

**OUTLINES**  
**OF THE**  
**LECTURES ON CHEMISTRY,**  
**DELIVERED IN THE**  
**COLLEGE OF PHYSICIANS AND SURGEONS**  
**OF THE**  
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**OUTLINES**  
**OF THE**  
**LECTURES ON CHEMISTRY,**  
**&c.**

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**FIRST DIVISION OF THE COURSE,**

Embracing an account of the General Properties of Matter, and a statement of the Laws relating to those Agents of Forces, which are concerned in the production of Chemical Phenomena.

**1. ATTRACTION.**

By attraction is meant the unknown power which causes particles or masses of matter to approach each other. When it acts on masses, at sensible distances, it is called remote attraction, or gravitation: when it operates on the minute parts of bodies, it is termed contiguous attraction. The latter is subdivided into cohesion, and chemical attraction, or affinity.

**1. COHESION.**

Cohesion is employed in bringing into contact particles of the same nature, so as to form them into masses.

Acts as an antagonist force to caloric.

Degrees of this property in different bodies.

Effects of temperature in modifying the power of cohesion.

Action of the cohesive force in liquids.

Methods of overcoming the cohesion of bodies.

1. By heat. 2. By mechanical power. 3. By the agency of affinity.

Production of crystalline forms.

1. By cooling from a state of fusion. 2. Deposited from vapours. 3. From a solution. Definition of solution.

Influence of temperature on the solvent power of fluids. Some substances equally soluble in hot as in cold water, &c.

How crystals increase in size. Method of obtaining them perfect and large.

Influence of a nucleus, threads, &c. on the crystallization of bodies.

Modification of form in consequence of foreign substances in the solution.

Circumstances which retard crystallization. Saturated solutions removed from the pressure of the atmosphere.

Production of crystals influenced by electricity.

Efflorescence. Deliquescence. Watery fusion.

Rapid crystallization produces heat.

Force with which liquids expand while passing into the solid form.

#### CHEMICAL ATTRACTION, OR AFFINITY.

It unites dissimilar particles and produces compounds possessed of new properties.

Sometimes feeble, as when a salt unites with water. Saturation. Proper chemical action is attended with remarkable phenomena.

Change of properties by the union of similar bodies, exemplified by experiments.

1. Of chemical properties.
2. Form.
3. Colour.
4. Density.
5. Temperature.

Chemical action influenced by cohesion. Most powerful in liquids, and rarely takes place when the acting bodies are both in a solid form.

Influence of elasticity on affinity.

How the union of mixed elastic fluids or gases is effected.

1. By pressure.
2. By heat.
3. By electricity.

Vapours of dissimilar bodies have a strong tendency to combine.

Solids unite with gases more readily when their cohesion is diminished.

Union of elastic fluids with liquids and solids.

When a body is capable of combining with a number of others, it attracts them unequally. Hence the ingredients of compounds may be disunited by the agency of superior affinity.

Experiments in illustration of this proposition.

Some bodies appear to have no affinity for each other.

Union of two bodies by the intervention of a third body.

Methods of determining the degrees of affinity which a body may possess toward a number of others.

Tables of affinity. Geoffroy's. Kirwan's. Objections.  
 Double decomposition. Diagrams for illustrating it.  
 Neutrality which is observed after the decomposition  
 of two salts.

Chemical equivalents, or equivalent numbers explained.

Uniformity of composition in compounds.

Different, but definite, proportions in which two or  
 more bodies combine.

Law of multiples. Combinations of gases.

Of the atomic theory. Ancient notions concerning  
 atoms. Revived by Newton. Higgins' theory. Opinions  
 of Dalton and Berzelius.

Series of atomic numbers.

Dalton's theory of compound atoms.

Objections to the atomic theory.

#### CALORIC.

Doctrines concerning its nature.

1. That it is a subtile, imponderable fluid. 2. That  
 the phenomena of heat depend on a peculiar motion  
 or vibration of the particles of bodies.

Experiments of Rumford, Davy, and others, in favour  
 of the immateriality of heat.

Heat considered as a force opposed to cohesion.

It expands all bodies.

Experiments on the expansion of gases, liquids and  
 solids.

Practical applications of this property.

The cohesion of solids not destroyed by heat. When the caloric is abstracted, they contract to their original dimensions with great force. Experiments in illustration.

Solids differ in their expansibility.

Thermometer. History of the instrument. Different kinds of thermometers.

Sanctorio's. Other air thermometers. Leslie's differential.

Thermometers filled with mercury, spirit of wine, linseed oil, &c.

Mercury expands more uniformly than any other fluid, and is therefore the best which can be employed for filling thermometers, except those for determining low temperatures, when spirit of wine is preferable.

Various forms of the mercurial thermometer. Graduation of the scale. Fahrenheit's, Reaumur's, Delisle's, and Celsius's, or the centigrade.

Thermometers give us no idea of the absolute quantity of heat.

Some characters of a good thermometer.

Instruments for measuring high temperatures—Wedgewood's, Guyton Morveau's, and Dr. Ure's pyrometers.

#### COMMUNICATION OF CALORIC.

Bodies differently heated, have a tendency to gain an equality of temperature. Their superabundance of caloric escapes in two modes.

1. By conduction, or the gradual passage of the heat into the neighbouring bodies.

2. By radiation, with incalculable velocity, in the same manner as light is emitted from a luminous body.

Conduction of caloric more rapid through some bodies than through others.

Experiments on the relative conducting power of different metals.

Why some bodies feel much cooler than others, which are of the same temperature.

Our feelings no accurate test of temperature.

Some bodies very slow conductors.

Why slow conductors crack by the sudden application of heat.

Liquids are very imperfect conductors, and heat is transmitted through them in a peculiar manner; viz. by a circulation among their particles. When this motion of the particles is obstructed, the distribution of the caloric is retarded. If heat be applied to the upper surface of a fluid, this part will become expanded, and lighter than the other portions, and consequently will retain its place; so that caloric is propagated in a very slight degree through liquids, in a *downward* direction. But when the lower stratum is heated, the warm particles ascend, and colder ones descend and take their place, which are likewise expanded and rise to the top; and so on, till at length the caloric pervades the whole mass of fluid.

Experiments in illustration of these propositions.

Liquids *appear* to conduct in a small degree, but the effect may be owing to the radiation of caloric through them.

*Effects of heat on gases.* These bodies are affected in nearly the same manner as liquids by caloric; *i. e.* they are slow conductors, but not perfect non-conductors.

Advantages of the motion or circulation produced in the air by the operation of heat, in the economy of nature.

The non-conducting power of clothing materials depends chiefly on the air which they contain.

Count Rumford's experiments for determining the relative non-conducting power of different materials.

Effects of snow in retaining the caloric of the surface of the earth. Use of double window-sashes.

#### RADIATION OF CALORIC.

Proofs of the rapid passage of caloric as it escapes from heated bodies. It radiates with such velocity as not to affect the air through which it passes.

The radiation and reflection of caloric exhibited by means of concave mirrors.

Effects of surface on the radiating power of bodies.

Solar heat, which is always in combination with light, passes through transparent bodies without heating them; but terrestrial heat is for the most part arrested by screens of glass and other transparent substances. Heat which accompanies very intense light, will, however, pass through glass.



The power of bodies to absorb radiant heat depends on the nature of their surface. Influence of colour on the absorbing power. Practical applications.

There is probably a continual interchange of caloric between all bodies, whatever be their temperature. Apparent radiation of cold. Coldness of the earth's surface on a clear still night accounted for: also the deposition of dew. Method of procuring ice in India, by exposing water to the cooling influence of radiation during serene, cloudless nights.

#### LATENT HEAT.

By this term is meant, that portion of heat which exists in bodies without affecting our sensations or the thermometer. A great deal of caloric may be absorbed by, or escape from bodies, without affecting their temperature. This is evident from the length of time which they require to change their state from solid to liquid, and from liquid to gaseous; or *vice versa*, during the whole of which they must be receiving or emitting heat. When water is freezing, or ice is melting, their temperature remains stationary. Hence caloric may exist in a *concealed* or *latent state*.

Methods of determining the quantity of latent heat in water and other bodies.

The capacity for heat exhibited by different bodies is very unequal. Methods of determining the capacity of solids, liquids and gases.

*Specific heat*, means the *relative* capacities of different bodies, compared with some standard. The standard

for solids and liquids is water ; and for aeriform bodies, common air.

The capacity of a body is altered by a change in its density ; thus the compression of air disengages caloric ; but when a gas is rarified, there is an absorption of heat, in consequence of an enlargement of capacity.

Formation of clouds explained.

The absolute quantity of heat which any body contains is unknown. Discordant calculations on this subject.

#### STEAM AND VAPOUR.

Bodies in passing from a liquid to an aeriform state, absorb a vast quantity of heat.

The boiling of a liquid is caused by the rapid formation and escape of vapour. The production of vapour in smaller quantities, and proportionate to the temperature, takes place before ebullition commences.

The relative volumes occupied by the same substance in the solid or liquid state, and in the form of gas, are very different.

Steam, at the ordinary pressure of the atmosphere, is more than eighteen hundred times rarer than water.

The boiling point of every liquid is invariable, while pressure remains the same ; but is lowered when the pressure is reduced.

Influence of altitude on the boiling of liquids.

In vacuo, ebullition takes place at  $120^{\circ}$  F. less temperature than in the open air.

On the contrary, increasing the pressure, raises the boiling point. In a strong vessel, water may be heated red hot without boiling. Papins' digester. Perkins' steam-gun.

The elasticity of steam increases in a constant ratio with the temperature, *i. e.* it is doubled for every 40° F.

Capacity, or latent heat of steam. How determined.

Production of cold by rapid evaporation, caused by the large quantity of caloric which is absorbed by the vapour. Freezing of water by evaporating ether on its surface.

Of the steam engine. Savary's and Newcomen's engines. Mr. Watt's improvements. High pressure engines.

Equal weights of steam contain the same quantity of caloric; the latent heat diminishing as the sensible heat increases.

Evaporation in vacuo is facilitated by the absorbing power of sulphuric acid or other materials. Mr. Leslie's method of freezing water.

Influence of evaporation from the surface of the body, or insensible perspiration, on the temperature of living animals.

Persons may endure, with little inconvenience, air heated far above the boiling point of water, provided their bodies perspire freely.

Manner of cooling liquids by evaporation.

Explanation of the *cryophorus* or frost-bearer of Dr. Wollaston, and of the *pulse glass*.

*Distillation.* Different vessels for performing this operation described. *Distillation in vacuo.*

*Ignition or Incandescence.* The temperature at which solid bodies become red hot, is probably about 810° F. Air cannot be heated so as to become luminous, except when it is in the state of flame. The luminousness of heated bodies is not satisfactorily accounted for.

#### SOURCES OF HEAT.

1. The solar rays. 2. Electricity. 3. Mechanical action. 4. Chemical action. 5. Vital action.

#### ELECTRICITY.

General remarks.

Electrical phenomena, observed when glass, sealing-wax, &c. are subjected to friction. 1. Attraction and repulsion. 2. Peculiar sensation. 3. Noise. 4. Light.

Division of bodies into *electrics* and *non-electrics*: also into *conductors* and *non-conductors*.

Insulation.

Circumstances affecting the conducting power of bodies.

Difference in the electrical phenomena of bodies excited by different electrics.

Bodies similarly electrified repel each other; but when excited with electricity of different kinds, they attract each other.

Circumstances which determine the kind of electricity, when any particular electric is excited.

Electricity may be excited by friction, compression, expansion, fusion, evaporation, crystallization, &c.

The forces of electrical attraction and repulsion are inversely as the squares of the distances.

Experiments on bodies charged with the two electricities.

Phenomena of induction, or electricity excited by the influence of a charged body at a distance.

Franklin's theory of electricity.

Du Faye's.

Electrical machines : essential parts ; theory of their action.

Experiments with the electrical machine.

Rapidity with which the electrical influence traverses conductors.

Electrical attraction and repulsion.

Inflammation of various combustibles.

Influence of points, &c.

Electrometers. Gold leaf. Quadrant. Discharging, &c.

Electrophorus, theory of its action.

Electrical spark.

Leyden pail. Electrical battery.

Effects of powerful discharges from the battery ; viz. strong shock sufficient to kill animals ; fusion and burning of refractory metals ; fracture of thick glass, &c.

Electrical powers are confined to the surfaces of bodies, and are not proportionate to the quantity of matter which they contain.

Kind of electricity ; how determined.

Electrical light.

Difference between quantity and intensity.

Passage of electricity through a vacuum.

Chemical effects of ordinary electricity. 1. Oxidation of metals. 2. Reduction of oxides. 3. Decomposition of water.

Franklin's discovery of the identity of electricity and lightning.

Lightning rods: how best constructed; degree of protection which they afford.

Electrical phenomena are not only exhibited by friction, but by pressure, contact, chemical action, &c.

Experiments of Galvani, in 1789, which gave rise to the science of electro-chemistry. Volta's researches on this subject, and his discovery of the electric or galvanic pile.

When electricity is produced by the contact of two different metals; the metal which possesses the strongest affinity for oxygen is positive, while the other is negative.

Voltaic circles: their classification by Sir H. Davy.

Of the electrical columns, or dry piles of De Luc and Zamboni. Volta's *courronne des tasses*.

Influence of acid and other chemically acting liquids on combinations of metals. Cruickshank's voltaic trough. Improved trough of Dr. Wollaston. Account of several large voltaic batteries, and of the phenomena which they exhibit. Resemblance between their effects and those produced by the common electrical machine.

Chemical effects produced by the voltaic apparatus :  
 1. The decomposition of water. 2. Decomposition of salts. 3. The remarkable transference of the ingredients of compounds to a distance, and even through bodies for which they commonly exhibit a strong affinity. 4. The metallic bases of the alkalies and earths separated.

Application of electro-chemical discoveries.

By a particular method of experimenting, compounds may be decomposed, and their ingredients carried to a distance, even by the ordinary electrical machine.

The electro-chemical doctrines of Berzelius and Davy explained.

The decomposing power of voltaic combinations depends on the *number of alterations*, and their power of heating or burning metals, on the *quantity of surface*.

The quantity of electricity excited by a voltaic apparatus is much greater than is produced by the common machine ; being far more than imperfect conductors can discharge.

*Calorimotor* or *Deflagrator* of Dr. Hare.

Dr. Greenhow's improvements in the voltaic battery.

Analogy between certain electro-chemical effects, and some of the phenomena of vitality.

Electrical fishes. 1. Torpedo. (*Raja electrica*.) 2. Surinam eel. (*Gymnotus electricus*.) 3. Electrical catfish. (*Silurus electricus*.) 4. *Trichurus indicus*. 5. *Tetradon electricus*.

Description of the apparatus by which they give a shock.

Theories of the action of the voltaic pile. 1. Fabroni's. 2. Volta's. 3. Davy's.

The electrical phenomena of the common machine, as well as those of voltaic arrangements, probably depend on chemical action. The amalgam always becomes oxidized when the former is in action; and the plates of the latter are corroded by the fluids employed in exciting them.

The electrical theories of Franklin and Du Faye again adverted to.

Electro-chemical doctrines of Davy and Berzelius.

Facts apparently favouring the opinion that but one electrical fluid exists.

1. Phenomena of positively and negatively electrified points: the former exhibiting a *brush*, the latter a *point* of light.

2. Passage of certain bodies, such as particles of ignited carbon, the flame of a candle, &c. from the positive to the negative pole.

Facts which seem opposed to the doctrine of a single electrical current.

1. The flame of phosphorus passes to the *positive* pole.

2. Discharge of a leyden phial through a card or quire of paper.

3. Certain bodies are unipolar, *i. e.* they are capable of transmitting but one kind of electricity.

#### ELECTRO-MAGNETISM.

History of this department of science. Discoveries of Professor Oersted, of Copenhagen, in 1819. Influ-



ence of a wire connecting the two poles of a voltaic apparatus in action, on a magnetic needle placed in different positions with respect to it. There appears to be a tendency in the needle to revolve round the conjunctive wire. The effect on the needle ceases when the communication between the electrical poles is interrupted. The connecting wires may be of copper, silver, or other metal than iron or steel, and while transmitting the electrical energy, it exhibits magnetic powers, but does not retain them. Steel alone becomes permanently magnetic. When the wire is twisted spirally, and a piece of steel placed in its axis, the latter acquires permanent polarity in a short time. The action of the magnet and conjunctive wire on each other, is reciprocal; the latter has a tendency to revolve round the former. Various kinds of electro-magnetic apparatus for producing rotary motion exhibited.

Influence of magnetism in modifying chemical affinity.

#### LIGHT.

Opinions of philosophers respecting the nature of light.

Generally regarded as a peculiar subtile fluid, emitted from luminous bodies in right lines, with inconceivable velocity.

Its velocity, calculated from observations on eclipses of the satellites of Jupiter, is 195,000 miles in a second.

Extreme minuteness of its particles inferred from their not injuring the eye.

Calculations respecting the momentum of light. Transparency. Laws of reflection and refraction.

Double refraction; especially as exhibited by transparent crystallized carbonate of lime.

Decomposition of light by means of a triangular prism of glass, into seven primary colours.

Solar spectrum explained by means of a diagram.

Relative spaces occupied by the different colours.

The colours when recombined produce *white light*.

Their different illuminating and heating powers.

The heating effects observed in the spectrum, appear to depend on a set of rays distinct from those which produce light.

Chemical effects of the spectrum; differ in different parts; probably not produced by the light itself, but a peculiar influence or agency, which always *accompanies* the light in the *solar ray*.

Chemical effects of compound or white light. Action of light on natural bodies, animals and plants.

Phosphorescence, or the emission of a feeble light, without heat or chemical change. Solar phosphori.

Influence of light in inducing magnetic powers.

## SECOND DIVISION OF THE COURSE,

Comprehending an account of the different Elementary or Simple Bodies discovered by Chemists, and the results of the mutual action of these Bodies on each other.

Opinions concerning the nature of simple substances.

Ancient philosophers maintained the existence of four elements.

The number of elementary bodies at present known, (excluding those which are called by some, the imponderables) is 53. These have never been separated into simpler forms of matter: but they may still be compounds.

Classification of simple bodies. That founded on their electro-chemical relations seems preferable to any other arrangement hitherto proposed.

Dr. Thomson's system, in which bodies are classed into combustibles and supporters of combustion, is objectionable in many respects.

Difficulty of defining combustion.

In the electro-chemical classification, there are five belonging to the first, or *electro-negative* class, viz. 1. Oxygen. 2. Chlorine. 3. Iodine. 4. Fluorine. 5. Bromine.

In the electro-positive or second class, there are 48 bodies, which may be subdivided into two sections.

1. The first includes those which are non-metallic, which are ten in number.

2. The second comprehends the true metals, of which 38 are known.

### ELECTRO-NEGATIVE BODIES.

#### 1. OXYGEN. =8.\*

In the gaseous state, it was discovered by Priestley, in 1774. Its name signifies to generate acid. Obtained by heating peroxide of manganese, nitre, or chlorate of potassa: the last yields the purest gas. Also by the action of sulphuric acid on oxide of manganese: rationale.

*Properties.* Colourless and inodorous, a little heavier than atmospheric air, and sixteen times heavier than hydrogen gas; slightly soluble in water: a powerful supporter of combustion.

Oxygen combines with nearly all the simple bodies, forming with them either *acids* or *oxides*. It is an abundant element, forming eight-ninths of the weight of water, one-fifth of the volume of atmospheric air, (and constituting its active principle,) and a large proportion of most earthy and mineral substances.

#### 2. CHLORINE. =36.

Discovered by Scheele in 1774, who called it *dephlogisticated marine acid*. Examined by Berthollet, who supposed it was a compound of muriatic acid and oxygen. Announced as a peculiar element by Davy, in

\* The number placed after the name of the body at the head of each article, indicates its prime equivalent, or atomic weight; hydrogen being =1.

1810 ; which opinion concerning its nature is now generally adopted.

Methods of obtaining chlorine. 1. From a mixture of muriatic acid and black oxide of manganese. 2. From a mixture of common salt, manganese and sulphuric acid. 3. By adding sulphuric acid to bleaching powder, (*chloride of lime*.)

*Properties.* A permanent gas of a yellowish green colour, from which circumstance its name (from the Greek) is derived. It has a peculiar suffocating odour ; is fatal to animal life. Sp. gr. 2, 5 ; absorbed by water ; supports combustion, forming by its union with electro-positive bodies, *chlorides* or *acids* ; condensable into a liquid by pressure ; when moist it may be reduced to a solid by cold, (a hydrate of chlorine). Possesses disinfecting powers. Displaces oxygen from its combinations. Suffers no change by the action of decomposing agents.

Unites with oxygen in four proportions.

1. Protoxide, 1 eq. chl. (36) 1 ox. (8) = 44.

2. Peroxide, 1 eq. chl. (36) 4 ox. (32) = 68.

3. Chloric acid, 1 eq. chl. (36) 5 ox. (40) = 76.

4. Perchloric acid, 1 eq. chl. (36) 7 ox. (~~46~~) = 92

The oxides exist in the gaseous form. Their colour is deeper than that of chlorine. Both are decomposed, with explosion, by a moderate heat, and resolved into mixtures of oxygen and chlorine. The *protoxide* is prepared from a mixture of chlorate of potash and mu-

riatic acid ; the *peroxide* from the same salt and sulphuric acid.

Chloric acid forms chlorates by uniting with bases. Properties of these salts.

Chlorine is an abundant element. Forms a constituent of common salt. How detected.

### 3. IODINE. =124.

History. Account of its discovery published in 1813. Determined to be a simple substance by Davy. First obtained from *kelp*. Dr. Wollaston's process. Dr. Ure's process.

*Properties.* A dark coloured solid, having the appearance of graphite or *black lead* ; friable ; taste and odour of chlorine ; poisonous. Sp. gr. 4, 44. Sparingly soluble in water ; stains the skin brown ; fusible and volatile. Its vapour is of a beautiful violet ; hence its name. It is a non conductor of electricity.

Iodine unites with most other elements, forming iodides or acids.

With oxygen it forms two acids : iodous and iodic. With chlorine it forms chloriodic acid.

Iodine has been found in certain mineral waters, and even in the ocean. Recently it has been discovered in the mineral kingdom, in combination with silver, mercury and zinc.

Methods of searching for it. Detected by means of starch, which forms with it a fine blue precipitate.

Uses of iodine as a medicine.

## 4. FLUORINE. =2? 18?

But little is known respecting this element. It has been separated in very minute quantities from fluoric acid, in which it appears to be united to hydrogen. It is a brownish solid. United with bases it forms fluorides. Derbyshire spar is probably a fluoride of calcium.

## 5. BROMINE. =77?

Discovered in 1826, by Balard. It exists in very small proportion in sea water, and in several marine productions.

*Properties.* A reddish brown liquid, emitting fumes of a very unpleasant odour; corrodes animal substances; poisonous. Sp. gr. 3. Volatile; not affected by electricity. Acts powerfully on combustibles, and on some of the metals. Acidifiable both by hydrogen and oxygen.

Method of separating it from sea water.

## ELECTRO-POSITIVE BODIES.

## FIRST ORDER.

Including those that are not metallic, viz.

- |                |               |
|----------------|---------------|
| 1. Hydrogen.   | 6. Boron.     |
| 2. Nitrogen.   | 7. Selenium.  |
| 3. Sulphur.    | 8. Silicon.   |
| 4. Carbon.     | 9. Zirconion. |
| 5. Phosphorus. | 10. Titanium? |

## 1. HYDROGEN. =1.

When uncombined it always assumes the form of a gas. Discovered by Cavendish in 1766.

Methods of obtaining it.

1. By the action of diluted sulphuric or muriatic acid, or zinc, or iron.

2. By passing steam over red hot iron.

*Properties.* A colourless gas. Odour unpleasant, as commonly prepared. Fatal to animal life. Non-supporter of combustion. Extremely inflammable. Burns silently, with a pale flame, if unmixed. Detonates with atmospheric air or oxygen gas. Musical sounds produced by burning it in a tube: how explained. Effects produced on the voice by breathing hydrogen mixed with common air. Hydrogen is the lightest body known; more than fourteen times lighter than atmospheric air: hence it is employed for filling balloons. A cubic foot of the gas has an ascending power of one ounce.

Hydrogen supposed to exist in the upper regions of the atmosphere, and its inflammation to be the cause of certain luminous meteors.

Opposed to this opinion is the fact that gases have a strong tendency to unite with each other.

Immense quantity of heat produced by the rapid combustion of hydrogen.

Compound, or oxyhydrogen blowpipe: invented by Professor Hare in 1801. Accounts of his and Professor Silliman's experiments published in England and France.

Experiments of Dr. Clarke of Cambridge, England, in 1816.



## Gurney's oxyhydrogen blowpipe.

## WATER.

Formation of water by the combination of oxygen and hydrogen gases. Composition of this fluid discovered by Mr. Cavendish in 1781. Confirmed by Lavoisier and other French chemists.

Analysis of water. 1. By passing steam over red hot iron. 2. By the action of diluted sulphuric acid on iron or zinc. 3. By the agency of electricity. Composed of 1 equivalent hydrogen (1) and 1 equiv. oxygen (8) = 9, its representative number.

*Properties of water.* Natural waters always impure. Sources of their impurities. Water nearly incompressible by a moderate force. Effects of great pressure. Cubic foot at 40° weighs 999.09141 ounces avoirdupois. Greatest density at 40°; importance of this property. Water contains air. Existence of air in water demonstrated.

Atmospheric moisture: quantity variable; how ascertained. Dalton's theory concerning the aqueous vapour in the air. Phenomena of dew. Clouds. Hygrometers or instruments for measuring the quantity of atmospheric moisture. De Luc's. Leslie's. Daniell's. Foggo's.

Hydrates, or definite compounds of water and metallic oxides or other bodies.

PEROXIDE OF HYDROGEN. Discovered by Thénard. It is hydrogen combined with twice the quantity of oxygen that exists in water.

*Properties.* A corrosive liquid of an oily consistence. Easily decomposed, giving up one proportion of its oxygen. Explodes by the contact of certain metals and combustibles. (See *Silliman's Journal*, xvii. No. 1.)

*Hydrogen and chlorine.* When mixed in equal volumes, unite with explosion by the action of heat, electricity, or the direct solar rays, forming MURIATIC OR HYDRO-CHLORIC ACID. When exposed to a moderate light, the combination takes place slowly.

*Properties.* A colourless gas; very acid; odour powerful. Neither supports life nor combustion. Sp. gr. 1.2847. Very rapidly absorbed by water. Not acted on by mercury. Liquid muriatic acid: how prepared. *Properties.* *Uses.*

Former and present opinion of chemists concerning the nature of muriatic acid. Lavoisier's, Berthollet's, Davy's, Murray's.

*Hydrogen and iodine.* Do not combine directly, but may be united by presenting hydrogen in a nascent state to iodine; forming hydriodic acid gas.

*Properties.* A gas resembling muriatic acid in many respects. Its solution in water forms liquid hydriodic acid. Its salts called hydriodates: some of them are employed in medicine.

Iodine is disengaged from its combinations by chlorine.

2. NITROGEN. =14.

Discovered by Dr. Rutherford in 1772. How obtained. 1. By removing the oxygen from atmospheric air. 2. Action of nitric acid on muscular fibre.

*Properties.* An invisible gas, rather lighter than atmospheric air. Non-supporter of life and combustion. Not absorbed by water.

Supposed by some chemists to be a compound.

Unites with oxygen in five proportions, forming two oxides and three acids.

1. PROTOXIDE OF NITROGEN. (*Nitrous oxide* or *exhilarating gas*.) Discovered by Priestly in 1782. Obtained by heating nitrate of ammonia.

*Properties.* A gas. Water absorbs its own volume. Sweetish taste. Certain combustibles burn brilliantly in it. Exhilarating effects when inhaled. Explodes with hydrogen gas.

Composed of 1 equiv. nitrogen. (14) and 1 of oxygen, (8) = 22 : or 1 vol. oxygen and 2 vol. nitrogen, the whole condensed into two vols.

2. DEUTOXIDE OF NITROGEN. (*Nitrous gas*.) Discovered in 1772 by Priestley. Formed by the reaction of nitric acid on metallic or inflammable bodies. Rationale.

*Properties.* Colourless gas, rather heavier than atmospheric air. Most burning bodies extinguished in it; though it supports the combustion of phosphorus. Slightly absorbed by water. Forms <sup>red</sup> and fumes when mixed with common air or oxygen! Mixed with hydrogen it burns silently! Absorbed by a solution of green vitriol. It is composed of 1 equiv. nitrog. (14) and 2 equiv. oxyg. (16) = 30 : or 1 vol. nitrog. and 1 vol. oxyg. ~~condensed into 1 vol.~~ unite without condensation

3. **HYPONITROUS ACID.** Has scarcely been obtained in a separate state, but ascertained to be composed of 1 equiv. nitrog. (14) and 3 equiv. oxyg. (24) = 38.

4. **NITROUS ACID.** Obtained by mixing 2 volumes of deutoxide of nitrogen, with 1 volume of oxygen.

*Properties.* An orange coloured gas. Condensable into a liquid by great pressure or extreme cold. Water absorbs its rapidity; but partially decomposes it. Forms *nitrites* by uniting with bases.

Composed of 1 equiv. nitrog. (14) and 4 equiv. oxyg. (32) = 46: or 1 vol. nitrog. and 2 vols. oxyg.

5. **NITRIC ACID.** Never obtained except in combination with water. Distilled from a mixture of nitre and sulphuric acid. Has been long known.

Method of obtaining nitric acid in the large way. Impurities of the commercial acid.

*Properties.* A colourless liquid. Sp. gr. 1, 5. When coloured, it contains nitrous gas in solution. Decomposed by light. Emits fumes. Extremely acid. Stains the skin yellow. Acts violently on most metals and combustibles, converting them into oxides or acids.

Composed of 1 equiv. nitr. (14) and 5 equiv. oxy. (40) = 54. In the liquid state it contains 2 equiv. water (18), and then its combining number is 68.

Synthetic proofs of its composition.

*Nitro-muriatic acid* or *Aqua regia*. Mixture of nitric and muriatic acids. Dissolves gold and platina.

*Uses.* In medicine. Etching. Dyeing. Metallurgy.

*Nitrogen and hydrogen.* Combine when one or both are presented in a nascent state, forming ammonia, or **VOLATILE ALKALI.**

Usually obtained from some of its compounds, e. g. by heating a mixture of muriate of ammonia and quicklime.

*Properties.* A colourless gas. Odour remarkably pungent. Rapidly absorbed by water; hence it must be collected over mercury. The saturated aqueous solution contains 520 times its bulk of the gas, and is lighter than water. Caustic and alkaline. Combustible in oxygen, but not in common air. Sp. gr. 0.59. Decomposed by electricity, which doubles its bulk and resolves it into a mixture of 1 vol. nitrog. and 3 vol. hydrog; or 1 equiv. nitrog. (14), and 3 hydrog. (3), =17.

It explodes with oxygen. Mixed with the same gas and passed through a hot tube it suffers decomposition.

Phenomena exhibited by the action of electricity on ammonia, or its compounds, placed in contact with mercury.

Reaction of chlorine and ammonia. Products.

*Nitrogen and chlorine.* Unite indirectly, forming **CHLORIDE OF NITROGEN.** Discovered by Dulong.

*Properties.* A yellowish liquid, heavier than water. Odour excessively pungent. Volatile. Detonates with extreme violence by heat, friction, or the contact of various combustibles.

*Nitrogen and iodine.* Form an analogous compound.

Ammonia sometimes formed during intense chemical action.

Its existence in rust of iron. Tests of its presence.

General properties of ammoniacal salts.

**MURIATE OF AMMONIA**, or *Sal-ammoniac*. May be obtained by the direct union of its constituents, in equal volumes : entire condensation of the gases takes place, and a white solid is the product.

*Properties.* A very soluble salt, of a sharp saline taste. Sublimes without change. Decomposed by alkalis and lime, with the evolution of ammonia.

Manufacture of sal-ammoniac in the large way.

*Uses.* In medicine and the arts.

**NITRATE OF AMMONIA.** A very soluble salt. Chiefly employed for the preparation of nitrous oxide. Rationale.

#### ATMOSPHERIC AIR.

General properties. Its height. Pressure. Employed as the standard of specific gravity for all other gases. Description of the air-pump.

Composition was of the air discovered by Scheele and Lavoisier. Experiments of the latter, performed in 1784. Other methods of analyzing air. 1. By the rapid combustion of phosphorus. 2. By the slow combustion of phosphorus. 3. By means of hydrogen. 4. By sulphuret of potassa. 5. By nitrous gas. 6. By a solution of nitrous gas in green vitriol. 7. By spongy platinum.

Atmospheric air is ascertained to be composed on an average of 79 nitrogen and 21 oxygen.

Some chemists suppose the true proportions are 80 nitrogen, and 20 oxygen.

Proust and others maintain that the air is a compound. Dulong's experiments opposed to this opinion.

The air is not uniform in its composition. Faraday's analysis of air from the Polar Regions.

Other ingredients in the atmosphere, viz.

1. Carbonic acid, constituting from .01 to .001 part of its bulk.

2. Aqueous vapour.

3. Other substances, in small and variable quantities.

The atmosphere is the great source from whence organized bodies obtain their nitrogen.

### 3. SULPHUR. =16.

*Properties.* A non-conductor of electricity, therefore an electric. Possesses high refractive powers. Crystallizes in octohedrons: two primary forms. Fuses at 220°. Sublimes at 570°. *Flowers of sulphur.* Melted and poured into water, it becomes viscid: employed in this state to take impressions of seals, &c. Insoluble in water, but taken up in small quantity by alcohol and ether. Fixed oils dissolve it.

Manner of obtaining sulphur. Its principal native compounds.

Unites with most simple bodies.

Its equivalent number is 16, or exactly double that of oxygen.

With oxygen it combines in 3, and according to some, in 4 proportions, forming as many acids.

1. **HYPOSULPHUROUS ACID.** Has only been obtained in union with bases. Consists of 1 equiv. sulph. (16), and 1 oxygen, (8) =24.

2. **SULPHUROUS ACID.** Formed by the combustion of sulphur in dry oxygen or atmospheric air: also obtained by abstracting oxygen from sulphuric acid. (The action of sulphuric acid and mercury.)

*Properties.* A gas at ordinary temperatures, but condensable into an extremely volatile liquid, by a cold of  $0^{\circ}$ , or by a moderate pressure. Odour suffocating. Destroys life. Extinguishes burning bodies. Water absorbs 30 vol. of the gas, and then acquires feeble acid properties. Effaces vegetable colours, but does not destroy them.

Application of the liquid anhydrous acid for producing very intense cold.

The gaseous acid is emitted by active volcanos.

It consists of 1 equiv. sulph. (16) and 2 equiv. oxygen (16) =32.

3 **HYPOSULPHURIC ACID.** Its existence rather doubtful. It is said to be composed of 1 equiv. sulph. (16), and 2.5 equiv. oxyg. (20), =36.

4. **SULPHURIC ACID.** *Oil of vitriol.* Discovered by the alchemists. Cannot be obtained by the direct combination of its elements.

*Properties.* When free from water or in an anhydrous state, it is a colourless solid. Its ordinary form is a liquid.



Viscid, pouring like oil. Sp. gr. 1.84. Boils at  $620^{\circ}$ : the boiling point depends on the quantity of water in combination. Freezes at  $15^{\circ}$  when concentrated, but at  $40^{\circ}$ , when of sp. gr. 1.78. Exceedingly acid. Corrodes animal and vegetable matter. Rapidly attracts moisture from the atmosphere. Much caloric evolved when mixed with water. The diluted acid, mixed with snow, produces extreme cold.

Composed of 1 equiv. sulphur. (16), and 3 equiv. oxyg. (24) = 40. The liquid acid contains 1 equiv. water (9); hence its number is 49.

Manufacture of sulphuric acid in the large way. Mixture of sulphur and nitre burned in leaden chambers over a stratum of water. Theory of the process. Concentration of the acid. German method of obtaining sulphuric acid. Mr. Hill's process. Impurities of the ordinary acid: how detected and removed. Method of determining its strength.

Native sulphuric acid. Found in volcanic countries, and in certain mineral waters. Tests of its presence.

*Uses.* In Bleaching. Dyeing. Metallurgy. For obtaining other acids, &c.

*Sulphur and chlorine.* Unite and form a greenish yellow volatile liquid which is converted into muriatic and sulphuric acids when thrown into water.

*Sulphur and iodine* form an analogous compound.

*Sulphur and hydrogen.* Form the compound called SULPHURETTED HYDROGEN. Discovered by Scheele in

1777. Obtained by heating sulphur in hydrogen gas. Also obtained by the action of diluted sulphuric or muriatic acid on certain metallic sulphurets. Rationale.

*Properties.* A gas at ordinary temperatures, but may be liquified by a pressure of 17 atmospheres, at 50°. Odour intensely fetid. Sp. gr. 1.19. Extinguishes burning bodies, but burns with a blue flame. Products of its combustion. Very deleterious to animals, even when mixed with much atmospheric air. Explodes with oxygen. Water absorbs 3 vols. of the gas. Acts powerfully on various metals and oxides. Reddens vegetable blues, and combines with bases like an acid. Decomposed by chlorine and iodine. Fuming nitrous acid when thrown into it causes violent detonation.

**BISULPHURETTED HYDROGEN.** A compound, discovered by Scheele. It contains two proportions of sulphur to one of hydrogen. Its existence doubted by Brande. Unites with bases, forming *hydroguretted sulphurets*.

#### 4. PHOSPHORUS. =12.

Discovered by the German alchemist Brandt.

*Properties.* A solid of the consistency of wax, colourless when pure, translucent. Highly inflammable, burning with a dense yellow flame, and emitting much white smoke. Sp. gr. 1.77. Melts at 100°, evaporates at 219°, and boils at 554°. Crystallizes. Poisonous. Luminous in the dark when the air is above 60°. Odour of the vapour alliaceous. Soluble in oil, alcohol and ether. Its combining number is 12.

Unites with oxygen in 3, perhaps 4, proportions.

1. OXIDE? Solid. Has been little examined.

2. HYPOPHOSPHOROUS ACID. Only obtained in combination with water. Composed of 2 equiv. phosph. (24) and 1 equiv. oxyg. (8) = 32.

3. PHOSPHOROUS ACID. Obtained by the action of protochloride of phosphorus on water; the water is decomposed, its hydrogen uniting with the chlorine, and the oxygen with phosphorus. Thus muriatic and phosphorus acids are formed: heat expels the former.

*Properties.* A crystalline solid. Absorbs oxygen by exposure to the air. Burns brilliantly when heated. Its salts are called phosphites.

Composed of 1 equiv. phosph. (12) and 1 equiv. oxyg. (8) = 20.

PHOSPHORIC ACID. The most important of the acids of phosphorus. It contains the maximum of oxygen. Obtained by burning phosphorus in oxygen gas, or by subjecting it to the action of nitric acid. It may also be procured from bones, which consist chiefly of the phosphate of lime. Process described.

*Properties.* A white solid, intensely acid, fusible into a transparent glass, in which state it is called *glacial phosphoric acid*. Very deliquescent, and soluble in water; its solution when concentrated is dense and oily. Decomposed by charcoal at high temperatures, yielding phosphorus and carbonic acid. Its salts are called phosphates: those with earthy and metallic bases are

insoluble. Many exist in the mineral kingdom. Composed of 1 equiv. phosph. (12) and 2 equiv. oxyg. (16) =28.

*Phosphorus and chlorine.* Unite in two proportions.

1. **PROTOCHLORIDE.** Formed by subliming phosphorus through corrosive sublimate. Rationale.

*Properties.* A limpid, extremely volatile fluid. Inflames spontaneously when spread on paper.

2. **PERCHLORIDE.** Obtained by placing phosphorus in dry chlorine gas. Spontaneous combustion takes place and the chloride is produced.

*Properties.* A white solid, extremely volatile. Immediately decomposes water, producing muriatic and phosphoric acids. Rationale.

*Phosphorus and iodine.* Unite forming a compound which decomposes water, with the production of phosphoric and hydriodic acids.

*Phosphorus and hydrogen.* Combine, forming two definite compounds.

1. **PHOSPHURETTED HYDROGEN.** Discovered by Davy in 1812. Obtained by heating hydrated phosphorus acid. Rationale.

*Properties.* A colourless gas, of a disagreeable odour. Does not take fire spontaneously in the air, but detonates when mixed with oxygen and heated to 100°. Explodes with chlorine. Decomposed by sulphur.

Composed of 1 equiv. phos. (12) and 2 equiv. hydrog. (2) =14.

**BIPHOSPHURETTED HYDROGEN.** Prepared by boiling phosphorus in a strong solution of potassa. Rationale.

*Properties.* A gas. Odour fetid, somewhat resembling that of garlic. Rather lighter than common air. Absorbed in very small proportions by water. Burns spontaneously when mixed with common air or oxygen! Products of its combustion. Easily decomposed by heat or electricity.

Composed of 1 equiv. phosph. (12), and 1 equiv. hydrog. (1) = 13.

*Phosphorus and sulphur.* When melted together unite and form a fusible compound, which is very inflammable.

#### 5. CARBON. = 6.

Charcoal is nearly pure carbon. Manner of preparing it.

Other forms of carbon: Diamond, graphite, anthracite, lampblack, coak, &c.

*Properties.* Insoluble in any menstruum. Indestructible by air or moisture. Not affected by heat when oxygen is excluded. Brittle. Inusible. (Silliman's and Vanuxem's experiments.) Corrects unpleasant odours, and removes colouring matter from various liquids: animal charcoal best for these purposes, on account of its great porosity. Density variable. Burns rapidly in oxygen. Absorbs large quantities of different gases. A good conductor of electricity; but in most of its forms, conducts heat very slowly. Use of charcoal to preserve the temperature of bodies.

The different kinds of carbon differ much in their combustibility. Causes of this difference.

Carbon unites with many elementary bodies, forming carburets, acids, &c. Its equivalent number is 6, which is lower than any other element except hydrogen.

Its affinity for oxygen very great. Combines with this substance in two proportions, forming in both cases gaseous compounds.

1. CARBONIC OXIDE. Obtained. 1. By heating charcoal and oxide of manganese. 2. By heating charcoal mixed with some compound containing carbonic acid; such as carbonate of lime or baryta. Rationale.

*Properties.* A gas, rather lighter than atmospheric air. Burns with a pale blueish flame. Is very easily lighted. Produces no water during its combustion, but carbonic acid only. Noxious to animals. Does not explode with common air.

Composed of 1 equiv. carbon (6), and 1 equiv. oxygen (8) = 14.

Carbonic oxide unites with chlorine by the action of light, and forms a compound, called by its discoverer, (Dr. J. Davy), PHOSGENE GAS.

*Properties.* Odour peculiar, and suffocating. Reddens vegetable blues. Combines with ammonia. Hence it resembles an acid. Has been called by some chemists *chloro-carbonic acid*. Water converts it into muriatic and carbonic acids.

2. CARBONIC ACID. Carbon united with the maxi-

num of oxygen. Discovered by Dr. Black, who called it *fixed air*.

Prepared by the action of diluted sulphuric or muriatic acid, or carbonate of lime.

*Properties.* A gas in its ordinary state, but has by employing extreme pressure, been compressed into a liquid by Faraday. Sp. gr. 1.519. It extinguishes flame, even when united with several times its volume of oxygen or atmospheric air. Fatal to animal life. Water absorbs one volume of the gas: the solution is sparkling and slightly acid. Soda-water, champaign, &c. Manner of impregnating water with the gas. Its effects on lime-water and caustic alkalies. Exists in the atmosphere: how demonstrated. Its sources. Constitutes the chief food of plants.

Composed of 1 equiv. carb. (6), and 2 equiv. oxyg. (16) = 22.

Tenant first analyzed this acid, by heating carbonate of lime with phosphorus. Rationale. It may also be decomposed by potassium. When passed through heated charcoal it becomes carbonic oxide: this change takes place in ordinary fires: flame of anthracite and common charcoal thus accounted for.

Carbonic acid is an abundant native compound: exists combined with earths, alkalies and metallic oxides, forming with them carbonates; also in an uncombined state. Occurs in wells, caverns, &c. Called *choak-damp* by miners. Grotto del Cano, in Italy. Mineral waters

charged with this gas. Source of the carbonic acid in these situations: probably the action of sulphuric acid on carbonate of lime, deep beneath the surface of the ground.

**CARBONATE OF AMMONIA.** Formed when 2 vol. carbonic acid and 1 vol. ammonia are mixed together over mercury: a dry volatile powder is formed.

**BICARBONATE OF AMMONIA.** Formed by passing carbonic acid through a solution of the common carbonate.

**SESQUICARBONATE OF AMMONIA.** The common sub-carbonate of the shops. Prepared by heating muriate of ammonia with carbonate of lime. Rationale.

Contains 1.5 equiv. carbonic acid (33), 1 equiv. ammonia (17), and 1 equiv. water (9.)

*Properties.* Solid, compact, semicrystalline, of a pungent ammoniacal odour.

Its uses in medicine.

*Carbon and chlorine.* Compounds of these elements first obtained by Faraday in 1821. Three are known.

1. **PERCHLORIDE OF CARBON.** Formed by exposing a compound of chlorine, carbon and hydrogen to the action of chlorine gas and light. The hydrogen is removed, and a chloride of carbon remains.

*Properties.* A solid, resembling camphor. Fusible and inflammable. Volatile. Sparingly soluble in water, but taken up by alcohol, ether, fixed and volatile oils.

Composed of 3 equiv. chlorine (108), and 2 equiv. carbon (12) = 120. When its vapour is passed through a hot tube it is converted into chlorine gas and carbon.



2. **PROTOCHLORIDE OF CARBON.** A limpid, colourless fluid at 0°. Volatile at 160°.

Composed of 1 equiv. chlorine (36), and 1 equiv. carbon (6) = 42.

3. **SUBCHLORIDE OF CARBON.** A soft fibrous substance, having the appearance of spermaceti. Fusible. Sublimes at a low temperature.

Composed of 1 equiv. chlorine (36), and 2 equiv. carbon (12) = 48.

*Carbon and hydrogen.* Many definite compounds of these elements are now known. Some exist in the liquid form, others are gases. Their nomenclature not yet determined.

4. **OLEFIANT GAS, or Percarburetted Hydrogen.** Discovered by some Dutch chemists in 1796. Prepared by heating a mixture of 4 parts of sulphuric acid and 1 part of strong alcohol in a retort. Rationale.

*Properties.* An invisible gas. Inodorous when pure. Burns with a dense white light, with the formation of carbonic acid and water. Forms an explosive mixture with 4 or 5 vol. of oxygen gas. Electricity resolves it into carbon and hydrogen. Deposits carbon when passed through a hot tube, and increases in bulk. Combines with chlorine, forming an oil-like liquid, called *chloric ether* or *hydrocarburet of chlorine*! Mixed with chlorine and inflamed, muriatic acid is formed, and much carbon deposited. Unites with iodine, forming a compound analogous to chloric ether.

Composed of 2 equiv. carb. (12), and 2 equiv. hydrog. (2) = 14; or 2 vol. carbon-vapour and 2 vol. hydrogen, the whole condensed into 1 vol.

2. LIGHT CARBURETTED HYDROGEN. Formed at the bottom of stagnant waters by the decomposition of vegetables. How collected. Its impurities.

*Properties.* An inflammable gas, burning with a yellowish white flame. Forms an explosive mixture with oxygen or atmospheric air. Products of its combustion. Not readily decomposed by heat. Not affected by chlorine, except when moist and exposed to strong light. Effects on the system when inhaled.

Composed of 1 equiv. carbon (6), and 2 equiv. hydr. (2) = 8; or 1 vol. carbon-vapour, and 2 vol. hydr., condensed into 1 vol.

This gas often occurs in coal mines. It is called *fire-damp* by the miners. Often causes dreadful explosions. Account of the safety lamp, and of the experiments of Sir H. Davy on explosive mixtures. Theory of flame. Aphlogistic or flameless lamp.

*Other compounds of carbon and hydrogen.* Those discovered by Mr. Faraday in oil gas, viz. the bicarburet and quadricarburet of hydrogen.

(a.) BICARBURET OF HYDROGEN. A colourless transparent liquid, having the odour of oil-gas. Sp. gr. 0.85. Boils at 186°, and congeals at 32°. Slightly soluble in water, but is taken up by volatile and fixed oils, ether and alcohol. Very combustible, burning with a bright flame and much smoke.

(b.) **QUADRO-CARBURETTED HYDROGEN.** A gas at common temperatures, but condenses at  $0^{\circ}$  into a liquid, which is the lightest known. Its elements are greatly condensed.

(c.) **NAPHTHA** from coal tar ; resembles the native liquid.

(d.) **NAPHTHALINE.** A crystalline solid, also obtained from coal tar.

**COAL AND OIL-GAS.** Historical account of gas-illumination. Experiments of Mr. Murdock and M. le Bon, in 1797 and 1798. Description of the coal-gas apparatus. Products of the destructive distillation of coal. Quantity of gas obtained from different kinds of coal. Advantages of gas over oil, tallow, &c.

Oil-gas apparatus. Gas-works in New York. Clegg's gas-meter. Relative value of oil and coal-gas : how determined. Condensed gas for portable lamps.

*Carbon and nitrogen.* A compound of these elements was discovered by Gay-Lussac in 1815. It is called **CYANOGEN.** Obtained by heating prussiate, or cyanide of mercury.

*Properties.* A colourless gas, of a strong pungent odour, resembling that of bitter almonds. Burns with a purple flame ! Water absorbs 4 vol. of it ; alcohol 23 vol. Detonates with oxygen, affording carbonic acid and nitrogen, as the results.

It is a bicarburet of nitrogen ; *i. e.* it is composed of 2 equiv. carb. (12), and 1 equiv. nitrog. (14) = 26.

It combines directly with metals, forming cyanides. With hydrogen it produces

**HYDROCYANIC ACID**, or *Prussic acid*. In combination with water, it was discovered by Scheele in 1782. Its real nature determined by Gay-Lussac. Obtained by heating a mixture of cyanide of mercury and muriatic acid. Rationale.

*Properties.* A very volatile liquid, emitting the odour of peach-blossoms. Boils at  $79^{\circ}$ , and freezes at  $3^{\circ}$ : it produces much cold by its evaporation. Soluble in water and alcohol. A most virulent poison; destroying both plants and animals. Antidotes. Decomposes spontaneously, in a very short time. Has feeble acid properties, forming salts which are poisonous.

Composed of 1 equiv. cyanogen (26), and 1 equiv. hydr. (1) = 27; or considered in the state of vapour, it contains 1 vol. of each ingredient, united without condensation.

Medicinal use of hydrocyanic acid. Best method of preparing it for this purpose. How to determine its strength. Tests of its presence.

**CHLORO-CYANIC ACID.** How obtained. Properties.

**CYANIC ACID**, or a compound of cyanogen and oxygen. Obtained for the first time, in an uncombined state, by Serrulas, in 1828. It is solid, white, and crystallizes in rhombs, scarcely soluble, and possessing but little taste. Composed of 1 equiv. cyanogen (26), and

2 equiv. oxygen (16) = 42.\* Exists in fulminating silver and mercury.

Another compound of chlorine and cyanogen, the *perchloride*, was discovered by Serrulas in 1828. It is a crystalline solid, very volatile and poisonous.

*Cyanogen and iodine.* First combined by Sir H. Davy. They form a flocculent crystalline body, called iodide of cyanogen, or cyanide of iodine, which is volatile and of a pungent odour. It has been employed in medicine.

**FERRO-CYANIC ACID.** United to iron, it forms *Prussian blue*, or ferrocyanate of iron.

**SULPHO-CYANIC ACID.** Discovered in 1803, by Poiret. Forms a blood-red salt with oxide of iron. Its base is sulpho-cyanogen, or a compound of sulphur and cyanogen; which, united to hydrogen, forms the acid.

*Carbon and phosphorus.* Unite and produce an inflammable solid compound, of a dark colour.

*Carbon and Sulphur.* A compound of these elements was discovered by Prof. Lampadius, in 1796. He called it *alcohol of sulphur*. It is a BISULPHURET OF CARBON. Obtained by passing the vapour of sulphur over red-hot carbon.

*Properties.* A transparent, colourless liquid. Specific gravity 1.27. Does not combine with water. Highly

\* See *Annal. de Chem. et de Phys.* Aout. 1829, and *Sill. Jour.* for July, 1829.

inflammable. Refractive power very high. Odour fetid; taste pungent and aromatic. Freezing point very low. Combines with alkalis, forming *carbo-sulphurets*. Extremely volatile, and produces intense cold while evaporating. The products of its combustion are sulphurous and carbonic acids.

It is composed of 2 equiv. sulph. (32), and 1 equiv. carbon, (6)=38.

A peculiar acid appears to be generated by the action of this liquid on a solution of potassa in alcohol. It was discovered by M. Zeis of Copenhagen, who calls it *Hydroxanthic acid*, and its base, *Xanthogene*.

6. BORON. =8.

The base of boracic acid discovered by Davy in 1807. It is obtained by the action of electricity, or potassium, on boracic acid. Gay-Lussac has recently obtained it by passing hydrogen gas over boracic acid heated to redness in a porcelain tube.

*Properties.* A solid of a dark olive colour, without taste or smell. Does not decompose water. Scarcely affected by any solvent. Burns in atmospheric air or oxygen gas, with the formation of boracic acid.

**BORACIC ACID.** Is the only known compound of this body and oxygen. It occurs native, as a volcanic product, but may be obtained from borax, (borate of soda) by means of sulphuric acid.

*Properties.* A white solid, generally assuming the form of crystalline plates or scales, in which state it

contains a definite quantity of water. Slightly soluble in water. Acid properties feeble. Dissolves in alcohol and communicates to it the property of burning with a green flame. Fusible into a glass. Promotes the fusion of various solids. Its salts are called borates : several occur in the mineral kingdom.

The anhydrous, or fused acid is composed of 1 equiv. boron (8) and 2 equiv. oxygen (16) = 24. In a crystallized state it contains 2 equiv. water.

FLUOBORIC ACID. A remarkable compound, obtained by distilling fused boracic acid with fluat of lime.

*Properties.* A colourless gas, of a penetrating pungent odour ; extremely acid ; extinguishes flame. Forms a dense cloud when it escapes into the air, owing to its combination with the aqueous vapour it meets with. Water absorbs it in great quantity. Attacks animal and vegetable matters, but not glass.

7. SELENIUM. =40.

A very rare substance, discovered by Berzelius, in 1808. It exists in certain native sulphurets and other ores, and has also been detected in volcanic sulphur.

*Properties.* Solid, brittle, nearly opaque, of a brownish colour, and feeble metallic lustre. Without taste or odour. Sp. gr. 4.32. Softens at 212° and becomes tenacious. Boils at 650°. Vapour deep yellow. A nonconductor of electricity. Burns at a high temperature, and emits a powerful odour of horseradish.

Unites with oxygen in three proportions.

1. **OXIDE OF SELENIUM.** A gas, having the odour of horseradish.

2. **SELENIOS ACID.** Crystallizes in slender prisms. Deliquesces in the air. A distinct acid, forming seleniates with bases.

3. **SELENIC ACID.** A colourless liquid, much resembling sulphuric acid.

With hydrogen, selenium forms a colourless gas which resembles sulphuretted hydrogen. It powerfully affects the nostrils.

### 8. SILICON. ~~=10.~~ *Si.*

The base of siliceous earth. Discovered by Davy. Method of obtaining silicon.

*Properties.* A dark brown solid, destitute of metallic lustre. Incombustible in the air, or in oxygen gas. Infusible. Insoluble in any menstruum, and scarcely affected by the strong acids, except a mixture of fluoric and nitric acids. Explodes with alkaline carbonates, also with fused hydrates of potassa, soda and baryta.

**OXIDE OF SILICON.** *Silica, Silix* or *Siliceous earth.* The only known compound of silicon and oxygen. It exists abundantly in a native state, constituting the chief ingredient of many earthy minerals. How obtained from these.

*Properties.* White, inodorous and insipid. When in the form of powder, harsh and dry to the feel. Infusible except by the most intense heat. Insoluble in



water, except under peculiar circumstances, but combines with that fluid, forming a hydrate. Not acted on by any acid except the fluoric. Forms definite compounds with earths and alkalies, which are called silicates; hence it is regarded as an acid. Native silicates are very numerous.

Composed of 1 equiv. of silicon (8) and 1 equiv. oxygen (8) = 16.

Silica united with an excess of alkali forms a compound, which is soluble in water: the solution was formerly termed *liquor of flints*. With a less proportion of alkali, it forms glass. Different kinds of glass. Pastes or artificial gems.

Account of the principal varieties of quartz, or native silica, viz. *rock-crystal, amethyst, chalcedony, opal, flint, hornstone, buhrstone, jasper and agate*.

**FLUOSILICIC ACID.** A compound of fluoric acid and silica, or probably, of the bases of these bodies. Obtained by heating a mixture of fluuate of lime, fine sand or pounded glass) and sulphuric acid, in a glass retort.

**Properties.** A transparent gas, having an odour resembling muriatic acid: emits white fumes when mixed with the air. Powerfully acid. Extinguishes flame, and destroys life. Partially decomposed when brought into contact with water; 260 vol. of gas absorbed and much silica deposited! Sp. gr. 3.61 Unites with ammonia forming a solid fluosilicate.

Native siliceous compounds.

## 9. ZIRCONION. =30 ?

The base of the earth zirconia. Obtained by heating a mixture of potassium, and fluete of zirconia and potassa.

*Properties.* A black powder, destitute of metallic lustre ; not acted on by water, and scarcely affected by acids, except by the fluoric ; a non-conductor of electricity. Burns when heated, and is converted into zirconia. Unites with but one proportion of oxygen, forming

ZIRCONIA. An earthy substance, allied both to silica and alumina. Sp. gr. 4.3, white, tasteless, forms salts with acids. Not soluble in caustic alkalies.

Method of obtaining it from the jargon or zirconite, and the hyacinth.

## 10 ? TITANIUM. =24.

Discovered by Rev. Mr. Gregor of Cornwall, but only in combination with oxygen. Generally regarded as a metal. Dr. Wollaston's metallic titanium is supposed by Peshier to be a compound of iron and titanium. It has two oxides.

1. PROTOXIDE. Purple : exists in the mineral called *anatase*.

2. PEROXIDE. White, infusible ; insoluble in acids after being heated. Possesses feeble acid properties, like silica : hence considered as an acid by some chemists.

**Titaniferous minerals.**

SECOND ORDER OF THE ELECTRO-POSITIVE BODIES, VIZ.  
METALS.

Difficulty of characterizing these bodies.

1. Their most striking property is a peculiar strong lustre. The lustre pervades the whole mass, and is retained even when the metal is in fusion.

2. They are opaque, except when reduced to extremely thin leaves.

3. They combine with oxygen and other electro-negative bodies, and then lose their metallic lustre.

4. They are good conductors of heat and electricity.

The number of metals at present known, or admitted to exist, is 38\*. Of these, 35 have been separated from all other bodies, and their properties determined.

Seven were known to the ancients, viz. gold, silver, iron, copper, lead, tin, mercury.

Manner in which the metals exist in the earth.

1. Native, (uncombined with other bodies.) 2. Alloys. 3. Oxides 4. Chlorides. 5. Iodides. 6. Fluorides. 7. Sulphurets. 8. Selenurets. 9. Salts.

Specific gravity of the metals. Some are the heaviest bodies in nature; others are lighter than water.

Their *malleability*, or capacity of being extended by hammering. Thirteen have this property: it is most remarkable in gold.

\* The new metals *pluranium* and *ruthenium*, lately discovered in the crude platinum of Oural, by M. Osann, are not yet sufficiently known to be added to this number.

*Ductility* is the capability of being drawn into wire. Method of drawing wire. Dr. Wollaston's process for making fine gold and platinum wire.

The strength of metals is expressed by the term *tenacity*. How ascertained.

Hardness of metals. Elasticity. Sonorousness.

Crystallization of metals.

Fusing point; differs exceedingly in different metals. Mercury is fluid at ordinary temperatures, while some metals can scarcely be melted by the strongest heat known.

Some of the metals are volatile at a moderate temperature, viz. cadmium, mercury, zinc, arsenic, tellurium, potassium and sodium.

All of the metals combine with oxygen; many are inflammable. Method of oxidizing them. 1. By heating them in the air. 2. By means of nitric acid. 3. By nitrate of potassa.

Metals unite with one, or several, proportions of oxygen. Colours of metallic oxides. The affinity of different metals for oxygen very unequal. Method of determining the composition of oxides.

Reduction of oxides. 1. By heat. 2. By the action of certain combustibles. 3. By the united action of heat and combustibles. 4. By electricity. 5. By the agency of light.

Metallic acids. Metallic salts.

Action of chlorine on the metals; often powerful.

General properties of chlorides. Chlorine rarely, if ever, unites with metallic oxides.

Action of alkalies, especially ammonia, on the metals: detonating *ammoniurets*.

Action of iodine. Metallic iodides, analogous to chlorides.

*Sulphurets*, or compounds of sulphur and the metals; how formed; are all brittle solids, except the sulphuret of silver. Some exhibit a metallic lustre. Other properties. A great number exist in the earth.

Selenurets, phosphurets, carburets, hydrosulphurets, hydrurets, &c.

*Alloys*, or compounds of metals with each other. *Amalgams*.

Thénard's classification of the metals.

CLASS I. Metals, the oxides of which cannot be reduced, or deprived of their oxygen by heat alone.

Ord. 1. Metals which decompose water at common temperatures.

- |               |             |               |
|---------------|-------------|---------------|
| 1. Potassium, | 3. Lithium, | 5. Strontium, |
| 2. Sodium,    | 4. Barium,  | 6. Calcium.   |

Ord. 2. Metals which are supposed to be analogous to the foregoing, but which at present are little known.

- |               |              |             |
|---------------|--------------|-------------|
| 7. Magnesium, | 8. Glucinum, | 9. Yttrium. |
|---------------|--------------|-------------|

Ord. 3. Metals which decompose water at a red heat.

- |                |           |               |
|----------------|-----------|---------------|
| 10. Manganese, | 12. Iron, | 14. Cadmium,  |
| 11. Zinc,      | 13. Tin,  | 15. Aluminum. |

Ord. 4. Metals which do not decompose water at any temperature.

- |                |                |                 |
|----------------|----------------|-----------------|
| 16. Copper,    | 21. Uranium,   | 26. Molybdenum, |
| 17. Lead,      | 22. Chromium,  | 27. Antimony,   |
| 18. Cerium,    | 23. Tungsten,  | 28. Bismuth,    |
| 19. Tellurium, | 24. Columbium, | 29. Cobalt.     |
| 20. Arsenic,   | 25. Nickel,    |                 |

CLASS II. Metals, the oxides of which are reduced by heat alone.

- |              |                |              |
|--------------|----------------|--------------|
| 30. Mercury, | 33. Platinum,  | 36. Iridium, |
| 31. Silver,  | 34. Palladium, | 37. Osmium.  |
| 32. Gold,    | 35. Rhodium,   |              |

1. POTASSIUM. =40.

The metallic base of the alkali potassa, discovered by Sir H. Davy in 1807.

His method of operating. Use of Pepy's apparatus. The metal afterwards procured in considerable quantities by Gay-Lussac and Thénard, by heating potassa in contact with iron. Curadau's, Tennant's and Brunner's processes.

*Properties.* White with a tinge of blue; lustre strong and metallic. Solid at 60° F.; softens at 70°; at 100° fluid. Malleable at 50°; but brittle at 32°. When heated to redness it volatilizes. Sp. gr. about 0.8: the lightest solid known. Exposed to the air it attracts oxygen and is gradually converted into potassa. Decomposes water with violence, leaving a solution of potassa. Burns with a rose-coloured flame.

Unites with oxygen in two proportions.

1. **PROTOXIDE**, *Potassa*, or *Caustic Potassa*. Formerly called vegetable alkali, but exists in many minerals. How obtained from plants. Hydrate of potassa.

*Properties.* A solid, extremely caustic; rapidly corrodes animal substances. Changes vegetable blues to green. Neutralizes acids and forms soluble salts. Very soluble in water; while dissolving, much heat is disengaged. The aqueous solution is called *aqua potassa*. Dissolves in alcohol. Unites with oils, forming soap; with silica and other earths forming glass.

It contains 1 equiv. potassium (40) and 1 equiv. oxyg. (8) = 48.

2. **PEROXIDE**. Formed by passing oxygen gas over heated potassa, or by heating potassium in the gas.

*Properties.* A crystalline orange-yellow substance; gives out oxygen when thrown into water, leaving ordinary potassa in solution.

It is composed of 1 equiv. potassium (48) and 3 equiv. oxyg. (24) = 72.

**CHLORIDE OF POTASSIUM.** The metal takes fire spontaneously in chlorine gas, forming a solid chloride. This compound was formerly called muriate of potassa.

**IODIDE OF POTASSIUM.** The crystalline solid obtained by evaporating to dryness a solution of hydriodate of potassa. Its use in medicine.

*Potassium and hydrogen* unite in two proportions; one of the hydrurets is a gas which takes fire sponta-

neously in the air; the other is a gray solid. The former is commonly produced in large quantities, during the ordinary process for obtaining potassium.

**SULPHURET OF POTASSIUM.** Obtained by uniting the ingredients directly. Process of Berzelius and Berthier. Common *sulphuret of potassa*.

**PHOSPHURET OF POTASSIUM.** How obtained. Properties.

*Salts of Potassa.*

**1. CHLORATE.** Obtained by passing chlorine gas through a solution of potassa. Chlorate and muriate of the alkali are formed at the same time: the former is separated by crystallization. Rationale.

*Properties.* Crystallizes in hexagonal plates; also in prisms. Soluble in 16 parts of cold water. Not affected by the air. Decomposed by a moderate heat, yielding abundance of the purest oxygen gas. Chloride of potassium left. Acts with energy on various combustibles. Decomposed by sulphuric acid. Uses:

**2. IODATE.** Formed by agitating iodine in a solution of potassa. Rationale.

*Properties.* It strongly resembles the chlorate in its action on combustibles. By heat it loses oxygen, and is converted into iodide of potassium.

**3. NITRATE.** *Saltpetre* or *nitre*. The most important salt of potassa. Its natural history.

*Properties.* Crystallizes in long, six-sided prisms. Very soluble. Taste sharp and cooling. Fusible be-



low a red heat, and at a higher temperature yields oxygen gas. Deflagrates violently with combustibles.

*Uses.* In the manufacture of gun-powder; nitric and sulphuric acids; as an antiseptic, &c.

*Fulminating powder*: how prepared.

*Black flux*, how prepared: its use in the reduction of metals.

4. NITRITE. Obtained by heating the nitrate till it loses one equiv. of oxygen.

5. CARBONATE, formerly *subcarbonate*. Carbonic acid unites with potassa in two proportions. The first carbonate is highly alkaline, very soluble and deliquesces when exposed to the air. Fusible at a full red heat, without losing its acid.

Composed of 1 equiv. potassa (48) and 1 equiv. carb. acid (22) = 70.

*Potash and pearlash*, of commerce. Method of determining their purity. *Salt of Tartar*.

6. BICARBONATE. How prepared. Crystallizes readily. Not affected by exposure to the air. Slightly alkaline to the taste; less soluble than the carbonate. Loses half its acid at a red heat. Medicinal use.

Composed of 1 equiv. potassa (48), 2 equiv. carb. acid (44) and 1 equiv. water (9) = 101.

7. SESQUICARBONATE. Discovered by Dr. Nimmo of Glasgow. Contains 1 equiv. potassa, 1.5 equiv. of carb. acid and 6 equiv. of water.

8. SULPHATE. Crystallizes in six-sided prisms,

which are permanent in the air ; contains no water of crystallization. Soluble in 16 times its weight of water at 60°.

Composed of 1 equiv. potassa (48) and 1 equiv. sul. acid (40.)

9. **BISULPHATE.** Acid to the taste ; much more soluble than the sulphate. Contains 2 equiv. of acid to 1 equiv. of base. Large quantities of it are obtained in the manufacture of nitric and sulphuric acids.

2. SODIUM. =24.

Base of the alkali Soda. Discovered by Davy, in 1807. May be obtained by the same processes as are employed for procuring potassium.

*Properties.* Resembles potassium, but is less fusible and rather heavier. It possesses the property of welding. Acts violently on water, but commonly without taking fire ; and soda is reproduced. Does not combine with hydrogen.

1. **PROTOXIDE, or Soda.** Generally obtained in the state of hydrate.

*Properties.* Solid, crystalline, highly caustic. In the air it becomes a carbonate, which effloresces. How distinguished from potassa.

It contains 1 equiv. sodium, (24) and 1 equiv. oxygen (8) =32.

2. **PEROXIDE.** An orange-yellow solid, containing 2 equiv. sodium and 3 equiv. oxygen.

**CHLORIDE.** Sodium inflames when heated in chlo-

rine gas, and forms a compound which is identical with *common salt*.

*Properties* Crystallizes in cubes; dissolves in  $2\frac{1}{2}$  times its weight of water at  $60^{\circ}$ : its solubility is not increased by heat. Decomposed by sulphuric acid, muriatic acid being evolved, while sulphate of soda remains: rationale. By solution in water it is converted into a *muriate*, in which state it exists abundantly in the sea.

Its component parts are 1 equiv. sodium (24) and 1 equiv. chlorine (36) = 60.

**Rock salt**, or native chloride of sodium. Immense deposits of this mineral in the earth.

Quantity of common salt and other ingredients in sea water. Brine springs and salt lakes.

Manufacture and uses of common salt.

#### *Salts of Soda.*

1. **SULPHATE.** *Glauber's salt.* Generally obtained from sea water after the common salt is separated.

*Properties.* Crystallizes in long deeply striated prisms; effloresces rapidly in dry air. Soluble in three times its weight of cold water, and in its own water of crystallization at  $212^{\circ}$  F.

Composed of 1 equiv. soda (32) 1 equiv. sul. acid (40) and 10 equiv. water (90) = 162.

Its uses in medicine; for obtaining soda; and in the manufacture of glass.

2. **NITRATE.** In a native state, exists abundantly in South America.

3. **PHOSPHATE.** Obtained by neutralizing the superphosphate of lime procured from bones, with carbonate of soda. **Rationale.** Employed in medicine as a cathartic.

4. **PHOSPHATE OF SODA AND AMMONIA.** Microcosmic salt.

5. **BORATE.** *Borax.* Occurs native in certain lakes in Thibet and Persia. **Properties and uses of the salt.**

6. **CARBONATE,** formerly *Subcarbonate.* How prepared from *Barilla* and *Kelp*, or the impure carbonates of soda of commerce. Also from the sulphate, by heating it with saw-dust and lime.

**Properties.** Crystallizes in octohedrons with a rhombic base. Effloresces in the air. Soluble in 2 parts of water at 60°, and in less than its weight of boiling water.

Composed of 1 equiv. soda (32) 1 equiv. carb. acid (22) and 10 equiv. water (90)=144.

*Uses,* in medicine, &c.

7. **BICARBONATE.** Obtained by exposing the carbonate in solution, or in crystals, to carbonic acid. It is slightly alkaline; much less soluble than the carbonate. At a red heat it loses half its carbonic acid.

Its constituents are 1 equiv. soda (32), 2 equiv. carb. acid (44) and 1 equiv. water (9)=85.

Employed as an antacid, and for making *soda-powders.*

3 LITHIUM. =10.

The metallic base of lithia, an alkali discovered in

the mineral called petalite by Arfwedson, in 1818. The metal resembles sodium. Its protoxide, which is LITHIA, is composed of 1 equiv. lithium (10) and 1 equiv. of oxygen (8) = 18.

This alkali has been found in several minerals, but never in vegetables: hence its name. Its properties. Has not yet been applied to any use.

4 BARIUM. = 70.

The metallic base of the earth baryta. Discovered by Davy, in 1808, by the agency of electricity.

*Properties.* Hard, dark gray, resembling cast iron, attracts oxygen strongly, and acts with energy on water.

1. PROTOXIDE. *Baryta, or Barytes*, so called from its great weight, discovered by Scheele, in 1774. How obtained from the native sulphate and carbonate.

*Properties.* Caustic and alkaline; combines rapidly with water and slakes, like quicklime. Sp, gr. 4. All its soluble compounds are poisonous. Its hydrate dissolves in twice its weight of boiling water and forms large crystals on cooling.

Composed of 1 equiv. barium (70) and 1 equiv. oxygen (8) = 78.

2. DEUTOXIDE. Formed by heating baryta in oxygen gas. It contains 2 equiv. of oxygen. Employed in preparing the deutoxide of hydrogen: theory of the process.

#### *Salts of Baryta.*

1. SULPHATE. Exists abundantly in the mineral kingdom. Very insoluble and heavy.

2. CARBONATE. Also found native; but is a rare mineral.

3. MURIATE. Crystallizes in large square plates, permanent in the air. Employed in medicine, and as a test for sulphuric acid.

5. STRONTIUM. =44.

The metallic base of strontia, discovered by Davy. It strongly resembles Barium.

STRONTIA, or the protoxide of this metal, was discovered by Dr. Hope in 1792. How obtained.

*Properties.* Slakes with water; highly alkaline. Its hydrate dissolves in boiling water and yields transparent tabular crystals. None of its salts are poisonous.

Composed of 1 equiv. strontium (44) and 1 equiv. oxygen (8) =52.

Its soluble salts tinge the flame of alcohol blood red, The muriate crystallizes in capillary prisms, by which character the earth is easily distinguished from baryta. The sulphate and carbonate occur native. Fine crystals of the former have been found in several parts of the United States. See Cleaveland's Mineralogy.

6. CALCIUM. =20

The metallic base of lime; obtained by electrifying this earth in contact with mercury. An amalgam of calcium is formed, from which the mercury is expelled by heat.

*Properties.* A white hard metal. Converted into lime by exposure to the air, or by the action of water. Sp. gr. above 4.

1. **PROTOXIDE, or Lime.** May be obtained by heating the pure native carbonate till the carbonic acid is expelled.

*Properties.* White, opaque, earthy, infusible in the best furnaces, but acts as a *flux* in promoting the fusion of other earths. Caustic and alkaline. Combines energetically with water, giving out much caloric and forming a hydrate. Forms insoluble salts with carbonic and sulphuric acids.

Composed of 1 equiv. calcium (20) and 1 equiv. oxygen (8) = 28.

The hydrate contains 1 equiv. water (9). It is sparingly soluble. *Lim<sup>e</sup> water* : properties and uses. *Cream of lime.* Burning or calcining of lime. Tests of the presence of lime. How distinguished from other earths.

2. **DEUTOXIDE.** Obtained by passing oxygen gas over heated lime. It contains 2 equiv. oxygen.

**CHLORIDE.** Prepared by evaporating to dryness a solution of the muriate of lime. Soluble in alcohol. Attracts water strongly and deliquesces in the air. Dissolved in water it forms the muriate, a salt which exists in sea water, and which may be obtained in crystals. Uses.

**CHLORIDE OF LIME.** *Oxymuriate of lime. Bleaching-powder or Bleaching salts.* Obtained by exposing dry hydrate of lime to chlorine gas. Different opinions respecting its nature. Use in bleaching : its advantages over uncombined chlorine. A powerful antiseptic.

**SULPHURET.** Method of preparing. Its properties and uses. Canton's phosphorus.

**PHOSPHURET.** Obtained by passing the vapour of phosphorus over heated lime. A phosphuret of calcium probably formed, the oxygen of the earth being displaced by the phosphorus, which remains combined with the metallic base. It decomposes water and per-phosphuretted hydrogen is liberated, which <sup>or</sup>inflames spontaneously when it comes in contact with the air.

### *Salts of Lime.*

1. **CARBONATE.** Occurs very abundantly in the mineral kingdom. It is supposed to constitute one-eighth of the crust of the earth. Its varieties are very numerous, and many of them important in the arts. Iceland spar and statuary marble are pure carbonates.

*Properties.* Insoluble and tasteless, effervesces with most acids. Loses its carbonic acid at a full red heat, and is converted into quicklime.

Contains 1 equiv. lime (28) and 1 equiv. carb. acid (22) = 50.

The principal native varieties are : 1. *Calcareous* or *Iceland spar* ; 2. *Granular limestone*, including statuary marble ; 3. *Fibrous* or *Satin spar* ; 4. *Compact limestone*, including most of the variegated marbles ; 5. *Chalk* ; 6. *Concreted carbonate of lime*, (oolite, stalactite and tufa) ; 7. *Magnesian limestone* ; 8. *Marle*.

2. **SULPHATE.** Also an abundant mineral.



*Properties.* A white salt requiring 400 parts of water for its solution. **Fusible.** In its ordinary state it contains 21 per cent. of water, which may be driven off by a moderate heat, leaving an anhydrous powder. This powder, when mixed into a paste with water, soon hardens into a solid mass.

It is composed of 1 equiv. lime (28) and 1 equiv. sulph. acid (40)  $\equiv$  68. The hydrated salt contains 6 equiv. water (54), which added to 68, makes its representative number in this state 124.

Native varieties of the salt: 1. Selenite, 2. Gypsum, 3. Plaster-stone. Uses in the arts and in agriculture.

Native anhydrous sulphate of lime.

3. PHOSPHATE. A very insoluble salt. Exists in bones, and in the mineral kingdom.

4. FLUATE. *Derbyshire spar.* A beautiful mineral, crystallizing in cubes, and presenting a variety of colours. Its primitive form, which is easily obtained by cleavage, is the regular octohedron. Most varieties phosphoresce when heated; the *chlorophane* shining with a green light. It is decomposed by sulphuric acid, yielding fluoric acid, which possesses the property of corroding glass. Method of engraving on glass.

7. MAGNESIUM.  $\equiv$  12.

The base of the earth magnesia. Its properties are but little known, as it has hitherto been obtained only in combination with mercury, in which state it decomposes water. There is but one oxide of this metal known, viz.

**MAGNESIA.** It may be obtained by heating the carbonate to full redness.

*Properties.* White, inodorous, slightly alkaline, scarcely soluble in water. When exposed to the air, it very slowly combines with carbonic acid. With sulphuric acid it forms a soluble salt.

Composed of 1 equiv. magnesium (12), 1 equiv. oxygen (8) = 20. When moistened with water and dried, it becomes a hydrate, consisting of 1 equiv. magnesia (20) and 1 equiv. water (9) = 29.

Native hydrate of magnesia discovered at Hoboken, New Jersey, by Dr. Bruce.

Calcined magnesia : its use in medicine.

*Salts of Magnesia.*

1. **SULPHATE.** *Epsom salt.* Occurs native in the earth, also dissolved in the waters of the sea, and in certain mineral springs.

*Properties.* Crystallizes in four-sided prisms, which are commonly very small. Taste bitter and saline. Slightly efflorescent in the air. Soluble in an equal weight of water at 60° and in three-fourths its weight of boiling water. Alkaline carbonates precipitate carbonate of magnesia from its solution. Composed of 1 equiv. magnesia (20), 1 equiv. sul. acid (40) and 7 equiv. water (63) = 123.

2. **CARBONATE.** The ordinary magnesia, or *magnesia alba* of the shops. Obtained by adding carbonate of potassa to a solution of sulphate of magnesia.

*Properties.* White, pulverulent, tasteless and nearly insoluble. A solution of carbonic acid dissolves it, forming the *liquid magnesia*. Decomposed at a red heat.

Composed of 1 equiv. magnesia (20) and 1 equiv. carbonic acid (22) = 42.

The precipitated kind contains hydrate of magnesia. Its use in medicine.

Native carbonates of magnesia.

3. MURIATE. Exists in sea water, and renders common salt deliquescent.

Magnesian minerals: serpentine, talc, soapstone, &c.

8. GLUCINUM. = 18.

The base of glucina, an earth discovered by Vauquelin, in 1798, in the beryl and emerald.

Glucina is allied to alumina. It forms with acids, salts which have a sweet taste: hence its name. It is insoluble in water, and has no action on vegetable colours. Dissolves in caustic alkalies and carbonate of ammonia.

9. YTTRIUM. = 34.

The base of an earth discovered by Prof. Gadolin, in 1794, in a mineral of Ytterby, in Sweden.

10. MANGANESE. = 28.

Discovered in 1774 by Scheele and Gahn. Method of obtaining it.

*Properties.* Hard, brittle, grayish-white, and of considerable lustre. Rapidly oxidized by exposure to the

air. Nearly infusible in the best furnaces. Sp. gr. 7. It combines with oxygen in five proportions.

1. **PROTOXIDE.** 1 equiv. mang. (28) and 1 equiv. oxyg. (8) = 36. This exists in the salts of manganese.

2. **DEUTOXIDE.** 1 equiv. mang. (28) and 1.5 oxyg. (12.)

3. **PEROXIDE.** 1 equiv. mang. (28) and 2 oxyg. (16). This is a very abundant native product. It occurs in black heavy masses; sometimes crystallized. When added to muriatic acid, chlorine is disengaged. Rationale. Yields abundance of oxygen gas at a red heat, and is converted into the deutoxide.

Uses in the arts, viz bleaching, glass-making, &c.

4. **MANGANESEOUS ACID.** 1 equiv. mang. (28) and 3 equiv. oxyg. (24).

5. **MANGANESIC ACID.** 1 equiv. mang. (28) and 4 equiv. oxyg. (32). Its salts are red, and deflagrate violently with combustibles.

**CHLORIDES.** The protochloride is a reddish crystalline solid: the perchloride is a greenish gas, above 10° F.

6. **FLUORIDE.** A gaseous fluoride has recently been discovered by M. Wöller.\*

#### *Salts of Manganese.*

They afford colourless or pink solutions; all of them contain the protoxide. With alkalies they yield a white hydrate.

\* See *Ann. de Chim.* xxxvii. p. 101, and Webster's Brande, ed. 2, p. 587.

Manganese exists widely diffused in the mineral kingdom. Tests of its presence.

### 11. IRON. =28.

Has been known from the remotest ages. How obtained pure.

*Properties.* Grayish-white, takes a high polish; the most tenacious of all the metals. Attracted by the magnet. Sp. gr. 7.8. Nearly infusible. Burns brilliantly with scintillations at a white heat. Not affected by dry air at ordinary temperatures. It rusts very slowly in pure water, when excluded from the air. It has but two oxides.

1. PROTOXIDE. Obtained by passing dry hydrogen over peroxide of iron at a low temperature.

*Properties.* Dark blue; takes fire when exposed to the air.\* Attracted by the magnet. Forms green salts with acids, which rapidly absorb oxygen from the atmosphere. It is precipitated in the form of a white hydrate by alkalies. Composition determined by the action of diluted sulphuric acid on iron.

It contains 1 equiv. iron (28) and 1 equiv. oxygen (8) =36.

2. PEROXIDE. Obtained by heating the protoxide while the air has access to it.

*Properties.* Red, and forms salts of the same colour. Not attracted by the magnet. Its solutions yield prus-

\* What was formerly considered as the protoxide of iron, is a mixture of true protoxide and peroxide.

sian blue with ferrocyanate of potassa ; and a black colour with tincture of galls.

Composed of 1 equiv. iron (28) and 1.5 equiv. oxygen (12) = 40.

Native oxides of iron. 1. Magnetic oxide of iron. 2. Specular oxide of iron. 3. Red oxide, or *red hematite*. 4. Hydrate of iron, or *brown hematite*. 5. Bog iron ore.

CHLORIDES. The *protochloride* is obtained by evaporating a solution of the protomuriate to dryness. It is a solid, of a grey colour and lamellar structure. The *perchloride* is formed when iron is burned in chlorine gas. It is a volatile brownish solid.

*Iron and sulphur.* These bodies unite in several proportions.

1. PROTOSULPHURET. How obtained. The native *magnetic pyrites* is a protosulphuret. It is attracted by the magnet. Yields sulphuretted hydrogen by the action of diluted sulphuric or muriatic acid : rationale.

Composed of 1 equiv. iron (28) and 1 equiv. sulphur

2. BISULPHURET. The common *yellow pyrites*, an (16).<sup>^</sup> abundant mineral. It crystallizes in cubes and octohedrons. Strikes fire with steel. By the action of heat it loses 1 equiv. of sulphur and is converted into the protosulphuret. It is subject to spontaneous decomposition, yielding sulphate of iron.

Composed of 1 equiv. iron (28) and 2 equiv. sulph (32)

Used for obtaining sulphur, and in the manufacture of sulphuric acid ; also for procuring green vitriol.

*Iron and carbon.* Several compounds of these bodies are known.

STEEL is a carburet of iron containing from one-fortieth to one-sixtieth of its weight of carbon.

Methods of manufacturing steel. *Blistered, tilted and cast steel.* *Wootz.* How to distinguish steel from iron.

Hardening and tempering of steel.

CAST-IRON. Iron combined with more carbon than exists in steel, and containing also the metallic bases of various earths.

How obtained from the ore by the process of smelting. Pig-iron. Different kinds of cast iron: viz. *white*, containing one-twenty-fifth carbon; *gray*, one-twentieth; and *black*, one-fifteenth: the last contains much graphite.

*Alloys of iron.* Not very numerous. They are obtained with difficulty. Several exists in a native state.

1. ARSENICAL IRON. A pretty abundant mineral, of a silver-white colour, brittle, giving out arsenical fumes when heated.

2. POTASSIUM and IRON. Formed in the process for obtaining potassium.

3. METEORIC IRON. Iron alloyed with from 5 to 12 pr. ct. of nickel, and a little cobalt. Occurs in detached masses, often of immense size, upon or near the surface of the earth, which are generally supposed to have fallen from the heavens. (Hypotheses of their origin to be treated of under the head of nickel.)

*Native terrestrial iron* is of very rare occurrence. It is generally free from admixture with other metals, and malleable. See Cleaveland's Mineralogy; also Silliman's Journal, vol. xii. No. 1; vol. xiv. No. 1; and vol. xvii. No. 1.

### *Salts of Iron.*

1. **SULPHATE.** *Copperas. Green Vitriol.* Occurs abundantly as a native product, being formed by the decomposition of yellow iron pyrites.

*Properties.* Occurs in pale green rhombic crystals, of a strong styptic taste. Soluble in two parts of cold, and less than one of boiling water. Alkalies precipitate from its solution a white hydrate. Not affected by tincture of galls, except it contains some persulphate. Absorbs oxygen when exposed to the air.

Composed of 1 equiv. protox. iron (36), 1 equiv. sul. acid (40), and 7 equiv. water (63) = 139.

Used in dyeing, making writing ink, fuming sulphuric acid, &c.

2. **PERSULPHATE.** Formed by boiling the protosulphate with nitric acid: a red solution is obtained, which does not yield crystals. It affords a deep blueish black precipitate with tincture of galls, and prussian blue with ferrocyanate of potassa.

3. **NITRATE.** Used by calico printers.

4. **CARBONATE.** Exists in a native state, constituting a valuable ore of this metal, called *sparry iron*. The argillaceous iron ores are impure carbonates of iron.



6. PHOSPHATE. A deep blue insoluble salt. It occurs native. Employed in medicine, and as a pigment.

7. *Prussian blue*. Discordant opinions of chemists concerning the nature of this pigment. Probably a *ferro-cyanate of iron*. Method of manufacturing it. Decomposed when boiled with metallic oxides, or alkalies.

8. FERRO-CYANATE OF POTASSA. How obtained  
Uses.

12. ZINC. =34.

Described by Agricola in 1520. Obtained from its ores by distilling them with charcoal.

*Properties*. Blueish-white; of a crystalline texture; brittle at ordinary temperatures, but malleable between 200F° and 300°. Fuses at 680°. Volatile at a white heat. Sp. gr. about 7. Burns with a dense white flame. Dissolves in sulphuric acid with the evolution of hydrogen gas. Combines with oxygen in but one proportion.

OXIDE OF ZINC. Obtained by heating zinc until it takes fire: the oxide is produced in the form of white flakes, which are extremely light. In this state it has been called *flowers of zinc*, *pompholix nihil album*, &c.

Composed of 1 equiv. zinc (34), and 1 equiv. oxygen (8) =42.

CHLORIDE OF ZINC. Formed by burning the metal in chlorine, or by evaporating the muriate to dryness.

It is a deliquescent semitransparent solid. Formerly called *butter of zinc*.

**SULPHURET OF ZINC.** *Blende.* Occurs abundantly as an ore.

*Salts of Zinc.*

1. **SULPHATE.** *White Vitriol.* Formed by the spontaneous decomposition of the native sulphuret. Crystallizes in white four-sided prisms, of a styptic astringent taste. Uses in medicine and in the arts.

2. **ACETATE.** Obtained by mixing a solution of the sulphate of zinc with acetate of lead : sulphate of lead is precipitated and acetate of zinc remains in solution.

3. **CARBONATE.** Occurs native, and is generally called *calamine*. Used for obtaining zinc and brass : also in medicine.

4. **SILICATE.** *Electric calamine.* An ore of zinc.

Other ores of zinc : red oxide, and franklinite, of New Jersey.

Uses of zinc. Alloys of this metal.

13. CADMIUM. =56.

Discovered in 1817 by Stromeyer. How obtained.

*Properties.* A white metal, resembling tin, malleable, fusible at 420°F, *volatile* at about 650°. Sp. gr. 8.6. It has but one oxide. Occurs associated with certain zinc ores.

14. TIN. =58.

Known in the earliest ages.

*Properties.* White, resembling silver. Scarcely af

lected by exposure to the air. May be reduced to leaves less than one-thousandth of an inch thick. Crackles when bent. Sp. gr. 7.9. Fuses at 442°F. Harder than lead.

There are two oxides of this metal.

1. **PROTOXIDE.** Formed by heating tin while exposed to the air; or by adding potassa to the solution of the protomuriate. Its salts attract oxygen from the atmosphere; their solutions when added to muriate of gold throw down a purple precipitate called *purple of Cassius*.

2. **PEROXIDE.** Obtained by the action of nitric acid on tin. A hydrate is thus formed, from which the water is expelled by heat. It possesses feeble acid properties.

Chlorine unites with tin in two proportions. The protochloride is a gray fusible solid: the perchloride is a colourless volatile liquid, which was formerly called *Fuming liquor of Libavius*.

There are two sulphurets of tin. The protosulphuret is formed by heating sulphur and tin in a crucible: the persulphuret is the *aurum musivum* of the alchemists. The latter is obtained by fusing a mixture of sulphur and oxide of tin. It has a metallic lustre and is used for bronzing plaster casts.

*Nitro-muriate* of tin; a liquid used in dyeing scarlet.

Alloys of tin. Tinning of iron plates. *Moiré metallique*, or crystallization of tin.

## 15. ALUMINUM. =10.

Discovered in 1828 by Wöller\*. Obtained by heating chloride of aluminum mixed with potassium. It presents the appearance of small gray scales of a metallic lustre. It is infusible, and a conductor of electricity. Takes fire when heated in the air, and is converted into alumina, the only oxide of this metal yet known.

**ALUMINA.** How obtained pure from alum.

*Properties.* Insipid, and insoluble : forms a ductile, cohesive mass with water. Forms several hydrates, which do not part with all their water except when intensely heated. Shrinks in the fire, on which property is founded the pyrometer of Wedgwood. Soluble in caustic alkalies.

Composed of 1 equiv. alum. (10) and 1 equiv. oxyg. (8) =18.

The sapphire and oriental ruby are nearly pure anhydrous alumine. Clays consist of this earth intimately mixed with silica. Alumina is the most abundant of all the earths except silica.

*Salts of Alumina.*

**ALUM.** This is a generic name for several compound salts which are composed of sulphuric acid, alumina and an alkali. Their general properties are similar. The most common variety is that with base of potassa, viz.

\* For a full account of Wöller's experiments on this metal, see Webster's Brande's Manuel of Chemistry, second edition 1828, p. 584.

## COPPER.

*Potassa-Alum.* Taste sweetish and astringent ; soluble in 5 parts of water at 60°, and in its own weight of boiling water. Crystallizes in regular octohedrons, which are permanent in the air. Exposed to heat it loses its water, and becomes spongy, or *alumen ustum*. Alum when heated with sugar, forms Homberg's pyrophorus, a compound which inflames spontaneously in the air. Manufacture of Alum. Use of the salt. Other varieties of alum.

Composed of 3 equiv. alumina (174), 1 equiv. sulphuric acid (88), and 25 equiv. water, (225) = 487.

Aluminous minerals. Manufacture of pottery.

16. COPPER. = 64.

This metal was known in the earliest ages. It often occurs in a native state.

*Properties.* Colour brownish-red ; lustre strong and metallic ; emits a peculiar odour when rubbed ; remarkably ductile and malleable ; fusible at a strong white heat. Sp. gr. 7.78. Tarnishes when exposed to the air. At a red heat is rapidly oxidized. Its salts are poisonous. There are but two oxides of this metal.

1. **PROTOXIDE.** It occurs native in the form of ruby-red crystals. Its salts are colourless, but they rapidly attract oxygen from the air and become blue or green.

Composed of 1 equiv. copper (64), and 1 equiv. oxygen (8) = 72.

2. **PEROXIDE.** Obtained by calcining the black

scales of copper : also by heating the nitrate to redness It is nearly black, soluble in acids, with which it forms blue or green salts.

Composed of 1 equiv. copper (64) and 2 equiv. oxygen (16) =80.

Tests of the presence of copper : ammonia affords a blue colour ; iron precipitates the pure metal.

*Chlorine and copper.* These bodies unite in two proportions. The *protochloride* is formed by heating copper with corrosive sublimate ; a solid is obtained having the appearance of resin. The *perchloride* is obtained by cautiously evaporating the permuriate to dryness.

SULPHURETS. Copper filings and sulphur heated together unite rapidly, exhibiting the appearance of combustion : the *protosulphuret* is thus formed. The same compound occurs abundantly as an ore. The *bisulphuret*, in combination with sulphuret of iron is another abundant ore of copper, called *copper pyrites*.

*Alloys of copper.* Brass, bronze, bell-metal, gun-metal, pot-metal, speculum-metal, &c.

#### *Salts of Copper.*

All the ordinary salts of this metal contain the peroxide.

1. **SULPHATES.** The bisulphate of the peroxide is *blue vitriol*. It is obtained by dissolving peroxide of copper in sulphuric acid.

Composed of 1 equiv. peroxide of copper (80), 2 equiv. sulph. acid (80) and 10 equiv. water (90) =250.

*Properties, and uses of the salt.*

2. **SULPHATE OF COPPER AND AMMONIA.** Ammoniumret of copper.

3. **NITRATE.** A blue deliquescent salt, used in the preparation of the pigment called *verditer*.

4. **CARBONATE OF COPPER.** Several varieties are found in the mineral kingdom.

Process for extracting copper from its ores. Uses of the metal. Sir H. Davy's method of protecting the copper sheathing of ships from corrosion.

17. LEAD. =104.

Has been known from the earliest ages. It very rarely occurs native.

*Properties.* Blueish-gray; tarnishes rapidly in the air; very soft and malleable, Tenacity feeble. Sp. gr. 11.35. Fusible at 612°F. In a melted state it becomes speedily covered with a crust of oxide. Cold sulphuric and muriatic acids scarcely affect it. It combines with oxygen in three proportions.

1. **PROTOXIDE.** How obtained: exists in all the salts of lead. It is yellow, tasteless, insoluble in water. Melts into a semitransparent glass below a red heat; easily reduced by charcoal. Promotes, in a remarkable degree, the fusion of other metallic oxides, and earthy matters.

Composed of 1 equiv. lead (104), and 1 equiv. oxygen (8) =112.

*Massicot* and *litharge* are impure protoxides of lead.  
Uses.

2. **DEUTOXIDE.** *Red lead* or *Minium*. Obtained by heating the protoxide in an open vessel. It is of a bright red colour. At a high temperature it parts with half an equiv. of oxygen by which it is reduced to the state of protoxide. It does not combine with acids. It contains 1.5 equiv. of oxygen.

3. **PEROXIDE.** Obtained by the action of nitric acid on red lead: rationale. It is of a dark brown colour. Heat expels from it one half of its oxygen. It contains 2 equiv. oxygen.

**CHLORIDE.** Formed by adding chloride of sodium to a solution of acetate of lead; small white crystals fall, which are the chloride. In a fused state it was formerly called *horn lead*.

The pigment called *patent yellow*, is a mixture of chloride and protoxide of lead. Method of preparing it.

**IODIDE.** A beautiful yellow compound.

**SULPHURET.** Occurs abundantly in the mineral kingdom, particularly in some parts of the United States, and is the only ore of lead which is worked. It is generally called *galena*. Characters of the ore, and method of reducing it.

Composed of 1 equiv. lead (104) and 1 equiv. sulph. (16).

#### *Salts of Lead.*

Those which are soluble are active poisons: the best antidotes are sulphates of magnesia and soda. Zinc precipitates from their solutions metallic lead. Tests of lead.



1. **SULPHATE.** A white insoluble compound which has been employed as a pigment. It occurs native.

2. **CARBONATE.** *White lead*. or *ceruse*. How manufactured. Used as a pigment.

3. **NITRATE** and other salts of lead. Alloys of this metal.

18. CERIUM. =50.

A rare metal discovered by Hisinger and Berzelius in 1804. Its name alludes to the planet Ceres, discovered a short time before by Piazzi.

19. TELLURIUM. =32.

First accurately described by Klaproth, in 1798. It is a rare metal, found chiefly in the gold mines of Transylvania. It is brittle and of a tin-white colour. With hydrogen it forms a gaseous compound, called *telluretted hydrogen*.

20. ARSENIC. =38.

Described as a peculiar metal by Brandt, 1733. It occurs native, and also in combination with various metals. Method of obtaining it from arsenious acid.

*Properties.* Very brittle, and of a crystalline structure. Colour steel-gray; lustre strong and metallic. Sp. gr. 8.3. Sublimes at 360°, without fusing. Its vapour has the odour of garlic. Speedily tarnishes in the air, but retains its lustre under water. Very combustible. Poisonous. It combines with oxygen in two proportions, forming two acids.

1. **ARSENIOS.** *White oxide* of some chemists. Also

called *white arsenic* and *ratsbane*. It is obtained during the roasting of arsenical ores. Also by the combustion of metallic arsenic.

*Properties.* White, semitransparent, solid; fracture vitreous; volatile at  $380^{\circ}$ ; its vapour is deposited in tetrahedral crystals; taste acrid and nauseous; inodorous when heated, except it be in contact with some combustible, when it gives out the odour of garlic. Slightly soluble in water; reddens vegetable blues, and combines with alkalis, forming salts, which are called *arsenites*.

Composed of 1 equiv. arsenic (38) and 1 equiv. oxygen, (8) = 46.

**ARSENITE OF POTASSA.** The active ingredient of the *Liquor potassæ arsenitis*, and of *Fowler's solution*.

Uses of *white arsenic* in the arts.

**2. ARSENIC ACID.** Obtained by the action of nitric acid on arsenious acid. It is a white, acid, deliquescent, solid, soluble in water. Its salts, which are called *arseniates*, are all insoluble, except those with alkaline bases. Many of them exist in the mineral kingdom.

**CHLORIDE.** Arsenic burns spontaneously in chlorine gas, forming a volatile fuming liquid.

**ARSENIURETTED HYDROGEN.** An inflammable gas, exceedingly poisonous. It burns with a blue flame.

**SULPHURETS.** Two are known. 1. *Orpiment*. It occurs native, and is of a lemon-yellow colour. It is used in calico printing, and in dyeing; also as a pig-

ment. Composed of 1 equiv. arsenic, and 1.5 equiv. sulphur. 2. *Realgar*. Also a native compound, but generally obtained by art. Its colour is bright red. Composed of 1 equiv. arsenic and 1 equiv. sulph.

Method of searching for arsenic in cases of suspected poisoning. Examination of the body after death. Contents of the stomach filtered and washed, if no arsenic in substance be found. The clear fluid treated with nitric acid to destroy animal and vegetable matters, and then submitted to the action of the following tests.

1. Weak solution of nitrate of silver ; arsenious acid throws down a yellow arsenite of silver.

2. Sulphuretted hydrogen ; a lemon-yellow sulphuret of arsenic is thrown down.

3. Lime water ; a white arsenite of lime.

4. Infusion of blue cabbage is turned red.

5. Ammonio-acetate of copper ; a green arsenite formed.

6. Wires from a voltaic pile immersed in the liquid, separate metallic arsenic at the negative side.

7. Evaporate some of the liquid to dryness, or take the yellow precipitate of No. 2 ; mix it with black flux and heat in a tube ; metallic arsenic will sublime. The metal may afterwards be examined and submitted to experiment.

## 21. URANIUM. =208.

Discovered in 1789, by Klaproth. Its ores are scarce. The metal has only been obtained in small

quantities. It is reddish-brown, and not affected by exposure to the air. With oxygen it unites in two proportions. The peroxide is orange, and is employed in porcelain-painting.

## 22. CHROMIUM.

=28. Thomson

Discovered in 1797 by Vauquelin, in an ore called the Red lead Ore of Siberia. He afterwards found it in the emerald and ruby.

*Properties.* Grayish-white, brittle, very infusible, little affected by exposure to the air, or by the action of acids. Sp. gr. 5.9. Unites with oxygen in three proportions.

1. **PROTOXIDE.** Bright green, and imparts the same colour to glass. It exists in a native state uncombined, and as the colouring matter of the emerald. **Uses.**

2. **DEUTOXIDE.** It is of a brown colour.

3. **CHROMIC ACID.** Occurs in ruby-red crystals; soluble in water; acid; converted into green oxide by heat. Forms salts which are remarkable for their brilliant colours. It is the colouring matter of the ruby.

### *Chromates.*

1. **CHROMATE OF LEAD.** There are two varieties of this salt. 1. The *red*, to which kind the native chromate of Siberia belongs: it contains 1 equiv. chr. acid (52), and 2 equiv. ox. lead (224). The *yellow*, called *chrome yellow*: how obtained. Contains 1 equiv. ox. lead and 1 equiv. chrom. acid. It is a beautiful and durable pigment.

CHROMATE OF POTASSA. 1. *Yellow*, or Chromate. 2. *Red*, or bichromate. Properties and uses of these salts.

Other chromates ; of silver, mercury, baryta, &c.

CHLORO-CHROMIC ACID of Dr. Thomson.\* A deep orange-red fuming and volatile liquid, remarkable for its violent action on combustibles. Its effects exhibited.

FLU<sup>o</sup>CHROMIC and CHROMIODIC ACIDS.

Nature of the ore called chromate of iron.

23. TUNGSTEN. =96.

Its existence inferred by Scheele in 1781, and soon after demonstrated by D'Elhuyart. It is a hard grayish-white, intractable metal. Unites in two proportions with oxygen, forming a dark oxide, and a yellow acid : the latter occurs native in Connecticut. The tungstate of iron, or *wolfram*, and tungstate of lime, or *calcareous tungsten* are the chief ores of the metal. None of its preparations are applied to use.

24. COLUMBIUM. =144.

A rare metal, discovered in 1801, by Hatchett, in a mineral brought from Connecticut. It is the *tantalum* of the Swedish chemists. It appears to form but one compound with oxygen ; viz. Columbic acid. Not yet applied to use.

\* See Dr. Thomson's elaborate and able paper on chromium, in the *Phil. Trans.* for 1827. The *gaseous chloro-chromic acid* discovered in 1825, by M. Unverdorben, and described in the *Edinburgh Journal of Science*, No. vii., is a mixture of muriatic acid and chlorine gases, with the vapour of true chloro-chromic acid.

25. NICKEL. =40. *Salsaigne*

Discovered by Cronstedt, 1751, in an ore which occurs in the Swedish copper mines.

*Properties.* A white malleable metal, obedient to the magnet. Sp. gr. nearly 9, very infusible, retains its lustre in the air and under water, oxidized at a red heat. Combines with oxygen in two proportions.

1. PROTOXIDE. Ash-gray. Its salts are green. Uses.
2. PEROXIDE. Black. Does not unite with acids.

*Alloys.* United with arsenic it constitutes ore called the *kupfer nickel*, or copper nickel, on account of its reddish colour.

An alloy resembling silver, much used in Germany, contains nickel, copper and zinc. It is much like the Chinese *white copper* or *pack-fong*.

Nickel exists in meteoric iron, and in meteoric stones: hypotheses concerning the origin of the latter.

## 26. MOLYBDENUM. =48.

Discovered by Hielm, in 1782, in a mineral resembling graphite or plumbago. It is a brittle, white, infusible metal. Not applied to any use.

## 27. ANTIMONY. =44.

First described by Basil Valentine, in the 15th century. It rarely occurs native or uncombined. The sulphuret is the ore from which the metal is always obtained.

*Properties.* White, with a blueish-gray tint, brittle, of a highly crystalline structure. Sp. gr. 6.7. Fuses

at 810° F. Not volatile at a high temperature. At a white heat takes fire and burns with a bright light, emitting abundance of white fumes, formerly called *flowers of antimony*. Its powder inflames spontaneously when thrown into chlorine gas. Little affected by exposure to the air, a superficial film of oxide being formed, which protects the metal beneath. It unites with oxygen in three proportions.

1. **PROTOXIDE.** Methods of obtaining it from the muriate and from tartar emetic.

*Properties.* Dirty white, insoluble in water, tasteless, fusible at a red heat without decomposition; but when in contact with air, oxygen is absorbed. Volatile at high temperatures. It unites with acids: its solutions give an orange-yellow precipitate with sulphuretted hydrogen.

Composed of 1 equiv. antim. (44), and 1 equiv. oxyg. (8) = 52.

2. **DEUTOXIDE**, or *Argentine flowers of antimony*. Formed when the metal is heated till it inflames. It is a white insoluble compound, possessing feeble acid properties, and has been called *antimonious acid* by Berzelius. It contains 1.5 equiv. oxygen.

3. **PEROXIDE**, or *Antimonic acid*. Obtained by the action of nitric acid on antimony. Forms salts called antimoniates. It contains 2 equiv. oxygen.

**CHLORIDES.** Two are known. The *bichloride* is obtained by passing chlorine over the heated metal. It is

a colourless, volatile, fuming liquid, resembling the chloride of tin. The *protochloride* is formed by throwing the metal in chlorine gas, or by heating it with corrosive sublimate. It is a soft solid, and was formerly called *butter of antimony*.

**SULPHURETS.** What is called *crude antimony*, is a protosulphuret. Composed of 1 equiv. antim. (44) and 1 equiv. sulph. (16). It has a lead gray-colour, and a fibrous or crystalline structure.

The only ore of antimony which is worked, is a protosulphuret. It has the appearance of crude antimony.

*Golden sulphuret* and *Kermes mineral*. *Sesquisulphuret* and *bisulphuret*. *Glass, liver* and *crocus* of antimony.

*James' powder* or pulvis antimonialis.

Uses of metallic antimony.

28. BISMUTH. =72.

Described by Agricola in 1529. It mostly occurs native.

*Properties.* Reddish white; lustre brilliant; structure highly crystalline; brittle; fuses at  $476^{\circ}$  and evaporates at full redness. Sp. gr. about 10. Tarnishes when exposed to the air, and oxidizes pretty rapidly at a high temperature. It has but one oxide, which is yellowish.

Preparation of the oxide: its uses in medicine. It is composed of 1 equiv. bismuth (72), and 1 equiv. oxygen (8) =80.

**CHLORIDE.** Formed by throwing the powdered metal



in chlorine gas ; inflammation take place, and the chloride is the product. It is a fusible grayish-white solid.

**ALLOYS.** Remarkable for their fusibility. Newton's alloy.

29. COBALT. =26 ?

Discovered by Brandt, in 1733. It occurs chiefly alloyed with arsenic, and is pretty constantly associated with ores of nickel. Methods of obtaining the pure metal.

*Properties.* Its colour is gray, with a tinge of red ; lustre very feeble ; brittle. Sp. gr. about 8.5. Fuses at 130° Wedg. Obedient to magnet; and may be magnetized ! Scarcely tarnishes in the air. It combines with oxygen in two proportions, but the composition of its oxides is not well determined.

1. **PROTOXIDE.** This is ash-gray ; unites with acids, forming rose-coloured salts. Tinges vitreous substances deep blue. Used in colouring porcelain and earthen ware. *Zaffre* is an impure protoxide, used for making smalt.

2. **PEROXIDE.** It is of a black colour and does not form salts.

Muriate of cobalt is used as a sympathetic ink.

30. MERCURY. =200.

One of the seven metals known to the ancients. It is mostly obtained from the native sulphuret.

*Properties.* Fluid at ordinary temperatures. Has

the colour and lustre of silver. Sp. gr. 13.5. Boils at 656°F. but evaporates slowly below this point. Freezes at 40°, and in a solid state is malleable. Not tarnished in the air, when pure. It has two oxides.

1. **PROTOXIDE.** Obtained by rubbing together calomel and potassa. It is black and speedily changes by friction, or the action of light, into peroxide and metallic mercury. Unites with most acids, forming salts, the solutions of which afford a *black precipitate* with lime water, and a precipitate of *calomel* with compounds containing chlorine.

Composed of 1 equiv. mercury (200), and 1 equiv. oxygen (8), =208.

2. **PEROXIDE.** *Red precipitate.* Obtained by the action of nitric acid on mercury, or by heating the metal in contact with air. It is brick-red, and appears in the form of minute shining scales, nearly insoluble. Resolved into mercury and oxygen gas at a red-heat. Unites with acids forming salts, the solutions of which afford an *orange precipitate* with lime water.

Composed of 1 equiv. mercury (200), and 2 equiv. oxygen (16) =216.

Chlorine unites with mercury in two proportions.

1. **PROTOCHLORIDE.** *Calomel.* Prepared by subliming a mixture of mercury and corrosive sublimate: rationale.

*Properties.* Solid, semitransparent; crystalline; inodorous and insipid, nearly insoluble in water. Sp.

gr. 7.2. Colourless when in lumps, or crystals, but when in powder yellowish-white. Lime-water and caustic alkalies blacken it.

Method of testing the purity of calomel, especially its freedom from corrosive sublimate.

Composed of 1 equiv. mercury (200), and 1 equiv. chlorine (36), =236.

2 BICHLORIDE. *Corrosive sublimate.* Prepared by subliming a mixture of bisulphate of mercury and common salt : rationale.

*Properties.* Solid; crystalline; colourless and semi-transparent; of an acrid nauseous metallic taste. A virulent poison. Sp. gr. 5.2. Soluble in 20 parts of water, at 60°, and 2 or 3 parts of boiling water. Soluble also in alcohol and ether. With alkaline muriates it forms double salts which are generally soluble. Lime-water and alkalies convert it into an orange hydrated peroxide.

Composed of 1 equiv. mercury (200), and 2 equiv. chlorine (72), =272.

Tests of the presence of corrosive sublimate. Antidotes.

CYANIDE. Prepared by boiling a mixture of peroxide of mercury, prussian-blue and water : rationale. Used for obtaining the compounds of cyanogen. It is composed of 1 equiv. mercury (200), and 2 equiv. cyanog. (52) : hence it is a bichyanide.

SULPHURETS. The *protosulphuret* is black. It con-

tains 1 equiv. mercury and 1 equiv. sulph. The *bisulphuret*, called cinnabar or vermilion, is bright red. Obtained by fusing one part of mercury and six parts of sulphur, and subliming the product. Contains 1 equiv. mercury and 2 equiv. sulph. Used as a pigment. *Ethiops mineral* of the older chemists is a mixture of sulphur and cinnabar.

### *Salts of Mercury.*

1. **SULPHATE.** Sulphuric acid heated with mercury, is decomposed, sulphurous acid gas is evolved and *bisulphate of the peroxide* is formed. It is used in preparing the chlorides of mercury. When washed with water, an insoluble yellow *persulphate* is left, called *Turpeth mineral*. There is also a *protosulphate*.

2. **NITRATES.** Mercury dissolved in cold nitric acid yields the *protonitrate*: with boiling nitric acid the *pernitrate* is formed. The latter is used for obtaining peroxide of mercury, by heat.

**FULMINATING MERCURY:** opinions concerning its nature. *Amalgams.* Purification of mercury. Uses of the metal. Supposed to exist in sea water.

### 31. SILVER. =110.

Known in the earliest ages of the world. It occurs native; also alloyed with other metals, and in combination with chlorine, iodine, sulphur, &c. How obtained pure.

*Properties.* White; of a brilliant lustre; highly malleable and ductile; retains its lustre in pure air and

under water. Sp. gr. 10.5. Fuses at a white heat. Burns at a very high temperature, with a green flame. It has but one oxide, which is of a deep olive colour, and consists of 1 equiv. silver (110) and 1 equiv. oxygen (8), =118.

**SULPHURET.** This is one of the ores of silver. It is of a lead colour, and malleable! The brown tarnish which silver acquires in impure air, is a sulphuret.

**CHLORIDE.** Occurs native. May be formed by adding common salt to a solution of nitrate of silver. It is white, but speedily becomes dark violet by the action of light. When fused, it is the horn-silver or *luna cornea*, of the older chemists. So called on account of its toughness and semitransparency. Ammonia readily dissolves it. Reduced to the metallic state by nascent hydrogen. Composed of 1 equiv. silver (110) and 1 equiv. chlorine (36).

**IODIDE.** Yellowish. Occurs native in Mexico.

**NITRATE.** Obtained by dissolving silver in nitric acid. It occurs in colourless flat crystals, which are anhydrous. When fused, it is the *lunar caustic* or *lapis infernalis*. Used as an escharotic, tonic and antispasmodic. Also as a test; for preparing indelible ink; dyeing hair black, &c.

**FULMINATING SILVER.** Probably a cyanate of silver. How obtained. Properties.

*Ammoniuretted oxide*, or Berthollet's fulminating silver.

**ALLOYS.** Silver coin. Silver-steel. Amalgam of silver. *Arbor Dianæ* Extraction of silver from its ores.

## 32. GOLD. =200.

Known in the earliest ages. Occurs generally in a native state : never mineralized by oxygen, sulphur, &c.

*Properties.* Orange yellow, of a brilliant lustre ; softer than copper ; more ductile and malleable than any other metal ; transmits a green light in thin leaves ; not affected by either air or water, at any temperature. Sp. gr. 19.3. Fuses at 32° Wedg. Scarcely soluble except in nitro-muriatic acid, and in a solution of chlorine : precipitated of a purple colour (purple of Cassius) by muriate of tin. It has two oxides.

The *protoxide* is but little known. The *peroxide* exists in the salts of gold ; it is nearly black, and is rapidly decomposed by heat and light. It possesses weak acid properties, and forms compounds which have been called *aurates*. Composed of 1 equiv. gold (200) and 3 equiv. oxygen (24) =224.

*Fulminating gold*, or ammoniuretted oxide.

CHLORIDES. The *perchloride* is obtained by evaporating the muriate slowly : it presents the form of red crystals, which deliquesce in the air. Used in medicine as an antisiphilitic. The *protochloride* is insoluble.

Reduction of gold from its solution, by bodies which attract its oxygen. Action of the green sulphate of iron.

Alloys of gold ; gold coin ; gilding ; gold mines and separation of the metal by the process of amalgamation.

## 33. PLATINUM. =96.

First mentioned by Antonio Ulloa, who visited Peru in 1735. Examined by Wood, in 1741; described by him in 1749 and 1750; full account of its properties published by Lewis in 1754.

*Properties.* White, but less brilliant than silver. Sp. gr. 21.53. Very malleable and ductile. Conducting power inferior to that of most other metals. Scarcely fusible in the best furnaces, but melts before the compound blow-pipe. Possesses the property of *welding*. Insoluble in sulphuric or nitric acids, but dissolves in a mixture of the two; also in a solution of chlorine. Muriate of ammonia precipitates from its solution a yellow powder, which is composed of chloride of platinum and muriate of ammonia; this, when heated to redness, leaves pure platinum in a spongy state. A precipitate is also thrown down by potassa, but not by soda. Combines with oxygen in two proportions; the protoxide contains one equiv. of platinum (96) and 1 equiv. oxygen (8); the peroxide, 2 equiv. oxyg. (16).

*Ammoniuretted oxide*, or fulminating platinum.

**CHLORIDES.** The perchloride is best known. Obtained by evaporating the nitro-muriatic solution to dryness. It is soluble in water. Action of muriate of tin, hydriodic acid, and sulphuric ether on the solution.

Dobereiner's discovery of the effects of spongy platinum on an explosive mixture of hydrogen and oxygen gases.

*Uses of platinum.* Its geological and mineralogical history. Methods of obtaining the pure metal.

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The four following metals have only been found associated with native platinum.

34. PALLADIUM. =56.

Discovered by Dr. Wollaston in 1803. It resembles platinum, but is much less dense, viz. 11.3. Malleable and ductile; not affected by air or moisture. Fusible at a high temperature. Soluble in nitric acid. Some of its alloys are employed in the arts.

35. RHODIUM. =44.

Also discovered by Dr. Wollaston in 1803. It has a white colour, is exceedingly infusible, and is not affected by any of the acids. Sp. gr. 11. Most of its salts are red; hence the name *rhodium*. It communicates valuable properties to steel.

36. IRIDIUM. =30?

Discovered by Tennant in 1803. It is the most infusible metal known; white; scarcely attacked by acids. Sp. gr. about 18. Its solution in muriatic acid undergoes changes of colour when exposed to the air. Not applied to use.

37. OSMIUM.

Also discovered by Tennant in 1803. A singular metal; remarkable for affording a volatile oxide which is soluble in water, and emits the odour of chlorine. Not applied to use.



## THIRD DIVISION OF THE COURSE,

Embracing an account of Organized Bodies and their Products.

These bodies are produced under the influence of vital action, which, in a remarkable manner, controuls and modifies chemical affinity.

They consist essentially of but few elements, united in different proportions, and held together by a feeble affinity; so that they readily undergo decomposition, either spontaneously or by the application of a moderate heat. They are also, in many cases, convertible into each other, by agents which produce a change in the proportions of their ingredients.

## VEGETABLE CHEMISTRY.

Organized bodies and their products, belonging to the vegetable kingdom, are less complex in their nature than those of animal origin; hence they will be first considered. By analysis they may be resolved into either *proximate* or *ultimate* principles.

Proximate principles are certain definite compounds, into which every vegetable substance may be separated, such as starch, gum, &c.

The ultimate principles are elementary or simple bodies; but four of which are essential to vegetables. They are carbon, hydrogen, oxygen and nitrogen; the last occurs in the smallest quantity.

Methods of performing the ultimate analysis of vegetables. Gay-Lussac and Thénard's. Cooper's.

Classification of vegetable principles as proposed by Dr. Turner, with some modifications.

1. *Vegetable acids*; or those vegetable substances which contain more oxygen than is necessary to form water with the hydrogen.

2. *Vegeto-alkalies*; or those which contain nitrogen, and are capable of forming definite compounds with acids.

3. *Inflammables*; or vegetable principles containing more hydrogen than is necessary to form water with the oxygen.

4. *Neutral principles*; including those which contain oxygen and hydrogen in proportions to form water.

5. *Anomalous principles*; those which cannot be referred to either of the preceding classes.

#### I. VEGETABLE ACIDS.

The number of distinct acids found ready formed in plants exceeds thirty, and probably many more exist. They have mostly a sour taste, are soluble in water, and produce salts when combined with bases, by the peculiar properties of which they are chiefly distinguished. A temperature of 700° F. or 800°, is sufficient to effect their decomposition.

##### I. TARTARIC ACID.

Obtained from *cream of tartar*, or bitartrate of potassa, by first forming an insoluble tartrate of lime, then decomposing this salt by sulphuric acid. Insoluble sulphate of lime is generated and tartaric acid, left in solution.

*Properties.* Very acid, but of an agreeable flavour ; crystallizes in colourless prisms and pyramids ; soluble in 5 or 6 times its weight of water at 60° ; the solution gradually changes into acetic acid ; nitric acid converts it (as it does most other vegetable acids) into oxalic acid ; forms a white crystalline precipitate (*cream of tartar*) when added to a solution of potassa, a very characteristic property. It is chiefly used in the preparation of *soda powders*. Its ingredients are 4 equiv. carbon, 5 of oxygen and 2 of hydrogen, besides an equivalent of water.

**TARTRATE OF POTASSA.** Contains one equivalent of each ingredient. It is much more soluble than the next salt.

**TARTRATE OF ANTIMONY AND POTASSA, OF *Tartar emetic*.** Obtained by boiling protoxide of antimony with *cream of tartar*, or bitartrate of potassa. It crystallizes in tetrahedons, which soon grow opaque in the air ; reddens vegetable blues, styptic and metallic to the taste, soluble in 15 parts of water at 60°, and in 3 of boiling water. Its solution decomposes spontaneously, but may be preserved by mixing it with alcohol. *Antimonial wine*.

Composed of 2 equiv. tart. acid, . . .	(66 × 2) =	132
3 “ protox. antimony, . . .	(52 × 3) =	156
1 “ potassa, . . .	=	48
2 “ water, . . .	(9 × 2) =	18
		354

**BITARTRATE OF POTASSA.** *Cream of tartar.* Exists in the juices of various fruits, especially the grape. It is always obtained from the incrustation which forms on the sides and bottom of wine casks.

Methods of purifying it. It is soluble in 60 parts of cold, and 14 parts of boiling water; taste acid and agreeable; decomposed by heat, yielding pure carbonate of potassa.

Used as a mild cathartic, and for the purpose of extracting tartaric acid. Also for preparing *black flux*.

**TARTRATE OF POTASSA AND SODA** or *Rochelle salt*.

## 2. OXALIC ACID.

This is a common ingredient of vegetables, especially of those which yield an acid juice. It is usually combined with potassa or lime. It may be obtained by the action of nitric acid on different vegetable principles.

*Properties.* Crystallizes in quadrangular prisms; very acid; soluble in twice its weight of cold, and in its own weight of boiling water; forms an insoluble salt with lime, acts as a violent poison in doses of from one to four drams. Its best antidote is magnesia, but chalk may be used as a substitute.

Composed of 2 equiv. carbon and 3 equiv. oxygen.

**OXALATES OF POTASSA.** There are three varieties, differing in the proportions of their constituents, viz. oxalate, binoxalate and quodroxalate. The second kind exists in the juice of sorrel and other acid plants: it is used for removing iron stains from linen.

**OXALATE OF LIME.** An insoluble salt, existing in large quantities in certain crustaceous lichens.

### 3. CITRIC ACID.

Exists in the juice of lemons, limes and sour oranges, and may be extracted by a process similar to that employed for obtaining tartaric acid. It may also be procured from gooseberries.

*Properties.* Occurs in colourless thick prismatic crystals, intensely acid, but of an agreeable flavour. Soluble in an equal weight of cold and in less than half its weight of boiling water. Forms an insoluble salt with lime, but scarcely renders lime-water turbid. With potassa it forms a deliquescent salt.

Used by calico printers; also for removing iron stains, and for making effervescing draughts with carbonated alkalies.

### 4. MALIC ACID.

This exists in sour apples and other fruits, and is often associated with the citric and tartaric acids. It may be prepared by digesting sugar in nitric acid. Its taste is agreeably sour.

### 5. BENZOIC ACID.

This acid is an ingredient of various balsams and other vegetable productions. Being very volatile it may be separated by heating these bodies in proper vessels. The acid sublimes in light flocculent crystals, of a fragrant odour and agreeable aromatic taste. It is sparingly soluble in water, but dissolves readily in alcohol. Its uses in medicine.

*Other vegetable acids.*

The most important of these are the following, viz.

**GALLIC ACID.** Found in gall nuts ; also in the bark and other parts of vegetables. It is usually associated with tannin. Its taste is slightly acid ; soluble in alcohol and in water ; forms a dark blue compound when added to the solution of any salt containing peroxide of iron. It is a constituent of writing ink, and of black dyes.

**SUCCINIC ACID** ; so called because obtained from amber. It is a solid, crystalline substance, of a sour taste, and forms a brown insoluble compound with peroxide of iron.

**MECONIC ACID**, only found in opium, united to the alkaline principle morphia.

**KINIC ACID** ; exists in peruvian bark, in combination with quinia and cinchonina.

## II. VEGETO-ALKALIES.

Proximate principles of an alkaline character, existing in vegetables in a state of combination with acids, in which state alone they are soluble to any extent in water. They are readily taken up by boiling alcohol, and deposited again as the solvent cools. Ammonia added to a solution of their salts throws down the alkali in the form of an insoluble precipitate.

General method of extracting these bodies from plants.

### 1. MORPHIA.

Discovered by Sertuerner in 1803. Hitherto only

found in opium, or the inspissated juice of the poppy, in which it exists combined with meconic acid.

*Properties.* It occurs in white prismatic crystals, scarcely soluble even in hot water ; unites with acids, forming soluble, very bitter salts. It is powerfully narcotic, even in very small doses.

This vegetable principle, in combination with acetic acid, is a most valuable medicine, and may advantageously be substituted for opium ; for it produces all the beneficial effects of that drug, without its ordinary unpleasant consequences.

The best antidotes for morphia, are carbonated alkalies. Dr. Hare's method of detecting opium.

**NARCOTINE.** The active principle of opium on which its *stimulating* effects depend. It is probably not an alkali, although one of its ingredients is nitrogen.

Preparations of denarcotized opium. Nature of the *black drop*.

## 2. CINCHONIA.

Occurs in the pale and red peruvian barks. It is a crystalline substance, scarcely soluble in water ; dissolves in boiling alcohol, and is thrown down in a crystalline state as the liquid cools. Its solutions are bitter, and have the flavour of peruvian bark.

The preparations of this alkali are but little employed in medicine.

## 3. QUINIA.

Another alkali discovered in the yellow, red and other species of peruvian bark, by Pelletier and Cavantou.

*Properties.* Soluble in boiling alcohol, and precipitated in a flocculent form as the liquor cools. Its solution, and all its salts, are extremely bitter. The sulphate is soluble in water.

An invaluable tonic medicine. Methods of testing the purity of the sulphate.

CORNIA; the active principle of the *cornus florida* or *dog wood*. It resembles quinia.

STRYCHINA; an alkaline substance found in several species of *Strychnos*. It is highly poisonous.

BRUCIA; the active principle of *brucea antidysenterica*.

VERATRIA; existing in the genus *veratrum*.

EMETIA; or the active principle of *ipecacuanha*.

SANGUINARINA; or the principle of *Sanguinaria canadensis*. Discovered by the late Professor Dana.\*

### III. INFLAMMABLES;

Or vegetable principles which abound in hydrogen.

#### I. OILS.

FIXED OILS. These are mostly obtained by expression from the seeds of plants. The greater number of them are fluid at ordinary temperatures. At 600°F they boil, and at a higher temperature are decomposed, yielding abundance of inflammable gaseous matter, consisting chiefly of light carburetted hydrogen and olefiant gases. Exposed to the air, most of them become rancid. Combine by heat with oxide of lead forming plasters.

\* Annals of the N. York Lyc. Nat. Hist. ii. 255.



They consist of carbon, hydrogen and a little oxygen.

**DRYING OILS.** Manner of preparing them. Heat evolved when oils are mixed with certain combustibles, occasioning sometimes their spontaneous combustion. Action of alkalies of oils. Nature of soap. Separation of fixed oils into *elaine* and *stearine*. Margarinic and oleic acids.

**VOLATILE OR ESSENTIAL OILS.** So called because they are volatilized at a moderate temperature. Manner of obtaining them. They all have a strong, and often aromatic odour; and, most of them, a pungent taste. They burn with a bright light, and emit much smoke. Strong nitric acid inflames them. The most abundant of the essential oils is *spirit of turpentine*. They may be separated into two principles, like the fixed oils, and by ultimate analysis they yield similar elements, but their carbon is in greater proportion.

Some chemists suppose that they contain no ~~water~~ *oxygen*.

**CAMPHOR.** A peculiar inflammable principle found in several species of laurel, and in other plants.

*Artificial camphor.* Prepared by passing muriatic acid through spirit of turpentine.

**RESINS.** Inflammable substances, existing in the juices of various plants, generally in combination with essential oils: the oils separate spontaneously as the juices exude, or they may be expelled by means of heat. They are solid, fusible, burn with a white, smoking flame, are soluble in alcohol, but insoluble in water. At <sup>high</sup> tem-

perature they are decomposed and yield the same products as fixed oils.

**AMBER.** A kind of fossil resin, which yields succinic acid when heated. How distinguished from *copal*.

**BALSAMS,** or compounds of resin and benzoic acid.

**GUM-RESINS. CAOUTCHOUC. WAX.**

#### IV. NEUTRAL PRINCIPLES;

Or those vegetable substances which contain oxygen and hydrogen in proportions to form water.

##### 1. STARCH OR FECULA.

Exists in various kinds of grain, and in the fleshy roots of many plants. How obtained.

*Properties.* White, friable, falls into powder in cold water; with hot water it forms a jelly, or milky solution. When heated it swells, grows black and inflames. If slowly roasted it is converted into a kind of gum. Diluted sulphuric acid changes it into sugar. With iodine it forms a deep blue compound: by this test the smallest quantity of starch may be detected.

**AMYDINE,** or amyline; a modification of starch.

Indian arrow-root, sago, tapioca, and salep, are varieties of starch.

**HORDEIN,** a peculiar principle existing in barley, and **ZEINE,** the basis of Indian corn or maize.

##### 2. GUM.

A dried exudation from various plants. Gum-arabic is the purest variety.

*Properties.* It dissolves in water, and the solution,

which is called *mucilage*, is adhesive, and long resists decomposition. Insoluble in alcohol.

*Varieties.* Gum-senegal; cherry-gum; tragacanth, &c.

### 3. SUGAR.

Abundant in sweet fruits, and in the juices of many plants. Method of extracting and purifying it.

*Properties.* Soluble in an equal weight of cold water, and in four times its weight of alcohol; crystallizes in rhombic prisms; forms insoluble compounds with various earths and metallic oxides. Nitric acid converts it into oxalic acid. Its solution ferments when mixed with yeast, and is converted into alcohol. Decomposed below a red heat, emitting an aromatic odour.

*Varieties of sugar.* Grape-sugar, honey, manna. Syrups and molasses.

### 4. GLUTEN.

A principle existing in wheat and other kinds of grain. Obtained from wheat flour, by washing it until the starch and soluble matters are removed.

*Properties.* Elastic, tenacious, but hard and brittle when dried; readily putrifies if kept in a moist and warm situation; yields ammonia by distillation; and emits an animal odour when burned.

Gluten was supposed by Taddei to consist of two peculiar principles; one soluble in water, called *gliadine*; the other insoluble, called *zimome*. Berzelius' new researches on this subject.

The gluten in flour is an important ingredient, for it

renders the dough tenacious, so that it retains the carbonic acid which is produced during the process of fermentation, and thus makes the bread cellular, or *light*.

Relative quantities of gluten in different kinds of flour.

### 5. LIGNIN.

Pure woody fibre, separated from all other principles. It is the chief constituent of the solid parts of plants.

*Properties.* White; mostly fibrous; insoluble in water, alcohol, or weak alkaline leys; almost indestructible in dry air. When heated in close vessels it is decomposed, yielding an acid empyreumatic liquid (consisting chiefly of water, tar and acetic acid) and abundance of inflammable gas: pure carbon remains in the retort. Concentrated sulphuric acid converts it into gum; diluted acid into sugar.

*Varieties of lignin.* Flax, hemp, cotton, &c. Cork is also allied to lignin, but it yields a peculiar acid, called the suberic, with nitric acid.

*Pyroxylic spirit*, an inflammable liquid somewhat resembling alcohol, obtained by the distillation of wood.

### FERMENTATION.

1. *Vinous fermentation.* A spontaneous process which takes place in certain vegetable juices and infusions; in which carbonic acid is disengaged, while an inflammable liquid, called alcohol is produced. The reaction of the vegetable constituents is promoted by

*yeast*, a natural species of which exists in the juice of grapes and other fruits.

The vinous fermentation succeeds best, when sugar is present in the liquid, but this ingredient is not essential to the process.

Manufacture of wine and malt liquors.

#### ALCOHOL.

When a fermented liquor is heated in a retort, the alcoholic part being most volatile, first distils over, but not in a pure state, being combined with a portion of water. It may be rendered nearly anhydrous, by substances which possess a strong affinity for water: also by inclosing it in a bladder suspended in a warm situation for several days.

*Properties.* Colourless; highly inflammable, burning with a pale blue and yellowish flame, and yielding by combustion only water and carbonic acid. Sp. gr. when pure 0.796; boils at 176° F.; not congealed by the most intense cold; dissolves a great variety of substances, such as resins, salts, alkalies, &c.

Composed of carbon, hydrogen and oxygen, in such proportions as to form olefiant gas and water. May be analyzed by passing its vapour through a red hot porcelain tube.

Quantity of alcohol in different kinds of spirituous liquors and wine; how determined. Use of the hydrometer.

## SULPHURIC ETHER.

Obtained by distilling a mixture of sulphuric acid and alcohol. The acid takes from the alcohol one half of its water. Hence ether is composed of the same ingredients as alcohol, but united in different proportions, viz. 2 equiv. olefiant gas and 1 equiv. water.

*Properties.* A colourless highly inflammable liquid ; sp. gr. about 0.700 ; boils at 90° F. ; freezes at —42° ; does not mix with water except in small proportion, but unites with alcohol ; dissolves various resinous substances, especially caoutchouc.

Uses of ether. Method of purifying it. Products of the slow combustion of ether. Sweet oil of wine. Anodyne liquor of Hoffman.

Sulphovinous acid, produced during the formation of ether.

NITRIC, MURIATIC, HYDRIODIC and ACETIC ETHERS. These differ essentially from the sulphuric ether in containing a portion of acid in chemical combination.

2. ACETOUS FERMENTATION. This is generally subsequent to the vinous. The vinous fermentation, if not arrested, will pass into the acetous ; which consists in the production of vinegar or acetic acid, and the absorption of oxygen. This change takes place slowly unless at a temperature above 65° F.

## ACETIC ACID.

Obtained from strong vinegar, or the pyroligneous acid : also by distilling various acetates with sulphuric acid.

*Properties.* A crystalline solid at temperatures below 55° F. ; but it commonly occurs in the form of a volatile liquid, exceedingly pungent, and capable of blistering the skin. Its vapour burns with a white flame.

Composed of 4 equiv. carbon, 3 equiv. oxygen, and 2 equiv. hydrogen. The concentrated kind contains 1 equiv. water.

**PYROLIGNEOUS ACID.** Obtained by the destructive distillation of wood. It is acetic acid intimately mixed with an empyreumatic oil, which communicates to it powerful antiseptic properties.

Distilled and concentrated vinegar ; and their uses.

*Salts of acetic acid.*

1. **ACETATE OF POTASSA.** It is deliquescent, and was formerly employed in medicine under the name of *diuretic salt*.

2. **ACETATE OF SODA,** crystallizes, and is permanent in the air. Much used for preparing concentrated acetic acid.

3. **ACETATE OF AMMONIA.** (*Spirit of Mindererus.*) Employed as a diaphoretic. Method of preparing it.

4. **ACETATE OF LEAD.** (*Sugar of lead.*) Crystallizes in small four-sided prisms, which are slightly efflorescent in the air ; very sweet, but astringent ; soluble in four or five parts of cold water ; the solution is rendered turbid by carbonic or sulphuric acids.

Used in medicine as an astringent, but is a dangerous

remedy in large doses. Its antidote is sulphate of magnesia.

5. ACETATE OF IRON. Used by calico printers.

6. ACETATE OF COPPER. *Verdigris*. Method of obtaining it. Uses.

#### 5. ANOMALOUS PRINCIPLES.

COLOURING MATTER. *Lakes*, or compounds of colouring matter and alumine. Theory of dyeing. Mordants or bases. Substantive and adjective colours.

INDIGO: nature of the peculiar principle which it contains. When deprived of oxygen it becomes green, and soluble in water, and in this state is applied to cloths; exposure to the air restores its blue colour.

CARMINE, HEMATIN, LITMUS, POLYCHROITE.

TANNIN: a common ingredient of vegetables, often associated with gallic acid. Catechu, rhatinia and kino, consist chiefly of this principle. It is difficult to obtain it perfectly pure. Its most important property is that of forming an insoluble precipitate with gelatine, which is the basis of leather. Artificial tannin.

EMETIN; the active principle of ipecacuanha.

Other vegetable principles of less importance, viz. *Caffein, Ulmin, Lupulin, Piperin, Rhubarbarin, &c.*

#### ANIMAL CHEMISTRY;

Animal substances, like vegetables and their products, are capable of being resolved by analysis into several distinct proximate principles. The ultimate elements of these principles, are the same as those of which plants



are constituted, viz. carbon, nitrogen, oxygen and hydrogen.

## I. SUBSTANCES WHICH ARE NEITHER ACID NOR OLEAGINOUS.

### 1. FIBRIN.

This constitutes the basis of the muscles, and forms a large proportion of the blood. Method of obtaining it pure. It is white, insipid, scarcely soluble in either hot or cold water, becomes a brittle, hard solid when dried. In a moist state it soon putrifies. Acted on by nitric acid, it yields a large quantity of pure nitrogen gas.

### 2. ALBUMEN.

Exists in most animal substances, especially in the serum of blood, where it occurs in a liquid state, or dissolved in water. The white of egg, affords the best example of this principle. In a solid state it forms a constituent of the skin, membranes, &c. When in solution, it is coagulated by heat, alcohol and various acids. Method of detecting minute quantities of albumen. When this principle is coagulated, it cannot be restored to its liquid state. Action of sulphuric acid on the white of egg.

### 3. GELATINE.

A constituent of the solid parts of animals, but not existing in the fluids. Soluble in water, forming an adhesive liquid, which gelatinizes as it cools; the solution yields an insoluble precipitate with tannin. Insoluble in alcohol. In a dried state it is *glue*, of which

isinglass is the purest kind. Sulphuric acid converts it into a kind of sugar.

#### 4. UREA.

A principle found in urine. It occurs in transparent colourless crystals, soluble in water and alcohol. Its aqueous solution may be kept a long time without change, but it remarkably promotes the putrefaction of other animal substances.

Sugar of milk, and of diabetes.

### II. ANIMAL ACIDS.

URIC ACID, formerly called *Lithic acid*. Exists in urine, and also in certain urinary calculi and gouty concretions. It occurs in minute crystals which are nearly insoluble in alcohol and water; with bases it forms urates, which are mostly insoluble.

*Purpuric, rosacic, lactic and other animal acids.*

### I II. OLEAGINOUS SUBSTANCES.

They are either fluid or solid. The former resembles in general properties the vegetable fixed oils, but they often contain other principles.

*Glycerine*, or the sweet principle of oils.

BUTYRINE, PHOCENINE, SPERMACEIN, ADIPOCIRE, &c.

Nature of the blood. Venous and arterial blood. Separation of the blood into *serum*, *fibrin*, and *colouring matter*. Opinions concerning the nature of the latter. Of the *buffy coat*.

Chemical phenomena of respiration. Animal heat; theories concerning its source.