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PINNOCK'S

Catechism

OF

CHEMISTRY,

intended to assist the Learner in unfolding the

Secrets of Nature.

LONDON,

Published by G. & W. B. Whittaker — 13, Ave Maria Lane.

1823.

Perkins & Heath. Patent Hardened Steel Plate.

A CATECHISM OF CHEMISTRY;

INTENDED TO

ASSIST THE LEARNER IN ATTAINING A KNOWLEDGE

OF THE VARIOUS

Chemical Substances

WITH WHICH NATURE ABOUNDS,

AND

THE PROCESSES THEY UNDERGO, TO RENDER THEM BENEFICIAL TO MANKIND.

EIGHTH EDITION.

ENLARGED AND CORRECTED.

LONDON:

PRINTED FOR G. B. WHITTAKER,

AVE-MARIA LANE.

Price Nine-pence.

PREFACE.

In a country where the Arts and Sciences are professed to be taught, it is astonishing that Chemistry should have been so long almost excluded from a course of liberal education. It is true that this observation is at the present time much less applicable than it was a few years ago; but, considering the extraordinary importance of the science, it is still by far too much neglected. In France it has long been otherwise: chemical knowledge is there considered an essential part of education; and though we are no advocates for imitating the frivolities of our Gallic neighbours, yet an imitation of their ardour in attaining scientific and philosophical knowledge cannot be too strongly enforced. In a commercial country, like Great Britain, an acquaintance with Chemistry possesses the highest advantages; for whatever station in life our children be destined to fill,—whether born to affluence, or compelled to cultivate the earth,—whether professors of medicine, or manufacturers of some staple commodity,—whether brewers, distillers, or soap-boilers,—whatever avocation, in short, they may be called on to pursue, the rudiments of Chemical Science must prove materially useful to them; while the ramifications are so various, that they present to the inquisitive mind an endless source of amusement and delight.

CATECHISM

OF

CHEMISTRY.

CHAPTER I.

Of the general Principles of Chemistry.

Question. WHAT is Chemistry?

Answer. That science which *investigates* the properties and mutual action of the *elementary* parts of bodies.

Q. Are not air, earth, and water, the elementary parts of bodies?

A. By no means: modern chemists have discovered that they may be decomposed, and consequently that they are compounds, and not simple bodies.

Q. What do you mean by decomposing a body?

Inves'tigate, *v.* to search out; to trace or find out by reason.

Elemen'tary, *a* simple, having only one principle for its essence.

SUBDIVISION I.

Malleable metals.

Gold,	Mercury*,	Lead.
Platina,	Copper,	Nickel.
Silver,	Iron,	Zinc.
Tin,		

SUBDIVISION II.

Brittle Metals.

Arsenic,	Cobalt,	Uranium.
Bismuth,	Tungsten,	Columbium or [Tantalium.
Antimony,	Molybdenum,	Iridium.
Manganesium,	Titanium,	Osmium.
Tellurium,	Chromium,	Rhodium.

Q. How do these simple bodies form compounds?

A. By means of a force called chemical attraction, or attraction of composition.

Q. How are compound bodies decomposed?

A. By the same principle.

Mal'leable, *a.* that may be beaten into plates with a hammer.

Brit'tle, *a.* that will break easily.

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* Mer'cury can be considered as malleable only, when, by excessive cold, it is fixed, and its fluidity destroyed.

Q. How is it possible that composition and decomposition can be *effected* by the same means?

A. Bodies may have different degrees of attraction for each other. Suppose I pour some *nitric acid* on copper-filings, for which it has a strong *attraction*, every particle of the copper will combine with a particle of the acid, and form a new body totally different from either: but if I wish to decompose this, I throw in some iron-filings, and, as these have a stronger attraction for the acid, it leaves the copper to unite with the iron, and the copper is precipitated in its former state.

Q. What is the cause of chemical attraction or affinity?

A. It is not certainly known, but supposed to arise from positive and negative electricity*, as they attract each other.

Effec'ted, *part.* performed, done.
Ni'tric a'cid, *s.* aquafortis.
Attrac'tion, *s.* the power which certain substances have of drawing others towards them.

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* Positive Electricity is, when a body is charged with a greater degree of electricity than it contains in its ordinary state; and Negative Electricity is, when a body is deprived of a part of the electric fluid which it usually contains.

CHAPTER II.

Of Caloric.

Q. What is Caloric?

A. Caloric is the term used by chemists to signify the matter of light and heat. It may be considered under two heads: free or *radiant* caloric, and combined caloric. The first, or free or radiant caloric, is also called heat or temperature; and means such heat as is sensible, and affects the *thermometer*.

Q. What are the properties of free caloric?

A. Free caloric has the power of *dilating* bodies; for it is so extremely *subtile*, that it pervades all substances; and, by forcing itself between their particles, causes them to occupy a greater space than before. When this is carried to a considerable degree in some bodies, it completely separates those particles, and they become fused or melted.

Q. What is the consequence of uniting caloric with a fluid?

A. It forces itself in such abundance between its particles, as completely to destroy

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Ra'diant, *a.* shining, sending forth rays.

Thermom'eter, *s.* an instrument which serves to ascertain the degree of heat.

Dila'ting, *part.* extending, spreading out, enlarging.

Sub'tile, *a.* thin, fine.

their attraction or *cohesion*, and they fly off in the form of vapour.

Q. By what means can you prove that caloric expands bodies?

A. Take a round piece of iron, and a ring that slides on it, and fits it exactly; heat the iron red-hot, and the ring will not then be large enough to admit it*.

Q. What is the next property of free caloric?

A. It always tends to diffuse itself equally, so that when two bodies are of unequal temperatures, the warmer gradually parts with its heat to the colder, till they arrive at an *equilibrium*. Thus, when a thermometer is applied to a hot body, it receives caloric; when to a cold one, it imparts it, till they both arrive at an equal temperature.

Q. Is cold then a substance or a negative quality?

A. Cold is merely a negative quality, simply implying the absence of heat.

Cohe'sion, *s.* the act of adhering or sticking together.
Equilib'rium, *s.* an exact equality.

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* To ascertain with great exactness the dilations of any solid body by heat, an instrument has been invented, called a pyrometer.

CHAPTER III.

Of combined Caloric, or specific and latent Heat.

Q. What is combined caloric?

A. When bodies contain considerable quantities of caloric, which is, as it were, imprisoned in them, and does not communicate the sensation of heat as free caloric does: this is called combined caloric, as being composed of specific *latent* heat.

Q. What is specific caloric?

A. Specific caloric means the relative quantities of caloric that different bodies can contain; for it has been ascertained, by modern chemists, that different bodies do not contain an equal quantity of caloric, when heated to the same temperature.

Q. Illustrate this by an example.

A. If you place a pound of lead, a pound of chalk, and a pound of milk, in a hot oven, they will be gradually heated to the temperature of the oven; but the lead will acquire this temperature first, as having the greatest capacity for caloric, the chalk next, and the milk last.

La'tent, *a.* hidden, not to be perceived by the senses.

Q. How can you ascertain that a less quantity of caloric enters into the lead than into other bodies, to raise it to the same temperature?

A. According to our former *theory*, that caloric has a tendency to an equilibrium. Place these three bodies in equal quantities of water of the same degree of coldness, you will find that the water in which the lead has been immersed will be the least heated, that of the chalk next, and the milk most of all.

Q. May not this proceed from the chalk and milk, though of the same weight, possessing greater quantities of matter than the lead?

A. Equal weight must always contain equal quantities of matter, though their *dimensions* may be different: therefore, when we want to know the relative capacities of different bodies for caloric, we must compare equal weights, and not equal bulks.

Q. What is latent caloric?

A. Latent caloric is that portion of insensible caloric which is employed in changing the state of bodies; that is, in converting solids into liquids, and liquids into vapour. When a body changes from solid to liquid,

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The′ory, *s.* doctrine.
Dimen′sion, *s.* the size of a body.

or from liquid to vapour, its *expansion* occasions a sudden increase of capacity for heat, and it immediately *absorbs* a quantity of caloric, which re-appears and becomes sensible, when the body which it has transformed *reverts* to its former state.

Q. What experiments prove this?

A. Snow may be cooled, by chemical means, many degrees below the freezing point. If this be exposed to a moderate heat, the thermometer *immersed* in it will gradually fall, till all the ice is melted. The reason is, that the new-formed liquid absorbs the caloric without its temperature being raised; but, when all the ice is dissolved, the thermometer again begins to rise.

Q. As solids, converted to fluids, absorb latent heat,—do fluids, converted to solids, give forth their caloric?

A. Yes; for instance: If you take *muriat* of lime, dissolved in water, and pour into the mixture a few drops of *sulphuric acid*, nearly the whole will be changed into a solid mass, and it will give out its latent heat so as to be sensibly felt.

Expan'sion, *s.* the art of stretching out a body, by which its dimension is increased.

Absorb', *v.* to suck up

Rever'ts, *v.* returns.

Immer'sed, *part.* plunged.

Mu'riat of lime, is lime combined with the muriatic acid, or the acid of common salt, called spirit of salt.

Sulphu'ric acid, oil of vitriol.

If you take a *solution* of *sulphat of soda*, made very strong, and corked in a bottle while hot, it will not *crystallize*; but, when it is cold, if you uncork the bottle, on the admission of the air, the salt will suddenly crystallize, and give out its latent heat, so that the bottle will be warm.

The heat that is felt on adding water to quick lime, proceeds from the water, on its being converted into a solid.

CHAPTER IV.

Of Atmospherical Air.

Q. Of what is atmospherical air composed?

A. Atmospherical air is composed of two gases, called oxygen and nitrogen gas.

Q. What is gas?

Solu'tion, *s.* a perfect union of solid bodies with a fluid, so that the solids shall appear perfectly dissolved and mixed with such fluid.

Sulphat of soda, Glauber's salts, prepared by pouring sulphuric acid on soda: this being diluted with water, and the water gently evaporated, the salts will crystallize.

Crys'tallize, *v.* to form into solid, regular, transparent bodies, like crystal.

A. Any fluid capable of existing in an *aëriform* state, under the pressure, and at the temperature of the *atmosphere*.

Q. Is not water, or any other fluid, when *evaporated* by heat, called a gas?

A. No; vapour is, indeed, an *elastic* fluid, resembling a gas; but it owes its elasticity to an increased temperature; and, on cooling, instantly returns to its original form: but gas has never yet been rendered liquid or solid by any degree of cold.

Q. In what proportions do oxygen and nitrogen exist in the atmosphere?

A. Oxygen gas constitutes rather more than one-fifth, and nitrogen gas rather less than four-fifths of the whole.

Q. Do they resemble each other in their qualities?

A. No; they are totally different. Oxygen gas may be *respired*, and likewise greatly

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Aë′riform, *a.* in the form of air.

At′mosphere, *s.* (pronounced *at′-mo-sfere,*) the air which surrounds the whole earth, and is absolutely necessary to the preservation both of animal and vegetable life: it grows thinner by degrees as we ascend into its upper regions, till, at length, it becomes totally unfit for respiration or breathing: when in a state of agitation, it is called wind.

Evap′orate, *v.* to dissipate moisture into fume, steam, and vapour.

Elas′tic, *a.* having the power of expanding when pressure is removed, or of returning to its original form, when the force which altered it no longer acts.

Respir′ed, *part.* breathed.

assists *combustion*, while nitrogen gas totally destroys both.

Q. How then can we breathe the atmosphere freely?

A. Were it composed of oxygen alone, we should, by respiring it, experience an intoxicating sensation, and an unnatural flow of spirits: it is only by the proportion above-mentioned that it exactly answers its intended purpose.

Q. How may these gases be separated?

A. Many ways: first, by combustion. If you place a lighted taper under a receiver that excludes the external atmosphere, it will burn a short time, and gradually expire. On examining the contents of the receiver, you will find it to be nitrogen gas, the oxygen having either become fixed by the combustion in the inflammable body, or formed a solution with it.

Second: metals having so great an *affinity* for oxygen, that, at some temperatures, they absorb, while at others they give it forth. Put some oxyde of manganese into a *retort*, place the retort in a furnace, and make it red-hot, connect the neck of the retort with a bent

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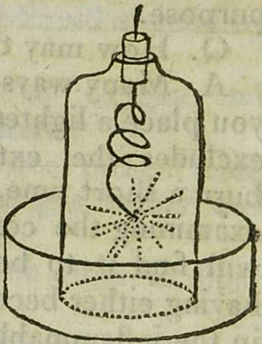
Combus'tion, *s.* the act of burning.
Affin'ity, *s.* attractive power.
Retort', *s.* a vessel in the form of a pear, being hollow, and having its smaller end bent, as in the figure.

tube, the extremity of which is immersed in a vessel of water, the oxygen will rise through the water in the form of bubbles, and may be received in a vessel for the purpose, and preserved for experiments as long as may be necessary*.

Q. By what experiment do you prove that oxygen is essential to, and *accelerates* combustion?



A. Iron itself may be burnt in pure oxygen gas. Take a vessel filled with it, introduce a *spiral* iron wire into the vessel through the cork, with a bit of lighted tinder attached to it; it will burn with a beautiful bright flame, till either the iron or the oxygen is totally expended.

Q. What becomes of the oxygen during the combustion?

A. It unites with the drops of melted iron that fall to the bottom of the vessel, and which are now become an oxyde of iron; this

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Accel'erates, *v.* hastens.
Spi'ral, *a.* in the form of a cork-screw.

* On a small scale, oxygen gas may be obtained with the apparatus represented in the figure. A is the water-bath, B the receiver to contain the oxygen, C the retort containing the manganese, D the stand, E the lamp, F the

may be proved by their being found heavier than the wire before it was burnt.

Q. Is there any other method of separating oxygen and nitrogen gas?

A. Yes, a very simple one: breathe through a tube into a receiver, till you feel yourself exhausted; the air in the receiver will then be nitrogen gas, mixed with carbonic acid gas, in which a taper will not burn.

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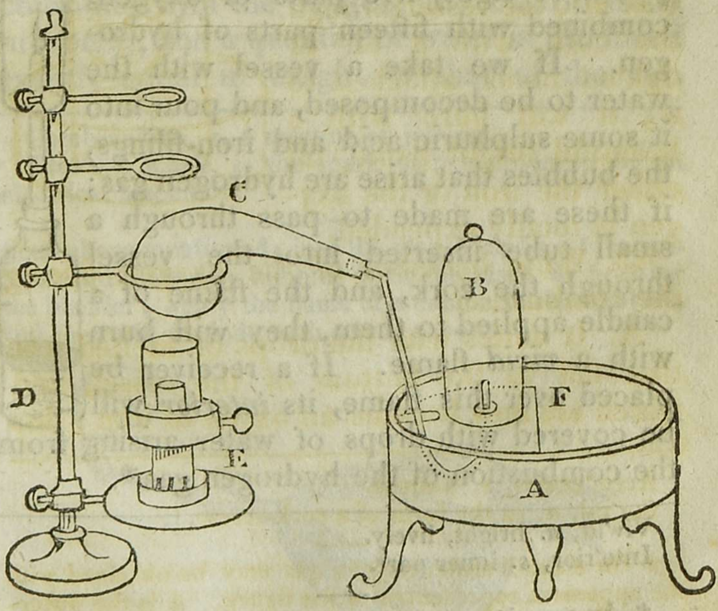
shelf on which the receiver stands, G the bent tube which conveys the oxygen from the retort to the receiver.



CHAPTER V.

Of Hydrogen.

Q. WHAT is Hydrogen?

A. It was formerly called inflammable air, as it is extremely combustible: it is now denominated hydrogen, which signifies to produce water.

Q. How does hydrogen produce water?

A. By combustion. Water is composed of eighty-five parts of oxygen, combined with fifteen parts of hydrogen. If we take a vessel with the water to be decomposed, and pour into it some sulphuric acid and iron-filings, the bubbles that arise are hydrogen gas; if these are made to pass through a small tube inserted into the vessel through the cork, and the flame of a candle applied to them, they will burn with a *vivid* flame. If a receiver be placed over this flame, its *interior* will be covered with drops of water arising from the combustion of the hydrogen gas*.

Viv'id, *a.* bright, lively.
Inte'rior, *s.* inner part.

* An amusing experiment may be made as follows:—Fill a bladder, provided with a stop-cock, (as in the figure), with oxygen and hydrogen gases, in the propor-

Q. Has this process ever been attempted on a large scale?

A. Yes; M. Lavoisier invented a very perfect and ingenious apparatus for the formation of water, by the *combination* of oxygen and hydrogen gases. Two tubes, the one conveying the requisite proportion of oxygen, the other of hydrogen gas, are inserted at opposite sides of a large glass globe previously exhausted of air; the two streams of gas are kindled by the *electric spark*, at the point when they come in contact; the hydrogen combines with the oxygen, the caloric is set at liberty, and a quantity of water is produced exactly equal in weight to that of the two

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Combina'tion, *s.* a meeting or joining.

Elec'tric spark, *s.* the spark of fire produced by an electrical machine.

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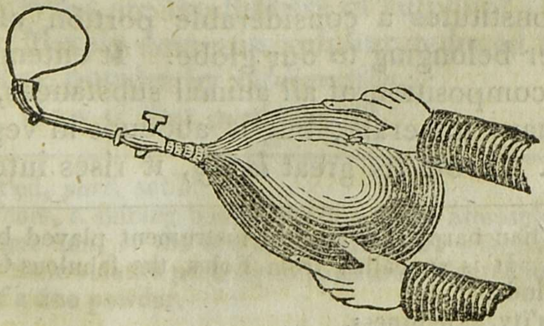
tions above mentioned; into the stop-cock fix a tobacco-pipe, and blow soap-bubbles with the gases, by pressing the bladder; apply the flame of a candle to the bubbles, and they will explode with a loud report.



gases introduced into the globe. Nearly a pound of water has been produced in this way; but it is a tedious process.

Q. Is there not another curious effect arising from the combustion of hydrogen gas?

A. Yes; if, instead of a receiver, we place over the flame a glass-tube, about two feet long, and an inch in diameter, open at both ends, a strong and rather a pleasing sound will be emitted, not much unlike that produced by the *Eolian harp*.

Q. What other properties has hydrogen gas?

A. It is specifically lighter than common air, and is therefore made use of for filling balloons. It likewise is extremely combustible; for, if a quantity be confined in a phial, and fired by means of the electric spark, it explodes with a considerable report.

Q. Is hydrogen found in any considerable quantities?

A. Yes; nature abounds with hydrogen; it constitutes a considerable portion of the water belonging to our globe. It enters into the composition of all animal substances, and of many minerals; but it abounds in vegetables. From its great *levity*, it rises into the

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Eo'lian harp, *s.* a musical instrument played by the wind. It is so called from Eolus, the fabulous God of the winds.

Lev'ity, *s.* lightness.

superior regions of the atmosphere, and, when *ignited* by a casual electric spark, or by any other means, it perhaps produces those *meteors* or luminous appearances we occasionally see.

CHAPTER VI.

Of Sulphur.

Q. What is sulphur?

A. Sulphur is a very combustible substance, that exists in a solid form at the temperature of our atmosphere. It is seldom found in a pure unmixed state; for its affinity to other substances is so great, that it is generally mixed with some of them: it exists, in a greater or less quantity, in the mineral, vegetable, and animal kingdom.

Q. What are the flowers of sulphur?

A. Merely common sulphur reduced to a very fine powder by *sublimation.*

Q. How is that performed?

Ignit'ed, *part.* set on fire.

Me'teors, *s.* shining bodies, floating in the atmosphere.

Sublima'tion, *s.* the act of distilling dry substances, so that their volatile parts fly off, and are collected in the form of a fine powder.

A. Some lumps of sulphur are put into a cucurbite*, which, when covered with its head, is placed over a sand-bath that is kept heated by a furnace. The sulphur soon begins to melt, a thick white smoke arises, which gradually *condenses* against the sides of the head, something like *vegetation*, from whence it has obtained its name.

Q. What advantages arise from this process?

A. It divides the sulphur into minute parts, and purifies it from those *heterogeneous* substances with which it is combined.

Q. What effect does the combustion of sulphur produce?

Conden'ses, *v.* thickens.
Vegeta'tion, *s.* plants, flowers, &c.
Heteroge'neous, *a.* of different natures.

* A vessel of earth, or glass (as in the figure), together with its head; it is called an Alembic. A cucurbic, B the head, C the sand-bath, D the furnace.

A. Combustion of sulphur produces, when combined with water and oxygen, sulphurous acid*.

Q. How is the sulphuric acid produced?

A. By burning sulphur with nitre over a surface of water in a leaden condenser.

Q. Does not sulphur readily combine with hydrogen?

A. Yes; and the combination is called sulphurated hydrogen gas. Of this nature are the Harrowgate waters, which can be exactly imitated by *impregnating* common water with this gas.

CHAPTER VII.

Of Phosphorus.

Q. What is Phosphorus?

A. Phosphorus has generally been considered as one of the simple bodies, though existing in nature closely combined with other substances, and never found in its pure separate state.

Impreg'nating, *part.* mixing, filling.

* We should be careful to remember, that the weaker acids are distinguished by the termination *ous*, the stronger by the termination *ic*; thus, sulphurous acid is the weaker, sulphuric acid the stronger of the two.—See Chap. XIII.

Q. What is the most remarkable property of phosphorus?

A. It is eminently combustible; it melts and takes fire at the temperature of one hundred degrees of Fahrenheit's thermometer, and absorbs in in its combustion half as much again of oxygen as its own weight.

Q. How is this proved?

A. If I put a little bit of phosphorus into a receiver filled with oxygen gas, and fire it by means of a hot wire, it will burn with such a vivid blaze, that the eye can scarcely endure its brightness. It is easy to ascertain the quantity of oxygen consumed. In the combustion of a pound of phosphorus, sufficient caloric has been disengaged to melt one hundred pounds of ice, as proved by the calorimeter.

Q. What is a calorimeter?

A. The calorimeter is a vessel, the inner surface of which is lined with ice, so as to form a sort of hollow globe of ice, in the midst of which the body, whose specific heat is to be ascertained, is placed. The ice absorbs caloric from the body until it has brought it down to the freezing point. The quantity of ice changed to water, which runs off through an *aperture* in the bottom, is a test of the quantity of caloric that the body to be examined has given out.

Ap'erture, *s*. an opening.

Q. Is the result of this combustion an acid?

A. Yes; phosphoric acid; and, if we duly proportion the phosphorus and oxygen gas, the result will be phosphoric acid of exactly the weight of those two substances previous to combustion.

Q. What is the method of producing phosphoric acid?

A. By simply exposing phosphorus to the atmosphere, it undergoes a slow combustion: a whitish vapour arises from this, which, united with water, produces phosphoric acid.

Q. Is phosphorus of any other service?

A. Yes; it serves to ascertain the purity or impurity of atmospheric air; for this purpose it is burnt in a *graduated* tube, called a eudiometer, which, shewing how much oxygen is absorbed by the combustion, shews what proportion of it there is in the air examined: what remains is nitrogen. When combined with sulphur, it forms a compound so extremely combustible, that matches dipped in it immediately take fire on coming in *contact* with the air. In very cold weather they require to be rubbed, to raise their temperature.

Grad'uated, *part.* having degrees marked on it.
Con'tact, *s.* close union.

Q. Will phophorus combine with hydrogen gas?

A. Yes; and the sulphurated hydrogen gas has this remarkable peculiarity, that it takes fire *spontaneously* at any temperature of the atmosphere. From this union probably proceed those delusive fires, called *ignis fatui*.

Q. Are there any other combinations of phosphorus?

A. Yes; it is frequently united with lime, and the combination is called phosphoret of lime, as the union of sulphur with lime is called sulphuret of lime; it has the singular property of decomposing water, by being simply thrown into it.

Q. How does it effect this?

A. By absorbing the oxygen of water, in consequence of which bubbles of hydrogen gas ascend, holding a small quantity of phosporous in solution; this is called phosphorated hydrogen gas; it takes fire and detonates on coming in contact with the atmosphere.

Q. Is there any other curious experiment to be made with phosphorus?

A. Yes; put a little solution of *potass*

Sponta'neously, *ad.* readily, of their own accord.

Ig'nis Fatui, *s.* commonly called Will o' the Wisp, or Jack a Lanthorn.

Pot'ass, *s.* an alkaline salt, obtained from the ashes of into a retort, with a small piece of phosphorus; place its neck in water, and heat it over the lamp; when it boils, bubbles will arise, take fire, and *detonate* as they leave the water.

CHAPTER VIII.

Of Carbon.

Q. WHAT is carbon?

A. Carbon is nothing more than the matter of charcoal in a state of purity, or unmixed with *foreign* ingredients.

Q. Is there much of this principle in nature?

A. Yes; carbon forms a considerable part of the solid matter of all organized bodies or vegetables; particularly wood.

Q How is pure carbon to be obtained?

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wood, by first washing them, and then evaporating the water; the residuum, or what remains, is potass: when purified, it is called pearlash.

De'tonate, *v.* to explode and make a report, as gun powder does.

Foreign, *a.* different from its nature.

A. The purest that can be obtained by art, still contains some hydrogen: that which is in common use, for *culinary* purposes, is always combined with other substances, hydrogen particularly.

Q. In what form does the purest carbon present itself?

A. The diamond has been found to be the purest specimen of carbon that has offered itself to the notice of chemists; the process of its *crystallization* is totally unknown. Cotton is likewise composed almost entirely of carbon.

Q. Is the diamond combustible?

A. Yes; by the rays of the sun, with a powerful *lens;* and, by burning it, its chemical nature has been ascertained: the product of this combustion, like that of all other carbon, has proved carbonic acid gas.

Q. What is carbonic acid gas?

A. Carbonic acid gas was formerly called fixed air. If I burn a piece of the purest charcoal in oxygen gas, it gradually combines with the oxygen, and gives out a gas, which is carbonic acid gas, as much in weight as the sum of the weight of the carbon and oxygen consumed.

Cu'linary, *a.* domestic, belonging to the kitchen.

Crystalliza'tion, *s.* the act of forming into crystals.

Lens, *s.* a convex glass, which has the property of collecting the rays of the sun into a focus or point, and thus setting fire to combustible matters placed in that focus.

Q. As carbonic acid contains so much oxygen, is it not wholesome to breathe?

A. Carbonic acid is not only unfit for respiration, but extremely pernicious, if taken into the lungs. Hence arises the danger from the fumes of burning charcoal.

Q. Can this acid be condensed into a liquid?

A. No; it is a permanent elastic fluid; but water may be strongly impregnated with it. Seltzer water is of this nature; the sparkling is occasioned by the attempt of the gas to escape.

Q. Have you mentioned all the properties of carbon?

A. No; that would be impossible in so small a treatise; it is merely necessary to give a general idea of its nature.

CHAPTER IX.

Of Metals.

Q. WHAT are metals?

A. Metals are bodies of a very different nature from those already examined; for they are some of the most brilliant, most *ponderous*, and most *palpable* substances in nature: they form a very important branch of practical chemistry.

Q. Are they generally found in their pure metallic state?

A. No; they are more or less oxygenated, or combined with sulphur, earths, or acids; they are found in the bowels of the earth, spread in strata or beds, combined with other substances called *ores*.

Q. Have not metals a great affinity for oxygen?

Pon'derous, *a*. heavy, of great weight.

Palp'able, *a*. the quality of being perceived by the touch.

Ores, *s*. the substances in which metals exist in the mines, and from whence they must be extracted by chemical means, before they can become serviceable to mankind.

A. Yes; but in different degrees. Some will combine with it only at a high temperature; others, as *manganese*, immediately absorb oxygen on being exposed to air, and crumble to an *oxyde* in a few hours.

Q. Do any other metals *oxydate* at the temperature of the atmosphere?

A. They all do, more or less, except gold, silver, and *platina*. Copper, lead, and iron, oxydate slowly in the air, and cover themselves with a sort of rust, which is the oxyde of the metal.

Q. Are metals combustible?

A. Yes, except gold, silver, and platina, at a very high temperature; but, with this exception, they will burn readily in oxygen gas, or by means of the voltaic battery, which is an apparatus lately invented for producing a peculiar kind of electricity*.

Mangane'se, *s.* one of the brittle metals mentioned in page 6.

Ox'yde, or Ox'ide, *s.* that substance into which metals are changed, by a combination with oxygen.

Ox'ydate, *v.* to change into an oxyde.

Plati'na, *s.* a white metal, much heavier than gold; found only in South America.

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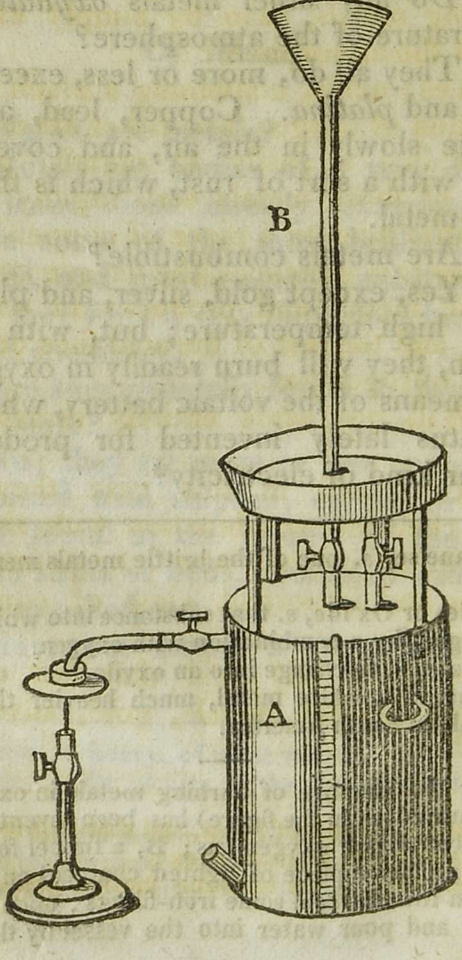
* For the purpose of burning metals in oxygen gas, the apparatus (as in the figure) has been invented. A, is a ve sel containing oxygen gas; B, a funnel for pouring in water; place a piece of lighted charcoal on the stand C, and on the charcoal some iron-filings, open the stopcock D, and pour water into the vessel by the funnel,

Q. Can the oxydes of metals be restored to their metallic state?

The gas will then be forced out of the vessel in a continued stream upon the charcoal, and the filings will burn with a bright flame.



A. Yes; by depriving them of their oxygen, which may be done by heating them red-hot with *charcoal;* carbon having greater affinity for oxygen than the metals.

Q. Is there not a more speedy method of oxydating metals, than by simply exposing them to the atmosphere?

A. Yes; acids, containing a much greater proportion of oxygen than either air or water, and yielding it easily to metals, produce oxydes of those metals very rapidly. Pour some nitric acid on a piece of copper-leaf, an *effervescence* commences, the oxygen combines with the metal, and produces an oxyde of copper, and the rest of the acid flies off in the form of nitrogen gas.

Q. Will not acids entirely dissolve metals?

A. Yes; and in this case they enter into a chemical combination with the acid, and form an entirely new compound, or a peculiar and important class of compound salts.

Q. Is there any acid that can dissolve the three perfect metals, gold, silver, and platina?

Char′coal, *s.* wood half burnt, and thus deprived of the oil and water which produce smoke.

Efferves′cence, *s.* an intestine motion productive of heat.

A. Only one; the oxygenated muriatic acid*, which can dissolve gold, or any other metal, rapidly. Silver is dissolved by nitric acid.

Q. Are there any metals capable of being converted into acids?

A. There are five: arsenic, molybdenum, chromum, tungstenum, and columbium, that will combine with a sufficient quantity of oxygen to form acids.

Q. Will metals combine only with acids?

A. They are capable of uniting also with sulphur, phosphorus, carbon, and with each other: these combinations are called sulphurets, phosphorets, carburets, &c.

The phosphorets offer nothing remarkable.

The sulphurets form that peculiar kind of mineral called pyrites.

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* Oxygenated muriatic acid may be thus produced: Put into a retort a mixture of three parts of common salt, and one part of the black oxyde of manganese in powder; place the retort in a sand-bath, plunge its beak into the water-bath, and *lute* a bent funnel into its mouth. When the mixture has acquired a moderate heat, pour into it, at intervals, two parts of sulphuric acid, somewhat diluted with water; a yellow gas then issues from the retort, which may be received in large phials with glass stoppers.

Lute, *v.* to join with a sort of paste, made of different ingredients, according to the nature of the substances in the retort.

The only carburets of iron of any consequence are steel and plumbago, or black lead.

Q. Is there any peculiarity in mercury?

A. Yes; it is *fusible* at the common temperature of our atmosphere, while other metals require a considerable degree of heat to fuse them. Mercury becomes fixed or solid when the cold is 72 degrees below the freezing point, which happens only in countries near the poles.

Q. What is verdigris?

A. Verdigris is a compound of salt, formed by the union of vinegar and copper; it is of a beautiful green colour, and much used in painting, but poisonous; therefore copper vessels should never be used unless previously cleaned with great care.

Q. Does copper produce any other salt?

A. Yes; the solution of copper in nitric acid affords a salt, that produces a curious effect on tin: take some *tinfoil*, sprinkle water and some of this salt on it, and wrap it up suddenly into a lump, a considerable vapour and sparks of fire will issue from it.

Q. Is there any other compound salt that deserves mentioning?

A. Yes; there is a beautiful green salt

Fu'sible, *a.* that may be melted.
Tin'foil, *s.* tin beaten into thin leaves.

produced by the combination of *cobalt* with muriatic acid, which forms a sympathetic ink. Characters written with a *solution* of this are invisible when cold, but, gently heated, assume a bluish-green colour.

CHAPTER X.

Of the Attraction of Composition.

Q. WHAT is the attraction of composition?

A. It is the attraction that subsists between bodies of different natures, which occasions them to combine and form a compound when they come in contact.

Q. Are there not some general laws of chemical attraction?

A. Yes; 1st, that it takes place only between bodies of a different nature, as between an acid and an alkali, or oxygen and a metal; 2dly, that it takes place only between the most minute particles of bodies; therefore the more minutely bodies are divided, the more readily they act upon each other: 3dly, that it can take place in a considerable number of

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Co'balt, *s.* one of the brittle metals, see page 6.

Solu'tion, *s.* a substance dissolved in water, or some other fluid.

bodies: 4thly, that a change of temperature always takes place at the moment of combination: 5thly, that the properties which characterize bodies in their separate state, are altered or destroyed by their combination: 6thly, that the force of chemical affinity between the *constituents* of a body is estimated by that which is required for their separation: 7thly, that bodies have, amongst themselves, different degrees of attraction.

CHAPTER XI.

Of Alkalies.

Q. What are alkalies?

A. Alkalies consist of *metallic bases*, combined with oxygen, have an *acrid* taste, a *pungent* smell, and a *caustic* action on the

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Constit'uents, *s.* the elements of which a body is composed.

Metal'lic bases, *s.* metals.

Ac'rid, *a.* tasting hot and bitter, and leaving a painful heat in the mouth.

Pun'gent, *a.* affecting the senses with a sharpness.

Caus'tic, *a.* operating like fire, both with respect to the eat it occasions, and the consumption it causes in the arts to which it is applied.

skin and flesh. They likewise turn the blue *infusions* of vegetables green.

Q. How many alkalies are there?

A. Three; potash, soda, and ammonia: the two former are called fixed alkalies, the latter *volatile* alkali.

Q. In what proportions are the metals and oxygen combined in these alkalies?

A. In potash, about 86 parts of potassium, to 14 parts of oxygen; soda, 77 parts of sodium to 23 of oxygen; ammonia, six parts of hydrogen, and one of nitrogen, or azote.

Q. What are the properties of potash?

A. 1st, It combines readily with oil or fat, and forms that useful compound called soap.—2dly, Melted with silecious earth or flint, it forms glass.—3dly, It is extremely useful in many other arts, and, combined with nitric acid, forms saltpetre.

Q. What is soda?

A. Soda so nearly resembles potash in its general properties, as scarcely to be distinguished from it, except by the difference of the salts which they form with acids.

Q. How is soda obtained?

A. Generally from the combustion of *ma-*

Infu'sion, *s.* the juice of vegetables, extracted by either hot or cold water.

Vol'atile, *a*, that readily flies off in vapour or fume.

rine plants, by an operation similar to that by which potash is obtained from other vegetables.

Q. Will soda assist in the formation of glass and soap, as potash does?

A. Yes; equally well, and, in some cases, it is preferred.

Q. What is ammonia, or volatile alkali?

A. It is of the same nature as hartshorn. It is generally extracted from a compound salt, formerly brought from Ammonia, in Lybia, and from thence called sal-ammoniac; but its scientific name is muriat of ammonia.

Q. When extracted from the salt, what kind of substance is ammonia?

A. Its natural form is that of gas; it is called ammonial gas.

Q. Of what does it consist?

A. Of nitrogen and hydrogen.

Q. What are its properties?

A. It assists in the formation of soap, but not of glass; and it has so strong an attraction for water, that it cannot be collected in a receiver over water, but over mercury only, as otherwise it would be totally absorbed. Hartshorn is water thus impregnated.

Q. What is sal volatile?

A. It is carbonat of ammonia dissolved in

Mari'ne, *a.* belonging to the sea.

water. In its *concrete* state it is called salt of hartshorn.

Q. From whence is muriat of ammonia, or sal-ammoniac, now obtained?

A. From any animal substance; such as wool, horn, bones, flesh, &c., by decomposition.

CHAPTER XII.

Of Earths.

Q. WHAT are earths?

A. Earths are substances composed of a metallic basis, combined with oxygen: they are incombustible.

Q. How many earths are there?

A. Ten; silex, alumine, barytes, lime, magnesia, strontites, yttria, glucina, zirconia, and jargonia. The last five, being of late discovery, are but imperfectly known.

Q. Do they enter into the composition of many substances?

A. Yes; from the most precious jewels, (diamond excepted, which is carbon,) to the commonest pebbles: in short, all the immense variety of mineral products may be referred

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Con'crete, *a.* formed by the union of several particles or substances.

to some of these earths, either in a simple state, or combined one with another, or blended with other ingredients.

Q. What are the peculiar properties of earths?

A. *Insipidity*, dryness, unalterableness in the fire, *infusibility*, &c. Barytes, magnesia, lime, and strontites, are called alkaline earths, because they possess all the properties of alkalies?

Q. What is silex?

A. Silex, or silica, abounds in flint, sand, sandstone, agate, jasper, &c. It forms the basis of many precious stones; strikes fire with steel; produces a variety of siliceous crystals, of which rock-crystal is the purest specimen.

Q. With what acid does silex combine?

A. With the *fluoric* only, which for that reason can never be kept in glass vessels; as, having a strong affinity for silex, it detaches that substance from the potash, and thus destroys the glass.

Q. What is alumine?*

A. Alumine is chiefly found in clay: when

Insipid'ity, *s.* tastelessness.
Infusibil'ity, *s.* not to be melted.
Fluo'ric, *a.* extracted from fluor, or Derbyshire spar. See page 51.

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* Alumine derives its name from a compound salt, called alum, of which it forms the basis.

pure, soft to the touch, makes a paste with water, and hardens in the fire. It is the most essential ingredient in pottery-ware, from the coarsest to the most delicate *porcelain*. It has a strong tendency to combine with silex. The *ruby*, *oriental sapphire*, *amethyst*, &c., consist chiefly of alumine.

Q. What is barytes?

A. Barytes is remarkable for its weight, and for its strong alkaline properties, such as destroying animal substances, turning blue vegetable colours green, and shewing a powerful attraction for acids.

Q. What is its use?

A. It is a very valuable chemical test, as from its great affinity for sulphuric acid, it will always *detect* it in any substance or combination whatever, by immediately uniting with it, and forming a sulphat of barytes.

Q. What is lime?

A. Lime is an oxyd of calcium. It is not met with in its simple state in nature, but combined with water and carbon; and it forms the common lime-stone. But these

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Por'celain, *s.* China ware.

Ru'by, *s.* a precious stone of a red colour.

Orien'tal, *a.* eastern, found in the eastern countries of Asia.

Sap'phire, *s.* a precious stone of a blue colour.

Am'ethyst, *s.* a precious stone of a purple or violet colour.

Detect', *v.* to discover.

substances are *volatilized* in the kiln by the heat. It is then called quick lime.

Q. What are its properties?

A. It is so caustic, that it is capable of decomposing the flesh of animals very rapidly, without their undergoing *putrefaction*. Water poured on it is immediately absorbed, and gives out its latent heat to a very considerable degree.

Q. Is not chalk a species of lime?

A. Yes; it is carbonat of lime, or lime combined with carbonic acid.

Q. Has lime any further properties deserving notice?

A. Yes; it combines with most acids; unites with phosphorus and with sulphur. It is the basis of all *calcareous* earths and stones, and is found both in the animal and vegetable creation.

Q. Is lime of much importance in the arts, &c.

A. Yes; it is a most essential requisite in architecture, agriculture, dyeing, &c.

Q. What is magnesia?

A. Magnesia is a fine white powder, very light; has not so great an affinity for acids as

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Vol'atilized, *part.* made to fly off in vapour.
Putrefac'tion, *s.* the act of growing rotten.
Calca'reous, *a.* partaking of the nature and qualities of calx or lime.

lime: it does not attract and *solidify* water, as lime does; but, when mixed with water, and exposed to the atmosphere, it slowly absorbs carbonic acid from it, and thus loses its causticity.

Q. Is it of any use in medicine, or the arts?

A. Yes; combined with sulphuric acid, it forms a powerful medicine, called sulphat of magnesia, or Epsom salts*.

CHAPTER XIII.

Of Acids.

Q. WHAT is to be observed of acids?

A. Acids are compounded of particular bases, combined with oxygen. If the portion of oxygen be very small, they are denominated merely oxydes. If a greater quantity of oxygen be combined, it is denoted by the termination *ous*; if the greatest, by the termination *ic*. Thus sulphureous acid is the weaker, sulphuric acid the stronger, of the two.

Q. How are they classed?

Solid'ify. *v.* to harden, to make solid.

* Epsom salts, so called because there is a spring near Epsom, the water of which contains them in great quantities.

A. First—Acids of known and simple *bases:*

Sulphuric,	Arsenical,	Fluoric,
Carbonic,	Tungstic,	Muriatic,
Nitric,	Molybdic,	Telluric,
Phosphoric,	Boracic,	Chromic.

Secondly—Acids of binary or double bases, or radicals, of vegetable origin:

Acetic,	Malic,	Succinic,
Oxalic,	Gallic,	Camphoric,
Tartaric,	Mucous,	Suberic.
Citric,	Benzoic,	

Thirdly—Acids of *triple* bases, of animal origin:

Lactic,	Bombic,	Lithic.
Prussic,	Sebacic,	
Formic,	Zoonic,	

Q. Can the first class of acids be decomposed?

A. Yes; if I pour a little sulphuric acid on a piece of iron, it immediately imparts its oxygen to the iron, and a sulphureous gas is *evolved*.

Q. What is sulphuric acid?

A. It is an acid obtained by burning sulphur and nitre in a close receiver over water;

Ba'ses, *s.* the principal constituent parts of any substance; thus, sulphur is the basis of sulphuric acid; carbon, of carbonic, &c.

Tri'ple, *a.* consisting of three.

Evolv'ed, *part.* sent forth.

it then becomes, by *concentration*, what is vulgarly called oil of vitriol.

Q. What extraordinary effect is produced by sulphuric acid?

A. When mixed with water, it evolves a heat nearly equal to that of boiling water.

Q. Is sulphuric acid of use in the arts?

A. Yes; it is particularly useful in *bleaching*, and in destroying vegetable stains, besides answering many other valuable purposes, too tedious to mention.

Q. Are there not certain neutral salts produced by the combination of this acid with alkalies, earths, and metals?

A. Yes; sulphat of potash, sulphat of soda, sulphat of lime, of magnesia, of alumine, of iron, &c. &c.

Q. What is phosphoric acid?

A. It is an acid obtained from phosphorus. The only salt of consequence derived from the acid is phosphat of lime, which is the basis of all bones.

Q. What is nitric acid?

A. Nitric acid is a combinatin of oxygen and nitrogen, which, when absorbed by water, is vulgarly called aqua fortis.

Q. How is nitric acid obtained?

A. Mix some nitrat of potash and sulphuric acid in a retort, and heat it; the sul-

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Concentra'tion, *s.* a bringing into a smaller compass.
Bleach'ing, *s.* the art of whitening linen.

phuric acid, having a greater affinity for potash than the nitric, will set the latter at liberty, which may be collected in a receiver.

Q. Will not the nitric acid dissolve metals?

A. Yes, except gold and platina; for this reason it is used by engravers to produce those impressions on copper-plates called etchings.

Q. How is this performed?

A. The plate is first thinly covered with wax, on which the drawing is made with a needle quite through to the plate; nitric acid is then poured on, which *corrodes* the copper where the wax has been removed, and produces the etchings.

Q. What salts may be produced from nitric acid?

A. Nitrat of potash, commonly called saltpetre; nitrat of ammonia, from which may be obtained the gaseous oxyde of nitrogen, which, if *inhaled* by the lungs, produces an intoxicating effect; and nitrat of silver, or the lunar caustic, much used by surgeons.

Q. What is carbonic acid?

A. An acid produced from the combustion of carbon, either in its purest state, as in the diamond, or from common charcoal. Light a piece of charcoal, place it under a receiver, and, when the charcoal is extinguished, the air will be found mixed with carbonic acid.

Corro'des, *v.* gnaws, eats away.
Inha'led ;*part.* drawn in.

Q. How can we separate the carbonic acid from the air with which it is mixed?

A. Introduce under the receiver some caustic lime, or caustic alkali, which will soon attract the whole of the carbonic acid to form a carbonat of lime or of soda.

Q. How can pure carbon be obtained from either of these carbonats?

A. By burning phosphorus in a close vessel with the carbonat, the phosphorus absorbs the oxygen, whilst the carbon is separated in the form of a black powder.

Q. Is carbonic acid gas found in abundance?

A. Carbonic acid gas is procured in abundance from many substances, and is constantly produced by the *respiration* of animals. It forms, however, not more than about one-thousandth part in the composition of the atmospheric air. If breathed, it causes instant death.

Q. Is it any where found unmixed with the atmosphere?

A. Yes; in the Grotta del Cané, near Naples, this gas exists in its purity; but as it is heavier than atmospheric air, it does not rise above two or three feet from the ground. A man may therefore stand upright in this cave with safety: but, to show the *deleterious*

Respira'tion, *s.* the act of breathing.
Delete'rious, *a.* deadly, fatal, causing destruction.

effect of this gas, they take a dog, and hold him near the ground: he is soon deprived of all appearance of life, and it is only by instantly throwing the poor animal into the neighbouring lake, that he can be recovered from this insensibility.

Q. Can you mention any other process by which carbonic acid gas is produced?

A. Yes; from fermentation: great quantities of it continually arise from *worts*, when in a state of fermentation; it is generally called fixed air. If a lighted candle be immersed in it, it is instantly extinguished; and it produces immediate death, if admitted into the lungs.

Q. Is this acid pernicious when admitted into the stomach?

A. It is generally considered the reverse, as it forms an ingredient in many mineral waters, which are denominated acidulous, as gaseous mineral waters. It likewise gives that lively pungent taste to *fermented* liquors, which is so much admired.

Worts, *s*. infusions of malt, used in making beer.
Ferment'ed, *v*. put in a state of intestine motion.

CHAPTER XIV.

Acids (continued).

Q. WHENCE is the boracic acid brought?

A. Boracic acid is brought from Thibet, where it is found combined with soda; it is easily separated from the soda by sulphuric acid, and appears in the form of shining scales.

Q. How may this acid be decomposed?

A. Several ways; if we burn potassium in contact with it, *in vacuo*, the potassium attracts the oxygen from the acid, and leaves its basis in a separate state.

Q. How is the decomposition of this acid effected?

A. By burning some of its bases in oxygen gas, its light is extremely brilliant, and the result is boracic acid.

Q. What is the use of this acid?

A. Its principal use is in conjunction with soda, forming borat of soda; or, as it is commonly called, borax. It promotes the fusion of substances, removes the oxyde from the surface of metals, and is often employed in *assaying* metallic ores.

In′ vacuo, (*Lat.*) in an empty space.
Assay′, *v.* to examine, to try.

Q. What is fluoric acid?

A. This acid is obtained from a substance found frequently in mines, called fluor or Derbyshire spar, which consists of lime and this acid.

Q. How is this acid obtained?

A. It is easily separated from the lime by the sulphuric acid, and, unless condensed in water, ascends in the form of gas.

Q. Has this gas any peculiar property?

A. Yes; it has a great affinity for silex, so that if it be put in glass vessels, they are corroded, and the *siliceous* part of the glass unites with the gas.

Q. What purpose may be answered by this property?

A. Engraving may be performed with it on glass, in the same manner as etching on copper by the nitric acid.

Q. What is molybdic acid?

A. Molybdic acid is a pale yellow powder, procured from the sulphuret of molybdenum, by distilling nitric acid off it repeatedly, till the sulphur and metal are both acidified. It requires a great quantity of water to dissolve it.

Q. What is muriatic acid?

A. Muriatic acid is generally obtained from the common sea-salt, from which it may be

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Sili'ceous, *a.* composed of flint.

disengaged by the sulphuric acid. It is remarkable for its peculiar and very pungent smell, and possesses, in a powerful degree, most of the properties of an acid. It has a remarkably strong affinity for water, and appears as a whitish cloud whenever it meets with any moisture.

Q. What peculiar property has it besides?

A. If burnt with sulphur, it detonates, or causes a report, with astonishing violence.

Q. Is there any other denomination for this gas?

A. As it is susceptible of a high degree of oxygenation, it is then called oxymuriatic acid.

Q. How is oxymuriatic acid to be obtained?

A. By distilling liquid muriatic acid over oxyde of manganese, which supplies it with the additional oxygen: it is but sparingly absorbed by water.

Q. Has this acid any peculiar property?

A. As muriatic acid extinguishes flame, this acid increases it, from the great quantity of oxygen combined with it. It is likewise of great service in destroying *putrid effluvia* and the *infection* of the small-pox; though the vapour of nitric acid is generally preferred for this purpose, as it is less offensive.

Putrid efflu'via, *s.* the fumes that arise from putrefying substances, or from putrid distempers.

Infec'tion, *s.* that which communicates a disease to others.

Q. What is chromic acid?

A. Chromic acid is compounded of chromium and oxygen, and forms an orange-coloured powder. It has a hot metallic taste, dissolves easily in water, and crystallizes. When mixed with different saline solutions, it assumes a variety of beautiful colours.

CHAPTER XV.

Of organized Bodies.

ON THE NATURE AND COMPOSITION OF VEGETABLES.

Q. WHAT do you mean by organized bodies?

A. Organized bodies are such as are endowed by nature with various parts, peculiarly adapted to perform certain functions connected with life, by which unknown principle they are distinguished from other compounds formed merely by chemical attraction.

Q. What is the first class of organized bodies, and of what are the individuals composed?

A. Vegetables: all of which are chiefly composed of hydrogen, carbon, and oxygen; but they change the proportions of these principles, by their various organs, in numberless ways, and form with them different kinds of juices and solids, which may be considered as their immediate materials.

Q. Enumerate some of them.

A. Sap,
Mucilage,
Saccharine matter,
Fecula,
Gluten,
Fixed oil,
Volatile oil,
Camphor,
Resins,
Gum Resins,
Balsams,
Caoutchouc,
Extractive colouring matter,
Tannin,
Woody fibre,
Vegetable acids, &c.

Q. Are all these materials found in an individual plant?

A. No; but they all have their origin in the vegetable kingdom.

Q. Are the combinations of these principles regulated by the laws of chemical attraction?

A. Yes; it is supposed that the organs of plants act *mechanically*, by bringing into contact such principles, and in such proportions, as will, by their chemical combination, form the various vegetable products.

Q. What is sap?

A. Sap is the principal material of vegetables, since it contains the ingredients that nourish the plant. The basis of this juice is water, and holds in solution the various other

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Mechan'ically, *ad.* in the manner of machines.

ingredients which are gradually *secreted* by the different organs appropriated for that purpose, as it passes through them in its circulation.

Q. What is mucilage?

A. Mucilage is a substance secreted from the sap, which sometimes *exudes* from trees in the form of gum.

Q. What is saccharine matter?

A. It is sugar; but it is never found in plants, being mixed with various ingredients: it abounds most in roots, fruits, and in a particular plant called the sugar-cane. The maple-tree likewise yields it in abundance.

Q. What is fecula?

A. Fecula is the name given to that *farinaceous* substance resembling flour, found in all seeds, and in potatoes, parsnips, &c. It is intended by nature for the food of young vegetables, until they acquire sufficient strength to obtain it by the root.

Q. What is gluten?

A. Gluten resembles gum, but differs in being *insoluble* in water, whereas gum is easily dissolved.

Q. What is fixed oil?

A. Fixed oil is decomposed by heat: it is

Secre'ted, *part.* formed, produced.
Exu'des, *v.* issues forth.
Farina''ceous, *a.* of the nature of farina, or flour
Insol'uble, *a.* not to be dissolved.

contained in the seeds of plants only, except the olive, from the fruit of which it is extracted.

Q. What is *volatile* or essential oil?

A. Oil that may be volatilized, but not decomposed by heat: it is contained in every part of the plant except the seed; but is found most abundantly in the rinds of fruits.

Q. Is not the perfume of plants and flowers an essential oil?

A. Yes; and it is very plentiful in the leaves of mint, thyme, and all *odoriferous* herbs.

Q. What is camphor?

A. Camphor nearly resembles volatile oil, but has some remarkable peculiarities; it is obtained chiefly from the camphor-tree, a species of laurel growing in China, and the Indian isles; is extremely volatile and inflammable; insoluble in water, but soluble in oil.

Q. What are resins?

A. They are volatile oils peculiarly modified by oxygen; part of their hydrogen and carbon being disengaged by combustion. Pitch, tar, turpentine, copal, mastic, and frankincense, are resins. Copal and mastic are used, dissolved in oil, or alcohol, as varnishes, being insoluble in water.

Vol′atile, *a.* that will fly off in vapour.
Odorif′erous, *a.* fragrant, productive of a sweet scent.

Q. What are gum resins?

A. Resins combined with mucilage. Myrrh and assafœtida are of this description.

Q. What are balsams?

A. Resinous juices, combined with a peculiar acid, called the benzoic acid; such are the balsams of Tolu, Peru, &c.

Q. What is caoutchouc?

A. Caoutchouc is that substance known by the name of Indian rubber: it exudes from two or three species of trees in the East-Indies, as a milky juice, into which moulds of clay are dipped, which forms little bottles, that are originally white, but blacken as they dry.

Q. What is extractive colouring matter?

A. That colouring matter which is extracted from vegetables, for the purpose of painting and dyeing: their tints are not, in general, so durable as mineral colours.

Q. What is tannin?

A. Tannin is an ingredient much used in the arts. It is obtained chiefly from the bark of trees, particularly of the oak; it is found also in nut-galls, and in a few other vegetables.

Q. What is woody fibre?

A. It is the hardest part of plants, and forms a kind of skeleton, which retains its shape after the other materials have disappeared.

CHAPTER XVI.

Of Vegetable Acids.

Q. How many vegetable acids are there?

A. Eleven:

The Mucous Acid, obtained from	gum, or mucilage.
Suberic, ...	cork.
Camphoric, . . .	camphor.
Benzoic, ...	balsam.
Gallic, ...	galls, bark, &c.
Malic, ...	ripe fruits.
Citric, ...	lemon-juice.
Oxalic, ...	sorrel.
Succinic, ...	amber.
Tartarous, ...	tartrit of potash.
Acetic, ...	vinegar.

Q. What are their general properties?

A. They are all decomposed by heat, soluble in water, and turn blue vegetable colour red.

Q. Is it necessary to describe these severally?

A. As their shades of difference are small, it may be necessary merely to mention that the oxalic acid, distilled from sorrel, is the highest term of vegetable acidification; and that the gallic acid constitutes what is called the *astringent* in vegetables. It is generally combined with tannin.

Astrin'gent, *a.* endued with the power of bracing or contracting the parts of the body.

Q. How may this astringent principle be detected in vegetable infusions?

A. By pouring in a little of the solution of sulphat of iron, which will produce a black precipitate, resembling ink.

Q. Are the vegetable acids always found pure?

A. By no means: they are frequently found in the state of compound salts; but, as the acid *predominates*, they are called acidulous salts. Such is cream of tartar.

CHAPTER XVII.

Of the Decomposition of Vegetables.

Q. Are vegetables as easily decomposed as minerals?

A. Much easier; for their composition being more *complicated*, they more readily undergo chemical changes; for the greater the variety of attractions, the more easily the *equilibrium* is destroyed, and new combinations introduced.

Predom'inates, *v.* has the ascendency.

Com'plicated, *part.* made up of many parts, intimately combined.

Equilib'rium, *s.* exact balance.

Q. Does this decomposition take place during the life of the plant?

A. No; it does not take place until the plant has produced its fruit, or seed, and ceased to be useful; unless some accident should cause its premature death.

Q. Into what principles does the decomposition of vegetables resolve them?

A. Into their simple and primitive ingredients, hydrogen, carbon, oxygen, and azote.

Q. Is this a quick process?

A. No; very long; during which a variety of new combinations is successively established and destroyed.

Q. Are any of these processes deserving attention?

A. Yes; in the highest degree. The decomposition of vegetables is always attended by a violent internal motion, produced by the disunion of one order of particles, and the combination of another. This is called fermentation.

Q. What ingredients are necessary to produce this decomposition?

A. Water and a degree of heat; for if vegetables be thoroughly dried, no decomposition will take place, nor when they are frozen.

Q. Are there not several successive fermentations in the decomposition of vegetables?

A. Yes; the first is the *saccharine* fermenta-

Sac'charine, *a.* of the nature of sugar.

tion, to which degree barley is fermented previous to its being dried for malt. Seeds likewise undergo this fermentation previous to the appearance of the young plant.

The second is the vinous fermentation, because its product is wine; thus beer is the wine of malt.

The third is the acetous fermentation, which converts wine into vinegar, by the formation of the acetous acid.

The fourth and last, is the putrid fermentation, which is the final operation of nature, and her last step towards reducing organized bodies to their simplest combinations.

CHAPTER XVIII.

Of the Composition of Animals.

Q. Of what are animals composed?

A. Of four *fundamental* principles; oxygen, hydrogen, carbon, and nitrogen, which form gelatine, albumen, and fibrine, the immediate materials of animals.

Q. Are animals, then, less complicated in their nature than vegetables, as they are made up of fewer materials?

Fundamen'tal, *a.* principal, that forms the foundation of all the rest.

A. They form the most complicated order of compound beings; their organization is more perfect and intricate; but, notwithstanding the wonderful variety observable in the texture of the animal organs, the original compounds may be reduced to the three heads before mentioned.

Q. As animal substances are so complicated, can they be easily decomposed?

A. As the scale of attraction increases in proportion to the number of ingredients, they are extremely susceptible of decomposition.

Q. Is their *analysis* easy, and has it been brought to perfection?

A. No; it is both difficult and imperfect; for as animals cannot undergo chemical examination while living, and are liable to alteration immediately after death, it is probable that, when submitted to the chemist's *investigation*, they are more or less altered in their combination and properties.

Q. What is gelatine?

A. It is the chief ingredient of skin, and of all the membranous parts of animals, and may be obtained under the forms of glue, size, isinglass, and transparent jelly.

Anal'ysis, *s.* the act of separating the elements of which a body is composed, or of reducing a compound body to its first principles.

Investiga'tion, *s.* examination.

Q. From what part of animals may gelatine be obtained?

A. From almost every part; but more plentifully from skin, bones, horns, &c. Isinglass is gelatine produced from a particular species of fish.

Q. What is albumen?

A. In its most simple state, albumen appears in the form of a *transparent viscous* fluid, without taste or smell; it *coagulates* with a moderate degree of heat, and can never be restored to its fluidity.

Q. Is albumen abundant in animal combination?

A. The substance that composes the *nerves*; the serum, or white part of the blood; the white of eggs, and the curds of milk, are little else than albumen variously *modified*.

Q. What is the reason that the white of an egg *tarnishes* silver?

A. Because it contains a little sulphur, which, at the temperature of an egg just boiled, will decompose the drop of water that wets the spoon, and produce sulphuretted hydrogen gas, which will tarnish silver.

Transpa'rent, *a.* clear, that may be seen through.
Vis'cous, *a.* clammy, sticky.
Coag'ulates, *v.* assumes the appearance of curd, becomes clotted.
Nerves, *s.* those organs of the body which afford sensation of feeling.
Mod'ified, *part.* arranged.
Tar'nishes, *v.* discolours.

Q. What is fibrine?

A. Fibrine is an *insipid inodorous* substance, having something the appearance of fine white threads adhering together; it is the essential constituent of *muscles*, or flesh, in which it is mixed with, and softened by, gelatine.

Q. What other substances enter into the animal system?

A. Many which are not peculiar to it; as oils, acids, salts, &c. Animal oil is the chief constitution of fat; it abounds in cream, and is obtained in the form of butter.

CHAPTER XIX.

Of Animal Acids.

Q. What are animal acids?

A. The acids which are peculiar to animals are few in number. Those that we find ready formed are:

The bombic acid, obtained from		silk-worms.
The formic,	. . .	ants.
The lactic,	. . .	whey of milk.
The sebacic,	. . .	oil or fat.

Insip'id, *a.* tasteless.
Ino'dorous, *a.* without smell.
Mus'cles, *s.* those organs of the body which move our limbs.

Those produced during the decomposition of animal substances by heat, are the prussic and zoonic: the zoonic is produced by roasting meat.

Q. What is the prussic acid?

A. Prussic acid is commonly obtained from blood, by strongly heating that substance with caustic potash; the alkali attracts the acid from the blood, and forms with it a prussiat of potash; from this the acid can be obtained pure, by means of other substances that separate it from the alkali.

Q. What is its use?

A. It has a strong affinity for metallic oxydes, and precipitates the solutions of iron in acids of a blue colour: this is the Prussian blue, so much used in painting.

Q. Does not this colour sometimes become darker by exposure to the atmosphere?

A. Yes; unless prepared with red oxyde of iron; so that if this precaution be not taken, the painter, having harmonized his colour with the greatest care, finds afterwards this harmony destroyed.

CHAPTER XX.

On Animalization, Nutrition, and Respiration.

Q. WHAT is animalization?

A. Animalization is the process by which the food is assimilated, or converted into animal matter.

Q. By what organ is this process performed?

A. Chiefly by the stomach, which is the organ of digestion, and the principal regulator of the animal frame.

Q. What is digestion?

A. It is the first step towards *nutrition;* it is supposed that a fluid found in the stomach, called the gastric juice*, which is an extremely powerful *solvent,* is the principal *menstruum* in this operation.

Q. Into what substance is the food converted by this process?

Nutri'tion, *s.* nourishment.
Sol'vent, *s.* something that dissolves.
Men'struum, *s.* a liquor used to dissolve any thing, or to extract the virtues of any ingredient by boiling.

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* The gastric juice is a fluid found in the stomach of all animals, which does not merely reduce the food into very minute parts, but totally changes its taste, smell, and properties.

A. Into an uniform pulpy mass, called chyme, which, mingling with the bile and other juices, is changed into a substance resembling milk, called chyle: this being collected into one large vessel, is poured from thence into the heart.

Q. What substance does it then form?

A. It then begins to form blood; but this change is not perfected till it has passed through the lungs, and becomes modified by respiration.

Q. What is respiration?

A. Respiration is the act of breathing, which consists of a mechanical and chemical process.

Q. What is the mechanical part?

A. The mechanism of breathing depends on the alternate expansion and contraction of the chest, by which the air is regularly admitted and *expelled*.

Q. What is the chemical process?

A. As the heart, by a particular motion, drives the blood through the *arteries*, from whence it returns through the *veins*, it undergoes considerable alterations during the circulation; some of its constituent parts being gradually separated from it for the nourish-

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Expel'led, *part.* driven out.

Ar'teries, *s.* large vessels, or pipes, which convey the blood from the heart.

Veins, *s.* smaller vessels, which convey the blood back to the heart.

ment of the body, &c., the bright red colour of the arterial blood changes by degrees to purple, by the time it is brought back through the veins; it is then unfit for circulation, until purified of the hydrogen and carbon which it has acquired.

Q. How is this effected?

A. By respiration. When the *venous* blood enters the heart, it is driven from hence into the lungs. Here, coming in contact with the air we breathe, the *super-abundant* hydrogen and carbon are absorbed by it, and the blood restored to its primitive purity.

Q. From whence proceed the hydrogen and carbon with which the blood is impregnated when it comes into the lungs?

A. It acquires fresh supplies from the chyle that mixes with it.

Q. What is supposed to cause the redness of arterial blood?

A. The addition of oxygen to the blood in the lungs, which, gradually entering into combination with the hydrogen and carbon in circulation, produces the purple colour.

Q. How is animal heat produced?

A. The process that purifies the blood, produces likewise that genial warmth called animal heat; for the oxygen in the air we

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Ven'ous, *a.* belonging to the veins.
Superabun'dant, *a.* more than is necessary.

breathe, combining with the hydrogen and carbon, disengages this heat.

Q. Is heat produced in the lungs only?

A. No; the combination of the oxygen with the hydrogen and carbon is only begun in the lungs, and continues gradually through the circulation; it is thus uniformly dispersed over the whole body.

Q. Is there any other circumstance that may contribute to this salutary purpose?

A. The blood, in its circulation, by degrees has its capacity for caloric diminished, and heat, of course, must be disengaged.

Q. How is it that heat is increased by exercise?

A. The circulation is quickened; respiration accelerated, and, consequently, a greater quantity of caloric *evolved*, which is carried off by increased perspiration.

Evol'ved, *part*. produced, unfolded.

CHAPTER XXI.

Explanation of Chemical Terms.

Alcohol, rectified spirit of wine.

Alloy, the mixture of any two metals. Thus gold is said to be alloyed when mixed either with copper or silver, for the purposes of coinage.

Alluvial depositions, the soil which is formed by the destruction of mountains, when their particles are washed down and deposited by torrents of water.

Argillaceous earths, those earths which contain alumine or clay.

Calcareous, composed of lime and carbonic acid, such as chalk, marble, &c.

Chalybeates, such mineral waters as are impregnated with iron.

Combination, the term used to express a true chemical union of two or more substances.

Crystallization is, when a salt, previously dissolved in water or other fluid, and, by evaporation, the fluid is driven off, the salt gradually assumes a solid form and regular figure.

Decantation, the pouring or drawing off the clear fluid, and leaving the sediment behind.

Detonation, the noise and explosion which any substance makes upon the application of fire. It is also called fulmination.

Digestion, in chemistry, signifies the dissolving any solid substance in a proper menstruum, sometimes assisted by heat.

Distillation, the operation which, by means of heat and moisture, separates volatile matters from those that are fixed, or matters more or less volatile from one another.

Effervescence, an intestine motion excited between the parts of two different bodies when they act upon each other, attended with bubbles, vapours, and a hissing noise, occasioned by the air in disengaging itself.

Efflorescence, a mealy powder on the surface of certain bodies.

Effluvia, the minute particles which *exhale* from most *terrestrial* bodies.

Empyreuma, a disagreeable smell arising from the burning of animal and vegetable matter in close vessels.

Essences, essential oils obtained by distillation from odoriferous vegetable substances.

Fixed, an epithet descriptive of such bodies as resist the action of heat, so as not to rise in vapour. It is opposed to volatile.

Fulmination, the explosion, with a loud report, of certain powders, by friction or heat.

Fusion, the passing of a solid body to a fluid state by means of heat.

Granulation, the operation of pouring melted metal into water, thereby dividing it into small particles.

Levigation, the act of reducing any hard substance to an impalpable powder, by grinding it in a mill, or on a stone with a muller.

Oxidation, or *oxygenation*, the combination of any other body with oxygen.

Exha'le, *v.* to send out vapours.
Terres'trial, *a.* earthly.

Precipitation, the separation of a body from the fluid in which it is dissolved, by adding a third substance, so that the former may re-appear in a solid state; the substance recovered is called a precipitate, and the body which occasions the precipitation, a precipitant.

Pyrometer, an instrument for ascertaining the degrees of heat in furnaces and intense fires.

Receivers, glass vessels, of a globular shape, adapted to retorts, for the purpose of preserving the volatile matter raised in distillation.

Soponaceous, partaking of the quality or appearance of soap.

Saturation, the act of impregnating one substance with as much of another as it will hold.

Solution, the dispersion of the particles of a solid body in any fluid in so equal a manner, that the compound liquor shall be perfectly clear and transparent.

Sublimation, the act of raising certain volatile substances by heat, and again condensing them by cold into a solid form.

Sublimation is, to dry matters, what distillation is to *humid* ones. It is the process by which the volatile are separated from the fixed parts of bodies, by the application of heat alone, without moisture.

Vacuum, empty space.

Volatilization, the reducing into vapour such substances as are capable of assuming that form.

Hu'mid, *a.* moist.

Printed by W. CLOWES, Northumberland-court, Strand, London.