygen, as well as hydrogen and nitrogen; and some experiments of Sir Humphrey Davy go to suggest, at least, that ammonia may, like the fixed alkalies, be an oxyde of a peculiar metal, or of some compound containing the elements of a metal.

James. Can the oxygen be obtained from ammonia?

Tutor. It never has as yet; and therefore it is assumed, that, since hydrogen and nitrogen alone are obtained by the electrical analysis of ammonia, the metal in question is either a compound of those two bases, or a component part of one of them. Should this fact be hereafter established, we shall have a metal, or metallic oxyde, whose natural state is that of an aeriform fluid.

Charles. I do not understand how this can be.

Tutor. Whenever mercury, after combination with another substance, retains, in a great measure, its characteristic properties, and forms an amalgam, it is inferred, that the change has been produced by its union with a metal; for metals only are capable of amalgamating with quicksilver. Now, when mercury negatively electrified in the Voltaic circuit is placed in con-

the solution of ammonia, it expands t
ve times its usual dimensions, and be
t like butter. By this combination the
gains an addition of only the $\frac{1}{12000}$th
s weight; but its specific gravity is so
creased, that, from being thirteen or
imes heavier than water, it becomes
e times heavier. Its colour, lustre,
and conducting powers remain unim-

Can the ammonia be reproduced?
When this amalgam is exposed to the
re oxygen is absorbed, ammonia is re-
, and the quicksilver recovers its me-
n.

Is a similar effect produced if
to water?
When thrown into water, ammonia is
d, quicksilver separated, and hydro-
at the same time evolved. Hence,
ation of the amalgam, mercury com-
ne or more of the elements of am-
therefore, there is reason to be-
ygen is one of the constituents of

rred, that the base is of

sition, that the unknown
ates with mercury, is of
mphrey Davy proposes

We may farther observe, that, when potassium is melted in ammoniacal gas, it is changed into an olive green fusible substance; the ammonia almost entirely disappears, and it is replaced by a volume of hydrogen equal to that which the same quantity of potassium would have disengaged from the water. When this olive coloured substance is gradually heated in contact with hydrogen gas, it enters into ebullition, gas is disengaged, and the mercury descends in the tube. When brought into contact with water in close vessels great heat is excited, and the products are potass and ammoniacal gas. Similar results occur when sodium is heated in ammoniacal gas.

Though these and other facts described by our best chemists cannot be easily explained, except on the supposition that nitrogen is an oxyde, yet the facts are not yet so clear as to be admitted without hesitation and doubt.

CONVERSATION XXVIII.

le EARTHS : *Of Barytes, Strontian, Lime.*

TOR. We are now to treat of the earths.
ies. Do you refer to the different kinds of on which vegetables grow ?
or. Yes : these have been analyzed, and een found to consist of a small number of , which have a variety of common proper-

rles. What are those properties ?
or. They are nearly insoluble in water : ave very little taste : they are incombus- and not five times heavier than water.
es. How many earths are there ?
or. There are nine, *viz.*

rytes.	4. Magnesia.	7. Glucina.
rontian.	5. Alumina.	8. Zirconia.
me.	6. Yttria.	9. Silica.

of these will require a particular descrip-

rles. *What is* BARYTES ?

Tutor. The word itself is of Greek origin, and denotes something heavy; hence the mineral from which it is obtained was formerly called ponderous spar.

James. Is not barytes found pure?

Tutor. No: it is always found united with the sulphuric or carbonic acids, and in these states it is called either the sulphate of barytes or the carbonate of barytes.

Charles. How is the barytes obtained in a state of purity?

Tutor. If you have the sulphate to work on, it must be reduced to powder, and mixed with charcoal powder, and kept some hours red hot in a crucible, which will convert it into a sulphuret of barytes.

James. Does the acid combine with carbon during the application of the heat?

Tutor. It does; and what remains is a compound of sulphur and barytes. The sulphuret is now to be dissolved in water, and nitric acid poured into the solution: the acid combines with the water, and the sulphur is precipitated.

Charles. The solution is now nitric acid and barytes.

Tutor. This is to be filtered, and evaporated till it crystallizes.

James. Are not the crystals nitrate of barytes?

Tutor. They are; but the nitric acid is easily driven off by heat, and the barytes remains pure.

Charles. How should you proceed, if you had the carbonate of barytes instead of the sulphate?

Tutor. I should dissolve the carbonate in weak tric acid, and thereby expel the carbonic acid; course, the remainder will be a nitrate of ba-tes, with which I should proceed as before.

James. By what properties is barytes distin-iished?

Tutor. It is about four times heavier than ater: it is of a grayish white colour: it has a irsh caustic taste: and is a most violent poison. tinges vegetable blues green; and, like the ted alkalies, it decomposes animal bodies.

Charles. Does it attract the moisture from ie air?

Tutor. It does; and, like quick-lime, when rinkled with water, it falls into a white pow-er.

James. Is heat given out on the occasion?

Tutor. Yes: and when water is poured on ire barytes it is slacked like lime, but more ipidly, giving out a greater quantity of heat. fter it is thus slacked it attracts the carbonic cid from the atmosphere, and loses its acrid pro-erties.

Charles. Then it is necessary to keep it in close essels.

Tutor. True. Barytes, completely diluted ith water, will, on cooling, crystallize, and as-ime the appearance of a stone composed of nee-le form crystals: these, when exposed to the ir, attract the carbonic acid and fall into powder.

James. Will water dissolve barytes?

Tutor. About the twentieth part of its weight.

the solution is limpid and colourless, and will convert vegetable blues to green. When exposed to the air, its surface is soon covered with a stony crust, consisting of barytes and carbonic acid.

Barytes combines with phosphorus as well as with sulphur, making with it the phosphoret of barytes.

Charles. Has it any action upon the metals?

Tutor. No: but it is capable of combining with several of the metallic oxydes.

Experiment 1. In this glass of distilled water, rendered slightly blue by the tincture of cabbage, I drop a few grains of barytes.

James. The blue is changed to green.

Tutor. Ex. 2. Water tinged red with Brazil-wood will, by the addition of a small quantity of barytes, be changed to a violet colour.

Ex. 3. In this phial is half an ounce of sallad oil; I will pour upon it an ounce and a half of concentrated solution of barytes, and then shake them together.

Charles. You have made a kind of soap: in this respect it is like the alkalies.

Tutor. It is. Ex. 4. Glass may be made with a few grains of silex and double the quantity of barytes, provided it be urged with heat by means of the blow-pipe; in this respect also it resembles the alkalies.

James. What do you mean by a blow-pipe?

Tutor. Here are two, Figs. 21 and 22. They are used for directing the flame of a candle or

.ny substance that requires to be acted
ı great heat.

ı. What is the bulb in the middle for?

It is intended to contain the moisture
y the breath. The other was invented
lack; it is of a conical shape, and is
venient for the purpose.

In this glass of water is dissolved a
y of sulphate of soda: I will add a few
a solution of barytes; white clouds
nmediately formed.

How is this accounted for?

Barytes has a stronger affinity for sul-
:id than any other body, forming with
instance, a sulphate of barytes, which
f the most insoluble substances: and
unites with the water. This property
:s renders it an excellent test for de-
ıe presence of any quantity, however
sulphuric acid.

Are the earths simple substances?

They were supposed to be so till the
ıg experiments of Sir Humphrey Davy
kalies; and the results of these led him
: chemists to conjecture, that the earths
isted of an alkaline base and oxygen.

ı. Did the same kind of experiments
in decomposing them?

No; it was found, that simple expo-
:he opposite electricities was not ade-
the separation of the principles which
the earths. Sir Humphrey Davy,

therefore, electrified the earths in contact with the oxydes of known metals, with the expectation, that the metallic base of the earth would unite with the metal contained in the oxyde which he employed, and form an alloy.

James. Did this answer with regard to barytes?

Tutor. Yes: a mixture of barytes and red oxyde of mercury yielded an alloy of mercury with the metallic base of the barytes.

Charles. Is it known in what proportion the base is to the oxygen?

Tutor. The proportion of the oxygen and metal has not been accurately ascertained in any of the earths; but the evidence, from analysis of their composition, is perfectly satisfactory, the inflammable base appearing uniformly at the negative surface in the Voltaic circuit, and the oxygen at the positive surface.

James. What is the metallic base of barytes denominated?

Tutor. It is named barium; and it is supposed to be four or five times heavier than water, and to consist of about ninety parts of metal and ten of oxygen.

The next earth in order is STRONTIAN, so named from the mine in Argyleshire, where it was first discovered.

James. Is this earth found in a state of purity, or combined with other matters?

Tutor. It is found in various parts of the world, and always combined with carbonic or sulphuric acid.

Charles. Then the mineral is either a carbonate or a sulphate of strontian.

Tutor. Certainly. To obtain the earth, we have only to expel the acid, by means somewhat similar to those described for the obtaining the barytes.

James. By what properties is it known?

Tutor. The mass is porous and a grayish white colour; its taste is acrid and alkaline, and it converts vegetable blues to green. It has not much action on animal bodies; nor is it poisonous.

Charles. Is it capable of being slacked, and of giving out heat like the barytes?

Tutor. It is: but it is not so soluble in water. The solution, called strontian water, is clear and transparent, and converts vegetable blues to green.

James. Does it combine with sulphur and phosphorus?

Tutor. It does; and the compounds are the sulphuret and the phosphoret of strontian. It combines also with some of the metallic oxydes; but has no action upon metals. It has the property of tinging the flame of a candle of a beautiful red, or purple colour.

Charles. How is that shown?

Tutor. By putting a little of the nitrate of strontian into the wick of a lighted candle, the flame will exhibit a lively purple. Or put some strontian, moistened with alcohol, into a silver spoon; set fire to the mixture, and, while burning, hold it over the flame of the candle.

Experiment. A beautiful red fire may be produced by mixing one part of nitrate of strontian with two or three parts of charcoal powder, and inflaming the mixture with a red hot poker.

James. If strontian is capable of decomposition, how is the base obtained?

Tutor. By the same process as barium, substituting the native carbonate of strontites for that of barytes. It is called strontium, resembles the barium, and may be converted into strontites by exposure to the air, or by contact with water. It consists of about eighty-six of metal and fourteen of oxygen.

You are well acquainted with LIME.

James. Yes: it is that from which mortar, used in building, is made; and I believe it is procured from chalk by burning.

Tutor. You are right: it is obtained also from marble, and another substance called lime-stone. These substances are combinations of lime and carbonic acid gas.

Charles. Are they called carbonates of lime?

Tutor. They are: water is also found in the compounds. By keeping them for some hours in a white heat, the water and carbonic acid gas are driven off, and the lime remains.

James. What are the properties that distinguish lime?

Tutor. You know the colour is white: it has a burning acrid taste, and will destroy animal substances. It tinges vegetable blues green, and then converts them to yellow. It is incapable of being fused.

Experiment 1. Though lime is perfectly infusible, yet, if heated with silex, which is also infusible by itself, they will melt.

Ex. 2. Three parts of lime and one of alumina will also melt with facility.

Ex. 3. One part of lime, one part of alumina, and two of silex will be readily fused.

James. By throwing water upon lime, it swells and falls to powder, giving out, at the same time, a considerable quantity of heat.

Charles. Is the heat sufficient to inflame combustible substances?

Tutor. It is: and in this manner vessels loaded with lime, and wagons also have sometimes been burnt.

James. How is the heat accounted for: the lime is cold and so is the water?

Tutor. Slacked lime is heavier than it was previously to the operation; the additional weight caused by the combination of part of the water with the lime, which thus becomes solid, and of course, in the act of becoming solid, it parts with caloric that kept it in a state of fluidity.

Charles. Will this account for the great degree of heat that is sensible on the occasion?

Tutor. It certainly gives out more caloric than evolved by the mere conversion of water into . If two parts of lime and one of ice be mixed, they combine instantly, and their temperature is raised to 212°, the heat of boiling water only.

James. What occasions the smell that is perceived during the slacking of lime?

Tutor. It is occasioned by part of the earth being carried off with the vapour of the water: this is clear, because vegetable blues exposed to the vapour are changed to green.

Charles. Is the difference which there is between lime and the chalk, from which it is made, wholly owing to the loss of the carbonic acid gas?

Tutor. Lime, when pure, is of an alkaline nature; the carbonic acid neutralizes it, so that chalk possesses scarcely any of the properties by which lime is distinguished. Chalk, marble, &c., are tasteless, without smell, have no action on animal bodies, and are scarcely soluble in water.

James. I know lime will dissolve in water, because I have seen lime-water made and used on various occasions.

Tutor. An ounce of lime-water contains but a single grain of lime: nevertheless it has an acrid and unpleasant taste, and changes vegetable blues to green. This water, exposed to the air, exhibits in a very short time the carbonate of lime on its surface by the thick pellicle that is formed on it.

Charles. How is that accounted for?

Tutor. Lime has a great attraction for the carbonic acid, of which there is always a portion in the atmosphere: the lime in the water combines a the acid of the air, and forms a sort of strong st; when this is broken, it falls to the bot- , and another succeeds; and in this manner whole of the lime may be speedily precipi- ed.

ames. Mortar for building is made of lime sand; does it become hard by absorbing the bonic acid from the air?

Tutor. The goodness of mortar depends efly on the preparation of the lime, from ich the carbonic acid should be completely elled; and it is supposed to owe its stony perties partly to the absorption of the car- ic acid, and partly to the combination of part he water, used in slacking it, with the lime.

harles. Is there a kind of crystallization that es place?

utor. There is; and the sand, if it be good free from extraneous matter, favours the stallization; in the same way as small sticks hreads assist the crystallization in saline and charine solutions.

ames. Do phosphorus and sulphur combine h lime?

utor. They do; and thus we have the phos- ret and the sulphuret of lime.

harles. To what other purposes, besides that naking mortar, is lime applied?

utor. It is used as a manure in agriculture; he business of tanning to take off the hair n the *skins*; and in refining sugar.

ames. How does lime act upon the land?

Tutor. By hastening the solution of all animal and vegetable matters with which it may meet, and by imparting to the soil a power of holding a greater quantity of moisture than it would without it.

Charles. Can so acrid a substance as lime be used in making sugar?

Tutor. The sugar is boiled in lime-water to deprive it of part of the acid, which is found in all saccharine substances.

James. Does the acid combine with the lime?

Tutor. It does: and then the sugar easily crystallizes. Lime is, as we have seen, used in soap-making; it is mixed with the alkali to take away the carbonic acid that may be mixed with it: the alkali is thus made more caustic, and fitter for the purpose of converting the fat into soap.

Charles. Has lime been decomposed?

Tutor. It has; and the metallic base is named Calcium, which has the colour and lustre of silver; but the instant it is brought into contact with air it takes fire, and burns with an intense white light and flame.

CONVERSATION XXIX.

ıesia, Alumina, Yttria, Glucina, and Silex.

ƆR. Pure magnesia is destitute of taste
ll : it converts vegetable blues to green ;
out no heat, like lime, by the effusion of
and water will not dissolve more than the
ısandth part of its weight.
ɛs. Is it ever found in tnis pure state ?
. No ; it is obtained from a salt that ex-
ɜawater, and which is composed of this
ıd sulphuric acid. It is also found in ma-
gs, particularly in some at and near Ep-
ıd, on this account, the salt was long de-
ed Epsom salt, but now it is called sul-
magnesia.
. How is the magnesia separated from
huric acid ?
. The salt is dissolved in water, and
weight of potass added. The pure mag-
immediately precipitated, because the
c acid has a stronger affinity for potass
magnesia.

Charles. Is the result pure magnesia and sulphate of potass ?

Tutor. It is ; the magnesia is precipitated, but the sulphate of potass remains in solution: the sulphate of magnesia, or Epsom salt of the shops, is generally procured from the *mother waters*, which remain after the separation of common salt from seawater.

James. What do you mean by mother water?

Tutor. The liquor which is left after the crystallization of salts. Thus when the common salt is separated from seawater, sulphate of iron is added to the remainder of the water : the sulphuric acid leaves the iron to unite with the magnesia, and the muriatic acid, that was left, combines with the iron. The products therefore are sulphate of magnesia and muriate of iron.

Charles. Is magnesia much used ?

Tutor. It is principally employed in medicine, both as a purgative, and as an absorbent to correct acidities.

James. Is it the pure magnesia that is used in medicine ?

Tutor. To correct acidities, the pure or calcined magnesia ought to be employed ; but, as an aperient, it should be the carbonate or mild magnesia.

Charles. Is not magnesia liable to be adulterated ?

Tutor. Yes ; and chalk is the substance usually employed for the purpose : sulphuric acid will detect the fraud, because, with chalk, it com-

s into an insoluble salt; whereas, with mag-
ı, Epsom salt is formed, which is easily dis-
ed.

mes. How shall I try whether this is adul-
ed?

utor. Take a little of it, and add some sul-
ic acid, diluted with eight times its weight
ater: if the magnesia is taken up, and the
ion remains transparent, it is certainly pure,
ıot otherwise.

harles. There is a considerable sediment.

utor. That shows the magnesia contained
k, which the sulphuric acid will not take up.

mes. Has magnesia likewise been decom-
posed?

utor. It has; but the base, called MAGNE-
, is but imperfectly known. It sinks rapidly
ater, though surrounded by gas, and pro-
es magnesia. In the air it is quickly changed,
g covered with a white crust, which, falling
powder, proves to be magnesia: it is sup-
ed to consist of sixty parts of metallic base,
forty of oxygen. The bases of the other
hs are not sufficiently known to give any
g like a description of them. There seems,
ever, no room to doubt, that they all consist
etallic bases and oxygen.

LUMINA is the next earth in order; and it is
alled, because it is obtained in the greatest
ity from alum, a substance well known in com-
ce *and the arts.*

mes. Of what is alum composed?

Tutor. Of sulphuric acid and this earth, which we are now to describe; of course, alum is denominated the sulphate of alumina, though it always contains a mixture of potash. Alumina was formerly called *argil*.

Charles. How is alumina obtained in a state of purity?

Tutor. The alum is dissolved in water, and to the solution, ammonia is added, as long as any precipitate is formed. This precipitate, washed and dried, is alumina, combined with a small portion of sulphuric acid. The nitric and muriatic acids are made use of, to free the alumina from the sulphuric acid.

James. What are the chief properties of this earth?

Tutor. It is destitute of taste and smell; it does not affect blue vegetable colours; it is dissolved by the fixed liquid alkalies, and is precipitated by acids unchanged: by fusion it may be united with the fixed alkalies, and with most of the earths; and, when moistened with water, it forms a cohesive mass, capable of being moulded into a regular form.

Charles. That is like clay, with which earthenware is made.

Tutor. Clay is a mixture of alumina and silex, and with these the finest earthen-ware, as well as common pottery, is made.

James. Is the beautiful Wedgewood ware made of the same substances as common pans [illegible]ishes?

tor. It is: the only difference is in the ortions and in the working of the materials. the better kind of articles, the alumina is en up in water, till the fine parts are sus- ed in the fluid, which is then passed through or even lawn sieves: it is then mixed a similar liquid, formed of flints ground a fine powder. The mixture is now dried kiln, and, after it is reduced to a proper istence by being beaten up with water, it mes fit for the manufacture of plates, cups, ers, dishes, &c.

mes. How is the fine smooth surface put these articles?

utor. When they have been exposed to heat rtain time, they are then glazed. Common ery is glazed with the oxyde of lead; what lled stone-ware is glazed by throwing salt the oven during the baking of the articles. yellow, or queen's-ware, is glazed with a position of white lead, flint, and flint glass.

arles. How are the different colours given?

utor. By the metallic oxydes; each of which, know, affords a different colour. The oxyde old is employed for the purple: red is given he oxyde of iron; yellow by the oxyde of r; green by copper; and blue by cobalt.

mes. Is alumina employed for other pur- s?

tor. Yes: it has a strong attraction for ring *matter,* and is therefore used by the printer and dier as a *mordant*; that is, a

sort of third substance to unite the colo
the cloth to be died or printed.

Fuller's earth is a compound of alumi
silex, and the affinity that alumina has for
substances renders this substance of gre
portance in scouring cloth and in taki
spots of grease from the floor and other
stances. Upon the whole it may be sa
that none of the earths are of more import
to mankind than this.

Alumina has another curious property
bulk is diminished in proportion to the h
which it is exposed.

Charles. I thought all bodies were incr
in magnitude by heat.

Tutor. This seems to be an exception t
general rule; and upon this principle
Wedgewood's thermometer or pyrometer is
structed for measuring great degrees of hea

The next earth to be noticed is YT
found, at present, only in Sweden: it has,
pure, the appearance of fine white po
and has neither taste nor smell: it has n
tion on the vegetable blues.

James. With what is it found in a st
combination?

Tutor. With oxyde of iron and silica
mineral from which it is obtained is calle
dolinite, from Professor Gadolin, who disco
it. Its specific gravity is nearly five time

* *See Scientific* Dialogues, vol. iv. Conver. xx

r, which is almost equal to that of some metals, and it has been thought to be a oxyde; but it is generally considered ubstance which connects the earths with tals. It may be fused with borax, and forms a kind of glass.

les. What is GLUCINA?

r. It is obtained from the beryl or eme- transparent stone, of a green colour, crystallized in the mountains of Siberia. ord glucina is derived from the Greek, ng sweet, because it gives a saccharine all the acids with which it combines.

les. What are the properties of this earth?

r. It is a soft white powder, very light, thout taste or smell; it has the property ering to the tongue. It has no action on le colours, and is infusible by heat.

les. What is ZIRCONIA?

r. It is obtained from a precious stone, *jargon*, or *zircon*, found in the island of , from which it derives its name. It is lso in the hyacinth.(*a*)

es. What are the properties of this earth?

r. It has the form of fine white powder, om taste or smell. It is soluble in acids, in liquid alkalies. It does not combine em in fusion. Being exposed to a strong ircon fuses, assumes a light gray colour, h a degree of hardness, on cooling, as to ire *with steel*, and to scratch glass.

a, or siliceous earth, is obtained from uartz, flint, rock, crystal, and many other stones ound in almost every part of the world.

Charles. Do flints and such hard substances ontain an earth?

Tutor. They do; and it is obtained by mix- g in a crucible one part of pounded flints and ree of potass, and then applying a heat suf- cient to melt the mixture. The mass is now be dissolved in water, the potass to be satu- ated with muriatic acid; when the moisture evaporated, a white powder is left behind, hich, when washed and dried, is silica in a tate of purity.

James. What are the properties of this earth?

Tutor. It is a fine white powder, tasteless, nd without smell; its particles have a harsh eel, as if they consisted of minute grains of and. It is not acted upon by any of the acids, xcept the fluoric: it is soluble in the fixed lkalies, and when melted with them it forms lass. It combines also with many of the me- allic oxydes, and with them makes various oloured enamels.

Charles. Can you describe the several in- redients of which the different kinds of glass re made?

Tutor. Flint glass, that of which decanters nd such sort of vessels are made, is formed of oda, pounded flints, and oxyde of lead. This s the most dense, transparent, and beautiful *lass, and from its beauty, it is often called ystal.*

. In what does that differ from crown
ɔw glass ?

. This is composed of soda and fine
y, without any mixture of lead. Bottle
composed of kelp and common sand ;
ɜn colour is owing to the presence of

. Could I make glass of silica and al-

. Yes : take one part of pure white
l three parts of potass, mix them together
ıste, and fuse them in a crucible, and the
glass.

ɜs. What are the properties of good

. It should be perfectly transparent and
'd. Its specific gravity varies, in proportion
ıantity of metallic oxyde that it contains.
ɔld it is brittle, but at a red heat it is one
nost ductile bodies known, and may be
ıto threads so fine as scarcely to be visi-
ıe naked eye.

is, as you must perceive, a very import-
h. It is the principal ingredient of those
'hich seem to constitute the basis of this
it is an essential part of good mortar, and
ı into the composition of all kinds of stone
d glass.

ıg thus gone over the alkalies and earths,
be worth while to recapitulate some of
t *interesting* particulars. Can you tell

me what are the essential properties of the alkalies ?

Charles. They may be volatilized : they are soluble in alcohol : and the compounds, which they form with carbonic acid and the oils, are soluble in water.

Tutor. What are the chief properties of the earths ?

James. They are fixed ;(*a*) insoluble in alcohol; and the compounds, which they make with carbonic acid and the oils, are insoluble in water.

Charles. Do not some of the earths agree with the alkalies in their taste, acridity, solubility in water, and in their effect on vegetable colours ?

Tutor. They do : these are barytes, strontian, and lime, as we have seen, and they are called alkaline earths : by some chemists they have been ranked as alkalies.

James. Are alumina, yttria, glucina, zirconia, and silica more properly earths ?

Tutor. They are, being tasteless, insoluble in water, and having no effect on vegetable colours.

Charles. What is become of magnesia in this arrangement ?

Tutor. That, says Dr. Thomson, is the link that unites the alkaline earths and earths proper together. Like the former, it tinges vegetable blues green ; and, like the earths proper, it is tasteless and insoluble in water.

James. What properties are common to the alkalies and earths ?

Tutor. They all combine with acids, except silica : they are incombustible, and incapable of combining with oxygen : they do not combine with metals, but have an affinity for several of the metallic oxydes.

CONVERSATION XXX.

Of Acids.

TUTOR. Do you know how *acids* tinguished?

Charles. They are, I believe, liquids cite the sensation of *sour* on the tongu is vinegar.

Tutor. It is not necessary that acid be in a liquid state, though they are gen that form; they are solid, liquid, or in t of gas.

James. I remember one of them is bonic acid gas; but what acid is there i state?

Tutor. There are several: such as t phoric acid, which exists in the form of c and the benzoic acid in fine beautiful flak

Charles. Is the taste of the campho sour?

Tutor. Rather a bitterish sour.

James. Of what is it composed?

Tutor. It is a combination of camp oxygen.

Charles. I recollect you told us before, that xygen was the principle of acidity.

Tutor. Almost all the acids consist of a cerin base united to oxygen, which is therefore onsidered as the cause of acidity; thus sulphur ombined with oxygen gives sulphuric acid.

James. Does oxygen itself possess acid proerties?

Tutor. It is not an acid, but the acidifiable rinciple; that is, by combining with certain subances it produces acids.

Charles. You said *almost* all the acids; what xceptions are there to the general rule?

Tutor. Sulphuretted hydrogen gas, which is combination of sulphur and hydrogen, without ny oxygen, has nevertheless all the properties an acid. There may be many other exceptons.

James. Does the combination of oxygen with substances produce acids as the results?

Tutor. No: oxygen combined with hydrogen l, as you have seen, give water; and, when ted to the metallic bodies, the results are les.(*a*)

mes. Is sulphuric acid sour, like strong gar?

tor. It would not be safe to taste it unless re very much diluted with water; and then uld give a sour sensation to the tongue.

rles. I believe there are other methods, t that of the taste, to distinguish an acid *ther substances.*

19*

Tutor. Yes: all acids change the *blue* vegetable colours to red.

James. What vegetable colours are used for this purpose?

Tutor. The syrups of violets, or of radishes, are very proper for the purpose; and on account of their properties, they are called *tests*. The tincture of litmus is perhaps the best of all chemical tests.(*a*)

Charles. What is this tincture?

Tutor. It is formed of a sort of moss, called archil, which grows among the rocks, and is of a most beautiful purple.

James. Why are these substances called tests?

Tutor. Because, by their means, we discover whether other substances are acids or alkalies. The acids change the *blues* to *red*; but the alkalies change them to *green*.

Another property of acids is, that they unite readily with water; and a third, that they combine with alkalies.

Charles. Is not the saline draught, which I have sometimes taken, an instance of the combination of the acid with an alkali?

Tutor. It is; the lemon juice is the acid, and the salt of tartar the alkali; by mixing them together in proper proportions, both the acid and alkaline properties are lost.

James. Acids then are known by their changing vegetable blues into red; by their union with water; and by their combining with alkalies.

. They combine also with most of the me-
ydes and the earths, and the compounds are
alts.

'*es.* Are these what are called *neutral*

. They are: though the term is fre-
confined to the combinations resulting
kalies and acids only.

s. What is meant by the word *neutral?*

. When substances, as an acid and alkali,
ed together, so as to disguise each other's
ies, they are said to neutralize one another;
compound, which is neither an acid nor
i, is called a neutral salt.

'*es.* How is the salt distinguished?

. By two terms or names: the one ex-
e of the particular acid made use of, and
r of the alkaline, earthy, or metallic base:
phates are neutral salts, composed of sul-
acid and some particular base: the sul-
f soda is a salt composed of sulphuric acid
a: muriate of soda is a compound of mu-
cid and soda.

s. Are there not sulphites and nitrites, as
sulphates and nitrates?

. Yes: the termination *ate* is employed,
e acid used is one of those which are com-
saturated with oxygen,* the names of
nd in *ic:* and the termination *ite* is used
e weaker acids are employed, and which,
one, have names ending in *ous.*

See vol. i, Conversation xiv.

Charles. Then sulphur*ic*, or nitr*ic*, or m
t*ic* acids, when combined with bases, give
ph*ates*, and nitr*ates*, and muri*ates*.

Tutor. They do: and sulphur*ous* and ni
acids give sulph*ites* and nitr*ites*.

James. Does every acid possess all the
perties which have been above described?

Tutor. No: But they all possess a suffi
number of them by which they may be disting
ed from other substances.

Charles. Are there many acids?

Tutor. A considerable number are enume
by chemists, who usually divide them into
classes: the *mineral*, which include the m
lic acids; the *vegetable*; and the *animal* a
they may be thus arranged:—

MINERAL AND METALLIC ACIDS.

Sulphuric,	Fluoric,	Molybdic,
Nitric,	Boracic,	Chromic,
Muriatic,	Arsenic,	Columbic.
Carbonic,	Tungstic,	

VEGETABLE ACIDS.

Acetic,	Citric,	Benzoic,
Oxalic,	Malic,	Prussic,
Tartaric,	Gallic,	Phosphoric.

ANIMAL ACIDS.

Phosphoric,	Benzoic,	Oxalic,
Sulphuric,	Uric,	Acetic,
Muriatic,	Rosaic,	Malic,
Carbonic,	Amniotic,	Lactic.

:s. I see that these acids are not all of
culiar to the separate classes.
. True ; the muriatic acid, which is rec-
nong the mineral acids, as a component
nuriate of soda, or common salt, is found
of the fluid animal substances. Benzoic
which is the result generally of a vege-
n, is discovered also in animal fluids.
. Is the division then into *mineral*,
', and *animal* acids a proper mode of clas-
t ?
. It has been rejected by many modern
, and by Dr. Thomson among others,
des the acids into three classes, which
1. Acid products ; 2. Acid supporters :
Combustibles. The acids belonging to
two classes have only a single base ;
e belonging to the third have commonly
iore bases.
:s. What is meant by acid *products ?*
. They are best described by their pro-
which are as follow : 1. They are form-
ombustion, and are themselves incombus-
They cannot be decomposed by heat
the intervention of a combustible body ;
xygen is an essential ingredient in them

. How many acids are there that are
ated acid products ?
. There are those which are formed of
phosphorus, and *carbon* ; but, as the first
stances can combine with two doses of

oxygen, the number may be reckoned five, *viz.* the sulphuric and sulphurous, the phosphoric and phosphorous, and the carbonic acids.

Charles. They are named then from their bases.

Tutor. They are. Besides these there are two others, the component parts of which are unknown: but which are named the *fluoric* and *boracic acids*, from the fluor spar, and borax, substances which contain them most abundantly. To-morrow we shall proceed to describe these acids more particularly; in the mean time, I hope you will not forget how acids are distinguished, whenever you may wish to examine the properties of any substance.

James. How shall I make the experiment?

Tutor. Here are two glasses, containing water tinged blue with the syrup of violets; to the one I add a drop or two of dilute sulphuric acid, which turns the blue to red; to the other I pour some solution of pure potass, which changes the blue colour to green.

Charles. Is that the only way of using the tests?

Tutor. No: you may stain some paper with the tincture of litmus, which, when dry, is a very good test; for upon this a little of any liquid may be dropped, and, if it contain an acid, it will change the colour instantly. Common writing paper, stained with the outside of the radish, or with an infusion of red cabbage, will answer the same purpose.

es. Red cabbages are easily to be had;
the infusion made ?

or. By pouring boiling water on some of ves sliced, and when cold it is fit for use. pour some of the infusion into three glass- will add to one an acid, to the second an and to the third a neutral salt; observe ference of the colours.

les. The first is a red, the second green, e third purple. What were the substances

r. The first was a few drops of dilute ric acid; the next was a solution of potass; other a solution of alum, which is a neu- lt, or a combination of alumina and sul- acid.

e is some tincture of litmus: I will add few drops of dilute muriatic acid; the is changed to a brilliant red. I will now to it a solution of potass, and the blue is estored.

es. Has the alkali destroyed the acid ?

r. It has: and by this method the colour liquor may be changed alternately from lue, and from blue to red at pleasure. The n of violets is the best test to discover alka- solution of potass will change the colour to if then diluted muriatic acid be added, the will become red. This experiment may ied at pleasure.

CONVERSATION XXXI.

Of the Sulphuric and Sulphurous Acids.

TUTOR. Sulphuric acid, which we are now to describe, is one of the most important articles in Chemistry: it was formerly called oil of vitriol, and even now is known more by that name, or by the name of vitriolic acid, than by sulphuric acid, which is its proper denomination. This glass bottle contains some of it.

James. Why was it called oil of vitriol; it has not the appearance of oil?

Tutor. To the touch it feels something like oil, and it pours from vessel to vessel like oily substances. It was formerly obtained from what is usuallly called vitriol, which is a compound of iron and sulphuric acid, and is now properly denominated a sulphate of iron.

James. I thought vitriol had been another name for copperas.

Tutor. In the arts they are frequently used as *synonymous* terms, because it is sometimes found *combined* with the oxyde of copper; but pr contains no copper, and therefore the opperas is evidently improper.

les. I think you told us, that the sulphuric a *compound* of sulphur and oxygen; why it in a fluid state?

r. Sulphur, as you have seen, burns with brilliant flame in oxygen gas: a union is rmed between the oxygen and the sul- out still in a state of gas; which gas must lensed with water.

s. Is it always combined with water?

r. It is; and in proportion to the smallness quantity is the excellence of the acid esti- To a certain degree the water may be off by distillation in a moderate heat; it is id to be *concentrated*. When concentra- nuch as possible, it is about twice as hea- vater.

les. In this state does it contain water?

r. In every hundred parts of concentrated ere are supposed to be 21 parts of water: portions are—

Sulphur	49
Oxygen	30
Water	21
	100

s. In what manner is this acid made?

r. On a small scale I can easily show you cess. I fill this glass jar with oxygen gas, ert it over a small quantity of water; then on the saucer within it I inflame some flo[wers of] sulphur, which burn with rapidity and [are con]verted into acid; this will be absorbed by th[e wa]ter.

Charles. How shall I know that it is an a[cid?]

Tutor. You may try it by means of the [test] described yesterday. Or take a small qu[antity] of it in a wine-glass, which you see is perf[ectly] clear: I will add a little of the solution of [ba]rytes or lime, which is also very transparent.

James. The mixture is now turbid.

Tutor. Yes: the acid precipitates the bary[tes,] which water of itself would not; this is a p[roof] that sulphuric acid was formed during the c[om]bustion, and united with the water.

Charles. Is oxygen gas absolutely neces[sary] in the experiment?

Tutor. No: if I had not oxygen gas alrea[dy] formed, I should have mixed the sulphur wi[th] some nitre, which contains oxygen gas, and th[e] experiment would have succeeded.

James. Is oxygen gas employed in places where this acid is manufactured on a large scale?

Tutor. No: the acid is procured by burning a mixture of nitre and sulphur in large chambers made for the purpose, lined with lead, and exposed to the atmosphere. The nitre supplies a proportion of oxygen, and the air of the atmosphere furnishes the rest.

Charles. Is water used to condense the gas?

Tutor. The floor of the chamber is covered with water, and, when it has imbibed as much acid as it will, it is drawn off, and concen- by distillation; an operation that can only sted to experienced persons.

es. As sulphuric acid is so much heavier ater, it must, I should think, be of a thick- sistence.

r. It is of an oily nature, as you will see, I pour it from one vessel to another: it is, heless, when pure, colourless as water, ransparent, and without any smell; but e is very penetrating, even after it is much with water. Here is a small quantity of in one glass, and about twice as much asure of sulphuric acid in another. They th of the common temperature of the at- ere.

rles. Yes; they appear cold.

r. I will suddenly mix them.

es. The glass is hotter than I can bear.

r. The bulk of the two bodies is less, now re mixed, than they were when separate, will account for the sudden evolution of Sulphuric acid, when highly concentrated, very great attraction for water, and will it rapidly from the atmosphere; hence been used as an hygrometer.*

rles. Is it ascertained how much the of this acid is increased by the attraction sture from the atmosphere?

r. This will depend on the strength of

ee Scientific Dialogues, vol. iv, p. 235—241.

the acid, and on the quantity of water in the air; but, in a single day, three ounces of sulphuric acid have imbibed an ounce of water.

James. Sulphuric acid and water mixed, cause heat: did you not formerly make use of this acid for a freezing mixture?

Tutor. Yes: four parts of ice, and one part of acid, cooled down to the same temperature of 32°, will produce a degree of cold as low as four degrees below zero; that is, 36 degrees below the freezing point.

Sulphuric acid is decomposed by the addition of any inflammable substance, as oil, sugar, charcoal, &c.

Experiment 1. If a piece of charcoal, made red hot, be immersed in some concentrated sulphuric acid, the acid will be decomposed, and part of its oxygen is attracted by the charcoal, forming carbonic acid, while part of the acid goes off in thick white fumes.

Ex. 2. Phosphorus, with the aid of heat, decomposes the sulphuric acid, by absorbing part of its oxygen.

Ex. 3. Bits of straw, as you shall see, become black in this acid.

James. They look as if they had been burnt.

Tutor. We shall find, that the constituent principles of vegetables are carbon, hydrogen, and oxygen. The hydrogen of the vegetable combines with the oxygen of the acid and leaves the straw in a carbonized state.

Charles. I see then that sulphuric acid an-wers to the definition of what you denominate a *acid product*; it is formed by the combustion f sulphur, which is a combustible, and oxygen, nd it is capable of being decomposed by a combustible substance and heat.

Tutor. If I throw a little of the acid in the fire ou will see it is incombustible. Here is a uantity of sulphuric acid diluted with water: if put into it some filings or shavings of iron or inc, you will perceive a violent action take lace.

James. Is that owing to a decomposition of the cid?

Tutor. No: the water, and not the acid is decomposed.

Charles. But water is a compound of hydron and oxygen.

Tutor. True: the hydrogen goes off in the m of gas, while the oxygen combines with the tal, which then becomes an oxyde of iron or c.

ames. Is the same effect produced with the r metals?

utor. Yes, in a small degree: which, how-, may be increased by the action of heat.

lphuric acid unites with all the alkalies and s, except silica, and with many of the metal-xydes, forming a peculiar kind of salts l *sulphates*. Thus a combination of barytes the sulphuric acid is called the sulphate rytes: the compound of sulphuric acid ne is a sulphate of lime: and the union of the oxyde of iron with this acid is called a phate of iron. We shall, hereafter, dev morning or two to the consideration of SAL

James. Is the sulphuric acid much used?

Tutor. It is employed in a variety of m factures, especially i dying: it is used in n cine and pharmacy, and on these accounts an object of considerable importance.

Charles. How is the sulphurous acid obtai

Tutor. By putting two parts, by weigh sulphuric acid and one of mercury into a retort, and applying to it the flame of an A lamp, the mixture effervesces, and throws gas, which may be received over mercury. gas is sulphurous acid. I will perform th periment.

James. The jar appears to contain no more than if filled with common air.

Tutor. Sulphurous acid, in a state of g colourless and invisible: but, if you were spire it by the mouth or nostrils, it wou highly injurious. It has a strong suffoc smell, like that emitted by the sulphur of m es, when lighted.

Charles. That, I know, is very disagree Does the sulphur, when burnt in the ope produce the sulphurous acid?

Tutor. It does, by combining with the o: of it: this acid is incapable of supporting bustion, as it is of animal life: it is about as heavy as atmospheric air?

James. How do you account for the formation of the sulphurous acid by means of the mercury?

Tutor. The mercury combines with part of the oxygen of the sulphuric acid; which, having lost a part of its oxygen, is converted into sulphurous acid.

In the experiment with the charcoal just now, the sulphuric acid, by parting with some of its oxygen, was reduced to sulphurous acid.

When phosphorus is used to decompose the sulphuric acid, part of the oxygen of the acid combines with the phosphorus, making phosphoric acid; and the sulphurous acid is driven off.

Charles. I understand this: the only difference between the two acids being the proportions of oxygen contained in them.

Tutor. Water absorbs this acid very greedily, and then it is called liquid sulphurous acid: in this state, if exposed to oxygen gas, or even to the atmosphere, it combines with the oxygen, and becomes sulphuric acid.

James. Is sulphurous acid much used in the manufactures?

Tutor. In a state of gas it is employed in destroying a number of vegetable and animal colours; and in bleaching wools, cottons, silk, &c.

Charles. Is it upon this principle that they burn pounded sulphur under newly manufactured worsted?

Tutor. Yes: as soon as it is well scoured, it is hung up in a close room, and under it is a charcoal fire, upon which sulphur is slowly

burnt; the fumes are a kind of sulphureous aci
By means of this acid various stains may be re
moved from linen or cotton clothes, if they a
first moistened with water. Silks, died of a li
or lilac colour, may, by an exposure to this ac
be changed to a beautiful flesh colour: it is a
cordingly used in colouring silk stockings.
red rose, on the contrary, will be changed by
to white, as may be seen by exposing one to th
fumes of lighted matches.

James. Does this acid combine with the earth
alkalies, and metallic oxydes?

Tutor. It does; and the compounds are ca
ed *sulphites*; thus we have the sulphite of p
tass, of barytes, &c. &c.

Charles. How are the sulphites formed?

Tutor. By passing the gas, as it proceeds fro
the materials, through the alkali, earth, &c.

CONVERSATION XXXII.

Of the Phosphoric and Phosphorous Acids. Of the Fluoric and Boracic Acids.

TUTOR. Phosphorus, saturated with oxygen, ns phosphor*ic* acid; and the phosphor*ous* l is phosphorus combined with a smaller por- of oxygen.

arles. How is the phosphoric acid formed ?

tor. There are many ways : the most ready s : simply to burn phosphorus in a glass re- r filled with oxygen gas. The phosphorus with rapidity and great brilliancy : a num- white flakes are deposited, which are ioric acid in a state of purity.

usual method of procuring this acid is to phosphorus, in small pieces, into hot ni- d. A violent effervescence takes place ; sphorus combines with the oxygen of the d the nitrous gas escapes.

. Is this the whole process ?

No : the liquid so obtained is to be ed to dryness, and afterwards heated in , to drive off all the water. It is ther solid, colourless, and transparent, and something like glass in appearance.

Charles. By what means do chemists evaporate liquids?

Tutor. Sometimes by exposing them to the air only, in shallow vessels: at other times, by placing the shallow vessel over a furnace called the *evaporating furnace*, which, notwithstanding its name, answers occasionally for digestion, distillation, and every operation that requires no greater heat than that of boiling water, as well as for the purposes of evaporation.

James. Of what parts does this furnace consist?

Tutor. I will describe it. Fig. 1. Plate I, vol. ii, represents a furnace of this kind: it consists chiefly of an ash-hole, *b*, and a place for fire, *a*; these are separated at *x* by a grate, which supports the fuel; the shallow vessel A is intended for the fluid that is to be evaporated, digested, or dissolved.

Charles. Is the vessel A placed immediately over the coals?

Tutor. It is sometimes: and in that case it is said to be operating with the naked fire; in other cases, a vessel of sand, or of water, is interposed between the fire and the saucer A, and then it is called a *sand* or a *water* bath. I will now describe another very useful furnace, called a portable furnace, Fig. 2, from the circumstance of its being easily moved from place to place.

ı. It is in the shape of a large crucible.

. It is a black-lead crucible, about a
ı, to the top of which is fitted the iron
; it is supported by an iron stand as H;
) the bottom is open, having a grate of
ch as F (Fig. 4.) The retort is sup-
ıy a sand pot, G (Fig. 5.)

es. What is the small hole at x for?

. It serves to give vent to the air, and
y the fire with fresh fuel. A chimney
wanted, be placed there. Fig. 6 shows
ı of the furnace, and explains the mode
tion at once.

. Can this be used as a water-bath,
as with sand?

. Certainly: by filling the pot G with
ıstead of sand. If an open vessel, instead
ırt, is used, this furnace is well adapted
xydation of metals.

. Is phosphoric acid always in a solid

. No: it is soluble in water, and makes
; noise during the solution, like that of
plunged in water. In a liquid state it
ıick oily appearance; it reddens vegeta-
s; it has no smell, but has a very acid

es. Does it combine with the alkalies?

. Yes, and with the earths and metallic
forming salts, known by the name of
tes: thus, phosphoric acid, combined

with barytes, soda, &c., forms phosphates of barytes, soda, &c.

James. Is it known what are the proportions of phosphorus and oxygen in the phosphoric acid?

Tutor. About forty parts of phosphorus and sixty parts of oxygen.

Experiment. Phosphoric acid and silica, when mixed together, and exposed to a strong heat, melt into a transparent glass, which neither acids nor alkalies can decompose.

James. To what purposes is the phosphoric acid applied?

Tutor. It is too expensive to be generally useful; but, if it could be procured at a cheap rate, it might be advantageously employed in several manufactures.

Charles. How is the phosphor*ous* acid prepared?

Tutor. By exposing phosphorus to the atmosphere for some time, it undergoes a slow combustion, and gradually becomes a liquid acid, which is viscous, and adheres to the sides of a glass vessel like oil.

James. Can this be obtained in a solid state?

Tutor. It readily combines with water, but cannot be obtained in flakes, or solid. It emits a strong smell of garlic; it has an acid taste, and produces the same effect on vegetable colours as phosphoric acid. It combines readily with the earths, alkalies, and metallic oxydes,

›rming with them *phosphites;* hence we have ıe phosphites of lime, iron, alumina, &c.

Charles. Does the same analogy then exist ith regard to the sulphuric and phosphoric cids, and their combinations?

Tutor. There does; carbonic acid also forms, ith the alkalies, earths, and some of the me-allic oxydes, carbonates. But of this we have lready spoken; we shall, therefore, proceed o the *fluoric* acid.

James. I think you said the composition of his was not known?

Tutor. I did: it is not certainly known; but ir Humphrey Davy, from experiments, con-luded, that it is a compound of oxygen with a ombustible base. In submitting it to electrici-y he found, at the negative pole, a gas evolved, hich, from its inflammability, appeared to be ydrogen.(*a*)

Charles. How is the fluoric acid obtained?

Tutor. It may be readily obtained from fluor r; or, as it is usually called, Derbyshire r.

harles. Do you mean that substance of which white candlesticks are made?

utor. Yes: it is formed into a variety of mental things; and it is composed of an called fluoric acid and lime. It is, there-technically denominated fluate of lime.

nes. How is it obtained?

or. By adding to the powdered spar, in *en retort,* an equal quantity of sulphuric acid, and applying to the retort a gentle heat. The sulphuric acid, having a stronger affinity to the lime than the fluoric, expels it, and unites with the lime; the fluoric acid comes over in the form of gas, which must be preserved in leaden vessels, or in glass coated with wax.

Charles. Will not the result be fluoric acid and sulphate of lime?

Tutor. Certainly. This acid is invisible and elastic, like the atmospheric air; it will not sustain combustion nor animal life. It has a pungent smell, is heavier than common air, and corrodes the skin very quickly.

James. Why are leaden vessels used?

Tutor. Because this acid has the singular property of corroding glass; so that no vessels made of that substance can withstand its effects. Hence it is applied to etching landscapes, and other figures on glass.

Charles. How is that done?

Tutor. By covering the glass with wax, and then by tracing the figures in the wax with instruments like those used by engravers. The glass, in this state, is exposed to the acid, either in gas or in a liquid state.

James. How is it obtained in a liquid form?

Tutor. The gas absorbs water greedily, and the compound is an acid heavier than water, and that has the property of turning vegetable blues to red. In this state, the acid will not freeze in a temperature higher than 9° below the freezing point.

Charles. Does it combine with any other rth besides lime ?

Tutor. Yes, with all the earths, alkalies, and tallic oxydes, forming with them salts, called *ates* ; thus we have the fluate of potass, magsia, &c. as well as the fluate of lime, or comn fluor spar.

James. Is the boracic acid of a similar nature the fluoric ?

Tutor. It is so far similar that its component rts are unknown ;(*a*) and it is obtained from rax, a species of white salt much used by artists soldering metals, and for other purposes.

Charles. How is the acid obtained ?

James. Dissolve the borax in hot water, and r the solutions ; add half of its weight of did sulphuric acid. Evaporate the solution a ; and, on cooling, a number of shining cryswill be formed, that are boracic acid in a solid ; they have no smell, but very little taste, edden vegetable blues.

nes. Can it be dissolved in water ?

tor. Yes, in about twelve times its weight. oluble in alcohol, and paper, dipped in the n, burns in it with a beautiful green flame. bines with the earths, alkalies, &c. formates, of which the common borax is the of soda.

stions and other Exercises, on the several Conversations in the foregoing Volume.

CONVERSATION I.

what respects are Chemistry and Natural Philosophy ected?
hat were formerly denominated the first elements?
what is the atmospheric air compounded?
hat is meant by gases?
'hat are the properties common to these gases?
hat is meant by simple bodies?
it possible to ascertain whether any particular body , or may not, be made up of others that are more le?
ɔw does Dr. Thomson arrange the simple substances?
hat are the classes of confinable bodies?
hat are the unconfinable bodies?
hat is observable in the combustion of wood and coal?
hat name do chemists give to red lead, and of what is mposed?
hat is the chemical name of the diamond?
hat is the distinction between charcoal and carbon?

CONVERSATION II.

*pe*at the definition of Chemistry.
*ia*t is the object of Chemistry, and with what is it con- *d* ?
t is meant by the terms analysis and synthesis?
hat is cinnabar composed?

Explain the distinction between simple and complex analysis.

How is Epsom salt analysed, and of what other substances is it composed?

What apparatus is necessary to perform the fundamental experiments in Chemistry?

What qualifications are requisite in a chemist?

Give me an instance or two, to illustrate the importance of Chemistry in the arts of life.

Of what other uses is the science of Chemistry?

CONVERSATION III.

How are the terms attraction and affinity distinguished?

What is meant by attraction of aggregation?

In what does this differ from attraction of cohesion?

Point out the difference between the aggregate, the heap, and the mixture.

How many kinds of aggregation are there?

Can all these be exhibited in any particular substances?

How is the attraction of aggregation destroyed, and what is the consequence of it?

What is the chemical name of Derbyshire spar, and how is it decomposed?

What escapes during the decomposition, and what remains after the decomposition?

How is the force of attraction of aggregation estimated?

How is it measured?

How does heat overcome the attraction of aggregation?

Give me an instance of crystallization.

CONVERSATION IV.

What do you mean by attraction of composition?

What very useful substance is formed upon this principle?

In what respects does glass differ from the substances of which it is formed?

Of what is the sulphuret of mercury compounded, and in what respects does it differ from its component parts?

What do you mean when you say two substances are chemically united?

What is alcohol?

How is gypsum formed, and by what other names is it ɔwn?
Vhat is the chemical name of sal ammoniac?
How would you make a smelling bottle?
What two pungent substances, by mixture, lose their ell?
What two fluid substances, by mixing, will produce a id?
What solid substances, by being rubbed together, will oduce a fluid?
Can you explain the meaning of the word saturated?
Will fluids, as water, dissolve any indefinite quantity of a id substance, as salt or sugar?

CONVERSATION V.

Jpon what principle does the attraction of composition ?
Of what is Glauber's salt formed, and by what other name t called in Chemistry?
Explain the difference between attraction of aggregation l attraction of composition.
What is meant by the word concentrated?
What is the second law of attraction of composition?
By what experiments is it illustrated?
What is the third law of this kind of attraction?
How is it illustrated?
What compound metal will melt in boiling water?
What is the fourth law of attraction of composition?
How is it illustrated?
s heat generally necessary to bring bodies into a state of *m* ?
*h*at is the fifth law?
w is it known that there is a change of temperature union of different bodies?
at experiments are mentioned in proof of this law?
he temperature ever lowered by chemical attraction?

CONVERSATION VI.

at is the sixth law of chemical affinity, and how is it *d* ?

In what respects does sulphate of potass differ from its component parts?

Of what is muriate of ammonia compounded?

Of what is the sulphuret of potass formed?

Of what is corrosive sublimate formed, and in what does it differ from its component parts?

What fluids, mixed together, will give a solid as a product?

What is the seventh law of attraction of composition?

What is the muriate of barytes?

What two clear fluids, by union, become, in appearance, thick like cream?

How is this phenomenon explained?

What experiments are mentioned to illustrate this law?

What is the eighth law of attraction of composition?

What two bodies, being chemically united, the specific gravity of the compound is different from the mean specific gravity of the component parts?

What is the reason, that a pint of water and a pint of alcohol, when mixed together, do not make a quart?

Give me an instance in which chemical affinity is capable of uniting two or more substances to a certain extent, and tell me the reason of it.

CONVERSATION VII.

What do you mean by simple affinity?

If nitric acid is poured into some muriate of soda, what will happen, and how is the fact explained?

What will be the result of a mixture of sulphuric acid and nitrate of soda?

Explain to me the specimen of a table of affinity.

How is a table of this kind practically applicable?

Look at the table, and tell me, whether muriate of soda can be decomposed by the sulphuric, nitric, and sebacic acids?

Can the sulphate of soda be decomposed by any of the acids?

How should I decompose the sulphate of potass?

Upon what principle are tables of affinity formed?

How is the force of affinity between an acid and a base *estimated?*

ıat is compound affinity, and what experiment is men
d to illustrate it?
ıy cannot sulphate of ammonia be decomposed by
cids?
ɔk to the figure (page 51,) and explain the nature of
ind of attraction.
what practical purpose is this method of double de-
osition applied?
w is it explained, that concentrated nitric acid has no
on iron, unless it be diluted with water?
olutions of nitrate of silver and muriate of lime be
l, what new substance will be formed?
at should the register of an experiment express?
at do you mean by the term menstruum?
ɔk at the diagram, in page 49, and explain its meaning.
the same with regard to the six following ones, pages

CONVERSATION VIII.

ıt is the natural effect of attraction upon the parts of
?
t is the principal agent employed to counteract this
ɔn?
effect is produced when the attraction prevails;
t when caloric is most powerful?
is the mean between the two?
familiar instance, in which one substance is in all
es.
eat exist in all bodies?
e this by an example.
coldness defined?
heat, or caloric, and in what state does it exist?
meant by caloric in a state of combination?
free caloric?
instrument is free caloric measured?
ıis subject illustrated with regard to fuel?
a general principle in nature?
e law given by Dr. Black on this subject?

CONVERSATION IX.

How is caloric defined?

Can it be had separate from other bodies?

What is meant by taking away caloric?

How is this explained with regard to the cooling bodies?

What is shown by the thermometer?

What is the cause of bodies in the same room, and in the same temperature, appearing, to the touch, some warm and others cold?

Of what is the thermometer a measure?

Explain this by an example.

What is Dr. Black's theory on the subject?

Explain the meaning of the word capacity.

What is Dr. Black's first inference on this subject?

What the second?

Why do we experience most cold in windy weather, equal temperatures of the air?

How is it known, that the thermometer is not affected by the wind?

In what situations are we liable to take cold?

What is Dr. Black's third inference?

By what instance is this illustrated?

Why are spongy bodies longer in heating and in cooling than those which are more dense?

Why are furs used in cold countries?

How is it proved, that flannels, &c. do not add heat to the body?

Why is snow beneficial to the ground?

What degree of cold has been experienced in some parts of Siberia?

CONVERSATION X.

In what state are bodies most, and in what least expanded?

Mention the experiments on this subject.

By what proportion do fluids expand?

What limits are there to the regular expansion of fluids

What is the cause of vessels filled with fluids bursting by frost?

Upon what does the contraction of the Wedgewood thermometer depend?

What is meant by latent heat?

Explain this by an instance.

Will the mercury of a thermometer rise while in ice, till it is all melted, although the vessel be immersed in boiling water?

What experiment is that of Dr. Black's on a lump of ice?

What is the cause of fluidity?

Why are ice and snow long in melting?

Explain the structure of an ice house, and the reason of the construction.

How is it proved, that ice absorbs heat from surrounding bodies?

Why does the hand, brought near a large lump of ice, suspended in a room, feel the sensation of cold?

What effect does caloric produce on ice and snow?

What is Dr. Black's experiment on this subject?

CONVERSATION XI.

How is it proved, that caloric is separated from liquid odies when they return to a solid state?

What experiments prove that bodies, passing from the uid to the aeriform state, absorb heat?

Upon what do the different degrees of heat of the boiling point of water depend?

How is water made hotter than 212°?

How are liquids cooled down in warm countries, and ow is the fact accounted for?

What is the reason that wet linen will freeze when the ometer is above the freezing point?

what benefit is perspiration to the human body?

what proportion does water, in a state of steam, con- more caloric than when in a liquid boiling state?

w are cream ices made, and what is the theory to ac- for the operation?

What means is mercury artificially frozen?

CONVERSATION XII.

Look to the figures and explain the uses of the retorts.
For what purposes is the pneumatic apparatus used?
In what respects do steam and permanently elastic fluids differ?
How is oxygen gas, or any other elastic fluid, transferred from one vessel to another?
Explain the experiment of the burning of iron.
What remains after the combustion?
Can most of the metals be burnt in oxygen gas?
Tell me the use of the tube c. in Fig. 4.
Of what is water composed?
Why is quicksilver used in some cases instead of water?
What is a sand bath?

CONVERSATION XIII.

Can oxygen ever be had separate from other bodies?
Mention some instances to prove that it is an important agent in nature.
Of what is oxygen gas composed?
Is oxygen necessary to combustion, and in the process what becomes of it?
What do you mean by oxygenation?
From what substances can oxygen gas be procured?
How is it procured from vegetables?
In the combustion of iron, does the remaining oxyde weigh as much as the metal and gas did separately?
What appearance does zinc, burning in oxygen gas put on?
Mention some other experiments made in this gas.

CONVERSATION XIV.

How many degrees of oxygenation are there?
Explain the table, p. 97.
What do you mean by the oxyde of sulphur?
Of what are the sulphurous and the sulphuric acids *formed?*
Explain what is meant by the terminations of ic and ous.

Do all substances admit of similar degrees of oxygenation?

Explain this by instances.

What do the different coloured oxydes denote?

Do the colours vary in the same way with regard to all metals?

What are the chief properties of oxygen?

Where does it exist in a state of nature?

What natural means are there of renewing the oxygen of the atmosphere?

What effect has light on vegetation?

What is the specific gravity of oxygen gas?

By what is oxygen gas peculiarly characterized?

CONVERSATION XV.

What other substances enter into the composition of the atmosphere?

Can azote be obtained alone?

Is it found in many substances?

What are its properties?

What are the proportions of oxygen gas and azotic gas in the atmosphere?

What experiment will show the difference between oxygen gas, common air, and azotic gas?

From what is azotic gas obtained?

What is the process, when obtained from sulphuret of potass?

What other substances will yield azotic gas?

Of what are animal substances chiefly composed?

How is the azote obtained from them?

Explain the combinations made with azote in the table.

By what properties is azotic gas distinguished from the other gas?

Is it known whether it be or be not a compound?

CONVERSATION XVI.

From what does hydrogen derive its name?

What was hydrogen gas formerly called?

Is this generally diffused in nature?

What [illegible] chief properties of hydrogen gas?
To w[illegible]se has it been applied, on account of its great lig[illegible]
Will [illegible]n animal life?
From [illegible]l it derive its name, inflammable air?
Will [illegible]thout the aid of atmospheric air?
What effects are produced by the inflammation of hydrogen gas with oxygen gas?
How are miniature balloons formed with this gas?
From wha[illegible]hydrogen gas obtained?
How is it [illegible]ined in a state of nature?
From what doe[illegible]s obtained from ponds in hot weather?
How is water de[illegible]?
What is the consequence o[illegible]ness of hydrogen gas?
What do you [illegible]hical candle?
How are the [illegible]nstructed?
What curious p[illegible]d of hydrogen gas?
By what experi[illegible]?

CON[illegible] XVII.

Is sulphur a simple or a compound body?
To what purposes has it been long applied?
In what state is it naturally found?
In what fluids is sulphur soluble?
What is meant by the term sulphurets?
What is meant by flowers of sulphur?
How are sulphur casts made?
What are the combinations of sulphur?
What is the liver of sulphur, and why was it so called?
How does sulphur burn in oxygen gas?
Why are some bodies more combustible than others?
For what is sulphur used?
Where is it chiefly found?

CONVERSATION XVIII.

From what is phosphorus chiefly obtained?
In what other substances is phosphorus found?
Why is phosphorus kept in water?

At what temperature does it take fire?
What are the fumes which are produced by the combustion of phosphorus in oxygen gas?
Explain, by Fig. 13, how this process is conducted on a large scale.
What are the combinations of phosphorus?
How is phosphorus made into rolls?
Will phosphorus inflame by friction?
How are the phosphoric bottles made?

CONVERSATION XIX.

What is the distinction between carbon and charcoal?
What is carbon?
How has the diamond been found to be combustible?
When diamond is burnt in oxygen gas, what is the result?
Can you explain how charcoal can be reckoned a compound of carbon and oxygen?
With what substances will carbon unite?
What is black-lead, and of what is it composed?
Why are black-lead crucibles used when a great heat is wanted?
Why is wood, that is fixed in the ground, charred?
To what purposes is charcoal applied?
How is charcoal made?
Why is charcoal used in hardening iron?
Can the same thing be done with the diamond?
How do you prove that charcoal absorbs moisture?

CONVERSATION XX.

Explain what is meant by combustion?
With what is combustion attended?
In combustion, are the substances consumed?
In regard to this subject, how are bodies distinguished?
What things are to be accounted for in combustion?
What is necessary in the process of combustion?
Explain the diagram, p. 135.
How is it known that light exists in combustible bodies?
Explain the theory of combustion?

Into what classes does Dr. Thomson divide all bo with regard to combustion?
What do you mean by supporters?
Which is the only simple supporter known?
Does oxygen burn?
Can incombustibles combine with oxygen?
Of what are the compound supporters formed?
What is the principle common to them all?
Do you understand the table, page 139?
Into how many kinds are combustibles divided?
Which are the simple combustibles?
Of what are the compound combustibles formed, how are they denominated?
What is the general term used for the new substi formed by combustion?
What are these products necessarily?
Do you recollect an instance of each?
Explain now what is meant by simple substances.
What are the four axioms relating to combustion?

CONVERSATION XXI.

What are the chief properties of carbonic acid gas?
Where is it found?
How is this transferred from one vessel to another?
What experiment proves that carbonic acid is hea than the common air?
How is this gas procured artificially?
What are the component parts of marble?
What do you mean by sulphate of lime?
Explain the meaning of the word *sulphate*.
How is it known that carbonic acid gas escapes in mentation?
For what purposes is this gas used?
What is the characteristic of good lime?
Why is carbonic acid gas nutritive to plants?
With what liquids is this found combined?
How is the suffocating property of this gas exhibited
To what purpose has this property of the gas been *plied?*
Does this gas exhibit acid properties?

What experiments prove this?
Of what is carbonate of lime composed?
What are the general properties of the carbonates?
What are the chief properties of carbonic acid gas?

CONVERSATION XXII.

Of what does the atmospheric air consist, and in what roportions?
What other substances are there in the air beside azotic nd oxygen gases?
How can the carbonic acid gas be separated from the air?
What is the white scum found on lime-water after it is xposed to carbonic acid gas?
How is the oxygen separated from the azotic gas?
What is the quantity of carbonic acid gas in the atmoshere?
Upon what does the salubrity of the air depend?
How is that ascertained?
How is nitrous gas obtained?
What are the properties of this gas?
Which is the most important property?
How is the salubrity of the air found out by a eumeter?
n the experiment with the eudiometer, what is the red our?
hat occasions the warmth in the tube?
hat other means are there of showing the purity of dift gases?
hat is a principal property of the sulphuret of potass?
at is Sir Humphrey Davy's eudiometer?
lain this by Fig. 15.
here any great variation with regard to the purity of in different places?
s the proportion of oxygen in the atmosphere fluc-

CONVERSATION XXIII.

is the light carbonated hydrogen gas, and what are *ties?*

Where is it found naturally, and how is it produced artificially?

Why is it denominated *light*?

What combinations are there of hydrogen gas, and how are they produced?

What is that called which was formerly denominated *hepatic* gas, and what are its chief properties?

What are the properties of the phosphorated hydrogen gas, and how is it obtained?

What are the ignes fatui, which are sometimes seen in marshy places?

What is meant by the gaseous oxyde of azote?

What are its properties?

From what substance is it obtained, and of what is it composed?

By what means is this or any other gas breathed?

CONVERSATION XXIV.

Of what is water composed?

Explain, by Fig. 19, the nature of the distillation of water.

What is put into the tube, in order to decompose the water?

What becomes of the charcoal?

What are the combinations formed by this experiment, and of what are they composed?

Of what do a hundred grains of carbonic acid gas consist?

Can the experiment be made with any thing else than charcoal?

How is the experiment explained when iron filings are used?

CONVERSATION XXV.

In order to form water of the gases, how are they brought into a state of combination?

Will you endeavour to explain the nature of the experiment, by means of Fig. 20.

Why do not the gases explode?

What is the combustion of hydrogen?

How is the purity of hydrogen gas found?
In this experiment, how are the gases obtained in a state of dryness?

CONVERSATION XXVI.

How many alkalies are there, and how are they denominated?
From whence is the general term derived?
What are the properties belonging to the alkalies?
Which are the fixed, and which the volatile alkali, and whence were they thus named?
How is potass obtained?
What are its properties?
What is the distinction between potass and the potash of the shops?
For what is potass used?
How is the sulphuret of potass formed, and what was it originally called?
Of what is soda formed?
What is there remarkable with regard to some of the plants that yield potass?
Is soda naturally obtained, and where?
What is the reason of the distinction *vegetable* and *mineral alkali*?
What are the properties of soda?
How is soap made?
What is the difference between hard and soft soap?
With what is soap coloured?
How would you make soap on a small scale?
To what purpose has woollen cloth been applied?
What is the test for estimating the qualities of water?
What is the cause of the hardness in water?
What is the distinguishing property of soft water?
What is ammonia?
How does it subsist in its purest form?
What is liquid ammonia?
From what is ammonia obtained?
Is ammonia greedy of water?
What substances will combine with ammonia?
Of what is the muriate of ammonia formed?

How is it glazed?
By what means are the different colours put on
Is alumina used in dying?
What is fuller's earth, and for what is it used?
What other property is there belonging to alumi
In what state, and where, is yttria found?
What is the specific gravity of yttria, and for wh
be used?
Describe the earth glucina.
Tell me where jargon is found, and what are it
ties?
From what is silica obtained, and how is it ob
the state of an earth?
What are the properties of silica, and to what u
applied?
Of what are the different kinds of glass formed
What are the properties of good glass?
What are the principal properties of the alkalie
What are the chief properties of the earths?
In what do some of the earths and alkalies agr
How is magnesia described?
What properties are common to the alkalies an

CONVERSATION XXX.

How are acids distinguished?
What acid is in a state of gas, and what in a sol
Of what is camphoric acid composed?
What is the cause of acidity?
What exception is there to the general rule?
What are the tests of acids?
Which is best, and of what is it made?
How are acids known?
What is meant by the term neutral salts?
How are salts distinguished?
What are sulphates?
Tell me the distinction between the salts, who
end in ate, and those ending in *ite*.
How are the acids usually divided?
Is this a proper mode of classification?
What are the properties of acid products?

h are the acid products, and from what are they
,

hat experiment can I know whether a substance is
?

CONVERSATION XXXI.

other names are there to the sulphuric acid?
was it called oil of vitriol?
has vitriol been called copperas?
hat is sulphuric acid composed?
are the proportions of the component parts?
is sulphuric acid discovered in a solution?
is the sulphuric acid obtained on a large scale?
is the result of mixing the sulphuric acid and water?
this acid attract the water?
is it decomposed, and what are the experiments on
ect?
do pieces of straw become black by being dipped
cid?
this acid answer to the definition of an acid product?
is the violent action accounted for, when metal
re thrown into diluted sulphuric acid?
what does this acid unite, and what is the general
the compounds?
hat purposes is this acid used?
is the sulphurous acid obtained, and what are its
es?
is the theory to account for the formation of sul-
acid?
hat is this acid used?
what substances does it combine?

CONVERSATION XXXII.

is the phosphoric acid formed?
in the construction of an evaporating furnace.
phosphoric acid always in a solid state?
what substances does it combine?
hat *proportions* are the phosphorus and oxygen in
?

In what does the phosphorous differ from phosphoric acid?

With what substance does the phosphorous acid combine?

From what, and how, is the fluoric acid obtained?

What are the properties of this acid?

To what purpose in the arts is this acid applied?

How is it obtained in a liquid form?

Does it combine with other substances beside lime?

From whence is the boracic acid obtained, and what are its properties?

What is borax?

AMERICA

Page 7. (a) T
riatic acids
many of the be
are regarded
with a peculiar
latter, with chl
Page 8. (a)
wood or coal.
given out pro
Page 9. (a
oxide of carb
other foreig
Page 10.
ties as we
their comp
chemistry,
science wh
the agenc
tions ar
Page 1
such val
This to t
synthesis
Page
tion tha
position

NOTES,

BY AN

?AN PROFESSOR OF CHEMISTRY.

) The existence of oxygen in the fluoric and ls is very questionable. In the opinion of best chemists of the present time, those acids as compounds of hydrogen; the former, ar principle, denominated *fluorine;* and the *lorine*. See note, page 241.

) As air is essential to this process, as well as , we are not to infer that the light and caloric ceed entirely from the burning substance.

) Charcoal is scarcely to be considered as an on. When freed entirely from moisture, and substances, it is pure carbon.

z) This definition is rather defective, as it ap- to the mechanical properties of bodies as to ition and chemical relations. The definition of en by Dr. Murray, is more appropriate: "The i investigates the combinations of matter, and of those general forces whence these combi- tablished or subverted."

) Chemistry may be *studied* as a science, and e information obtained, merely from books. *ractice* of chemistry only that analysis and ly as methods of inquiry.

a) It would require a more extended opera- *one here* described to *demonstrate* the com- *uber's* salt.

age 29. (*a*) This furnishes an example of *precipit*...
en a solid substance is separated from a fluid, in wh...
as dissolved by the addition of another substance, it
to be *precipitated*, and the substance added is call...
re-agent.

age 31. (*a*) This law is, nevertheless, expressed i...
is rather too positive. The experiment with quick...
and sal ammoniac, mentioned in page 23, affords a...
ence of chemical action, independent of solutio...
er instances might be named.

age 35. (*a*) The oxygen, in uniting with the lead, quit...
aseous form, and becomes solid; hence red lead i...
pound of lead and *oxygen*.

age 38. (*a*) Every chemical fact affords an eviden...
ie existence of this law. A right comprehension of it
nt constitutes the basis of chemical knowledge, and
is to the reflecting mind a view of Nature and of Pro-
nce, that can hardly fail to excite the highest degree of
ght and admiration.

age 40. (*a*) The opinion that the natural and direct
ency of affinity is, to unite bodies in definite propor-
s, appears evidently to be gaining ground among che-
s. This doctrine is supported by a great number of
ortant and interesting facts. Its final establishment,
ver effected, will go farther to reduce the science of
nistry to exact and intelligible principles, than any re-
which has lately been obtained.

age 55. (*a*) There are many substances which appear
gether incapable of undergoing a change from a solid
liquid or a gaseous state, without a subversion of
e affinities which retain their elements in that bond of
n which gave rise to their particular properties. This
ue with respect to many substances in the vegetable
animal kingdoms. Wood, for instance, cannot be
ed, nor will caloric act upon it to any considerable
nt, without destroying it as wood.

age 56. (*a*) The young reader must be again cautioned
nst *the conclusion*, that the heat which we feel from
ire is derived entirely from the fuel. This will be ex-
d further on.

62. (*a*) It has been ascertained, since the time of

Dr. Black, th...
body, or issu...
ture of its sur...
of the surfac...
city of absorb...
in the text
owance.

Page 66.
Mercury fre...
Fahrenheit.

Page 69.
ther the mo...
rtained b...
ood at st...
, there
al law ...
probabi...
aration ...
ive attr...
tly inc...
cting b...
highly i...
pon its ...
he arts of
most indis...

Page 9...
he purpo...
found to
water wi...

Page ...
Chemist...
the term...
Thus th...
roxide,
highest
the deu...
that m...
highest
terms ...

Pa...
mon...

, that the celerity with which heat enters into a issues from it, depends very much upon the na- surface. Slight changes in the colour or texture face, produce very obvious changes in its capa- sorbing or radiating caloric. The position stated xt must, therefore, be received with great al-

5. (*a*) This is probably a typographical error. freezes at a higher temperature than —42° of it. It is commonly stated at —39.

9. (*a*) The contraction of clay continues long moisture has been expelled, as is pretty well as- by weighing the thermometric pieces of wedg- successive periods during their ignition. Clay refore, be considered as an exception to the ge- of expansion by heat. Its contraction arises, in bility, from such a change produced in the con- of its particles by caloric, as occasions the co- raction between them to exert itself with a con- creasing force. This property of clay, of con- by heat, instead of expanding as other bodies do, interesting to the welfare of civilized man; for consolidation and hardening in the fire depend f pottery, brick making, &c.; arts which are al- spensable to human convenience.

3. (*a*) Leaves, of almost any kind, will answer se, but pump or well water will generally be succeed better than pure rain water. Distilled l yield but a very small quantity of gas.

7. (*a*) Dr. Thomson, in his valuable System of y, designates the different oxides, by prefixing to oxide, syllables derived from the Greek numerals. words protoxide, deutoxide, tritoxide, and pe- re used to express the first, second, third, and legree of oxygenizement of any substance: Ex. xide of lead would denote the second oxide of l, the peroxide of mercury would indicate the tate of oxygenizement of quicksilver. These ll probably come into general use. Vol. 2, p. 55.

02. (*a*) Azote, or nitrogen, is by no means a com- edient in vegetable matter. It occurs generally

in animal substances; and its presence in them serves in some measure, as characteristic of their nature.

Page 110. (*a*) It is not necessary to apply heat to the retort. The better way is, to pour water on the filings, and then to add the acid, till the effervescence and heat become considerable

Page 111. (*a*) This air is not pure hydrogen. It always contains a portion of carbon.

Page 119. (*a*) The light is generally of a beautiful blue tint, but not so brilliant or dazzling as that produced by some other combustibles.

Page 121. (*a*) There is no danger of its inflaming by the heat of the hand, if friction be carefully avoided.

Page 126. (*a*) See note, (*a*) page 9.

Page 128. (*a*) The existence of oxygen in charcoal has been satisfactorily disproved by the experiments of Allen and Pepys, who ascertained that when equal quantities of *well prepared* charcoal and of diamond were burned in oxygen gas *equal quantities of carbonic acid were produced*. There must, therefore, have been some fallacy in the experiment which gave 36 parts of oxygen in 100 of charcoal.

Page 130. (*a*) An excellent dentrifice may be prepared by pulverizing together, in a common mortar, a piece of charcoal and a lump of chalk, and sifting the mixed powder through muslin.

Page 140. (*a*) There is, at least, one exception to this. Oxygen combines with carbon in a certain proportion forming carbonous oxide, which is neither acid nor metallic.

Page 141. (*a*) That oxygen is not the only supporter of combustion is now the opinion of many of the most distinguished chemists of Europe and America. Further notice will be taken of this subject in a future page.

Page 149. (*a*) It is this gas which collects in wells that remain for some time covered, and which has, in so many instances, proved fatal to those who have attempted to descend for the purpose of cleaning the well, or performing some other operation at the bottom. It is always dangerous to descend a well, or vault, or even a deep cellar, that has been long closed up, without the precaution of letting down a lighted candle. If the candle burn with its al brightness, no danger need be apprehended; but if urn feebly, or go out, the danger is great. By leaving se cavities open for some time, the carbonic acid gra-lly mingles with the atmosphere, and safety is restored. nore expeditious mode of cleansing them of the dele-ous gas, is to let down a quantity of newly slaked lime, a tub or bucket. The lime rapidly absorbs the acid , the place of which is immediately supplied by the at-sphere.

'age 153. It is surprising how such an error as this uld have found its way into these pages, especially as fact is stated further on, that no sensible variation in relative quantities of oxygen and azote have been nd in the air of different countries. As far as experi-nt has gone, the quantity of oxygen in the air is always same, in all countries, at all seasons, and under all nges of temperature, moisture, &c. Hence the "salu-y of the air we breathe" depends upon changes with ich we are not yet acquainted, and not upon any varia-1 in the quantity of oxygen it contains.

'age 157. (*a*) By the term "purity," here used, are we understand salubrity, or healthiness? It will surely not denied, that some countries and situations are more lthy than others. The miasma, or noxious effluvia, ich is regarded as the cause of sickly seasons and places, f so subtle a nature as to have hitherto eluded chemical estigation.

'age 160. (*a*) There is a singular omission in this expe-ent. Diluted sulphuric, or muriatic acid, must be led to the powder in the bottle.

'age 161. (*a*) This is merely conjecture.

'age 163. (*a*) If proper care be taken in preparing this , it need not stand so long over water. It may be used h safety in one hour.

'age 215. (*a*) Zircon is found in several places in the ited States, particularly in a crystallized form, embedded granite, on the margin of the Delaware river, near enton bridge.

'age 218. (*a*) The terms *fixed* and *volatile*, as applied to *e substances*, must be considered as indicating only *ive degrees* of cohesive attraction, and, of course, fusibility by heat. They are none of them absolutely fixed, i. e. they may all be fused by the application of a heat sufficiently intense.

Page 221. (a) There are a few metallic bases which form acids with oxygen.

Page 222. (a) A better test than either of those mentioned, is an infusion of the red or blue cabbage used for pickling. If hot water be poured on the sliced leaves of this cabbage, a blue liquor is obtained, which, when fresh, is an extremely delicate test of acids.

Page 241. (a) The more recent views of Sir H. Davy and others, assign to this acid a peculiar composition. It is regarded as a compound of hydrogen, and a principle which acts the part of an acidifier, and which is found only in the fluates. It is accordingly denominated *fluorine*.

Page 243. Boracic acid is considered at the present time as a compound of oxygen, and a peculiar substance obtained by treating the acid with potassium. This substance, (the base of the acid,) is called boron.

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Fig. 25
Fig. 19.
B
A
a
W
R
Z
F
Fig. 21.
Fig. 22.
G
Z
M
C
Y
H
B
N
Fig. 20.
h
A
Fig. 23.
Fig. 24

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