Geo W Bradford

1830

AN

EPITOME

OF

CHYMICAL PHILOSOPHY;

BEING AN

EXTENDED SYLLABUS OF THE LECTURES ON THAT SUBJECT, DELIVERED AT DARTMOUTH COLLEGE;
AND INTENDED AS A TEXT-BOOK
FOR STUDENTS.

BY JAMES FREEMAN DANA.

"SPARSAS COLLIGERE FRONDES."

CONCORD, N. H.
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....
1825.

DISTRICT OF NEW-HAMPSHIRE, *to wit.*
District Clerk's Office.

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"Sparsas Colligere frondes."

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The following work is compiled from various authorities. References are consequently made to the original works and memoirs, which have been consulted in its preparation, both with a view to acknowledge the sources of information, and to direct students to publications in which the subjects are more elaborately discussed.

It is hoped that some peculiarities which the following pages present, will not be unacceptable to the chymical public, or totally unworthy of their notice.

The object proposed in this publication is, *to comprise the principal facts and doctrines of Chymistry, in a condensed form, adapted to the use of those who wish to acquire a knowledge of the* PHILOSOPHY OF THE SCIENCE, *without entering into the details of laboratory practice, or being encumbered with the minutiæ of processes, and descriptions of substances, which are interesting only to the professed practical and operative chymist*; and thus to furnish a work which should be useful as a Text Book of the Science, as it is usually taught in our academies and colleges. How far this object has been now attained, those only can form a competent judgment, who possess a sufficient knowledge of the subject to be instructers in the science.

A brief description has been given of all the undecompounded bodies, and of their most interesting and useful compounds; among the latter, those have been selected, which are important in the arts, or which are employed in the laboratory as a source of other curious or useful chymical preparations.

In the order of arrangement of ponderable bodies, a deviation has been made from the strict scientific arrangement founded on their electrical relations. Water, a substance universally diffused, and obvious to several of the senses, has been selected as a subject better adapted to the first experimental examination by a novice, than oxygene gas, an invisible elastic fluid; and the analysis of water leads directly to the consideration of the properties of its constituents, oxygene and hydrogene, and of the properties of gaseous bodies in general.

A minute explanation of the phenomena, or rationale of experiments, has not been given, in order to afford a sufficient opportunity for the exercise of the mind in reverting to the Principles of the Science, which it is hoped are detailed with sufficient precision and clearness to be comprehended by any one who devotes a reasonable degree of attention to the subject.

The work has been published under the peculiar disadvantages arising from the great distance at which the writer resides from the press, and the consequent impracticability of inspecting the proof sheets with a desirable degree of minuteness and attention; it is believed, however, that no important errors occur in its pages.

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AN EPITOME

OF

CHYMICAL PHILOSOPHY.

PART I.

CONTAINING THE GENERAL PRINCIPLES OF THE SCIENCE, AND THE CHYMISTRY OF INORGANIC SUBSTANCES.

AN EPITOME, &c.

1. Chymistry treats of the specific differences in the nature of bodies, and of the phenomena, and changes in constitution to which their mutual actions give rise.

The actions which bodies exert upon each other are the result of the operation of *general* or *universal powers* or *forces;* the effect produced, is different in different substances; we shall consider,

I. The general forces productive of chymical phenomena, and the laws which govern them; or the general theory of the Science.

II. The particular effects which are produced in different bodies by the agency of these general powers; or the chymical history of individual substances.

2. Matter is known to us only by its properties; some of which are considered as *essential* properties, others as *accidental.* They have been supposed to reside in some substratum or substances, but, "so little are the qualities of a substance distinguishable from the substance itself, that, what we term a substance is expressive only of the coexistence of certain qualities." (Brown *on Cause and Effect.*) Of the ultimate constitution of matter we are totally ignorant; the hypothesis of Newton, which supposes matter to be composed of hard impenetrable and indivisible particles, seems well adapted to convey distinct notions of chymical phenomena. No argument respecting the unlimited divisibility of matter can be drawn from geometrical or mathematical demonstrations, in which we evidently reason about our own conceptions and not about real existences. Facts, connected with the history of the atmosphere, indirectly establish the finite divisibility of matter; "all the phenomena accord entirely with the supposition that the earth's atmosphere is of finite extent, limited by the weight of ultimate atoms, of definite magnitude, no longer divisible by repulsion of their parts." (Wollaston. *Phil. Trans.* 1822.)

3. Matter exists under four different forms, viz. *Solid, Liquid, Gasseous,* and *Etherial;* these are distinguished from each other by sensible and obvious properties. Under the three first forms,

2

matter is easily subjected to experiment; under the latter, it cannot be confined in vessels and examined, it is known by its action on our organs and its effect on other matter. (Davy. *Chym. Philos.*) These forms of matter and the changes which they exhibit depend on attraction and the powers producing repulsion.

OF ATTRACTION.

4. Attraction is the force by which bodies tend to approach each other and to enter into a more or less intimate union; when it acts on masses of matter at sensible distances it is called *remote attraction;* when on particles of matter at insensible distances, *contiguous attraction.* Gravitation, electricity, and magnetism offer examples of the former; cohesion and chymical affinity of the latter. The phenomena and laws of gravitation are not subjects of chymical enquiry; but the other kinds of attraction are intimately connected with chymical action: their laws and influence in the phenomena of nature and art are the objects of chymical philosophy.

5. When contiguous attraction unites particles of the same kind it is called *cohesion,* but when it unites particles of different kinds it is called *affinity.*

OF COHESION.

Attraction of aggregation; Homogeneous attraction.

Bodies exist in the solid, liquid or gasseous form according to the greater or less action of cohesion on their particles. It is exerted with very different degrees of force in different bodies; the particles of the diamond and of a drop of water are united by this power. *Tenacity,* which is an effect of cohesion, is measured by the weight which is required to break the solid subjected to experiment; in some metals it may be increased by hammering, rolling, wire-drawing and alloying.

The force of cohesion is destroyed by many mechanical operations, and by the action of liquids, and of heat upon many solid bodies.

6. When the causes which subverted the force of cohesion cease to act, the body returns to its original form, which, if it be a solid, is presented in regular geometrical figures called *crystals,* or in a confused and shapeless aggregate, or in a powder. The latter is often produced from a liquid by the addition of another body; an insoluble solid is separated and appears under the form of a fine powder, or of flocculi; the solid so

produced is called a *precipitate;* the operation is *precipitation;* the substance added to the liquid to produce the effect is the *precipitant*, and is not necessarily in the liquid form.

7. A *crystal* is a regular geometrical solid, possessing a regular rectilinear internal structure. Substances of the same composition crystalize in the same form, or in one, which by known laws, may be referred to the same original form; but different substances, with some exceptions, assume different figures, and hence we can often read the chymical composition of a body in its mechanical structure.

8. Crystallization is the process by which crystals are obtained; and on the slowness with which it is conducted, their beauty and perfection depend. Bodies will not crystallize unless their particles possess perfect freedom of motion, and this is communicated either (*a*) by the agency of caloric, or (*b*) by the action of a solvent; absolute solution however is said not to be necessary in all cases. (WATT. *Accum's Crystallography.*) Substances which have been melted by heat, may, by slow cooling, be obtained in a crystalline form; sulphur and some of metals afford examples of this; other substances, converted into vapour by the same agent, crystallize during condensation, as iodine, calomel, camphor, &c. Bodies which have been dissolved in a liquid may be obtained in crystals either (*a*) by cooling the solution made at a high temperature, or (*b*) by evaporating a portion of the liquid: in common cases the evaporation may be continued until a pellicle forms on the surface of the liquor. Those substances which have so strong attraction for their solvent that they cannot be procured from it in crystals by the ordinary method, may sometimes be obtained by the agency of another body; and those substances, which in solution will not bear a high temperature without decomposition, may sometimes be procured in crystals, by being placed over a surface of oil of vitriol in an exhausted receiver of an air pump, a rapid evaporation being thus produced without elevation of temperature. A mere approximation of particles will not produce crystals, for bodies often occupy a less volume before, than they do after crystallization.

9. The hardness, colour, brilliancy and transparency of crystals often depend on a portion of water which they contain; it is called *water of crystallization*, and sometimes constitutes more than half the weight of the crystal; some crystals on exposure to dry air lose this water, and fall into a powder, these are said to *effloresce;* others on exposure become liquid,these *deliquesce;* others on exposure to heat melt in their own water of crystallization and suffer *watery fusion.*

10. The formation of crystals is accompanied by an elevation of temperature, a phenomenon very obvious in rapid crystallization.

11. Crystallization is much facilitated by the presence of a solid nucleus upon which the formation may commence. Man-

ufacturers often avail themselves of this fact; we find twigs in copperas, and threads in sugar-candy, upon which these substances have crystallized. The best nucleus is a crystal of the substance which is the subject of experiment.

12. Light and electricity materially influence the process of crystallization ; that portion of a saline solution which is exposed to light will first crystallize ; the crystals of camphor in bottles are most abundant on the side exposed to light. It is often noticed that an abundant crop of crystals will be deposited during or soon after a thunder storm, and Dr. URE found that negative electricity facilitated, and positive electricity retarded the formation of crystals.

13. A saturated solution of some salts in boiling water will remain fluid on being excluded from the air, but on admission of the air often crystallize; this has been referred to atmospheric pressure, an explanation ingeniously refuted by the simple experiment of GAY LUSSAC ; slight agitation, or a crystal of the salt dropped into the solution, will produce crystallization. The phenomenon is not yet satisfactorily explained ; it is probably connected with a polarity of the particles. (COXE. *An. Phil.*)

14. Some salts crystallize with much greater facility than others ; thus two salts dissolved in the same liquid may be separated from each other by cautious evaporation, the one which requires the greatest quantity of fluid for its solution being first crystallized.

15. Crystals are bounded by faces, edges and angles. *Faces* or *planes* are those smooth surfaces which lie evenly between their bounding lines ; *edges* are formed by the meeting of two planes ; *solid angles* by the meeting of three or more planes in one point. The planes which terminate a prism are called *terminal planes ;* those at the sides, *lateral planes ;* the face on which a crystal is supposed to stand is called the *base.* When the end of a crystal is formed by two planes inclined to each other like the roof of a house, it is said to be *culminated ;* if three or more planes, meeting in a solid angle, terminate the prism, they form a pyramid which is called the *summit ;* the planes which form the summit are called *acuminating planes,* and the edges produced by their junction, *edges of the pyramid.* When an edge or solid angle is cut off and replaced by a single new face it is said to be *truncated,* if by two or more new faces it is bevelled. A very short prism is called a *table.*

16. Various theories have been proposed to explain the formation of crystals ; they have yielded to the theory of *Haüy* as modified by *Wollaston.*

Lapidaries have long known that gems when broken in certain directions afford smooth and polished surfaces ; in other directions those which are rough and uneven ; this is the case with all *crystallized bodies ;* the smooth faces indicate the existence of *natural joints.* If we apply the edge of a knife to a cube of fluor spar and endeavor by the aid of a gentle blow to cut it in directions parallel to its faces, we shall find a strong resistance, and if we succeed in dividing it, the new surfaces will be rough and unpolished; but this cube readily admits of divisions in directions by which the solid angles are truncated, and the new surfaces are smooth, shining and polished; by continuing the division equally on all the angles we at length obtain a solid octaedron; in the latter case we evidently open the natural joints, in the former the crystal is *broken.* This development of crystalline structure by dividing the natural joints is called *mechanical dissection,* and it is well exhibited in the hexagonal crystals of carbonate of lime; in this substance, the three alternate edges formed by the meeting of the terminal with the lateral planes, readily admit of truncation at one end of the prism, while the intermediate edges resist division; at the opposite end of the crystal, these intermediate edges alone will yield, and thus six new faces are developed; by continuing divisions in planes parallel to those new faces, the hexagonal prism is at length converted into an obtuse rhomboid. The solid so obtained by mechanical division is called the *primitive form,* upon which, as a foundation, the crystalline structure is erected. All the variety of crystals which have been examined, afford only six primitive forms, viz.

1. The parallelopipedon, including all solids bounded by six faces parallel two and two. 2. The tetraedon. 3. The octoedron. 4. Hexangular prism. 5. Dodecaedron with rhomboidal faces. 6. Dodecaedron with triangular faces.

17. It is evident, from the small number of primitive forms, that some of them must be common to many crystals; but it is found that the faces of the primitive nucleus of one substance are not inclined to each other at the same angle as those of another substance or compound having a *similar* primitive form; there are several substances which acknowledge the obtuse rhomboid as their primitive nucleus, but the rhomboid of carbonate of lime has obtuse angles of 105.5,° that of pearl spar 106.5°, of iron spar 107, and that of the Tourmalin 113°. It is an object of importance to measure these angles with precision; this is effected by an instrument called a *Goniometer,* of which there are several kinds, and the best is *Wollaston's reflective goniometer.* From facts similar to those above stated, it was inferred that substances of different composition never assumed precisely the same primitive form; but it has been shown, that several bodies, both simple and compound, may replace each other in compound bodies susceptible of crystallization, without affecting the primitive form. Substances capable of thus changing the *composition* without changing the *form* of crystals are called *Isomorphous bodies.* MITSCHERLITZ. *Edin. Phil. Jour.*

The primitive form is always susceptible of division in directions parallel to its faces, in which case its figure is not changed; but sometimes it may be divided in other directions, and new solids are developed, which, being the ultimate results of mechanical division, are called *integrant particles* by *Haüy*; they are three in number, viz. 1. *Triangular prism*, 2. *Tetraedron*, 3. *Parallelopipedon*, being solids bounded by four, five and six faces. There are instances in which we are unable to decide which of two solids is the integrant particle; a slice of fluor spar may be easily split into acute rhombi, which by removing a tetraedron from each extremity affords octoedra; which, in their turn, afford rhombi and tetraedra; each tetraedon affords one octoedron and three little tetraedra, and so on indefinitely; thus the octoedron and tetraedron have equal claims to be considered as the integrant particle; the latter, however has been adopted, because it is the more simple solid; but no number of tetraedra can be so arranged as to form an octoedron, nor can any number of octoedra be so united as to form a tetraedron, unless they be put together by their edges, and thus arranged they will leave large vacuties between them; a structure not adapted to form the basis of a permanent crystal. To obviate this incongruity, Wollaston suggested that the integrant particles of all crystals might be considered as spheres or spheroids, which by their mutual attraction have assumed that arrangement which brings them as near as possible to each other; this view of the subject has been ingeniously illustrated by its author, and has received confirmation from the experiments of Mr. Daniel, (*Jour. Science and Arts, vol.* 1.) in which the crystalline structure was developed by chymical processes; salts which appeared to be destitute of crystalline structure were proved to consist of crystals, by mere abstraction of certain portions, without altering the relative arrangement of those which remained; a fact which does not appear to admit of any other explanation, than this, *that crystals are formed by the combination of an indefinite number of spherules.*

18. The figures of crystals which are erected upon the primitive form are called *secondary forms;* they are supposed to be produced by the addition, to the faces of the nucleus, of successive layers called *laminæ of superposition*, which, proceeding from the primitive form, progressively diminish in certain directions by the abstraction of particles from their edges or angles; this abstraction is called *decrement*, and where it does not obtain, the crystal augments in size. The tenuity of the laminæ of superposition is so great, that more than 50,000 have been found in 1-12 of an inch. (*Haüy. Nat. Philos.*) A cube, by a series of decreasing laminæ on each of its faces, will form a dodecaedron if the decrement be on the edges, but an octoedron if it be upon the angles; by *intermediate* and *mixed* decrements a multitude of other figures may be produced, and the same primitive form become the basis of many secondary crystals.

☞*Haüy's Natural Philos. vol.* i. Cleaveland's *Mineralogy, vol.* i. Gorham's *Chymistry, vol.* i. Accum's *Crystallography.*

OF AFFINITY.

Chymical attraction; Attraction of composition; Heterogeneous attraction.

19. If oil and water, or water, oil and mercury be agitated together, they do not act on each other, but soon separate and exhibit their original characters; they do not combine, and have no affinity for each other; but if olive oil and a solution of potassa be agitated together, they form a milky fluid in which neither of them is recognised; they unite and form a chymical combination; and bodies which unite chymically are said to have an *affinity* for each other, and those which do not unite, under any circumstances in which they have been placed, are correctly said to have no affinity for each other.

20. *Affinity* is the force by which different kinds of matter are united together to form a substance having new properties and relations. It is mutual and reciprocal between those substances which it combines; A cannot be said to have an affinity for B while B, has none for A.

Combination is the intimate union or assimilation of two or more different kinds of matter into one substance; in a *mixture* a difference of parts can be detected, and these parts, with the exception of those of mixed gasses, and perhaps some other bodies, can be separated from each other by mechanical means.

Decomposition is the separation of the parts of a compound from each other; it may be spontaneous, or the result of art; in the latter case, when effected with a view to discover the nature and quantity of the *component* parts, it is called *analysis*. The reproduction of a compound by uniting its *component* or *constituent* parts is called *synthesis*. "The words *analysis* and *synthesis* are applied in all cases where bodies are resolved into, or compounded from, any other kinds of matter." DAVY.

21. The properties of bodies are in some instances totally changed by chymical combination; the form, color, taste, smell and other physical properties, as well as the chymical qualities, are altered.

The innumerable variety of substances which exist in the material world owe their difference of properties to this effect of chymical action in the combinations of a few original bodies. The properties of compounds cannot be inferred from any knowledge of the properties of their constituent parts; they must be learned by experiment; in some instances inert substances remain inert after combination, and active bodies retain their activity, yet the reverse is most generally the case.

22. Chymical action is usually accompanied with a sensible change of temperature, and often with an evolution of light. The production of heat and light in our common fires, of heat in fermentation, and of cold by mixing snow and salt, are familiar illustrations of this effect.

23. A change of density so uniformly accompanies chymical action, that it has been considered as sufficient evidence of combination; although there are exceptions to this very general law in the union of chlorine and hydrogene, and of oxygene with nitrogene in forming nitric oxide, yet it seldom occurs that the density of a compound is the mean density of its constituent parts; it is sometimes greater and sometimes less.

Gay Lussac discovered a singular law of condensation in the union of gasseous bodies; when two airs combine together, and the compound retains the gasseous form, the contraction, if any, always bears some simple proportion to the volume of one of the gasses present, being equal to it, or twice, thrice, &c. as great. Thus,

Vols.		Vols.		Vols.		Vols.
100	carbonic oxide with	50	oxygene form	100	carbonic, contraction	50
100	nitrogene - - -	50	ogygene -	100	nitrous - - - -	50
100	nitrogene - - -	300	hydrogene -	200	ammonia - - -	200

or twice the volume of nitrogene, &c.

There are many instances in which a gas combines with a solid body, and increases in density without any alteration of volume.

24. Some substances will combine, under ordinary circumstances, whenever they come in contact with each other, as nitric oxyde with oxygene, but others, which have a mutual affinity, are prevented from uniting by the operation of several circumstances.

(*a*) *Temperature* has an important and extensive influence over chymical action; it exalts, retards and often subverts chymical affinities, so that bodies which unite at one temperature refuse to combine, or remain combined at another temperature. The influence of increased temperature in chymical action is sometimes referable to the diminution of the force of cohesion (d.24) by liquefaction, the liquid form and perfect freedom of motion among particles being most favourable to chymical action; but in other cases, the effects are complicated and probably connected with the electrical state of the combining bodies.

(*b*) *A previous state of combination* modifies the action of a body upon other substances; it generally diminishes and often prevents chymical action.

(*c*) *Specific gravity* in some instances appears to retard and prevent chymical action; its influence however is very limited.

(*d*) *Cohesion* often opposes an effectual obstacle to chymical action; hence the utility of the mechanical processes, and of solution which diminish or destroy this force. Solid antimony introduced into chlorine gas is slowly acted upon; but the metal in fine powder, takes fire the moment it touches the gas; there are many similar examples of this effect of cohesion, yet there are instances in which two solids will act chymically on each other.

(*e*) *Mechanical action or compression* appears in some instances to modify chymical action; its effect on solid bodies is inconsiderable, but on gasses, and on gasses and liquids, it is more obvious. Gasses are highly elastic and compressible, and elasticity may be regarded as opposed to chymical action. Water, under ordinary pressure, dissolves a small portion only of most gasses; but, under increased pressure, by which the particles of the gas are approximated to each other and to the liquid, a large portion is dissolved. When a large quantity of a gas has been dissolved in a liquid by the aid of great pressure, it suddenly resumes the elastic form on removing the compressing force and passes through the liquor in a multitude of small bubbles; this may be seen at soda fountains or in uncorking a bottle of champaine, cyder or porter. Sir JAMES HALL found that great pressure prevented the decomposition by heat of some bodies, whose elements are easily separated from each other by that agent under ordinary pressure. *Diminished* pressure seems in some instances to facilitate chymical action. *M. Bellani de Monza* found that phosphorus burned more readily in rarefied oxygene gas than under the pressure of the air. And the same appears to be the fact with subphosphuretted hydrogene. (THENARD. *Tracti de chimie, ed.* 3. *Tome* i. 14.)

(*f*) *The electric state* of bodies exerts such an extensive and important influence on chymical action that Electricity and Affinity seem to depend on the same power. Bodies in the same electric stated on ot unite; those in different electrical states do combine. (*See* § 70)

25. The laws, which regulate the relative proportions in which bodies combine, when combination is accompanied with total and complete change of properties, are different from those which obtain where these changes are less obvious. It may be questioned whether all the latter instances are truly cases of chymical combination: the action between the substances is never energetic, nor has it been observed that it is accompanied with electrical changes, which are manifested in cases of undoubted chymical action.

26. *The elements of every true chymical compound invariably exist in the same relative proportion to each other;* water is always composed of 1 part by weight of hydrogene and 8 parts of oxygene; sulphuric acid always contains 16 parts of sulphur and 24 parts of oxygene; sulphuric acid and magnesia, in Epsom salts, are always in the ratio of 40 to 20. Pure white limestone, from whatever source it is procured, always contains 28 parts of lime for 22 of carbonic acid, and carbonic acid, whether derived from limestone, or from the combustion of the diamond, or of pure charcoal, or evolved in fermentation, or in respiration, or obtained from fissures in mines, always contains carbon and oxygene united to each other in the invariable pro-

portion of 6 of the former to 16 of the latter by weight; *the elements in the same compound always bear the same ratio to each other.*

There are instances in which two bodies will unite only in one relative proportion, as oxygene and hydrogene, (§131) hydrogene and chlorine, nitrogene and hydrogene; but generally two bodies will unite with each other in more than one proportion; thus, carbon and oxygene unite, as above stated, in the ratio of 6 to 16 to form *carbonic acid*, but the same elements form another compound called *carbonic oxide*, in which the carbon is to the oxygene as 6 to 8; the weight of the carbon being the same in both compounds, the quantity of oxygene in one, is *double* that in the other,

Carbonic oxide containing 6 carbon and 8 oxygene.
Carbonic acid - - 6 carbon and $8\times 2=16$ oxygene.

A similar result is presented by all bodies which unite with each other in more than one proportion to form different compounds. Thus, there are two oxides of mercury,

The first, contains mercury 200, - oxygene 8.
The second, contains mercury 200, - „ $16=8\times 2$.

There are two carbonates of potash; the bi-carbonate contains precisely twice as much acid as the carbonate, the quantity of alkali being the same in both; there are innumerable examples of the same kind; hence *when one substance combines with another in more than one proportion to form different compounds the numbers indicating the larger proportions are exact multiples of those by which the smallest proportion is represented;* a remarkable illustration of this is presented in the combinations of oxygene with nitrogene, the weight of the nitrogene in each being 14: that of the oxygene in the five compounds respectively is 8. 16. 24. 32. 40. being 1. 2. 3. 4 and 5 times 8, the smallest proportion.

26. (*bis*) It is not by weight only that substances unite in such determinate and multiple proportions; Gay Lussac discovered that *gasses or airs unite with each other in the most simple ratios in volume or bulk;* 1 volume uniting to 1, or 1 to 2, or 1 to 3, &c. In combinations by weight there is no simple multiple ratio between the weight of the elements in the *first* compound; the oxygene, e. g. is not equal to, or twice or thrice, &c. the weight of the azote in nitrous oxide, or of the carbon in carbonic oxide; it is only when there is a second compound formed by the same elements, that the new proportion, of the body which has been added, becomes a multiple of the first; but in combinations by volume, the bulk of one of the gasses in the *first*, as well as in the other compounds, is always equal to, or is some multiple of that of the other; thus

Vols.		Vols.	
100	oxygene combine with -	200	hydrogene;
100	ammonia - - -	50	carbonic acid;
100	ammonia - - -	100	carbonic acid;

100 nitrogene - - - 300 hydrogene;
100 nitrogene - - - 50, 100, 150, 200 & 250 volumes of oxygene; the volumes correspond to the relative proportions by weight as above stated.

The relative weights in which bodies mutually combine referred to a common standard as unity, are said to be *equivalent* to each other; an example will illustrate the use of this term, *equivalent*, happily introduced into the science by WOLLASTON. It was stated above that pure limestone consisted of 22 parts of carbonic acid and 28 parts of lime, and Epsom salts of 20 parts of magnesia and 40 of sulphuric acid. Now let the sulphuric acid be combined with the lime, and the carbonic acid with the magnesia and it will be found that 40 parts of sulphuric acid combine with 28 of lime and form 68 parts of sulphate of lime; and that 22 parts of carbonic acid unite with 20 parts of magnesia and produce 42 parts of carbonate of magnesia: 22 parts of carbonic acid are *equivalent* to 40 parts of sulphuric acid, because in this proportion they neutralize the same weight of magnesia or of any other alkaline base; and 20 parts of magnesia are *equivalent* to 28 of lime, for, they neutralize the same weight of any acid. When the relative quantities of any two or more alkalies, required to neutralize a given weight of any acid, are ascertained, it will be found that the same relative quantities will be required to neutralize any other acid; the same remark applies to the relative weights of acids required to neutralize alkaline bodies.

The smallest relative weights in which bodies combine, referred to a common unit, have been called *Prime equivalents*, or simply *Primes* by DR. URE.

Hydrogene and oxygene, have each been assumed as the unit of weight to which other bodies have been referred; hydrogene, being the lightest ponderable body, appears to possess peculiar claims to this office.

By arranging the numbers indicating the relative combining weights, or equivalent quantities of different substances, on a moveable scale, like Gunter's sliding rule, and writing against them the names of the substances they respectively represent. WOLLASTON constructed a *logometric scale of chymical equivalents*, an instrument stamped with the ingenuity and accuracy of its illustrious inventor and capable of solving with ease many problems which daily occur to the practical chymist.

The doctrine of definite proportions, of which the above is a concise view, has been much blended with hypothetical notions; the first systematic view of this subject appears to have occurred to DALTON, and the facts on which it rests have been amply established by *Richter*, *Proust*, *Davy*, *Wollaston*, *Gay Lussac*, *Berzelius*, *Thompson*, and many others.

27. There are instances, which in the present state of the science are considered as instances of chymical combination, where bodies unite with each other in every assignable pro-

portion, and an indefinite ratio between them obtains; as in the union of some gasses with liquids, of water with spirit or with acids, and metals with each other; the elements of such combinations cannot be separated from each other by mechanical means (§23.e) nor is there an obvious difference of parts. There are numerous instances in which a body will unite to another in every proportion up to a certain point; but at this point, under a given temperature, the combination ceases; as in solution, when a solid unites with a liquid and the liquid form is retained; here the particles of the solid are uniformly diffused through the liquid in opposition to gravity; the liquid is called the *solvent or menstruum*, and has generally been considered as the active agent; the solid is dissolved, because the attraction between it and the menstruum is superior to the force of cohesion which unites its particles. When the liquid is not susceptible of dissolving any more of the solid, affinity and cohesion mutually balance each other, and the liquid is *saturated*, but a fluid saturated with one salt, is frequently capable of dissolving even an increased quantity of another. Heat generally, though not invariably, promotes solution; pulverization of the solid, and agitation of the solid and liquid together, by increasing and renewing the points of contact facilitate the process.

The philosophy of solution, and of the other instances of indefinite combination has not yet been satisfactorily elucidated; the points of difference between them and *cases of undoubted* chymical action are so apparent, that the subject obviously requires new experiments and investigation.

28. Some bodies have a stronger tendency to unite than others, and when several substances, capable of combining, are brought together, those only will unite which have the strongest affinity for each other; if 20 parts of magnesia be mixed with 28 parts of lime and introduced into 68 parts of nitric acid sp. gr. 1. 5, the lime alone will unite with the acid, and after the action has ceased the magnesia will be found untouched; if the compound between nitric acid and magnesia be acted upon by lime-water, it will be instantly decomposed, the lime unites with the acid in consequence of its superior attraction and displaces the magnesia; this is an example of single affinity or *single elective attraction*, where one body is capable of separating another from its combination with a third. The decomposition of many substances may be effected in a similar manner; in some instances where decomposition cannot be effected in this way it may be produced by *double affinity* or *complex affinity*; in this case two compounds mutually decompose each other, and two new compounds are the result; thus a solution of acetate of lead added to a solution of sulphate of zinc produces sulphate of lead and acetate of zinc. It may in general be inferred with great certainty that such decompositions will occur on mixture of two compounds, if one of the new compounds formed exists in the solid or æriform state; but the action of compounds on each other is peculiarly modified by tem-

perature, state of dilution, &c. Salts, which in solution mutually decompose each other, are called *incompatible salts.*

When two neutral compounds mutually decompose each other, the two new compounds produced, are also neutral; this is an inference from the doctrine of chymical equivalents, and appears to be amply supported by facts.

29. The affinities and chymical properties of compounds do not appear to be the modified affinities of their component parts; an opposite opinion, which has been supposed to afford a happy explanation of some peculiar cases of chymical action, has been maintained by BERTHOLLET; more recent investigations do not support the position.

30. Combination between bodies is much stronger in some proportions than in others. When the one proportion of one substance is combined with two or three proportions of another, the second and third proportions of the latter are separated with greater facility than the first; nitric acid by abstracting oxygene is easily converted into nitric oxide; this with more difficulty into nitrous oxide, and this still more forcibly resists decomposition.

When one proportion of a body is combined with two or more proportions of another, it resists chymical action more strongly than when combined with single proportion. (24. b.)

Hence it appears that one proportion of any substance is attracted with more force by two proportions of another body than by one proportion; and that a second or third &c. proportion is united to a given body with less force than the first proportion. These effects have been referred to the increase of the force of affinity by augmenting the relative quantity of matter.

31. M. BERTHOLLET has endeavoured to prove that decompositions are not the result of thestronger over the weaker affinity, but that they are always determined by some extraneous forces, and that elective attractions cannot strictly be said to exist. He supposed that the powers of bodies to combine or produce decomposition depend upon their relative affinities multiplied by their weight or quantity of matter, a product which he denominated the chymical mass; this view of the subject is evidently founded upon the assumption that affinity and gravitation depend upon the same power. According to this view, when two substances are in competition to combine with a third, each ought to obtain a proportion in the ratio of its affinity and quantity of matter, a conclusion not supported by facts; in the example before referred to (28) the lime combines with the acid to the *entire* exclusion of the magnesia. It follows also from this view of affinity, that in all cases the weaker affinity of any substance may be rendered effectual by increasing its quantity; but there is no reason from experiment to infer that any portion of magnesia however large would decompose nitrate of lime; or that any quantity of silver or of oxalic acid would decompose sulphate of lead.

32. Elasticity, cohesion and some other circumstances have been supposed to determine decompositions, rather than differences in the force of affinity; thus when potassa is added to sulphate of magnesia or to sulphate of ammonia, it combines with the acid, it is supposed, not because it has the strongest affinity for it, but because the magnesia has a strong tendency to become solid by cohesion, and the ammonia to assume the elastic form of gasses. But to explain chymical action by supposing the effects of forms of matter which are about to appear, seems no less absurd than to suppose that the properties of a substance can cause its formation. These extraneous forces cause the separation of a body after it is produced, but it does not appear how they can determine its production. Differences in the force of affinity are universally admitted to exist, and this alone seems adequate to explain the phenomena of decomposition. The facts presented in the definite combinations of bodies, and in every instance of chymical analysis are in direct opposition to the view of affinity presented by Berthollet.

(☞Davy's *Elements of Chym. Phil. Article VI. Divis. I.*☜) Murray's *System of Chymistry, Vol. I. Ed. IV.*—M'Neven *on Atomic Theory.* Ure's *Diction. Chym. Article Equivalent.*

OF ELECTRICITY,

And its connection with Chymical Phenomena.

33. When polished flint glass and a piece of dry and warm silk are briskly rubbed together, both will be found, on separation, when brought near to very light bodies, as pith balls, ashes, &c. first to attract and then to repel them; similar properties are exhibited by sealing wax rubbed by dry and warm flannel, or by paper rubbed by caoutchouc; sometimes, when these substances are possessed of their attracting and repelling powers, small sparks of light and distinct snapping sounds are manifested by them; these phenomena are *electrical*, and these bodies are said to be *electrically excited.*

34. An apparatus for exhibiting electrical effects is called an electrical machine; it may be advantageously constructed by mounting a cylinder of glass so as to be made to revolve between two parallel metallic cylinders, to one of which is attached a cushion of silk which presses against the glass cylinder, and to the other, a number of small points opposite to, but not touching the glass; the latter cylinder is called the *prime* or *positive conductor*, the former, to which the cushion is attached, the *negative conductor.* All the cylinders are supported on glass pillars. (Brande's *Manual. Amer. Edit. p.* 37.)

35. When two pith balls, suspended on filiaments of flax, are attached to either conductor, and the machine put in action, they will *repel* each other; but if one ball be connected with the *prime*, and the other with the *negative* conductor, they will *attract* each other when the machine is in action. When the two balls are on the same conductor, they receive the same electrical influence or state; on different conductors, a different electrical impulse; hence, *bodies similarly electrified repel each other, and dissimilarly electrified attract each other.*

If one pith ball be electrified by the glass tube, and another by the silk with which it has been rubbed, they *attract* each other; and so of two balls, one of which has received the impulse from the sealing wax and the other from the flannel; in all cases the *rubbing*, acquires a *different* electrical state from the *rubbed* body; but when a ball electrified by sealing wax rubbed with flannel, is brought near another, electrified by silk rubbed by glass, they repel; and so of two balls, one of which is electrified by glass and the other by the flannel; phenomena which prove that the eleciric state of the glass and flannel, and of the sealing wax and silk, are similar.

The term *electrical repulsion* denotes merely the appearance of the phenomenon; the separation being probably referable to the new attractive power which bodies acquire, when electrified, for the air and other surrounding bodies. (BRANDE.)

36 All substances under certain conditions are capable of exhibiting electrical phenomena; the substances in which they were first manifested were *vitreous* and *resinous* bodies, and hence the different electrical states have been called *vitreous* and *resinous;* a body under the influence of the one attracts a body under the influence of the other. All electrical phenomena have been explained on the supposition that electricity consists of *two* subtle fluids, the particles of each kind being highly idorepulsive, but attractive of the other; these two fluids, combined with each other, exist in all bodies, and their decomposition and reunion produce electric phenomena. FRANKLIN, however, noticed that the *resinous* electricity was sometimes exhibited by vireous bodies, and *vice versa*, and hence he regarded the phenomena as depending on the presence of *one* subtle fluid, which becomes in excess in vitreous bodies, and deficient in resinous bodies; thus when glass is rubbed by silk, the fluid leaves the silk and enters the glass; it is *condensed* in the latter and *rarefied* in the former; and to represent these two states, this illustrious philosopher used the terms *plus* and *minus*, or *positive* and *negative;* all bodies, on this hypothesis, are supposed to contain a portion of this fluid, and electrical phenomena depend on the disturbance and restoration of its equilibrium. (*See* HARE. *Silliman's Jour. Vol.* 7, *and* URE's *Dic'y. Art. Electricity.* BIOT *Traite de Physique, Tome ii.*) The states of positive and negative appear to be merely *relative.*

37. The phenomena of electricity and its influence in the operations of nature and art may be pursued independently of

any hypothetical ideas. "Some have asserted the existence of an electric fluid with as much confidence as they do the existence of *water*; and others have even attempted to shew that it is a fluid composed of several elements. It is impossible in sound philosophy to adopt such hasty generalizations, none of the facts which have been brought forward in favour of the actual existence of one or two fluids can be considered as conclusive." (DAVY.)

38. The kind of electricity exhibited by bodies does not depend on any power peculiar to and inherent in them, but on their mutual action on each other. The substances enumerated in this table are rendered positive when rubbed by those below them, and negative by those which precede them in the list.

Cat's skin,
Polished glass,
Woollen cloth,
Feathers,
Paper,
Silk,
Gumlac,
Rough glass. (BIOT.)

39. Instruments for ascertaining the presence and kind of electricity are called *electrometers*. Two delicate pith balls or two strips of gold leaf suspended by a brass cap and wire in a cylinder of glass, hang in contact when unelectrified, but when electrified they diverge; if their divergence is increased on the approach of flint glass rubbed by silk they are said to be *positively* or *vitreously* electrified; if their divergence is diminished, *negatively* or *resinously* electrified: hence the kind of electricity may be ascertained. The single leaf electrometer of Dr. HARE appears to be an instrument of great delicacy. (*Silliman's Journal, vol.* 7.)

40. Some substances when touched by an electrified body receive the influence instantly in every part, but other bodies only at the point of contact; the former are called *conductors*, the latter *non-conductors*; among the former are the metals, well burnt charcoal, plumbago; among the latter, glass, shellac, rosins, sulphur, silk. There are bodies whose conducting power is intermediate between the conductors and non-conductors, as alcohol, ether, acids, saline solutions, water, and other bodies; these are *imperfect conductors*. Non-conductors are also called *insulators*, and a conductor supported on a non-conductor is said to be *insulated*. The same body is sometimes a conductor, and at others a non-conductor: wax is a non-conductor,—when melted it becomes a conductor; the same is the fact respecting glass; the diamond is a non-conductor, but well burnt charcoal is a very good conductor.

41. The two electrical states are always coincident; when one part of a body or system of bodies is positive, another is invariably negative, and these two states are always equal and capable of neutralizing each other; the prime conductor of an

electrical machine is positively electrified, the opposite conductor negatively: connect the two by a wire or chain, and they exhibit no electrical signs.

42. (*a*) If an unelectrified and insulated conductor be brought near an electrified body, and a thin stratum of air, glass, or other non-conductor intervene between them, it exhibits electrical signs: that portion which is nearest to the electrified body assumes the opposite state of electricity; and the portion farthest removed, if it be near a conductor connected with the ground, exhibits the same electric state as the electrified body; and the middle portion is neutral. The conductor which exhibits these phenomena is said to be *electrified by induction* or *position.* Electricity by induction may thus be manifested in a long series of insulated conductors, provided the last be connected with the ground; and if an electric spark passes between the two last, sparks may be noticed at the same instant between all the others. Each of the conductors, under these circumstances presents two electrical poles, the one positive and the other negative; and exhibits a striking analogy to the opposite *poles* of a magnet. Strips of tin foil pasted on glass, with a small space between them, may be considered as insulated conductors, and they exhibit similar phenomena; they may be so arranged as to exhibit *luminous letters, flowers, &c.*

(*b*) The portion of an *uninsulated conductor*, which is brought near an electrified body, assumes the opposite electricity by *induction.*

(c) A thin plate of glass, or other non-conducting or imperfect conducting substance, placed in contact with and between two conductors, one of which is connected with the ground, and the other with an electrified body, becomes electrified. That surface, which is connected with the electrified body, assumes its electric state, the other gains the opposite state of electricity by *induction.* If the conducting bodies are removed, the two surfaces of the non-conducting body, to which they have been applied, exhibit opposite electricities.

43. On the principle of induction depend the phenomena of the electric spark, of accumulated electricity, and of lightning; and with the aid of the general principles respecting electric attractions and repulsions (35) it explains all the amusing and popular electrical experiments, as the electrical dance, electrical mills, electrical bells, &c. &c.

44. In the phenomenon of the common electrical spark, a thin stratum of air becomes electrified in the same manner as the glass plate (42.*c.*) When the hand of a person standing on the ground is presented near the positive conductor, the hand becomes negative by induction, and these states become exalted, until the opposite polarities neutralize each other; and the restoration of the electric equilibrium is accompanied with the electric spark.

45. The Leyden phial is a thin glass jar coated internally

and externally within about two inches of the top, with tin foil. When the inner surface is charged positively by connection with the conductor of an electrical machine, the outer surface, being connected with the ground, becomes *negative* by induction; and when the two surfaces are connected by a conductor, a powerful spark appears, and the electric equilibrium is restored. The *electrical discharger*, which is a metallic wire with balls at its extremities, jointed in the middle and fixed to a glass handle, is used to connect the opposite surfaces of a Leyden jar.

46. If a Leyden jar be charged to a certain degree, it will furnish a spark of *one inch* in length. Let it be again charged to the same degree, and connected with another jar of the same capacity, so that the inner coating of the second jar communicates with the inner coating of the first, and its outer coating with the outer coating of the first; now discharge both systems thus united, and the spark will be only *half an inch long;* the *quantity* of electricity is conceived to be the same in both cases, but its *intensity* only half as great in the latter as in the former instance. The length of the spark, and the indications of electrometers, are measures of the *intensity*, and not of the absolute degree or *quantity* of electric power.

47. A number of electrical jars, so arranged that they may be simultaneouly charged and discharged, forms an *electrical battery;* a similar instrument may be made of panes of glass and tin foil. (*Silliman's Jour. vol.* i.)

48. The only use of the coatings is to distribute the electric influence equally over the surface; they may be removed and the glass jar, or plate will remain charged. (42.*c.*)

49. If a number of electrical jars be insulated, and so arranged that the inside of the second may be connected with the outside of the first, the inside of the third with the outside of the second, and so on indefinitely, the inside of the *first* being connected with the conductor of the machine, and the outside of the last with the ground, they will all be found electrically charged, when the machine is put in action; they exhibit an arrangement similar to the series of insulated conductors, (41.*a.*) and the outside of the first charges the inside of the second, &c.

50. Large surfaces become electric by induction much more slowly than small ones; and the discharge from them is violent in consequence of the great accumulation of electricity. The fine *point* of a conductor becomes electric by induction instantly, and to a great *intensity*, and an immediate and silent annihilation of the polarities commences, and continues until the electric equilibrium is restored; the *quantity* of electricity on a point must be indefinitely small; its *intensity* is very great, and hence the utility of *pointed* conductors on buildings, the invention of FRANKLIN founded on his own magnificent discovery of the indentity of lightning and electricity; and hence, too, the importance of having the parts of electrical apparatus of rounded forms and destitute of any asperities. A brush of light ap-

pears to proceed from a point held near a *negative* conductor; but a bright *star* appears fixed on it when near a *positive* conductor.

51. Clouds are more or less electrical; the earth over which they float is brought into the opposite state of electricity by induction; and the discharge which takes place when the clouds approach within a certain distance, constitutes *lightning*; the vibrations of the air, produced by the discharge, are the cause of *thunder.*

52. The appearance of the electric spark or light depends principally on the properties of the ponderable matter through which it passes, as on the air or vapours, &c. In dense air the light is bright and vivid: in highly rarefied air no spark is seen, but only a diffused light whose colour, &c. is much influenced by temperature. In the most perfect mercurial vacuum that Davy could produce, a dense and green electric light appeared when the apparatus was hot, but became less vivid as it was cooled, and at —20 was not perceptible except in a very dark place; the phenomena in a vacuum above melted tin were, nearly the same. (*Phil. Trans.* 1822.) The restoration of the electric equilibrium appears to be accompanied with an elevation of temperature; by placing ether and spirits of wine or powdered rosin in the circuit, they may be inflamed; and when the metals are made to transmit relatively large *quantities* of electricity, they are fused.

53. The action of the Electrophorus, and of electrical condensers, depends on the principle of induction. The electrophorus consists of two parts, of a resinous plate half an inch in thickness, covered on the under surface with tin foil, and having its upper surface smooth and polished; and of a polished metallic disc, of less diameter than the resinous plate, and to the centre of which is attached a glass handle. When the resinous plate is rubbed with dry and warm fur, it becomes negatively electric, and the metallic disc, being placed upon it by its glass handle, and then removed, exhibits weak electric powers; replace it, and touch it with the finger, and a small spark will be noticed between the finger and the disc; and on again raising the disc by its handle, it will be found positively electrified, and will give a spark of one or two inches in length. Under favourable circumstances this process may be often repeated without fresh excitation. The metallic disc touches the resinous plate only on a few minute points, from which, on its *first* application, it receives a small electric influence. When applied a second time, it rests on these small non-conducting resinous points, and very near to the plate, and exhibits phenomena similar to those of an insulated conductor near an electrified body. The under surface of the disc becomes positive by induction, and its upper surface becomes negative. This polarity of the plate is destroyed by contact of the finger; and the whole exhibits positive electricity on removal from the resin.

54. The *condenser* consists of two metallic discs three or four inches in diameter ; the one fixed and insulated, the other moveable and not insulated. They are placed parallel and opposite, and so near each other, as to be affected by induction. When the insulated disc is connected with a gold leaf electrometer, and so slight a degree of electricity communicated to it, that the leaves will just perceptibly diverge, the divergence becomes very much increased on sudden removal of the uninsulated plate ; very small portions of electricity may thus be made manifest. (See 39.)

55. There are many other sources of electricity besides those already mentioned. Electrical changes often accompany changes of form; as when water is vaporized, or is frozen; when melted sulphur or resin become solid. And a disturbance of electric equilibrium is produced by disruption of parts, by pressure, by changes of temperature, and by contact of different bodies.

56. When two insulated metallic discs, one of zinc and the other of copper, are brought into contact, the former after separation is found to be positively, and the latter negatively electrified. Any two dissimilar metals under similar circumstances produce similar effects; the metal most easily oxidizable being uniformly in relation of *positive.*

57. When a wire of silver is made to touch the nerve of a recently killed frog, and a wire of zinc to touch the muscular parts, the limb will experience violent convulsions, from the disturbance of the electric equilibrium produced by bringing the two wires in contact; and when a piece of zinc is placed over the tongue, and a piece of silver under it, a peculiar sensation of taste will be perceived when the two metals are made to touch each other: these experiments have been called *Galvanic experiments.*

58. When zinc is placed in water, it is slowly corroded; but if a piece of silver be placed in contact with it under the surface of the fluid, the corrosion is more rapid. If a few drops of oil of vitriol be now added to the water, bubbles of air will be formed on both metals; but if the zinc be withdrawn, the production of bubbles ceases. It is abundantly established, that contact of dissimilar substances produces electrical changes, and that these changes may be accompanied by chymical effects.

59. The apparatus, by which the connection between electrical powers and chymical attraction is best exhibited, is the Voltaic apparatus ; the magnificent invention of VOLTA, who discovered the method of increasing the electrical effects of two metals, by alternations of different metals and a fluid.

When plates of zinc and copper, six or eight inches square, and pieces of cloth soaked in brine, are arranged in the order of copper, zinc, moistened cloth, copper, zinc, moistened cloth, and so on, till a series of two or three hundred are raised, they form a *Voltaic pile.* Let this pile be insulated; and on applying one hand at the bottom and the other at the top of the column, both hands being previously moistened with water, a smart electric shock will be perceived. When the two ends of the pile are connected by a wire having a piece of well burnt charcoal at its extremity, a *spark* will be seen. A delicate electrometer, connected with the *zinc* extremity of this pile, is affected with positive electricity; one with the copper end, with negative electricity; and one connected with the middle of the pile, is not affected at all. When small wires or thin leaves of metal are made to connect the two ends of the pile, they are fused or burnt. These phenomena are analogous to those produced by the electrical machine and apparatus.

60. The chymical powers of the Voltaic instrument are of more recent discovery than its electrical effect. When two platinium wires connected with the two extremities of the pile are plunged into a vessel of water, oxygene gas is evolved at the positive, and hydrogene gas at the negative wire. The same wires, introduced into sulphuric or phosphoric acid or into metallic solutions, will cause a separation of the inflammable matter or metal at the negative pole, and of oxygene at the positive. When a solution of any salt composed of acid and alkali is exposed to the action of these wires, the acid collects round the *positive* and the alkali round the *negative* wire. If the solution of the neutral salt be placed in two cups, and the fluid in them be connected with filiaments of moistened cotton or asbestos, the wire from the negative pole be plunged into one cup and that from the positive pole into the other, the salt will suffer decomposition, and the acid and alkali will pass by each other, and each be found at its respective pole. If there be three cups, one containing water and in contact with the negative pole, the second containing weak nitric acid, and the third a solution of glauber salts and connected with the positive pole, after a certain time, if the liquids be connected with moistened cotton, the alkali will be found to have been transferred through the acid and eliminated at the *negative* pole. These experiments demonstrate the power of the apparatus over chymical action; the most solid aggregates and firmest compounds cannot resist its operation. With feeble electric powers, compounds are separated into their proximate elements; and with stronger powers, into their ultimate elements.

A wire of platinum, or of any other metal which connects the two extremities of the pile, acquires magnetic properties so as to attract or repel the magnetic needle. A delicate magnetic needle is the most sensible electroscope yet discovered.

61. There are several modifications of the Voltaic apparatus; some to render it a more convenient instrument than the pile, and others to exhibit more distinctly some of its peculiar properties: and different forms of it are employed according as it becomes desirable to exhibit its simple electric properties, or its powers of ignition and fusion, or its chymical agencies, or its magnetic relations.

The form of the apparatus, proposed by Mr. **Cruickshanks**, is the *Voltaic* or *Galvanic trough*, and combines many advantages; it is made by soldering plates of zinc and copper together so as to form double plates, which are cemented into wooden troughs, leaving cells, between each pair of double plates, which are to be filled with fluids. If the fluid consist of diluted acids, the zinc end of the trough will be in the relation of positive, the copper end negative. An apparatus of this form, consisting of two hundred double plates six inches square, the cells being filled with a fluid consisting of one part each of nitric and sulphuric acids, diluted with sixty parts of water, is capable of exhibiting in a satisfactory manner the fusing, igniting, chymical and magnetic powers of the instrument.

62. If a piece of charcoal connected with the negative end of a battery of 1000 six inch double plates, be made to touch another piece connected with the positive end, a vivid light is produced; and if the charcoal points be drawn some inches apart, a brilliant arch of intense light appears between them, in which platinum fuses like wax in common flames; sapphire and quartz are melted, and the diamond and charcoal disappear and seem to evaporate.

63. The new Galvanic instruments, the *Calorimotor* and *Galvanic Deflagrator*, invented by our countryman, Hare, exhibit in the most decided manner the calorific powers of the Voltaic arrangement. In these instruments the plates of copper and zinc can be suddenly and simultaneously immersed in the liquid, which is contained in troughs, in which there are no partitions or cells. Very slight *electric* powers are evinced by these instruments; but in the hands of their inventor, and of Prof. Silliman, they have produced brilliant and unexpected results. (*Silliman's Journal*, *Vols.* 1, 3, 5, 6.)

64. The apparatus, consisting of two large plates of copper and zinc disposed in the form of a coil, constructed by Mr. Pepys, is evidently the form of the *Calorimotor* originally proposed by Prof. Hare, and some instruments of that form were made in Philadelphia. Its electric power is very feeble. A wire which is made to connect the plates becomes heated and powerfully magnetic; and hence it has been called the *magnetomotor;* the magnetic properties of the calorimotor appear to have been first noticed by Mr. G. T. Bowen. (*Silliman's Journal*, *Vol.* 5.)

65. A Voltaic apparatus, formed by combinations of dry and solid materials, without the intervention of any liquid, was constructed by De Luc. It consists of thin plates of zinc, silver-leaf and paper, arranged in the order in which they have been named, in a tube of glass, at each end of which is a metallic cap closely in contact with the plates. One end of this instrument exhibits the positive, and the other the negative electricity. Mr. Singer, with a series of 20,000 of these plates, 5-8 inches in diameter, charged a Leyden jar, which afforded a

spark, and a shock, and fused wire. As yet *no chymical* effects have been produced by this arrangement. (*Gorham's Chymistry—Edin. Encyclo. Article Electricity.*)

66. The fusion of metals by the intense heat excited when they transmit large quantities of electricity, is a limit to their conducting power; and the intensity of heat excited is influenced by the cooling powers of the medium in which the metal is placed. A platinum wire in water, is less heated by the transmission of a certain quantity of electricity than in air, and less heated in air than in a vacuum; but independently of fusion there appears to be a limit to their conducting power, and different metals appear to possess this property in very different degrees. When they are kept cool by immersion in water, their relative powers of conducting Voltaic electricity may thus be expressed:

Silver - - - -	100
Lead and copper - -	86+
Tin - - - -	18.5
Platinum - - -	16
Iron - - - -	13.8.

That "the conducting power of metallic bodies varies with the temperature, and is *lower* in some inverse ratio as the temperature is higher," is established by the researches of Davy. An experiment, which may be called the *Voltaic paradox*, is explained on this principle. If a fine platinum wire be heated red hot in the Voltaic circuit, and the flame of a spirit lamp be applied to any part of it so as to heat that part to *whiteness*, the rest of the wire becomes cool and ceases to be red, in consequence of the *diminished* conducting power of the white hot portion; but if a piece of ice be applied to any part of the red hot wire, the remaining portions become heated to *intense whiteness*, in consequence of the improved conducting power of the cool portion, by which a larger quantity of electricity can be transmitted. It has been assumed that the heat excited by the passage of electricity through metals was inversely proportionate to their conducting power; but "the excitation of heat occasions the imperfection of conducting power; and till the causes of heat and electricity are known, and of that peculiar constitution of matter, which excites the one and transmits and propagates the other, our reasoning on this subject must be inconclusive." (Davy. *Phil. Trans.* 1821.)

67. The intensity of electric power in the Voltaic instrument appears to bear some proportion to the *number* of the plates; and it has been supposed that its heating and igniting powers depended on their *size;* an opinion which does not seem to be supported by experiments with the Defflagrator. The apparatus constructed by Mr. Children consisting of twenty pairs of plates, each 6 feet by 2 feet 8 inches, appears to be less powerful than this instrument; it however forms a perfect contrast to the *elementary battery of* Wollaston which consisted of only

two plates, one of which was a silver thimble, from which the top was removed and its sides flattened till they were 2-10 inch asunder: a thin leaf of zinc was then cemented into this space, and the two plates connected with fine platinum wire $\frac{1}{3000}$ inch in diameter. When this apparatus was immersed in sulphuric acid, the wire was *ignited* and *fused.* In this little instrument the zinc was opposed on all sides by the silver, and Dr. Wollaston suggested an important improvement in the Voltaic instrument, which consists in the extension of each copper plate so to oppose it to both surfaces of each zinc plate. The *quantity* of electricity is supposed to be much increased by this arrangement, and its advantages have been fully developed in the American instruments.

68. A Leyden jar or battery, having its outer surface connected with either extremity of a Voltaic pile, is instantly charged to the full intensity of the apparatus, by a momentary contact of its inner surface, with a wire connected with the opposite extremity of the pile, and is capable of affording a spark and of communicating a shock, &c.

69. Dr. Wollaston in an ingenious series of experiments proved that the common electrical machine was capable of producing chymical phenomena, similar to those produced by Voltaic arrangements; and the difference in their effects is supposed to depend principally on the difference of quantity and intensity of the electricity afforded by the two. The *quantity* of electricity from Galvanic arrangements is probably very great, while its intensity is so small that the dry cuticle acts as a non-conductor, and the spark from very large batteries is only 1-30 or 1-50 inch in length.

70. The intimate connection which subsists between electricity and the chymical powers of matter, and the manner in which the latter are modified or destroyed by the former, is the foundation of the Electro-Chymical Theory of Davy.

"*Suppose two substances whose particles are in different states of electricity, and that these states are so exalted as to give them an attractive force superior to the force of cohesion, a combination would be formed, which would be more or less intense, according as the energies are more or less perfectly balanced; and the change of properties would be correspondingly proportional.*" (*Phil. Trans.* 1807.)

When we bring two bodies, capable of combining, into the same electric state, they refuse to combine; and if we bring two bodies, which ordinarily do not act chymically on each other, into different electrical states, that action is induced. The decomposition of water and of other compounds has already been referred to; on the separation of their elements from each other, the one passes to the positive, and the other to the negative pole of the battery. Generally the metals, inflammable bodies, alkalies, earths, and oxides pass to the *negative* pole, and oxygene, chlorine, iodine, and the acids to the *positive* pole. Hence it would appear, since bodies similarly electrified repel, and dissimilarly electrified attract each other, that those substances which pass to the negative pole are naturally in a state of positive electricity, and that those which pass to the positive pole are naturally negative. The former have been called *electro-positive* and the latter *electro-negative.* It must be remembered that these states are *relative,* and a substance which, on its separation from one body, passes to the positive, may, on its separation from an other, pass to the negative surface.

71. Those bodies which in masses act most powerfully on each other *electrically,* are those which *combine* with the greatest facility, when their particles have freedom of motion. DAVY found that metals and solid bases, by mechanical contact of solid acids, became *positive,* and the acids *negative;* and by analogy he extended this fact to all cases of bases acting on acids. This opinion has been amply confirmed by M. BEQUEREL in some experiments made with electroscopes of new construction. He found a remarkable difference between the electrical effects produced by *mechanical contact* and by *chymical action.* The metals by mechanical contact of acids become positive, the acids negative; and by contact with alkalies the metals become negative, the alkalies positive. But when chymical action occurs, the metals and bases become *negative,* and acids *positive;* oxides comport themselves like acids. This difference between the electric effects of mechanical and chymical action affords the means of ascertaining whether two solutions, when put together, form a mixture or a combination: if the former, each solution will exhibit the *same* electricity that the solid, from which it is formed, presents; but if the latter, the opposite states of electricity will be induced: thus citric acid and muriate of ammonia, and citric acid and common salt, exhibit their peculiar electricities both in the solid and liquid state, and exhibit new proofs of the difference between mechanical mixture and chymical combination. (25) (BRANDE's *Journal, No.* 34.) The heat and light which often accompany both chymical and electrical action, probably result in both cases from neutralization of electrical states.

72. Of the Electro-chymical Theory "it is difficult to speak in the cold language of philosophy." It hardly admits of a doubt that electrical attractions and repulsions and chymical attractions depend on "the same power acting in one case on the masses, and in the other on the particles."

Important practical applications in the arts have been founded on this theory: as in the preservation of the copper on ships, &c. &c., and it affords a satisfactory solution of numerous phenomena which were before inexplicable.

73. Some bodies of the imperfect conductor class seem capable, under *certain* circumstances, of conducting only one kind of electricity. Thus, if flame of phosphorus, or if perfectly dry soap be connected with *both* ends of the Voltaic battery and with the ground, the electricity of the *negative* pole only is dis-

charged. The flames of hydrogene, wax, camphor, &c. under similar circumstances discharge only the positive electricity. All these bodies, when connected with *one* pole of the battery, only discharge its electricity; a circumstance probably depending in part on induction. These facts were first noticed by Mr. Erhman; and substances which exhibit these peculiariies he calls *unipolar bodies:* they are incapable of being active in any part of the pile. Mr. Brande has shown, by some very ingenious and satisfactory experiments, that the phenomena presented by different flames harmonize with the Electro-chymical Theory. The flames of camphor, &c. are attracted to the negative pole; and consisting of much inflammable matter and being naturally positive, will, as new portions successively come in contact with the negative pole, tend to neutralize its electricity, and not to conduct it; and for a similar reason, the flame of phosphorus, which consists of ignited acid matter, being naturally negative, will be attracted to, and neutralize the electricity of the positive pole.

74. Some animals are endued with the power of communicating at will a powerful electric shock, as the torpedo and electrical eel. The apparatus by which this is effected is analogous to some forms of the Voltaic instrument, and is abundantly supplied with nerves. The very frequent use of it produces the debility and death of the fish. The contact of tendons and nerves of a recently killed frog will produce contraction of the muscular parts; and it has been suggested that secretion and other recondite phenomena of the living system may be dependent on electrical agencies; an idea, which has derived probability from the experiments of several accomplished chymists and eminent physiologists.

75. There is no plausible hypothesis of the action of the Voltaic instrument. The electric equilibrium is disturbed by contact; the accumulation of power at the poles *may* depend on induction, and the continued action of the instrument on the chymical changes of the fluid which fills the cells.

☞ *Davy's Elements, Art. Electricity. Haüy's Nat. Phil.—Singer's Eelectricity. Donovan's essay on Galvanism. Hare and Silliman in the American Journal of Science, &c.*

76. M. Seebeck discovered that an electrical current may be produced, in a circuit composed of different metals, by disturbing the equilibrium of temperature. Take a bar of antimony 8 or 10 inches long, and half an inch in diameter; connect its ends by twisting a brass or copper wire round them so as to form a loop, and let there be several coils of the wire at each end. If the flame of a spirit lamp be applied to heat one end, every part of the wire affects the magnetic needle. The electric current seems to pass from the cold to the heated end of the wire. Currents so produced have been called *Thermo-electric*, to distinguish them from the voltaic current, which may be called *Hydro-electric.*

The following is a list of some *Thermo-electrics* by Prof. Cumming; they being used two together, each body is in the relation of positive to those which follow, and of negative to those which precede. *Bismuth*, *Mercury*, *Platinum*, *Silver*, *Tin*, *Lead*, *Brass*, *Copper*, *Gold*, *Zinc*, *Iron*, *Antimony*.

77. The experiments which have hitherto been made on this new subject appear to justify the conclusions, that the intensity of force in thermo-electric combinations, as in the Voltaic circuit, increases with the number of alternations of metals; that the deviations of the needle of the electroscope augment with the number of thermo-electric elements in a given circuit, but become less apparent in proportion as the length of each element increases; and hence, in complex circuits, very short elements must be employed to produce decided effects; that the quantity of electricity in thermo-electric circuits is much greater, and the *intensity* much less, than in hydro-electric combinations. The thermo-electric combinations, which produce effects of great magnitude on the needle, produce no sensible chymical action, or ignition: they affect the limbs of a frog, as do metals slightly dissimilar, but they do not produce taste as do simple hydro-electric combinations. (*Fourier and Œrsted. Brande's Journal, No.* 31.)

OF ELECTRO-MAGNETISM.

78. There is a mineral substance, called the loadstone, which possesses the property of attracting iron filings, and these adhere to different parts of it in greater or less quantities: they are particularly accumulated at two opposite points, and stand, as it were, on end. The mineral, an ore of iron, which possesses this property, is said to be magnetic, and its properties to depend on magnetism. The points around which the iron filings are accumulated, are called *magnetic poles*. We are entirely ignorant of the nature of magnetism. The phenomena presented by magnetized bodies have been explained on the supposed existence of a magnetic fluid or fluids.

79. The magnetic influence may be communicated by the loadstone to some metallic bodies, particularly to iron and steel, and it is exerted through water, glass, metals, flame, &c. &c. A steel bar, which has been rendered magnetic by the loadstone, or by other methods, is called a *magnet;* and if it be suspended by a filament of silk, so as to move easily in a horizontal plane, it does not turn indifferently to every part of space, but takes a direction nearly north and south. A small magnetized steel bar, delicately mounted on a central pivot, is called a *magnetic needle*. In some places, the north end of the needle deviates from the true meridian towards the east, and in other places to-

wards the west, and sometimes to a very great degree ; this deviation is called the *declination* of the *magnetic needle*, or *variation.*

The vertical plane in which the needle directs itself is called the *magnetic meridian.*

80. If the north extremity of one needle be presented to the north extremity of another, it repels it; but if to the south extremity, it attracts it; and the south extremity of one needle repels the south, but attracts the north extremity of another. Hence the two polar extremities of a magnet or needle are dissimilar; the one attracts what the other repels, and *vice versa.*

81. When a magnet or loadstone is brought near a magnetic needle, the two poles act at once on it ; but the pole which is nearest acts most powerfully, and the needle turns towards the magnet that pole which is most strongly attracted, and averts the one which is repelled. After the needle has taken a position of equilibrium, if we turn it ever so little from its place, it returns to it again, by a series of oscillations, in the same manner as a pendulum, pushed from the perpendicular line, returns to it again by the attraction of gravitation. A similar motion takes place in a magnetic needle turned ever so little from its magnetic meridian, so that the earth acts on a magnetic needle like a true magnet or loadstone; and the magnetism residing in the southern hemisphere is called *austral magnetism*, and that in the northern hemisphere *boreal magnetism.* Hence, as dissimilar magnetisms attract each other, we must suppose that the extremity of the needle which points to the north is charged with *austral magnetism*, and the opposite pole with *boreal magnetism.*

82. Take a steel bar and suspend it delicately by an axis in the middle between the two ends, so that it may move easily, but in a vertical plane only; if the bar be now carefully magnetized, it will not in this latitude remain any longer in a horizontal position; but the end which possesses the *austral* magnetism will decline downwards, and after a few oscillations will rest at a determinate angle with the horizon: this angle is called *the dip of the needle*, and is very different in different places; the apparatus by which it is ascertained is called the *dipping needle*, in which the needle probably points to the magnetic pole of the earth. Near the equator is a zone where there is no dip; to the north of this zone, the extremity of the needle charged with the *austral* magnetism declines from the horizontal; and to the south of this zone the opposite extremity declines. The poles of the earth and of a magnet can be considered only as *centres of action.*

83. A piece of soft iron held near a magnet becomes itself a temporary magnet: this phenomenon is analogous to electrical excitement by induction; and that part of the iron which is nearest the magnet assumes the opposite magnetic state.

Take a little bar of soft iron and attach one end of it to a magnet, it immediately acquires all the magnetic properties; and to its opposite end another little bar will adhere, which in in its turn becomes magnetic and capable of supporting a third bar. Other bars may be attached till their total weight exceeds that which the magnet is capable of sustaining. As soon as the first bar detaches itself, the others all separate and fall: and if we try to unite them, they will be found incapable of supporting each other, although they retain some feeble remains of magnetism. It is not necessary that the first bar should be in contact with the magnet; it may be kept at a distance by the intervention of paper, or glass; but then the total weight this supported at a distance will be less than in contact. If bars of steel be employed instead of soft iron, their adherence to each other is less readily effected; but it is more durable, and they retain more perfectly the magnetic states they have acquired by being in contact with each other and with the magnet.

84. A soft unmagnetized bar of iron three or four feet long held in the direction of the dipping needle becomes a temporary magnet by the action of the earth's magnetism. Its lower extremity acquires an austral, and its upper a boreal magnetism. The latter will repel the south end and attract the north extremity of a needle; and the former presents the reverse phenomena. That these effects are due to the sudden developement of magnetism by position, is readily shown by reversing the ends of the bar, for they instantly assume the reverse magnetic states.

85. The same loadstone or magnet may successively render magnetic any number of bars without losing any of its own power: it seems only to develope a hidden principle. In the same manner an electrified body loses nothing of its electricity in exciting electricity by induction.

86. If a wire of platinum or silver be placed horizontally in the direction of the magnetic meridian, and a delicately suspended magnetic needle be placed under it, no effect is noticed; but if the wire be made to connect the two extremities of a powerful Voltaic battery, the needle instantly declines from its position: one end goes to the west, the other to the east, the north end being slightly elevated, the south a little depressed. The position of the needle depends on the direction of the supposed electrical current through the conjunctive wire.

87. The pole of the needle, *over* which the positive electricity enters, declines to the *east;* but the pole, *under* which it enters, declines to the *west*; the degree of declination thus experienced by the needle depends on its sensibility and on the power of the battery; its maximum is 90°.

If the needle be placed near and parallel to the conjunctive wire, and in the same horizontal plane, it does not decline; but if it be on the east side, the pole near the positive influence dips; but if on the *west* side, it rises.

If the conjunctive wire be placed east and west, and the supposed electric current pass from east to west, the pole of the needle, which is brought very near to it, *dips*.

If the conjuctive wire be placed vertically, and the electric current be supposed to pass *downward*, the pole of the needle which is presented to us declines to the *west;* but if the wire be placed opposite a point between the extremity and the middle of the needle, it declines to the *east*.

In all the above experiments the phenomena are reversed if the direction of the supposed electrical current is reversed. These curious phenomena were discovered by ŒRSTED.

88. It has been shown by DAVY that a wire transmitting common electricity affects the needle in the same manner as the conjunctive wire, and that both are capable of attracting iron filings; and that a steel bar may be rendered strongly and permanently magnetic by being placed transversely near a wire which transmits an electric charge. Indeed, he found that the transmitting wire, the air and surrounding space became magnetic, and that steel bars, made sines or tangents of circles round the wire, become magnets. (*Edinburg Journal*, 4, 173.) Wires of all the metals which have been subjected to experiment become magnetic, while transmitting the electric current; the *best conductors* become most powerfully so; thus two inches of silver wire 1-30 inch diameter, when transmitting the influence of a powerful battery took up 32 grs. iron filings; a similar wire of copper, 24 grs.; of platinum, 11 grs.; and of iron only 8 2-20 grs.

89. The influence of electricity on the needle, or in forming magnets, may be transmitted through non-conductors. Thus a steel needle, inclosed in a glass tube, about which is a wire, wound spirally, becomes a permanent magnet on transmitting an electric charge through the spiral. The polar states acquired by the needle depend on the direction of the spiral and of the supposed electric current.

90. M. AMPERE has found that two wires, transmitting the electric current in the same direction, attract each other; but if in opposite directions they repel each other; so that two wires similarly *electro-magnetic* attract each other, and dissimilarly *electro-magnetic* repel each other; this is the reverse of ordinary electric attractions and repulsions. (See 35.)

91. The phenomena presented by the conjunctive wire may be explained on the supposition that *a current or vortex of magnetism is put in motion round its axis; the direction of it depending on that of the supposed electrical current, and hence no fixed poles are exhibited by the wire.* WOLLASTON. It is the property of circular action, to produce motions in directions precisely contrary at the two extremities of the same diameter. Dr. WOLLASTON, from this view of electro-magnetic state of the conjunctive wire, supposed that a pole of magnet presented to it would cause it to attempt to revolve on its axis. The ex-

periments of **Faraday** amply demonstrate that a wire properly suspended and transmitting electricity, will *revolve* round the pole of a magnet, and that a magnet may be made to revolve round the wire; the directions of these motions depending on that of the electric current, and on the pole of the magnet; he found also, that motions are produced in a horizontal conjunctive wire by the action of the terrestial magnetism, and that these motions are in planes perpendicular to the dipping needle; that is, the wire has a tendency to revolve or describe a cylinder round the magnetic pole of the earth, the radius of which cylinder is the line of the dip prolonged to the magnetic pole; and he found also, that a wire transmitting the electric current may be made to revolve round the line of the dip, by the action of terrestial magnetism in the same manner as round the pole of a magnet which points to the south. The same cause which produces these motions determines a wire ring, turning on a vertical axis, to move into a plane east and west of the magnetic meridian; or if it turns on an east and west horizontal axis, to move into a plane perpendicular to the dipping needle. A variety of instructive experiments show the connexion between electricity and magnetism. Thermo-electrical combinations have been made to revolve round the poles of magnets, by Professor **Cumming**.

92. The *electro-magnetic-multiplicator* which is an electroscope, is founded upon the effect produced by the conjunctive wire on the needle. In this apparatus the conjunctive wire makes several convolutions longitudinally round the needle; the upper part of the wire and the lower part are traversed by the electric current in opposite directions, and the effects produced by the upper and lower horizontal portions of it are thus added together; the pole, over which the positive electricity enters, passing to the east, the pole, under which it enters, to the west—(90.) (*Barlow on Magnetic Attractions—Faraday and others in Brande's Journal.*)

OF CALORIC.

93. **Caloric**, the agent which produces the phenomena of heat, is generally considered to be material; its presence produces the sensation of heat; its absence, that of cold. It exists in two states, viz. that of free caloric, and that of combined caloric; it is regarded as a fluid of extreme tenuity, moving when free, under the form of rays like light, invisible, highly elastic, imponderable, tending to an equilibrium, penetrating all bodies, dilating and expanding them, reducing solids to liquids, liquids to vapors or airs, decomposing compounds, and uniting with different bodies in different proportions to produce the same elevation of temperature.

94. Temperature is the state of a body, in relation to its power of communicating or receiving caloric; if a body communicates heat to another, it is said to be of a higher temperature; if it receives caloric from another, of a lower temperature. The temperature of any body depends on the quantity of caloric it contains. If this quantity be increased, the temperature rises; if it be diminished, the temperature falls.

95. Our own sensations, being influenced by the state of the sentient organ, and by the *kind* of matter which is applied to it, give us very limited knowledge of the properties and habitudes of caloric in different bodies, or in different forms of the same body. Hence instruments have been constructed to measure temperature. Their operation depends on the expansion, which caloric produces in bodies. With one or two exceptions, all bodies increase in bulk by increase of temperature, and diminish in volume by diminution of heat. The *Thermometer* and *Pyrometer* are constructed on this principle. Plunge the bulb of a thermometer into boiling water; the fluid contained expands and rises in the tube; dip it into cold water, and the fluid sinks; place it in its original situation, and the fluid soon regains its original dimensions. It is evident that it is the *excess* of the expansion or contraction of one body over that of another, which indicates temperature. This excess is measured by a scale of equal parts, called *degrees.*[*] The thermometer is employed for measuring temperatures which are not very elevated; the pyrometer for measuring intense degrees of heat.

96. When a number of bodies, of unequal temperature, are brought near each other, they eventually acquire a common temperature, whether they are in contact with each other or not. This arises from the tendency of caloric to assume an equilibrium of tension or elasticity, and is supposed to be produced by the ideo-repulsive power of its particles. Caloric emanates from bodies in a vaccuum, through gases or airs in direct lines or rays, and a body is thus cooled without the agency of the surrounding medium; but the surrounding medium *has* an importaut influence on the celerity with which bodies are cooled or heated: so that caloric is distributed in two modes; the one, by *radiation*, and the other by the actual contact of other matter, or by *slow communication.*

97. If two polished concave metallic mirrors be placed opposite and parallel to each other, and six or eight feet distant, a delicate thermometer placed in the focus of one, will instantly indicate an elevation of temperature when a hot body is placed in the focus of the other. The mirrors themselves suffer but a small elevation of temperature in a long time. This

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[*] The divisions on the scale are arbitrary; Farenheit's scale is generally employed in this country; on this the freezing point of water is marked 32°, and the boiling point of water at 212°, the distance between these points is divided into 180 equal parts.

fact admits of explanation only by supposing that the rays of caloric which fall upon one mirror are reflected by it to the other, and by this are converged to the focus in which the thermometer is placed. If the thermometer be withdrawn from the focus, its temperature falls.

98. A heated body in the air, becomes the centre from which a multitude of rays of caloric emanate in all directions. They pass with a velocity which has not yet been measured, and do not heat the transparent and elastic media, like air, through which they pass. It is highly probable that all bodies, at all temperatures, when surrounded by air, radiate caloric. If they radiate more than they receive, their temperature falls; if they receive more than they radiate, their temperature rises. Radiation goes on better in vaccuo than in air.

99. When radiant caloric impinges against a body, part is absorbed and part reflected. The absorbing and reflecting powers of bodies are in an inverse ratio to each other; but the absorbing and radiating powers are in a direct ratio. Non-metallic unpolished bodies have the greatest radiating and absorbing powers. And generally *dark* colored bodies, as presenting the *greatest surface*, have the greatest radiating power.

100. Radiant caloric exists in the solar ray; but there appear to be some differences between this and radiant caloric from terrestial bodies. Though it seems that the higher the temperature of the heated body, the nearer does the caloric it radiates, approach in its properties to the solar heat. (De la Roche—Brande.)

101. During night, the earth's surface radiates heat, and receives none in return either by reflection or radiation from other bodies. Hence its temperature falls; hence dew is deposited, or frost appears; hence a thermometer placed on the ground often indicates a temperature 8 or 10 or 14 degrees colder than the air. (Wells *on Dew.*) Stoves, steam pipes for warming apartments, coolers and boilers, and all apparatus for radiating or receiving caloric rapidly, it is evident, should be *black;* and vessels for retaining heat, should be of polished metal.

102. When a body is partially exposed to the fire, not only that part, which is presented to its immediate action, is heated; but the caloric is communicated through it to a greater or less distance. This communication of caloric through bodies is supposed to depend in part on the attraction of the body for caloric; and in part on the ideo-repulsive power of the particles of caloric; but the effect is immediately dependent on an inequality of temperature. Those bodies, which possess the power of easily conducting caloric through them, are called *good* conductors; those, which possess this power in an imperfect degree, are called *bad, or non-conductors.* Dense bodies are generally good conductors; and light porous spongy bodies, imperfect conductors. The same substance, in different

states of aggregation, has different conducting powers; as iron and iron filings. The action of the safety lamp depends on the conducting power of metals. (*See Combustion and Flame.*)

Count **Rumford** ascertained, in his experiments on the conducting powers of substances used as clothing, that the imperfect conducting power does not depend on the quantity of the material employed, but upon the presence of *air* in the interstices of the fabric; the more dense and close the texture of the same materials, the less air they contained, and the better their conducting power.

Liquids are so inferior as conductors of caloric, that the opinion has been entertained that they were absolute non-conductors. Gases, if they are conductors, possess that property in a very inferior degree; but it is difficult to ascertain whether they are conductors or not. **Davy** found that the same thermometer raised to the same temperature and exposed to an equal volume of different gases required, to cool from 160° to 106° F. in

	Minutes.	Seconds.
Atmospheric air	2	0
Hydrogene gas	0	45
Olefiant gas	1	15
Oxygene	1	47
Azote	1	30
Nitrous oxide	2	30
Carbonic acid	2	45
Chlorine	3	6

Hence, the conducting power appears to be in some inverse ratio to the density of the gases. The nature of the surface of the hot body does not influence the conducting power of the gases, but the state of the gases as to moisture has an influence. **Rumford** shewed that moist gases were better conductors of heat than dry ones.

The practical application of these general principles respecting the conducting powers of bodies, is found in the construction of ice houses of double doors and windows, lining of furnaces, &c. &c. &c.

103. When a pint of water of the temperature of 100° is mixed with a pint of the temperature of 50°, the resulting temperature is as near as possible to 75°, or the mean; but when a pint of water and one of quicksilver at unequal temperatures are mixed, the temperature of the mixture is never the mean. If the water loses 2 degrees, an equal bulk of quicksilver will gain 3 degrees; and the same quantity of heat which will raise the temperature of a given weight of water one degree, will raise that of the same weight of quicksilver 19°. Different bodies, either in weight or volume, require different degrees of heat to raise them to the same temperature; or different bodies in equal weights contain at the same temperature different quantities of caloric. This is called *specific heat*

or *caloric*, and the power by which it is retained is called *capacity for heat*. Thus mercury has less capacity for heat than water. The same caloric which raises the temperature of water one degree, raises that of an equal weight of oil, two degrees. Hence oil has only half the capacity of water for heat.

Many bodies exist in different states, in which they indicate the same thermometric temperature. Thus water may be liquid at 32° or solid at 32°; it may be a boiling liquid at 212°, or in the state of steam at 212°; but when ice passes to the state of water, or water to the state of steam, it absorbs great quantities of caloric; and when steam is condensed, or water frozen, heat is extricated. This is due to a change of capacity for heat, which accompanies a change of state. The heat absorbed does not affect a thermometer, and has therefore been called *latent heat* by Dr. BLACK, who first demonstrated these relations of bodies to caloric, and they appear to be universal. (*See Sections* 107 *and* 108.)

Different bodies have, and the same body in different states, has, different capacities for heat; and it appears also, that the capacities of some liquids for heat decreases as their temperature increases. Thus in cooling water from 212 to 200=12°, less ice will be melted than in cooling it from 132 to 120; but it appears that the capacity of solid bodies, and of gases, increases with their temperature and volume.

A beautiful relation between the relative combining weights of simple substances, and their specific heats, has been discovered by PETIT *and* DULONG; viz. that taken in the ratio of their combining or equivalent proportions, they have the same capacity for heat.

104. From the change of capacity which bodies suffer when changing their state, some philosophers have endeavored to deduce the degree, at which bodies contain no caloric, or the real zero. Thus the capacity of ice to that of water at 32°, is as 9 : 10. Water at 32° contains 1-10 more caloric than ice at 32, and this quantity it appears is 140 degrees. Now 140×10=1400°; so that this degree below the freezing point of water or Farenheit's scale would appear to be the real zero. To shew the fallacy of the principle it need only be stated that LAVOISIER and LAPLACE placed the real zero at some thousand degrees above that point.

105. All bodies, except water, expand or dilate when exposed to heat, and contract when exposed to cold; and for the same elevation of temperature, gases expand more than liquids, and liquids more than solids; nor does it appear that any two solids or liquids expand equally for equal increments of heat. The metals are the most expansible solids: and zinc expands more than tin; tin more than copper; copper more than iron; and iron more than platinum. When brittle bodies, which are imperfect conductors of heat, are exposed

to a sudden change of temperature, they are broken. It is of great importance to have an accurate knowledge of the relative expansibility of the different metallic substances which are employed in the construction of time keepers and astronomical instruments. The rate of going of clocks, &c. depends on the length of the pendulum; and this is constantly varying with the temperature. The source of error has been made the means of obviating its effects. Two metals of different expansibilities are so adjusted, that the effect of one is counteracted by that of the other, and the pendulum maintained of the same effective length.

The expansion of solids and liquids is not equable for equal increments of heat at different temperatures. An addition of 5 degrees of heat will produce less expansion at 100°, than at 500°. As heat increases the volume of bodies, it is obvious that it must diminish their specific gravity. Hence when heat is applied to the bottom of a vessel of water, (at 40° F.) or any other fluid, the heated portion dilates and rises, while the colder parts descend, and are heated, and elevated in their turn. Currents in the ocean are produced by a difference of temperature in different parts of the globe.—All pure gases and vapors expand equally for equal increments of heat, in all parts of the thermometric scale. They expand 1-480 of their volume at 32° for each degree of Farenheit. 100,000 parts at 32° become 137,500 parts at 212°. This law was discovered by Gay Lussac and Dalton, each independently of a knowledge of the experiments of the other. In airs a change of density is the consequence of change of temperature: hence the ascent of smoke, and the origin of winds.

When water at the temperature of 50° is cooled, it continues to diminish in volume, till it attains the temperature of 40°, and if the temperature be diminished still lower, it begins to increase in volume, and continues to expand by diminution of temperature until it freezes. So if water at 32° have its temperature raised, it gradually decreases in volume till it arrives at 40°, and then begins to expand; so that the greatest density of water is at 40°; and this liquid forms a remarkable exception to the general law of expansion of bodies by elevation of temperature. It is from this fact that lakes and ponds are frozen only at the surface; and this peculiarity is often connected with the formation of mists and fogs.

Some bodies, at the instant they pass from the liquid to the solid state, augment in volume; water, cast iron and many other substances offer illustrations of this.

106. When bodies are exposed to a certain degree of temperature, which is probably specific for each substance, they begin to emit light; but suffer no chymical changes. This emission of light is called *ignition* or *incandescence*. The light first emitted is red, and as the temperature is raised, the color grows lighter and at length becomes white. Some bodies may

be white hot, at temperatures which do not render other bodies luminous. This is well illustrated in the *aphlogistic or glowing* lamp, in which a wire of platinum is ignited in an atmosphere which itself is not luminous. *Flame* is gaseous matter ignited, and its temperature is very elevated.

107. Solid bodies by the application of heat become liquid or suffer *fusion*. Fusion occurs only between the integrant particles of bodies, and not between the constituent particles. Many compound bodies have their constituent particles separated from each other at temperatures below that required for their fusion; and hence these substances cannot be fused.

All solid bodies have a particular and determinate temperature at which they melt or become liquid; ice at 32°; tin, 442°; lead, 612°, &c. Those bodies, which are good conductors of heat, melt nearly as soon at the centre as the surface; imperfect conductors, as ice, sulphur, &c. melt only at the surface. Some bodies pass through every degree of softness till they become liquid. Others pass suddenly from one state to the other. There are several circumstances which prevent a liquid from congealing at the precise point at which it passed from the solid to the liquid state; and many liquids may be cooled below their freezing or congealing point; but the moment the congelation commences, the temperature mounts suddenly to that degree of heat at which the solid would become liquid, owing as we shall see to the extrication of its *latent heat*.

The most important phenomenon connected with the fusion of bodies is, that in passing from the solid to the liquid state, their capacity for heat increases. Heat is consequently absorbed; it is insensible to the thermometer, and has been called *latent heat*, or, to express the relations of heat to a body in its different forms, *caloric of fluidity*. If a pound of water at 172° be mixed with a pound at 32°; the result is two pounds at 102° nearly. But if a pound of ice or snow at 32° be mixed with a pound of water at 172°, it produces two pounds at 32°. Here 140° have disappeared, and have been employed in converting the ice to water, and its sensible heat is not increased. There are many other methods by which this important fact, first demonstrated by Black, may be illustrated; and the same general law governs the fusion of all bodies. From this fact we see that water cannot be frozen until it has parted with its latent heat; and hence the rise of temperature during the congelation of liquids cooled below their freezing point. Hence the theory of freezing mixtures. The freezing of bodies is a warming process to those in their neighborhood; hence the moderation of temperature which precedes a fall of snow, and hence the gradual changes of temperature in spring and fall.

108. Liquids by increase of temperature are converted into gases or vapors, possessing mechanical properties similar to common air. The phenomena presented by the vaporization of all liquids are similar.

(*a*) When water is exposed in vessels of glass or metal to the action of fire, it expands to a certain degree; and then that portion which is nearest the source of heat, suddenly becomes very much enlarged in volume, and is converted into steam, which being transparent and invisible, and much lighter than the liquid portion, rises rapidly through it like bubbles of air, producing the phenomena of *ebullition* or *boiling;* it is not till the whole liquid has attained a certain temperature, which is fixed and specific for each fluid under given conditions, that the phenomena of boiling are presented. The process is usually preceded by *simmering*, in which the first portions of vapor formed are suddenly condensed by the colder liquid.

(*b*) The atmosphere, like other ponderable bodies, presses on the substances on which it rests; and this pressure is on an average equal to a column of mercury 30 inches high. Atmospheric, or any other pressure, has an important influence on the boiling of liquids. Ebullition occurs only when the temperature is such, that the vapor formed shall have an elasticity or tension sufficient to counteract this pressure; and this temperature is different in different liquids: in water it is 212°; pure spirit 175°; ether 96°; mercury 656°; under a presssure = 30 in mercury. If the pressure be increased, the boiling point is elevated; if the pressure be diminished,the liquid boils at a lower temperature. This is readily proved by placing hot water under the receiver of an air pump and exhausting the air. Ether, in this situation, *boils* at common temperatures; the same fact is illustrated by the *chymical paradox.* Insert a stop cock air tight into a Florence flask containing water; cause the water to boil, till the steam escapes freely by the open stop cock; then remove it suddenly from the heat, and close the stop cock; when the water ceases to boil; plunge the flask into a vessel of *cold* water, and ebullition instantly recommences, but ceases again if the flask be removed. In this case, a vacuum is formed over the hot water by the condensation of the steam, and the pressure is thus removed. The temperature of a liquid when boiling never alters if the pressure remains the same; all the caloric it receives is employed in the formation of vapor.

(*d*) The boiling points of fluids are affected by holding substances in solution, as sugar, gum, salt, and by the materials of which the vessel is formed; GAY LUSSAC found that water boiling in a *glass* vessel indicated a temperature of 214.2° while water boiling in a *tin* vessel beside it was only 212.6°, and in platina 210.875°. A pinch of pounded glass, or of iron filings thrown into the two former vessels, instantly reduced the temperature, and the ebullition continued. A thermometer plunged near the bottom of a vessel containing a liquid which is boiling by the application of heat to the bottom, indicates a higher temperature than it does near the surface. This we might expect both from the pressure of the superior strata or portions of the fluid, and from a greater length of the same stem or tube of the thermometer introduced into the liquid. Different substances adhere with different degrees of force to each other, and the adhesion of the fluid to the sides of the vessel may not be unlike the effects of viscidity in elevating the boiling point. The introduction of iron filings, &c. presents a number of minute points, which give origin to minute bubbles of steam, which seem to throw off vapor as points do electricity.

(*e*) Where liquids pass to the state of vapor, their capacity for heat is increased, and they absorb and render latent large portions of caloric. A pound of water at 212° will not raise a single ounce of that fluid to its own temperature, it will raise a pound of water at 32 to 122°. But a pound of steam at 212° will raise the temperature of five or six pounds of ice cold water to the boiling point. Let it be supposed that it raises five pounds only, then each pound of water has its temperature raised 180° and 180×5=900° which has been given out by the steam without sensible diminution of temperature. WATT has shown that whatever period be assigned for raising the temperature of water from 50° to 212°, six times that period will be required to convert the water to vapor, provided the heat to which it is exposed remains uniform. Now in the first period the water receives 162°, and 162°×6=972°, which becomes latent in the vapor, and which is again evolved when that vapor is condensed. Other liquids when converted into vapor present similar phenomena. Hence we see the reason why steam scalds so severely; why we cannot render water in open vessels more than boiling hot; hence, too, the utility of steam in warming apartments, for heating rollers by which muslins and delicate printed cottons are dried; for it does not render their temperature higher than 212°; and hence its utility in warming baths, &c. One gallon of water in steam, will heat 18 gallons at 50,° to 100°. The volume of fluids, when converted into vapor, is much increased, and the elasticity or expansive force of vapor is much augmented by increased temperature. Hence the mechanical effects of steam, and of other vapors.

The specific gravity of vapors of different fluids is different. Generally those fluids whose boiling point is lowest, produce vapors of the greatest specific gravity.

(*f*) Liquids pass into vapor without artificial elevation of temperature, or the phenomena of ebullition. In a vacuum, vapor is always formed to a certain extent. Other circumstances being the same, the quantity of vapor formed (*a*) is proportional to the space it has to occupy. If we compress a vapor to one fourth its volume, three fourths of it will be reduced to the liquid state. The quantity of vapor formed (*b*) increases with the temperature, but in a greater ratio. More vapor is produced by a liquid in passing from 60° to 70° than from 50° to 60°. And lastly, the quantity of vapor (*c*) depends on the nature of the liquid, and is generally, though not always, in an inverse ratio to the temperature required for boiling. Phenomena are presented by liquids exposed to the air or to any gas which has no chymical action on them, precisely similar to those which occur in a vacuum. The vapor being formed more slowly in the latter circumstances ; but eventually the same quantity of vapor is formed, having the same elasticity and tension, and exerting the same pressure on the sides of the vessel containing it. A current of dry air accelerates evaporation, not by dissolving the liquid, but by presenting new portions of air in which no vapor exists. During spontaneous evaporation, cold is produced from the increased capacity of the vapor for heat. Some fluids when exposed to the air are in part frozen in consequence of the cold produced by the evaporation of another part. By particular arrangements water may be frozen by a similar evaporation ; as in the CRYOPHORUS, and under an exhausted receiver over a surface of sulphuric acid, by which the vapor is rapidly absorbed. Water contained in a small thin glass tube, surrounded with cotton moistened with ether, may be readily frozen by the evaporation of the ether. Hence the cold produced by coolers and alcarazars. Cold is produced during the rarefaction of gases; heat, by their condensation. And hence the coldness of the upper regions of the air, and the warmth of deep mines and caves.

Steam, which is produced under high pressure, has its sensible heat increased, but its latent heat proportionally diminished ; so that the absolute quantity of heat in steam is the same under whatever pressure it is produced. If a pound of steam at 212° heats five times its weight of water to 212, a pound of steam at 300°, will do no more. (DESORMES & CLEMENT. *Thenard Traitè, to.* iv. *Ed.* 3.)

When steam of great elasticity, is allowed to escape suddenly from a cock or small orifice in the boiler, the hand may be held close to the place at which it issues without being scalded by it; and the water itself of the boiler does not scald under these circumstances. The issuing steam, and the water are found to be below the temperature of 212° by the thermometer. This remarkable effect is probably owing to the sudden rarefaction of the issuing steam in the first case, and to the sudden formation of steam of great rarity in the second, by which a large quantity of sensible heat is rendered latent. It is however not easy to conceive why steam highly compressed, should fall below 212,° its temperature under ordinary pressure, on being allowed to escape from an orifice into the atmosphere. (HENRY'S *Chym. Ed.* 9.)

At very elevated temperatures, the whole of a liquid will be converted into vapor, in vessels which will permit the utmost dilatation of the liquid while in a liquid state. Ether is converted into vapor in a space less than twice its original bulk at 320° F. and then sustains a pressure of 37 or 38 atmospheres:

alcohol requires for this effect a space less than thrice its volume, at 405° F. and a pressure of 119 atmospheres. (CAGNIARD DE LA TOUR. *Brande's Jour.*)

109. Caloric produces decomposition of compounds, when one of their constituents is volatile and the other fixed; and if the affinity between two substancss is not very strong, they may be separated from each other by heat, even if both be volatile: thus alcohol may be separated from water. Generally, the decomposition of bodies by heat gives origin to the formation of new compounds, by the union of the elements in new proportions.

110. The sources of caloric are the sun, and certain artificial arrangements at the surface of the earth. The heating or calorific rays in the sun's beam may be separated from the colour-making rays, by means of a triangular glass prism; a fact first noticed by Sir W. HERSCHEL. When the solar rays are concentrated by appropriate lenses, they produce a very intense temperature.

Percussion, friction and compression, produce elevation of temperature; the evolution of caloric in these instances has been referred to a change of capacity for heat; an idea which does not seem to be countenanced by the ingenious experiment of DAVY, in which he melted two pieces of ice by their mutual friction.

In all the cases of vivid and energetic chymical action between bodies, ignition, or inflammation occurs. The caloric thus evolved has been, probably without sufficient reason, supposed to result from change of capacity.

111. The nature of caloric is not known; it has been by some considered as a peculiar imponderable body; by others the phenomena have been referred to peculiar motions among the particles of matter.

112. The apparent radiation, reflection and absorption of cold depend on the principles already explained. The thermometer, which indicates a diminution of temperature, being considered as the heated body which radiates caloric, and receives none in return, either by radiation or reflection from other bodies.

☞DAVY. *Chym. Phil.* URE's *Dictionary.*

OF LIGHT.

113. THE phenomena of light have been supposed to depend, either on the emission of particles from luminous bodies, or, on the vibrations excited by them in a peculiar ethereal fluid, universally diffused. The motion of light, is progressive; it is

about eight minutes in passing from the sun to the earth, nearly 195,000 miles in a second.

114. A body, which, placed between the eye and the light totally intercepts its passage, is said to be opaque; and the manner in which light is intercepted proves that it passes in right lines or rays from the luminous body as a centre. Bodies which permit the light to pass through them are said to be transparent; there are various degrees of transparency, from the highest, when nearly all the rays pass, to the lowest when nearly all are intercepted; the rays which are not transmitted by transparent bodies are in part absorbed by them, and in part turned or thrown back, from their surfaces. The latter are said to be *reflected;* the angles of reflection and of incidence are equal. A ray of light which passes *obliquely* from one transparent uncrystallized medium to another of a different density is bent out of its course, or *refracted.* The sines of the angles of incidence always bear the same ratio to those of the angles of refraction. Transparent bodies, not only occasion the refraction of the *white* sunbeam, but they also decompose it into different colors; this effect is called *Dispersion.* The refractive, and dispersive powers of bodies are not proportional to each other. A knowledge of the refractive powers of bodies, often enables us to detect fraudulent adulterations of oil, &c. &c.

115. When a ray of light is made to pass through a triangular prism of glass, it is divided into seven different and brilliant colors, viz. red, orange, yellow, green, blue, indigo, and violet. The colored image thus produced is called the *Spectrum;* the red rays are least, the violet most refrangible. If a ray of white light 1-20 inch broad is made to traverse a clear prism of flint-glass, and fall upon the eye at 10 feet distance, only four colors are to be noticed, viz. red, yellowish-green, blue and violet. (WOLLASTON.) The various colored rays of the spectrum suffer no farther alteration in passing through a second prism; but when they are collected by a lens, they reproduce *white* light. Bodies were supposed by NEWTON to absord all the rays of light, except those which produce the peculiar color which they exhibit; these are reflected to the eye. BERARD concentrated by a lens all that portion of the spectrum which extends from the green, to the extreme border of the violet; and by another lens collected the remaining portion of the spectrum. The latter produced a focus of *white* light of intense brilliancy.

116. A ray, or pencil of rays of light, reflected, at a given angle, from different substances, presents certain properties, differing from those which it presents when reflected at any other angle. These properties are peculiar to certain sides of the ray or pencil of rays; and the rays or pencils of rays which possess them are said to be POLARIZED, or to indicate polarity, in the same way that particles of iron, when in the vicinity of a magnet, indicate polarity, by possessing a property in one of

their sides or extremities, which they do not possess at the other extremity.

117. A beam of light which passes through a transparent crystal of calcarious spar, or divers other crystalized bodies, is divided into two portions, and objects seen through such bodies appear double; the crystals which possess this property are called *doubly refracting*. One portion of the pencil of rays is refracted according to the common laws of refraction; the other obeys a peculiar law. The former is said to suffer the *ordinary refraction;* the latter, the *extraordinary refraction*. Both portions acquire the properties of *polarized light*. (*Edin. Phil. Jour. Vol.* 1.) A ray of polarized light, when passing through certain media, loses its properties and is *depolarized.*

118. The different colored rays of light possess different heating powers. There is an increasing calorific effect, from the violet, to the red end of the spectrum; and it appeared in the experiment of HERSCHEL, that the maximum heating power, was just *without* the spectrum on the red end; so that the *heating* rays, seemed less refrangible than the *colored* rays. BERARD, however, found that the greatest heat was produced in the colored spectrum, at the extreme border of the red rays. The *calorific* rays are susceptible of polarization.

119. Many substances, when exposed to the sun's rays, suffer chymical changes which do not occur in the dark. Thus chlorine and hydrogene unite *with explosion;* chlorine decomposes water; moist chloride of silver and many colored stuffs are changed on exposure to the sun's rays. Even glass itself, hard and unalterable as it is, is changed by the solar rays. (FARADAY.) Chymical changes are produced more rapidly by the violet, than by the red rays; and BERARD, found that the rays of half the spectrum including the *red*, produced no effect on chloride of silver, in two hours; whereas the rays of the remaining portion of the spectrum, concentrated by a lens, produced an almost immediate effect. WOLLASTON, found the rays which operate these changes more refrangible than the violet rays, and that they produce their effects in the *unilluminated* space at the border of the violet. It thus appears that there are not less than three kinds of rays in the solar beam; viz. the *colorific*, the *caloric*, and the *chymical* rays. DAVY has traced some very ingenious analogies between the effects of the sun's rays, and electrical agencies. MORICHINI has shown that steel acquires magnetism by exposure to the violet ray; and it is stated, that CONFIGLIACHI found magnetism communicated by every other ray. (*Brande's Jour. No.* 29.) Col. GIBBS has also proved the influence of the sun's light in magnetism. (*Silliman's Jour. Vol i.*)

120. The most intense light generated in combustion, does not appear to possess any chymical powers; but it has been shown by BRANDE that chlorine and hydrogene will unite, with explosion; and that chloride of silver is changed, when exposed to the

light emitted by *charcoal ignited in the Voltaic circuit.* The moon's rays possess no chymical powers.

The effects of the sun's rays are very complicated; healthy vegetation occurs only in the light; and plants made to grow in rooms partially illuminated always bend towards the light. Plants, secluded from the light, are blanched, and changed in taste and other qualities. By exposure to the sun's rays, plants produce certain chymical changes in the atmosphere.

121. Many minerals, when exposed to a heat below redness, become luminous, without suffering combustion. They are said to be *phosphorescent;* fluor spar, and certain other compounds of lime are examples of this. Oil, tallow, &c. become luminous when heated. Many bodies after exposure to the sun's light continue to shine when in the dark; these are called *Solar phosphori.* The most simple solar phosphorus is made by calcining oyster shells for an hour: they are then to be carefully removed from the fire and cooled. After exposure to the sunshine a few minutes, they continue to shine in the dark. Many bodies of this kind always emit the same colored light, even when they have been exposed to the different rays of the spectrum. Some bodies are spontaneously phosphorescent, as the common fire fly, and other insects. Salt water fish, just before they begin to putrefy, and wood, in certain stages of decomposition, are beautifully phosphorescent. Many bodies become phosphorescent by electric discharges, passing through them, or near them. There is no plausible theory of phosphorescence—but it appears connected with the electrical states of bodies. (Dumas & Peletier. *Brande's Jour. No.* 33.)

OF CHYMICAL NOMENCLATURE.

122. The number of undecompounded bodies already known is fifty-two; and to these, names have been given, significant of some remarkable circumstance connected with their history or nature, and to serve as convenient roots from which other names may be derived. The names of compounds are intended to indicate their principal constituents. Three of the undecompounded bodies, viz. *Oxygene*, *Chlorine*, and *Iodine*, may with propriety be associated in one groupe. The former is *always*, the two latter are generally, electro-negative. From a partial view of the philosophy of combustion, they have been called supporters of combustion. One of the undecompounded bodies, *Azote*, is a non-metallic uninflammable substance. Six are non-metallic combustible substances, viz. *Hydrogene*, *Sulphur*, *Phosphorus*, *Carbon*, *Boron, and Selenium*: forty-one are metals, or

are believed to be such; and there is one body whose nature is not *certainly* known, viz. *Fluoric acid.*

(*a*) When oxygene unites with other bodies, it produces compounds called oxides, or acids, or alkalies; but there are acids, and alkalies which do not contain oxygene. The compounds into which oxygene enters, which are neither acid nor alkaline, are called oxides; and this name is prefixed to that of the substance with which it is combined, as *oxide of lead.* If there be many oxides of the same base, the Greek numerals are prefixed, to express the different proportions of oxygene, as *deut*oxide, *trit*oxide, and *per*oxide, the latter always expressing the highest degree of oxidizement in *oxides.* When a base, by combination with oxygene forms acids, that which contains the smallest portion of oxygene has the termination *ous* added to the name of the basis; and that which contains the larger quantity has the termination *ic;* as sulphur*ous*, and sulphur*ic* acid. Where there are intermediate compounds, the term *Hypo*, or *Hyper* is prefixed to the name of the acid; thus *Hypo*-sulphuric acid indicates one that contains less oxygene than the sulphuric acid; *Hypo*-phosphorous acid one that contains less oxygene than the phosphorous acid: the term *hyper*, expresses an acid which contains more oxygene than the one to which it is prefixed. If only one acid is formed by the union of oxygene with a basis, the termination is in *ic*, as carbon*ic acid.*

The combinations of chlorine and of iodine are indicated in a manner similar to those of oxygene; as chlorides, *deuto*-chlorides, iodides, *deut*iodides, &c. &c.

(*b*) Many acids are formed by the union of hydrogene with other bodies. The name of such acids has the usual termination, with the prefix, *hydro*, as *hydro*chloric, *hydr*iodic, &c.

(*c*) The combinations of inflammable bodies with each other, and with the metals, have the termination *uret*, as *sulphuret* of carbon, *carburet* of iron; or sometimes for euphony the termination is *uretted*, as sulph*uretted* hydrogene. When the syllable *bi*, is prefixed, as *bi*-sulphuret, *bi*-carburet, &c. it indicates twice the quantity of sulphur, carbon or phosphorus that exists in the sulphuret, carburet, phosphuret, &c.

There is one substance, consisting of azote and carbon, which performs the double function of a simple and compound body: it frequently combines with bases as does oxygene, and to express this important relation, it has received the name of cyanogene, and the compounds are called *cyanides;* thus, cyanide of mercury, not azoto-carburet of mercury, &c. hydro-cyanic acid; not hydro-azoto-carbonic acid. Combinations of metals with each other are called alloys, unless mercury is one of them; and then they are called amalgams.

(*d*) Acids, terminating in *ous*, when they combine with alkalies or oxides, change that termination into *ite;* and acids in *ic* change it to *ate;* thus sulph*ite* of soda; sulph*ate* of soda; or, if the acid be combined with an oxide, the word expressing the degree of oxydizement is prefixed, as *proto*sulphate of iron; *per*sulphate of copper. An excess of acid in saline compounds is generally indicated by the prefix *super*, as *super*tartrate of potash; but the prefix *bi*, is generally preferable, as indicating the quantity. An excess of alkali is sometimes denoted by the prefix *sub*; as *sub*carbonate of potash.

OF WATER. (9)

123. (*a*) By cautious and slow distillation of common water in vessels of silver or gold, water may be obtained pure, and free from foreign matters. (*b*) It is colorless, transparent inodorous, and tasteless; slightly elastic, and compressible. (Canon; Perkins.) It is the standard to which the specific gravity of all solid and fluid bodies is referred, and is accordingly assumed as 1.000: it is 11,948,65 heavier than hydrogene, at 40° F. and one cubic inch weighs 252.968 grains. When subjected to strong and sudden pressure it becomes phosphorescent. (Thenard 1.186.) At 32 Farenheit, water congeals, and crystallizes in small acicular needles, which cross each other at angles of 60°, or 120°. A particle of new fallen snow, often exhibits the crystalline appearance; at the moment of congelation, water becomes much augmented in volume. The specific gravity of ice is 0.94. At 212° Faranheit and 30 in: B. water boils in open vessels; steam has a specific gravity 0.6235, air being 1. It is between 9 and 10 times more heavy than hydrogene, 100 cubic inches weigh about 21 grs.; one cubic inch of water affords between 1700 and 1800 cubic inches of steam.

124. (*c*) The chymical affinities of water are very numerous,but not energetic; it ordinarily suffers or produces little change of properties. It communicates that fluidity to bodies which is favorable to chymical action; and hence it is the common medium by which bodies are brought to act on each other.

The chymical agency of water is derived from its solvent power; almost all saline bodies, earths, alkalies, acids, &c. &c. are soluble in this fluid. Gases, are dissolved by it; but the effect is due in many cases to mechanical action; (24.e.) at a given temperature water takes up the same volume of some gases, let the pressure or their condensation, be what it may. Air is expelled with difficulty from water either by boiling or by the removal of the atmospheric pressure. Water, which is deprived of air, is vapid, and incapable of supporting the life of aquatic animals and vegetables. It is owing to the great solvent power of water, that it never occurs perfectly pure in nature.

125. Water enters into true chymical union with many bodies; and produces compounds which are called *Hydrets.* (Young's *Med. Lit.*)

126. All natural waters may be divided into common waters, sea waters, and mineral waters. Common waters may be employed for the various purposes of domestic economy; those which are called *hard waters*, contain variable quantities of saline substances which act chymically on soap.

Sea water contains a large portion of common salt, together with several other substances in solution: its temperature varies with the latitude; between the tropics, the temperatue is highest at the surface; in the polar regions, the temperature increases with the depth. Sea water freezes at 28° F.

Mineral waters, are such as differ so much from common water and sea water, in color, smell, taste, &c. that they cannot be employed in domestic economy; some of them possess the properties of hard waters in an eminent degree. Those which contain much carbonic acid are called *acidulous;* if iron predominate, *chalybeate;* if the odour of putrid eggs is evolved, *hepatic;* and if salts predominate, *saline.*

127. There are few bodies which suffer decomposition with greater facility than water; and among the various methods of effecting it, that by Voltaic electricity is the most satisfactory. When a platina wire from each end of the Voltaic trough is introduced into pure water, two gases are procured; the one, evolved at the positive pole, is *oxygene gas*, the other at the negative pole is *hydrogene gas.* These possess peculiar and distinct properties. It has been abundantly proved, that these two gases by their combination with each other produce water; both analysis and synthesis show that water is composed of

Oxygene	1 volume -	1 prime	= 8	88.89
Hydrogene	2 volumes -	1 ,,	= 1 or per cent.	11.11 = 100.000

The facility with which the elements of water are separated and united, has a very important influence in many chymical phenomena.

OF GASES,

The name gas, is given to all fluids which are capable of existing in the elastic state, under the pressure of the atmosphere, at common temperatures.

The gases possess certain properties in common, which it is proper to consider in order to compare the degree in which they belong to different æriform fluids.

(*a*) Gases possess the mechanical properties of the atmosphere, elasticity, and weight; and their *volume* is *always inverse-*

ly as the compressing force. A gas which occupies 60 cubic inches under ordinary pressure, occupies only 30 cubic inches under a double pressure; 20 cubic inches under a triple pressure, and 15 cubic inches under four times that pressure.

(*b*) It is very important to know the precise *specific gravity* of the different gases, in calculating the proportions into which they enter in different compounds, as well as in ascertaining their equivalent numbers. The relative specific gravity of some gases is shown in the following

TABLE OF THE SPECIFIC GRAVITY OF GASES.

Barometer 30.——Thermometer 60.

NAMES OF GASES.	Weight of 100 cub. inch. grains.	Specific gravity, Hydrogene 1.	Specific grav. common air being 1.
Hydrogene	2.117.	1.	0.0694.
Oxygene	33.87.	16.	1.1111.
Chlorine	76.25.	36.	2.500.
Euchlorine, oxide of chlorine	72.	34.	2.361.
Muriatic acid gas	39.183. ?	18.5	1.2847. ?
Iodine (vapor)	244.679.	125.	8.678.
Hydriodic acid gas	133.371.	63.	4.340.
Nitrogene	29.652.	14.	9.722.
Nitrous oxide	46.574.	22.	1.527.
Nitric oxide	31.75.	15.	1.0416
Ammonia	18.	8.5.	0.591.
Atmospheric air	30.5. ?	14.50. ?	1.
Sulphur (vapor)	33.88.	16.	1.1111.
Sulphurous acid gas	67.77.	32.	2.222.
Sulphuretted hydrogene	35.89. ?	17.	1.18. ?
Phosphorus (vapor)	25.416.	12. ?	0.833.
Phosphuretted hydrogene	27.52.	13.	0.902.
Subphosphuretted hydrogene	29.64.	14.	0.772. ?
Carbon (vapor)	12.87.	6. ?	0.422.
Carbonic oxide	29.64.	14.	0.972.
Carbonic acid [ant gas)	46.57.	22.	1.525.
Carburetted hydrogene (olefi-	29.63.	14.	0.9720.
Cyanogene	55.	26.	1.805.
Fluoboracic acid	73.5.	34. ?	

(*c*) Many philosophers, have devoted their time and ingenuity, to determine with accuracy the specific heat of gases. The following table contains the general results of the experiments of De la Roche & Berard.

TABLE OF THE SPECIFIC HEAT OF SOME GASES.

NAMES OF GASES.	In equal volumes.	In equal weights.	
Atmospheric air	1.000.	1.000.	(Unity.)
Hydrogene	0.9033.	12.340.	
Oxygene gas	0.9765.	0.8848.	
Nitrogene	1.0000.	1.0318.	
Nitrous oxide [gas)	1.3503.	0.8878.	
Carburetted hydrogene (olef.	1.5530.	1.5763.	
Carbonic oxide	1.0340.	1.0805.	
Carbonic acid	1.2583.	0.8280.	

(*d*) The gases are absorbed by all bodies which possess a certain degree of porosity.

The following table presents the general results of the experiments of Saussure on this subject.

GASES absorbed	by charcoal.	by Meerschaum	by Adhe. Slate.	by Ligni. Asb'tos	by Saxon Hydro.	by Quartz
Ammonia	90v'ls	15.	11.3.	12.75.	64.	10.
Muriatic acid	85.				17.	
Sulphurous acid	65.				7.87.	
Sulphuretted hydrogene	55.	11.7.				
Nitrous Oxide	40.	3.75.				
Carbonic oxide	35.	5.26.	2.	1.7.	1.0.	0.6.
Olefiant gas	35.	3.70.	1.5.	1.7.	0.8.	0.6.
Carbonic acid	9.42.	1.17.	0.55.	0.58.		
Oxygene	9.25.	1.49.	0.7.	0.47.	0.6.	0.45.
Nitrogene	7.5.	1.6.	0.7.	0.47.	0.6.	0.45.
Gas from moist charcoal	5.0.	0.85.	0.55.	0.41.		
Hydrogene	1.75.	0.44.	0.48.	0.31.	0.4.	0.37.

It is necessary to deprive the solid body of the air which it naturally contains, before subjecting it to the gas; and this is effected either by heat, or exposure under an exhausted receiver of the air pump.

Solids, chymically the same, in different states of mechanical aggregation, absorb different quantities of gas: charcoal of boxwood will absorb 7.5 times its volume of air; that of cork, an inappreciable quantity.

During the absorption of gases by solids, there is a rise of temperature, proportional to the absorbability of the gas, and the rapidity of its condensation.

Solids absorb a greater number of volumes of the more absorbable gases under a rare, than under a dense atmosphere; but a greater *weight*, under the latter.

When a solid, saturated with one gas, is exposed to the atmosphere of another, a portion of the first is expelled and a part of the second absorbed.

(*e*) All gases are absorbed by liquids, and most of them are again expelled by heat, or diminution of external pressure.

100 volumes of water absorb of

Sulphurous acid	4378.	Volumes.
Sulphuretted hydrogene	253.	
Carbonic acid	106.	
Nitrous oxide	76.	
Olefiant gas	15.3.	
Oxygene	6.5.	
Carbonic oxide	6.2.	
Gas from moist charcoal	5.1.	
Hydrogene	4.6.	
Nitrogene	4.1.	(Saussure.)

Different liquids absorb different quantities of the same gas. Water absorbs its own bulk, and alcohol about twice its bulk of carbonic acid.

The absorption is facilitated by first freeing the liquid from air by boiling, or by the air pump, and, by a brisk and long continued agitation.

The lightest liquids generally possess the greatest power of absorbing gases; but when there is no chymical action,the heaviest gases are most abundantly absorbed by a given liquid.

The quantity of gases absorbed by a given liquid is always in direct ratio to the pressure.

It is yet a subject of controversy whether the absorption of gases depends on a chymical or mechanical action; probably however in most cases on the latter. (Henry.)

(*f*) Different gases under the same circumstances escape with different degrees of velocity through small orifices or needle holes. The specific gravity of the gas seems to have no influence in this; for, under equal pressure,

Carbonic acid required	4 min.	6 sec.
Olefiant gas	3 „	3 „
Oxygene	5 „	45 „

to escape in equal quantities; and hydrogene escapes three times more quickly than olefiant gas. These differences cease to exist at low pressures.

It is remarkable that the gas which escapes with the greatest facility at low pressures, passes with the least, at high pressures. (Faraday, *Brande's Jour. No.* 6.)

In their movement through pipes, gases present phenomena similar to those offered by the more incompressible liquids; a fact deserving the attention of those who are engaged in transmitting gases through long tubes in gas lighting. (Girard *by Henry.*)

OF OXYGENE GAS. (8)

128. (*a*) When powdered black oxide of manganese, or nitre, is exposed to a red heat in an iron bottle, an abundant quantity of aeriform matter is produced, which is nearly pure *oxygene gas:* it may be obtained perfectly pure by heating chlorate of potassa to redness in a glass retort; it may be collected over water.

(*b*) Oxygene gas is a colorless, tasteless, inodorous, and invisible, permanently elastic fluid, like common air. 100 cubic inches weigh, at mean temperature and pressure, 33.87 grains. Its specific gravity is 16. hydrogene being 1.

(*c*) It possesses the property of supporting combustion in an eminent degree: a lighted candle, or ignited sulphur, phosphorus, charcoal, or iron, introduced into this gas, burns with great brilliancy.

It combines with all other simple bodies.

Water, under great pressure, absorbs much of this gas, but derives no new properties from it.

(*d*) Oxygene exists abundantly in nature. In the gaseous form it constitutes a portion of the atmosphere. Many bodies into which it enters have acid powers; and hence the name, oxygene, from the Greek words, which signify "producing acid."

(*e*) No breathing animal can long exist without this gas. Its action on the living system is highly stimulant. A small animal lives longer in a given portion of this gas than in the same volume of air, but dies, long before the oxygene is exhausted.

(*f*) It has sometimes been used as a stimulant in medical practice; and is employed occasionally in the laboratory, to produce intense heats; a current of it being thrown from a blow pipe on ignited charcoal.

(*g*) Oxygene gas was discovered by Priestley, August 1, 1774; and by Scheele without a knowledge of Priestley's experiments in 1777; it has been known by the names of dephlogisticated air, empyreal air, vital air.

OF HYDROGENE GAS. (1)

129. (*a*) When soft iron or zinc filings are covered with sulphuric acid diluted with six times its bulk of water, hydrogene gas is evolved, and may be collected over water; it may also be procured from the decomposition of water effected by passing steam through an ignited gun barrel.

(*b*) When perfectly pure, it possesses the mechanical and sensible properties of common air; as it is usually prepared, it has a slight fetid odor. 100 cubic inches weigh 2.117 grs. It is the lightest of all ponderable bodies. Its specific gravity is 1, being the unit to which the gravity of other gases is referred; compared with air, its sp. gr. is 0.0694 (Thomson) or 0.0688 (Berzelius & Dulong.)

(*c*) Hydrogene gas is inflammable, but does not support combustion. When a lighted taper is plunged into a vessel of hydrogene gas open to the air, the gas takes fire; but the taper is extinguished. It inflames at the temperature of 1000 F. but the flame is hardly visible in day light if the gas is pure. Prof. Hare and Mr. Morey have shown that the flame of hydrogene is rendered luminous, like that of oil, by adding spirits of turpentine to the usual mixture for generating the gas. (Silliman's *Jour. Vol.* 2.)

If an electric spark be passed through a mixture of hydrogene and oxygene gas in certain proportions, detonation ensues.

The same effect is produced by the contact of a flame. A more feeble detonation may thus be produced in a mixture of hydrogene gas and common air.

A current of hydrogene, issuing from a small orifice, may be inflamed. It then constitutes Boyle's philosophical candle. When a tube 18 or 20 inches long, and 1 or 1½ inch in diameter is brought over this flame, musical tones are produced; an effect, which is referable to a rapid succession of detonations, produced by the mixture of the ascending current of atmospheric air with the gas, in explosive proportions. The effect is not peculiar to hydrogene. (FARADAY.)

Hydrogene gas is not rapidly absorbed by water—100 cubic inches of this fluid absorb only 4.6 cubic inches at 60° F. and 30 inches barometer.

Hydrogene unites with many bodies. Some of its compounds have very powerful acid properties. (137.)

(*d*) Hydrogene exists in many compound bodies, but is never found pure naturally; its name is derived from the Greek words which mean "producing water."

(*e*) Animals plunged in this gas are suffocated, and die rather from a want of oxygene, than from any positive deleterious power which it possesses. It may be respired, and is said to render the voice shrill. Its presence is said to produce, in some degree, the effect of light on growing vegetables.

(*f*) It is employed, from its great lightness, for filling balloons; and from its inflammability, for procuring light. This may be effected in a manner discovered by DOBEREINER. A small jet of hydrogene gas is thrown upon platina sponge, at common temperatures. The *platina becomes ignited* and *the gas inflamed.* This effect is supposed to depend on electrical agencies. The gas and platina forming an electrical combination, in which the former represents zinc in the common Voltaic instrument. It is also employed in eudiometry. (*See atmospheric air.*)

(*g*) Hydrogene gas appears to have been first examined by CAVENDISH.

130. *Hydrogene and oxygene.* Hydrogene gas, by combustion, combines with oxygene, in the ratio of two volumes of the former to one of the latter.

The only product is water (127); during the combustion of hydrogene, (*a*) very intense heat is excited, the origin of which cannot be referred to a change in the capacity of the combining bodies. On this fact the celebrated *compound blowpipe* or *oxy-hydrogene blowpipe* was constructed by HARE. The two gases are contained in separate reservoirs, and made to meet in one point, just as they issue from them. At this point they are inflamed, and by a little care in regulating the egress of the gases they may be made to issue in the proportions in which they constitute water. The flame is hardly perceptible; but a most intense heat is excited by it. Platina may be made to boil in it. The most refractory gems, stones and earths were first fused in it by Silliman and Hare; and there is hardly a more brilliant experiment than the combustion of a watch spring in it, by which a shower of bright scintillating fire is produced. Mr. Skidmore, of New-York, has shown that the mixed gases,issuing from the blowpipe, burn under water. (Silliman's *Jour. Vol.* 5.) This instrument was known and employed in the United States, and all the brilliant results obtained by it, long before it appears to have excited the attention of foreign chymists. At length, Dr. Clarke, of Cambridge, England, who could not be ignorant of the instrument, availed himself, in some experiments, of the temperature produced by the combustion of oxygene and hydrogene; and thus the attention of the philosophers in Europe was turned to the subject. Dr. Clarke possesses the *rare* merit of using a form of the blowpipe constructed by Mr. Brooke, and rendered safe by Wollaston's faggot of capillary tubes, which were founded upon Davy's beautiful discoveries on the nature of flame; of having repeated the experiments of the American chymists, Silliman and Hare, and, without presenting any one new result, of claiming the *whole* credit for himself. (Silliman's *Jour. Vol.* 2.)

131. There is another compound consisting of oxygene and hydrogene, which has been called *peroxide of hydrogene*, or *oxygenized water*. The process for procuring it is complicated. Water is acidulated with muriatic acid, and *peroxide* of barium dissolved in it. The *prot*oxide of barium is then precipitated by adding sulphuric acid. Oxygene is thus left in combination with the liquor. The solution of the peroxide, and precipitation of the protoxide, may be repeated till the liquor contains many times its volume of oxygene. The muriatic acid is then to be separated by the addition of sulphate of silver, and the sulphuric acid, by Barytic water; and lastly, the clear liquid concentrated by exposure in an exhausted receiver with sulphuric acid. (108.*f*) The liquor is clear and colorless, of a sp. gr. 1.45. Its taste is peculiar and metallic; when applied to the skin it produces pain.

It produces violent detonation, when dropped on dry oxide of silver, or on many of the metals minutely divided.

It is decomposed by heat, or by shreds of animal membrane introduced into it. It is composed of

Hydrogene	1	Prime	=	1
Oxygene	2	Primes	=	16
				17

Water has been united with thirty times its volume of oxygene. Oxygenized water has been successfully employed in removing the stains from the paintings of some of the Old Masters.

This curious and interesting compound was discovered by Thenard, and to him we are indebted for the investigation of its properties.

OF CHLORINE. (36)

132. (*a*) When a mixture of black oxide of manganese and muriatic acid is heated in a retort, a yellowish gas is produced called *chlorine.* It may also be procured by heating in a retort, a mixture of black oxide of manganese 3 parts, common salt 8 parts, sulphuric acid 4 parts, and water 5 parts; the gas must be collected over warm water. (133.)

(*b*) Chlorine is an elastic fluid of a yellowish green color, and hence its name; is transparent, of an astringent unpleasant taste, and a suffocating disagreeable odor. 100 cubic inches at mean temperature and pressure, weigh 76.25 grs.: its sp. gr. is 36, hydrogene being one.

When pure, it is not altered by light, heat or electricity.

When perfectly dry chlorine gas is subjected to a low temperature; under a pressure of four atmospheres, it readily passes to the form of a liquid. (FARADAY.) Liquid chlorine is very fluid and limpid, excessively volatile at common temperatures, and of a sp. gr. 1.33 ?

(*c*) Chlorine is distinguished by its power of bleaching, an effect, however, depending on the presence of water, which suffers decomposition. Some combustible bodies burn in the gas. A lighted taper burns with a dull red light, and a dense smoke is evolved. Iron wire ignited in a coil and plunged into the gas, glows with a red heat accompanied with the evolution of dense red vapors. A brass wire consumes rapidly when plunged red hot into the gas, and brilliant sparks are thrown out. Phosphorus, antimony and arsenic in fine powder, burn spontaneously in this gas at common temperatures. Charcoal cannot be made to burn in this gas even when its affinity is aided by a powerful Voltaic instrument.

Some of the compounds of this substance have acid properties; others are not acid and are called *chlorides*; many of these resemble salts.

(*d*) The gas is very deleterious to animal life; when pure it speedily produces death, and even when largely diluted with atmospheric air, the respiration of it is attended with alarming and painful symptoms. When the hand is introduced into this gas a sensation of heat is perceived. (HARE.)

(*e*) It exists in many compounds; in muriatic acid, common salt, &c.

(*f*) It is employed for fumigating apartments in hospitals, and for destroying contagion; for these purposes it was first used by MORVEAU. The compounds of chlorine are extensively employed in the art of bleaching. Its application to this purpose is due to BERTHOLLET.

(*g*) It was discovered by SCHEELE, in 1774. Its properties were afterward investigated by BERTHOLLET, who considered it as a compound of oxygene and muriatic acid. GAY LUSSAC and THENARD first remarked that the phenomena produced by it might be explained on the *supposition* that it was undecompounded; and Davy has fully elucidated its nature, and demonstrated that the effects produced by it will not admit of satisfactory explanation on Berthollet's hypothesis.

133. *Chlorine and water.* Chlorine gas is rapidly absorbed by cold water. The liquid has the color, taste, smell and bleaching properties of the gas. The solution evolves oxygene when exposed to the light: this arises from the decomposition of the water. A saturated solution of chlorine becomes solid at 46°. The *hydret* of *chlorine* is yellow and may be obtained crystallized; it is soluble in alcohol. It consists of

Chlorine	27.7.
Water	72.3.
	100.0.

a composition which approaches nearly to 1 prime of chlorine and 10 of water. (Faraday, *Brande's Jour. No.* 29.)

134. *Chlorine and oxygene.* These two bodies may be obtained in combination with each other by indirect methods; they unite in three proportions.

(*a*) *Oxide of chlorine*, or euchlorine, may be procured by moistening 8 or 10 grains of chlorate of potash with sulphuric acid. The mixture is a yellow powder when the proper proportions of acid and salt are employed. This is to be *very* cautiously heated in a small retort; the temperature should not exceed 150°. Oxyde of chlorine is evolved, and must be collected in small vessels over mercury.

(*b*) At common temperature and pressure it is a gas of a bright lively green color, of an aromatic but peculiar suffocating odor. It affects the eyes like smoke; taste, astringent, but not acid.

100 cubic inches weigh 72? grs.—sp. gr. 34 hydrogene 1. By cold and strong pressure this gas may be obtained in the liquid form; it is then a very deep yellow colored fluid. (Faraday.)

(*c*) This gas is distinguished by the facility which it suffers decomposition. A very gentle elevation of temperature will produce this effect. The decomposition is accompanied by explosion. The heat of the hand will sometimes produce this effect; and hence great caution is necessary in experimenting with it.

When phosphorus is introduced into the gas it produces explosion, takes fire, and burns with great brilliancy.

The gas possesses feeble bleaching powers when moisture is present. Water rapidly absorbs the gas, and acquires a yellowish green color. The solution has a pungent smell, corrosive astringent taste, and by exposure to the sun's rays, suffers decomposition: chlorine gas and *chloric acid* are produced.

(*d*) When the gas is decomposed, two volumes expand and become three, consisting of one of chlorine, and two of oxygene.

It consists of

Oxygene	4 primes	= 8 × 4 = 32 or 2 vols.	condensed to two volumes.
Chlorine	1 prime	= 36 or 1 vol.	

(*e*) It was discovered by Davy in 1811.

135. The two other compounds of chlorine with oxygene are *acids.* Acids are a very important class of chymical agents, and are distinguished by the following general properties, viz.

(*a*) They have a sour taste, which, in many of them, is very strong and corrosive.

(*b*) They change the blue or purple vegetable colors to a bright red.

(*c*) They combine, in definite proportions, with alkalies, earths and oxides, and form salts; this is their most important property.

(*bis.*) *Chloric acid.* When a current of chlorine gas is passed through water in which oxide of silver is diffused, the oxide is decomposed. The silver unites with a portion of the chlorine and forms an insoluble chloride. The oxygene unites with another portion of the chlorine and forms chloric acid: the liquid may be heated and filtered, and then contains the pure acid. It is a colorless and inodorous liquid, of a very sour taste; it does not give precipitates with any metallic solution. By combination with earths, alkalies, and oxides, it forms *chlorates,* (formerly called oxy-muriates.)

It consists of

Chlorine	1 prime =		36
Oxygene	5 primes =	8 × 5 =	40
and its equivalent number is			76

It was discovered by Gay Lussac.

136. *Perchloric acid* is procured by distilling oxychlorate of potash with an equal weight of sulphuric acid.

It is a compound of

Chlorine	1 prime	=	36
Oxygene	7 primes	8 × 7 =	56

Its properties have been imperfectly ascertained.

137. *Chlorine and hydrogene.* When a mixture of equal volumes of these gases is exposed to light, they combine and produce *muriatic acid gas,* or hydro-chloric acid gas. The mixture explodes with violence when exposed to the direct rays of the sun, or to the light of the Voltaic spark, or to the action of the electrical spark.

(*a*) Muriatic acid gas is readily procured by distilling common salt and sulphuric acid. The gas must be collected over mercury.

(*b*) It is a colorless and transparent gas, of a sour taste and a pungent suffocating odor: it produces white fumes when mixed with moist air.

100 cubic inches at mean temperature and pressure weigh 39.164 grs.—its sp. gr. is 18.5. hydrogene being 1.

By cold, and strong pressure it may be reduced to a colorless liquid. (FARADAY.)

When pure, it is not altered by light, heat, or electricity.

(*c*) This gas extinguishes combustion and flame. When some metals are heated in the gas, they decompose it, combine with the chlorine and evolve the hydrogene. Some metallic oxides, on the contrary, when heated in it, afford oxygene to the hydrogene, and the chlorine is extricated.

It is composed of

Chlorine	1	volume, or 1 prime	= 36
Hydrogene	1	" "	1
and its equivalent number is			37

(*d*) It was discovered by CAVENDISH; first examined by PRIESTLEY, and its true nature demonstrated by DAVY.

138. *Muriatic acid gas and water.* Water greedily absorbs this gas: one cubic inch absorbs between 480 and 548 times its bulk, and becomes warm; and permanently increased in volume, six parts becoming nine.

Ice, introduced into the gas is melted with great rapidity.

(*a*) The solution of the gas in water constitutes the liquid muriatic acid, and is readily formed by passing a current of the gas, produced from 32 common salt, 22 sulphuric acid and 7 of water, into water kept cold by ice.

(*b*) The liquid, when pure, is colorless and transparent; as commonly prepared, it has a yellow tinge. It has a pungent odor, and a very acid and corrosive taste; it blisters the skin. Its specific gravity varies with its strength, the strongest being the most dense;

Sp. gr.	contains grains acid gas in 100 of the liquid.
1,10	20,388
1,15	30,582
1,20	40,777 (URE.)

The acid gas is extricated when the liquid is boiled.

The muriatic acid is always employed in the liquid watery solution, for the purposes of the arts. Many oxides disolved in it produce chlorides; the oxygene and hydrogene forming water, and the metal and chlorine, forming a chloride.

The liquid acid has been long known. The present process for procuring it was invented by GLAUBER.

OF IODINE.

139, (*a*) Lixiviate kelp in cold water; evaporate the solution to separate the easily crystallizable salts, and there remains a dense oily fluid; add sulphuric acid in excess to it, and boil the mixture; filter, and introduce the clear liquor into a long necked flask, and heat it with its own weight of powdered black oxide of manganese. Iodine is separated, and rising in violet vapors, condenses in the neck of the flask. Wash out the solid crystals with cold water, and dry them on blotting paper.

(*b*) Iodine at common temperatures is an opaque, crystalline, soft friable, solid of a greyish black color and a semi-metalic lustre. Its odor resembles that of chlorine; its taste is hot and acrid; and it stains the skin yellow.

Its specific gravity is 4,948.

It is a conductor of electricity, and like oxygene and chlorine is evolved at the positive Voltaic pole from most of its compounds. It is very volatile. At 120° it forms a violet vapor, fuses and rapidly vaporizes at 220°.

The specific gravity of the vapor is 125; hydrogene 1.

(*c*) It combines with many bodies, with the production of heat, and with potassium with heat and light. Its compounds are *Iodides*, or acids. Some of them are of important use. It is soluble in water, and in spirits of wine; and in very minute quantity produces a blue color with starch.

(*d*) It has been employed with distinguished success in some glandular complaints, and as a tonic.

It was discovered in 1812 by M. COURTOIS of Paris: its properties were elucidated by VAUQUELIN, GAY LUSSAC and DAVY.

140. *Iodine and Oxygene. Iodic acid* is procured when a current of euchlorine (134) gas is passed among the crystals of iodine contained in a small tube. Two compounds are formed, one of chlorine with iodine; the other of iodine and oxygene. The former may be separated by heat; the latter thus procured is a white, semi-transparent body, without smell, and of a sour taste; deliquescent, and very soluble in water.

It consists of

Iodine	1 prime	=125
Oxygene	5 primes	40
its equivalent number or prime is		165

It was discovered by DAVY, 1814.

141 *Iodine and chlorine. Chloriodic acid* is easily obtained by bringing the two bodies in contact with each other. They unite and form a yellowish red compound, of a crystalline texture; deliquescent, fusible, and volatile; easily dissolved in water; the solution is acid

It consists of

Iodine	1 prime	125
Chlorine	1 prime	36

It was discovered by DAVY, 1814.

142. *Iodine and Hydrogene. Hydriodic acid.* (*a*) When four parts of iodine are moistened with water: and mixed with one

part of phosphorus, an elastic fluid is rapidly disengaged, and may be collected over mercury.

Hydriodic acid gas is colorless and transparent; of an acid taste, and a pungent odor, similar to muriatic acid gas.

100 cubic inches weigh 133,371 grains; its sp. gr. is 63; hydrogene 1.

(*b*) Hydriodic acid gas is decomposed when mixed with chlorine gas, and iodine is evolved. It is decomposed by mercury; iodine is absorbed, and half the volume of gas remains, which is hydrogene. Hence it is composed of equal volumes of vapor of iodine and hydrogene: or

1 prime of Iodine	125
1 prime Hydrogene	1
its prime equivalent is	126

143. Hydriodic acid gas is rapidly absorbed by water, and forms a strong acid similar to muriatic acid. The liquid Hydriodic acid may be easily obtained by passing a current of sulphuretted hydrogene gas through water in which iodine is diffused, and the sulphur separated by filtration, and the excess of sulphuretted gas driven off by heat.

The liquid acid boils at 260° and distils over in appropriate vessels. The strongest acid has a sp. gr. 1,7. By exposure to the air it suffers decomposition. Iodine is soluble in this acid.

OF NITROGENE. (14)

144. (*a*) WHEN 100 measures of common air are mixed with 80 measures of nitrous gas (146) in a wide vessel over water, a red vapor is produced; this is soon absorbed, and leaves a quantity of gas, which, after washing with lime water, is *nitrogene gas.*

(*b*) Nitrogene gas is a colorless, transparent, tasteless, inodorous, elastic fluid.

100 cubic inches weigh 29,64 grs. Its sp. gr. is 14.

(*c*) Its properties are rather negative than positive. It does not support combustion; is not inflammable; does not render lime water turbid; does not redden vegetable blue colors; does not support life, and is nearly insoluble in water.

(*d*) It combines with many bodies, and produces very important compounds.

(*d*) It exists abundantly in nature; constitutes a large portion of the atmosphere, and enters into the composition of animal bodies.

(*e*) It was first recognized as a peculiar gas by RUTHERFORD in 1772; and has been called azote, from its not supporting life.

145. *Nitrogene and Oxygene* unite in five proportions with each other, forming two oxides and three acids.

(*a*) *Nitrous Oxide*, or Protoxide of Azote, is readily procured by heating nitrate of ammonia in a retort to a temperature of about 420°. The gas is to be received over warm water.

(*b*) Nitrous oxide is a colorless and transparent elastic fluid; of a faint but agreeable odor, and sweet taste.

100 cubic inches weigh 46,574 grains, its sp. gr. is 22.

(*c*) A lighted candle burns in this gas with brilliancy; and phosphorus, sulphur, iron wire,&c. when introduced into this gas in a state of vigorous combustion or ignition, burn with nearly the same brilliancy as they do in oxygene; yet phosphorus may be melted and sublimed in the gas without taking fire.

When two volumes of this gas are mixed with two volumes of hydrogene gas, and the mixture fired by the electric spark, water is formed, and two volumes of azote remain; and as hydrogene combines with half its volume of oxygene, it is evident that nitrous oxide consists of two volumes of nitrogene united to one of oxygene, condensed to two volumes: or

Nitrogene	1 prime	14
Oxygene	1 "	8
		22 the prime of nitrous oxide.

The most remarkable property of this gas is the power it has when respired, of exhilarating the animal system to a very great degree, without conseqent debility; this property was first noticed by DAVY. It is sometimes employed as a stimulant in medicine. It was discovered by PRIESTLEY in 1772; and its properties were elucidated by DAVY in 1799.

146. *Nitric oxide;—(deutoxide of azote; nitrous gas)*—when nitric acid diluted with three times its weight of water, is poured on cuttings of copper, there is a copious evolution of this gas; it may be collected over water. (*b*) It is a colorless, transparent elastic fluid; but whether it has taste or smell, cannot be ascertained, owing to its instantaneous action on oxygene. 100 cubic inches weigh 31.75. Its specific gravity is 15.

(*c*) When placed in contact with oxygene gas, red vapors are produced which consist of hyponitrous and nitrous acid vapor. Nitric oxide extinguishes the flame of a candle, or the combustion of charcoal or phosphorus; if the latter be in very vivid combustion, it continues to burn in the gas with great brilliancy. When mixed with hydrogene, it burns by the application of flame, with a green colored flame. The mixture is not fired by the electric spark. A solution of copperas absorbs this gas abundantly.

(*d*) Charcoal at a red heat decomposes this gas; and arsenic or zinc when heated in it, effects its decomposition, by absorbing its oxygene; one half the original volume of the gas remains, which is azote;—hence the composition of this body is

Nitrogene 1 prime =14
Oxygene 1 " 8×2=16

its equivalent number, or prime is 30

(*e*) There are few substances whose action on the powers of life, both animal and vegetable, is more prejudicial than that of nitrous gas.

(*f*) It is employed in eudiometry, or analysis of the atmosphere. (156.)

(*g*) It was discovered by Priestley in 1772.

147 (*a*) *Hyponitrous acid.* Fill a small tube with mercury, and invert it in that liquid; and then pass into the tube 5 or 6 measures of nitric oxide (146) and then a small quantity of a solution of pure potash. No change ensues; but if one measure of oxygene gas be added, there is an absorption of gas equal to five measures. All the oxygene, and four measures of nitric oxide have disappeared, and the alkaline properties of the potash are neutralized, and crystals of hyponitrite of potash may be procured.

Hyponitrous acid has not been procured in an insulated form, but always in combination with some basis. Its nature, and the proportion of its constituents are evident from its mode of formation. It is composed of

Nitrogene 1 prime=14, or 1 volume
Oxygene 3 primes 8×3=24, or 1.5 volume.

its prime equivalent will be=38. (Gay Lussac.)

Hyponitrous acid is doubtless formed when nitric oxide gas is mixed with atmospheric air. (*Silliman's Journal.*)

148. (*a*) When two measures of oxygene gas, and one of nitric oxide are mixed, they unite and form a deep orange colored vapor, which is nitrous acid vapor. The condensation is equal to two measures. The experiment must be made in vessels exhausted of air, as the vapor produced is rapidly absorbed by water, and by mercury.

(*b*) Nitrous acid vapor is of a red orange color, pungent suffocating odor and sour taste.

100 cubic inches weigh 48.69 grs. Its specific gravity is 23 ? By cold and pressure the vapor is reduced to a liquid (*d*)(Dulong.)

(*c*) This vapor supports the combustion of a candle, or phosphorus, or charcoal; but extinguishes that of sulphur. This vapor is readily absorbed by water; the solution is of a green color and a sour taste.

(*d*) The liquid nitrous acid is procured by distilling nitrate of lead. The vapor which is generated is to be exposed to a low temperature, at least to—4F. The liquid acid is at that temperature colorless and transparent; at 15° it becomes yellowish; at 32° fawn colored; orange at 60°; and the color grows deeper and deeper as the liquid approaches its boiling point, which is only 82°F—The sp. gr. of this acid is 1.45.

When dropped into water, it suffers decomposition; nitric acid is formed, and nitric oxide evolved, which is in part retained by the liquid, and gives it a green color.

When acted upon by salifiable bases, both nitrate and nitrite are formed.

(*e*) The composition of this acid is shown both by analysis and synthesis. It is composed of

Nitrogene	1 volume or 1 prime	14
Oxygene	2 volumes or 4 primes	=8X4=32
and its prime equivalent is		46

149. (*a*) *Nitric acid* is obtained when pure nitre is distilled in glass vessels, with an excess of pure sulphuric acid. The common nitric acid—(*aqua fortis*,)—procured by the distillation of common nitre 112 lbs. and common oil of vitriol 56lbs. is not pure, but may be rendered so by the addition of nitrate of silver, and nitrate of barytes, and redistillation from a little pure nitre.

(*b*) Nitric acid is a colorless and transparent liquid, of a pungent smell, and very sour, corrosive taste; it stains the cuticle yellow. Its specific gravity varies with its strength; the strongest is 1.5, and it then contains 79.7 per cent. of real acid,and 20.3 of water; 1 proportion of acid and 7 of water. Nitric acid of 1.5 boils at 210°, but the weaker acid requires a higher temperature for ebullition; and acid of 1.42 requires a temperature of 248° for boiling, and then distils unaltered; acid weaker than 1.42, grows stronger by boiling, and acid stronger than 1.42, weaker. The strong acid freezes and becomes solid at—60°F.

(*c*) Nitric acid dissolves nitric oxide gas, and suffers some remarkable changes in color according to the quantity of gas dissolved. The *common nitrous acid*, is nitric acid holding nitrous gas in solution. Nitric acid is decomposed with great ease; light effects the decomposition, and many metals and inflammable bodies decompose it by the aid of heat.

Strong nitric acid absorbs water from the atmosphere. Nitric acid combines with the salifiable bases and forms *nitrates*.

(*d*) The acid is of extensive use in the arts; it is employed for etching on copper, as solvent of metals, and as a tonic in medicine, and for other purposes.

(*e*) When nitric acid in vapor is passed through a red hot porcelain tube, it is resolved into oxygene and nitrogene gases, in proportion of 2.5 of oxygene and 1 of nitrogene. And the composition is also shown by synthesis; 100 volumes of oxygene uniting with 133.3 of nitric oxide. The latter consists of equal volumes of oxygene and nitrogene. Nitric acid is composed of

Nitrogene 1 prime	=14=	1 volume
Oxygene 5 primes	8X5=40	2.5 volumes.
and its equivalent number is	54	

Nitric acid was known to the alchymists. Its composition was discovered by CAVENDISH, who produced it by passing a succession of electric sparks through a portion of common air confined over a solution of potash. Nitre was thus obtained.

The ratio of the oxygene to nitrogene in the several compounds of these bodies affords an elegant illustration of definite and multiple combination.

Nitrous oxide,	1	prime	of nitrogene	=14+one	prime	oxygene=8
Nitric oxide	1	"	"	14+two	"	oxygene=16
Hyponitrous acid	1	"	"	14+three	"	oxygene=24
Nitrous acid	1	"	"	14+four	"	oxygene=32
Nitric acid	1	"	"	14+five	"	oxygene=40

150. *Nitro muriatic acid,*—(*aqua regia.*)—When two parts of nitric and one of muriatic acid are mixed with each other, they suffer mutual decomposition. Heat is produced on mixture, and bubbles of gas are evolved; chlorine is extricated, as is indicated by its smell. The nitric acid yields oxygene to the hydrogene of the muriatic acid; water is formed, and nitrous acid produced. This acid owes its power of dissolving gold to the chlorine it contains.

151. *Nitrogene and chlorine.* This compound may be formed indirectly, by exposing chlorine gas in a tall vessel over a solution of nitrate or muriate of ammonia; at the temperature of 60° or 70° the gas is absorbed, and an oily matter is formed, which sinks in water. This is chloride of nitrogene. Its odor is strong and pungent, Its sp. gr. is 1.65. It is not easily congealed by cold; and is very volatile; distils at 160°, and is decomposed with violence at 212°. It is dangerously explosive; a small globule, not larger than a pin's head, produces violent detonation. The contact of the fixed oils, or of phosphorus, causes it instantly to explode. Alcohol converts it into a white substance. Mercury decomposes it and evolves the nitrogene.

It consists of

1 volume of nitrogene or 1 prime =14
4 " chlorine or 4 primes 36×4=144

152. *Nitrogene and Iodine.* When iodine is placed in water of ammonia, hydriodic acid is formed, and a brown powder is produced, which is composed of nitrogene and iodine. It explodes on the slightest touch, and the peculiar color of iodine may be then noticed; it explodes by heat, and should therefore be dried upon some absorbent substance; it evaporates when exposed to the air.

153. *Nitrogene and hydrogene*—*Ammonia*—This compound is an ALKALI. There are many bodies, products of chymical operation which are called alkalies; they posses the following general properties, viz.

(*a*) They have an acrid and peculiar taste.

(*b*) They change vegetable blue colors to a green; yellows, to a brown, and reds to a purple.

(*c*) They corrode and dissolve animal bodies; and form soaps with oils.

(*d*) They combine with the acids and form salts.

153 (*bis*) When two parts of dry quick lime and one of muriate of ammonia (*sal ammoniac*) are introduced into a retort and a gentle heat applied, an elastic fluid is generated, which is ammoniacal gas. It must be collected over mercury; the gas may be deprived of moisture by passing it through fused chloride of calcium contained in a thin glass tube, covered with muslin, moistened with ether.

(*b*) Ammonia possesses the transparency and mechanical properties of air; it has a very pungent smell, and an acrid taste. 100 cubic inches weigh 18 grs. Its sp.gr. is 8.5. (*c*)It extinguishes flame; but burns with flame if a wide mouthed vessel be used to contain the gas on which the experiment is made (SILLIMAN.) It renders many vegetable blues, green, and yellows, red.

(*d*) When ammonia is passed through a red hot iron tube, it is decomposed. A succession of electric sparks passed through the gas decomposes it. (HENRY.) One volume of ammonia affords, by its decomposition two volumes of a mixture of hydrogene and nitrogene; consisting of three of hydrogene and one of nitrogene. It is composed of

$$\left.\begin{array}{l}\text{Nitrogene. 1 prime}=14\\ \text{Hydrogene: 3 primes}=3\\ \hline\end{array}\right\}\text{ or }\left\{\begin{array}{l}\text{1 volume}\\ \text{3 volumes}\end{array}\right\}\text{ condensed to two.}$$

its equivalent number is 17

This gas is often produced during the decomposition of animal substances, and is formed during the rapid action of nitric acid on some metals.

(*e*) It is speedily fatal to animals plunged into it.

154. *Ammonia and water.* Water rapidly absorbs ammonia; it condenses 460 times its bulk at 50°, and expands in volume; the specific gravity of this water of ammonia varies with its strength, the lightest being the strongest.

Sp. gr. 0.8750	32.5 ammonia	67.5 water	
0.9435	14.5 "	85.47 "	
0.9692	9.5 "	90.5 "	(DAVY.)

Ice when introduced into ammoniacal gas, melts with great rapidity, and forms liquid ammonia. Ammonia is always employed in medicine and the arts, in solution.

155. Ammonia combines with acids, producing a class of salts, which are generally soluble in water, volatile and decomposable by heat, and evolve the odor of ammonia when mixed with quick lime or potash, and produce a yellow precipitate with muriate of platina.

(*a*) *Chlorate of ammonia*, is produced by adding carbonate of ammonia to chloric acid; it crystalizes from its solution, in needles; has a sharp taste and produces a slight detonation on burning coals, it consists of

Ammonia 1 prime 17 + chloric acid, 1 prime = 76.

(*b*) *Iodate of ammonia*, is a crystaline salt decomposable by heat. *Hydriodate* of ammonia, is a soluble, deliquescent salt; volatile, but not decomposable by heat in close vessels.

(*c*) *Muriate of ammonia* (*sal ammoniac*) is produced when muriatic acid gas and ammoniacal gas are made to act on each other in equal volumes; as it usually occurs, it is in meniscus shaped cakes, of a greyish white color and penetrating taste; it is tough and not easily reduced to powder. It is soluble in water, and from this solution may be procured in crystals. It sublimes by heat without decomposition, and is employed in the arts for a variety of purposes. It occurs native in several parts of the world, especially near volcanoes. It consists of

Ammonia 1 prime=17+Muriatic acid 1 prime=37.

(*d*) *Nitrate of ammonia.* This salt is readily procured by adding carbonate of ammonia to dilute nitric acid and evaporating the liquid; the form under which the salt is presented, depends on the degree to which the evaporation is carried; it may be obtained in six sided prisms, or in fibrous masses, or in more compact cakes; its taste is acrid and bitter: it is soluble in water, and decomposed by heat. It is employed for obtaining the exhilarating gas. It is composed of ammonia 1 prime=17, and nitric acid 1 prime=54, united with variable proportions of water according to the peculiar state in which it is obtained; neglecting the water, it may be considered as composed of two primes of nitrogene, three primes of hydrogene, and five primes of oxygene, and by its decomposition by heat to produce the exhilarating gas, two primes of nitrogene unite to two of oxygene and form the nitrous oxide; the remaining three primes of oxygene unite to the three of hydrogene to form water; and there are no other products.

OF THE ATMOSPHERE.

156. The atmosphere is essentially composed of oxygene and nitrogene gases, probably mixed with each other, and it surrounds the earth to a great height. Besides oxygene and nitrogene, it is evident that the other gaseous matters which are produced at the earth's surface, together with vapor of water must occasionally exist in the air; but none exists in it, in an appreciable quantity, but carbonic acid gas and vapor.

(*a*) The atmosphere when seen in a large body appears of a blue color, hence the appearance of the sky and of distant mountains. The color of the blue is deeper in proportion as the atmosphere is free from vapors of any kind, and on the top of high mountains the blue verges to black. An instrument has been invented called the *cyanometer*, to determine the shade of blue which the heavens present, and thence infer the clearness of the air.

(*b*) 100 cubic inches of air weigh 30.698 grains. (Biot.) It is 820 lighter than water, and 14.5 heavier than hydrogene.

The weight of atmospheric air, is shown by weighing an exhausted flask, and then observing its increase of weight when filled with air.

The mechanical properties of the air are exhibited by means of the air pump; it is constructed on the same general principles as a common pump, excepting that the valves and other parts are fitted with more accuracy.

The pressure of the atmosphere is shown by the force with which a bell glass, exhausted of air, is held upon the plate of the air pump; and this pressure is exerted in all directions. In a common pump the water is forced into the partial vacuum in the machine, by the pressure of the external air; and the same pressure sustains the column of mercury in the barometer; the space or vacuum above the mercury in a barometer is called the *Torri cellian vacuum.*

(*c*) There are many ways of ascertaining the proportion of oxygene and nitrogene in the air; the processes are founded upon the abstraction of oxygene; and as the salubrity of the air was supposed to depend on the quantity of oxygene it contained, the analysis of the air was called *eudiometry*; the instruments employed, eudiometers.

1. A solution of the alkaline sulphurets absorbs oxygene; they were employed by Scheele, and a peculiar apparatus for using them was invented by Dr. Hope, and improved by Dr. Henry.

2. *Nitric oxide gas*, has been employed with different success by different experimenters; the method of Gay Lussac is the best; 100 parts of atmospheric air are to be introduced into a wide vessel over water, and then the same volume of nitric oxide gas added; red vapors are produced, and the absorption is complete in one minute; the amount of the diminution, divided by 4 gives the per cent. of oxygene. 100 vols. air + 100 of nitric oxide, diminish $84 \div 4 = 21$. In this analysis of the air, nitrous and hyponitrous acids are formed. One half the oxygene 10.5 vols. unite with 42 of nitrous gas and form hyponitrous acid; and the remaining 10.5 of oxygene unite to 21 of nitrous gas and form the nitrous acid; and the whole condensation is 84 vols. (*See Silliman's Journal.*)

3. Nitrous gas may be dissolved in a solution of chloride of iron, (muriate) and employed in eudiometry, as first proposed by Davy.

4. Phosphorus may be heated in a given portion of air; but the most eligible method of using phosphorus, is that proposed by Berthollet. A stick of phosphorus is introduced into a given portion of air over water, white vapors are produced by the combination of phosphorus with oxygene, which are rapidly absorbed by water; the residual gas is increased about 1-40th of its bulk, by dissolving a portion of phosphorus, which of course must be substracted.

5. Hydrogene gas is elegantly employed as an eudiometric substance; a given portion is mixed with atmospheric air, and the mixture fired in a strong glass tube, by the electric spark; one third the diminution of volume indicates the oxygene; this is VOLTA's method; an improved apparatus for firing the mixed gases was invented by Dr. URE. An easy and correct mode of using hydrogene gas,in the analysis of air,and one which is remarkable for its simplicity,is that proposed by DOBEREINER,and founded on his discovery of the singular power which finely divided platinum possesses, of determining the combination of hydrogene with oxygene. A quantity of spongy platina is made into a small pellet with pure alumine,and then heated nearly to redness; this after it is cool may be introduced into a mixture of hydrogene and atmospheric air in a glass tube over mercury; water is instantly produced, and the quantity of oxygene is known by dividing the diminution by 3. A mixture of oxygene and hydrogene so dilute that it cannot be inflamed by the electric spark, may be made to unite by this preparation of platinum.

(*d*) Air from various parts of the world, from great heights above the surface, and great depths below it, from healthy and unhealthy situations, has been found by various analyses to consist principally of oxygene and nitrogene gases, in the ratio of

$$\left.\begin{array}{llll} 21 \text{ volumes or} & 23.3 \text{ per cent. of} & \text{oxygene} \\ 79 \quad \text{“} & \text{or } 76.7 \quad \text{“} & \text{nitrogene.} \end{array}\right\} \text{nearly.}$$

A small portion of carbonic acid, less than one part in 100, exists in the atmosphere; it may be detected and its quantity determined by lime water.

(*e*) This singular uniformity of composition in the atmosphere, notwithstanding the difference in the gravity of the gases, has been explained on several suppositions; perhaps it depends on the different electrical states of the gases, which are not sufficient to overcome their elasticity,but only to produce an uniform mixture; the experiments of DALTON and BERTHOLLET favor this view of the subject.

(*f*) The presence of water in the atmosphere is indicated by the exposure of deliquescent salts, or strong sulphuric acid to its action; instruments called *hygrometers*, or *hygroscopes*, have been invented to determine the relative humidity of the air. The most perfect instrument of the kind, which indicates the absolute and relative humidity, was invented by Mr. DANIEL, (BRANDE's *Journal*, *Vol.* 8 *et seq.*) 100 cubic inches of atmospheric air, and of all other gases, contain at 60°F. nearly 1-3 grain of aqueous vapor.

157. In all accurate experiments, where gases are concerned, due attention should be paid to the change of volume they suffer by changes of atmospheric pressure, and by changes of temperature, and proper allowance made for the moisture they may contain. Rules for estimating the amount of these various influences may be found in the excellent Manual of Mr. BRANDE, and in Dr. HENRY's Chymistry, and in many other works.

OF SULPHUR. (16)

158. (*a*) SULPHUR is found crystallized and amorphous; of a yellow color, opaque, or semi-translucent; has a peculiar odor; is gritty between the teeth; and very brittle. Sp. gr. about 2. Sulphur is a non-conductor of electricity; becomes electric by friction; the kind of electricity developed depends on the substance by which it is excited. It possesses inferior conducting powers for heat.

(*b*) Sulphur suffers peculiar changes by elevation of temperature. At 180° the odor is very strong; at 220° it fuses; and as the temperature rises, it continues to increase in volume, but becomes viscid; at a temperature between 350° and 400° it becomes of a deep chocolate color; and if it be now poured into water, it remains soft and ductile like wax for some time. In this state it is employed for making sulphur casts. At 580° sulphur sublimes in close vessels, and forms the *flowers of sulphur.*

(*c*) Sulphur unites with water, but is not soluble in that fluid. When an acid is added to a solution of an alkaline sulphuret, a white precipitate falls, which is hydret of sulphur. (THOMSON.) It may be procured also by subliming sulphur in vessels filled with steam, or by dropping water on melted sulphur. Sulphur combines with many other bodies, forming a very important class of compounds.

(*d*) Sulphur is found pure and crystallized in the vicinity of volcanoes, but its principal source is from roasting certain metallic sulphurets.

(*e*) Sulphur is employed for various purposes. It forms an ingredient in gun powder, and in vermilion, and is used in bleaching woollens, silk and straw.

159. *Sulphur and oxygene*, unite in four proportions.

(*a*) *Hyposulphurous acid.* This compound may be obtained by passing a current of sulphurous acid gas through a lixivium made by boiling pure strontia or barytes and sulphur in water. Sulphur is precipitated, and the earth is converted into a *hyposulphite;* the earth may be separated by sulphuric acid. It can hardly be obtained pure, and is generally in combination with some base. Hyposulphurous acid has a strong tendency to form compound salts with oxide of silver and alkaline bases. Its acid powers are feeble, and the neutral hyposulphites appear to contain two primes of the acid.

(*b*) It is composed of

Sulphur 1 prime=16
Oxygene 1 prime 8

Its equivalent number is =24

Its habitudes have been investigated by Mr HERSCHEL (*Ed. Phil. Jour.* 1 & 2.)

(*a*) *Sulphurous acid.* This compound is procured by boiling oil of vitriol on mercury or tin in a retort. The gas is to be collected over mercury. It may also be procured by burning sulphur in oxygene gas.

(*b*) By passing the gas over fused chloride of lime, into a matrass whose temperature is kept at zero by being surrounded by snow and salt, it is reduced to a liquid state. (Bussy.) Fluid sulphurous acid is colorless and transparent, and very volatile. Specific gravity 1.45. It boils at 14°; it produces great cold during evaporation. When dissolved in water nearly to saturation, the acid collects at the bottom of the vessel; and if touched there with a glass rod, is evaporated.

(*c*) *Sulphurous acid gas* is a colorless, transparent elastic fluid, of a pungent smell, like that of burning sulphur, and of an acid taste. 100 cubic inches weigh 67.75. Its specific gravity is 32.

(*d*) Sulphurous acid gas is not combustible, nor does it support flame. It first reddens, then destroys vegetable colors. It is decomposed by hydrogene at high temperatures.

(*e*) It is found in a gaseous state near the craters of some volcanoes.

(*f*) It is composed of oxygene and sulphur, the volume of the former not being altered; hence its proportions may be learned by the difference in the specific gravity of oxygene, and of sulphurous acid. It consists of

Sulphur 1 prime =16
Oxygene 2 primes 8X2=16

its equivalent number is 32.

(*g*) It is extensively employed in bleaching woollens and silks, and fabrics of straw.

160. *Sulphurous acid and water.* Water absorbs 33 times its volume of sulphurous acid, and acquires the peculiar smell, taste and the bleaching powers of the gas. The gas is not expelled from the water by freezing. It remains combined with the ice, and renders it heavier than water. Boiling disengages the gas; the solution absorbs oxygene, and oil of vitriol is formed. Chlorine in the solution occasions the formation of muriatic and sulphuric acids.

161. Sulphurous acid unites with the salifiable bases and forms *sulphites.* They are all converted into sulphates on exposure to the air, by absorbing oxygene. A strong heat decomposes them or converts them into sulphates, and they have all a sharp disagreeable sulphurous taste. (Ure.) They are not applied to any use.

162. (*a*) *Hyposulphuric acid* is procured by passing a current of sulphurous acid through water in which black oxide of manganese is diffused. A neutral solution is obtained containing Hyposulphate, and sulphate of manganese Barytes is then added; and after separating the precipitate, the solution consists of Hyposulphate of Barytes. A cautious addition of sulphuric acid precipitates the Barytes.

(*b*) Hyposulphuric acid is a colorless and transparent fluid. By exposure under an exhausted receiver with sulphuric acid, it may be concentrated. A heat below 212° decomposes it, and sulphurous and sulphuric acids are formed.

It consists of

Sulphur	2 primes	16X2=32
Oxygene	5 primes	8X5=40
		72

It may be considered as composed of 1 prime of sulphurous acid, and 1 of sulphuric.

(*c*) This acid, whose history and nature have not been elucidated, was first recognised by Gay Lussac and Welther.

163. Hyposulphuric acid combines with salifiable bases, forming *Hyposulphates*. They are all soluble; and when mixed with sulphuric acid yield sulphurous acid by heat; and by the aid of a high temperature form neutral sulphates.

164. *Sulphuric acid* is procured by burning a mixture of about 15 parts of sulphur and 2 of nitre in leaden chambers, the floors of which are covered with water; the water becomes acid, and, by concentration and distillation, yields sulphuric acid or oil of vitriol. The sulphur, by burning, forms sulphurous acid gas; and the nitre affords nitric oxide gas, which, coming in contact with atmospheric oxygene,forms red vapors; between which and sulphurous acid there is no action, unless moisture be present. But when a certain portion of moisture is present, the two gases act on each other, and form a white solid, which is instantly decomposed by water. The nitrous vapors yield a portion of oxygene to the sulphurous acid, and convert it to sulphuric acid, while they revert to the state of nitric oxide, and again coming in contact with atmospheric air, perform the same office of receiving oxygene and transfering it to a new portion of sulphurous acid.

165. Sulphuric acid exists in the solid, or fluid form. In the former it is *anhydrous;* in the latter, combined with variable proportions of water.

166. *Anhydrous sulphuric acid*, which is procured by the distillation of green vitriol, is an opaque white solid, difficult to cut, and fuming in the air. It is fusible, and when liquid, it is more fluid than oil of vitriol; it is highly refractive; it is more easily vaporized, than fused. Its specific gravity is 1.97. It is deliquescent, and when put into water dissolves with a hissing noise, and oil of vitriol is formed. When dissolved in oil of vitriol, it forms a fuming liquor; the anhydrous acid forms a *red* solution of indigo, and unites with bases, and produces sulphates.

167. (*a*) *Liquid Sulphuric acid* (oil of vitriol) is a colorless, transparent fluid, of an oily consistence, without smell, but of an intensely sour taste, even when largely diluted with water. The brown color of the acid of commerce is generally owing to the accidental introduction of vegetable matter.

The specific gravity of sulphuric acid varies with its strength; the strongest being most dense; the strongest is 1.846, and contains 81.63 per cent. of real, or anhydrous acid.

(*b*) Sulphuric acid has a strong attraction for water. When exposed to the atmosphere, it absorbs vapor and increases in volume. From its attraction for water, it has been employed in artificial refrigeration. (*See* 108. *f.*) Concentrated sulphuric acid, mixed with water, produces a great elevation of temperature, 4 parts of acid and one of water at 50° produce a mixture, whose temperature is about 300°. Acids of different density freeze with different degrees of facility: that of 1.78 freezes as easily as water. (MURRAY'S *System.*) By exposure to a red heat in a porcelain tube, oil of vitriol is resolved into sulphurous acid, oxygene, and water; it is decomposed by some of the metals.

(*c*) Sulphuric acid is found in a liquid form in Java and in some other parts of the world. (SILLIMAN'S *Jour. Vol.* 1.)

(*d*) Sulphuric acid consists of

Sulphur	1 prime	16	=	anhydrous acid	40
Oxygene	3 primes	24		water	9
Water	1 prime	9			——

The water is evolved when it combines with salifiable bases, and its equivalent number is 40.

(*e*) This acid is of great importance in the arts, and in chymical investigations.

(*f*) It was known to the alchymists.

168. Sulphuric acid, when dropped into a hot and concentrated solution of iodic acid, forms *Iodo-sulphuric acid*, a yellow, fusible, crystallizable compound, which is partially decomposed by heat.

169. Sulphuric acid, with salifiable bases forms sulphates; those which are soluble give a white precipitate with any soluble salt of Barytes; heated with charcoal, they are converted to sulphurets.

170. *Sulphate of ammonia* is formed by passing ammoniacal gas into sulphuric acid, or adding carbonate of ammonia to the point of neutralization. It crystallizes in hexangular prisms; is of a pungent and bitter taste; exposed to heat, it loses a portion of ammonia, and a *bisulphate* remains. It is employed as a source of muriate of ammonia, being heated with chloride of sodium, or common salt. It occurs native about the craters of volcanoes, and near some Tuscan lakes.

Sulphate of ammonia consists of

Sulphuric acid	1 prime=40
Ammonia	1 prime=17
	——

Bisulphate of ammonia, of

Sulphuric acid	2 primes=80
Ammonia	1 prime =17
	——

171. *Sulphur and chlorine* unite when they are heated together. Chloride of sulphur is a greenish fluid of a pungent suffocating odor; and of sp. gr. 1.6. It does not possess acid properties; by the action of water it forms sulphurous and muriatic acid, while a portion of sulphur is deposited.

It consists of

Sulphur	1 prime=16
Chlorine	1 prime 36

It was first procured by Thomson.

172. *Sulphur unites with Iodine;* a black solid crystallizable compound is formed; it was first examined by Gay Lussac.

173. *Sulphur and hydrogene* unite and form *sulphuretted hydrogene*, and according to most chymical books, *super-sulphuretted hydrogene;* the existence of the latter is doubtful.

(*a*) *Sulphuretted hydrogene* is procured by acting on protosulphuret of iron with diluted sulphuric acid; it is to be collected over warm water. At common temperatures it is gaseous, colorless, and invisible; but of a strong, fetid, disagreeable odor. 100 cubic inches weigh 35.89 grs. Its sp. gr. is 17.

(*b*) *Sulphuretted hydrogene* is combustible. It burns with a blueish flame, depositing sulphur; the combustion is rapid if it be previously mixed with atmospheric air, or oxygene gas,

It possesses distinct acid properties; and reddens delicate vegetable blue colors. It has been called *hydrosulphuric acid*, and *hydrothionic acid.* It is absorbed readily by water; this fluid takes up twice the bulk of gas, and acquires a sweetish and nauseous taste, and the intolerable odor of the gas. The solution is employed as a test of metals; it suffers decomposition on standing, and sulphur is deposited.

Chlorine and iodine decompose this gas, and a few drops of nitric acid introduced into a phial of it produces its decomposition.

(*d*) Sulphuretted hydrogene is composed of

Sulphur	1 prime=16
Hydrogene	1 prime= 1

The volume of hydrogene is not altered by combination with sulphur.

(*e*) It is very fatal to animal life; some birds speedily die, when confined in an air containing only $\frac{1}{1500}$ of the gas. Its application to the external surface has proved fatal.

174. Sulphuretted hydrogene combines with the salifiable bases, and forms hydrosulphurets.

175. *Hydrosulphuret of ammonia.* When the two gases come in contact, they unite in equal volumes, and produce a yellow crystallizable compound; it may also be procured by passing a current of the gas through water of ammonia.

When concentrated it evolves white fumes, and has a peculiarly nauseous smell. It consists of

Sulphuretted hydrogene	1 prime=17
Ammonia	1 prime=17

It has been employed in the practice of medicine.

175. (*bis*) *Sulphuretted hydrogene and sulphurous acid.* When three volumes of the former, and two volumes of the latter, both perfectly dry, are mixed together over mercury, they are entirely condensed into a solid body of an orange yellow color.

(*a*) Its taste is acid, hot, and permanent.

When it is perfectly dry it does not redden litmus paper, but immediately produces that effect when moist. It is decomposed by water, alcohol, nitric and sulphuric acid, and sulphur is sepated. A moderate heat decomposes it, and pure sulphur remains.

(*b*) It was discovered by THOMSON; he considers it as an acid, and calls it *hydrosulphurous acid*, and states its composition to be

Sulphur	5 primes	80
Oxygene	4 primes	32
Hydrogene	3 primes	3

(HENRY's *Chym.*)

OF PHOSPHORUS. (12)

176. (*a*) PHOSPHORUS is procured by distilling solid phosphoric acid mixed with its weight of powdered charcoal, in a coated earthen retort, whose beak is plunged beneath the surface of water during the operation. When the body of the retort attains a full red heat, a large quantity of gaseous matter escapes, and a substance distils, over which is a reddish color, and of the consistence of wax; this is impure phosphorus; it is purified by being melted under the surface of warm water, and there squeezed through a piece of fine shamoy leather. An impure phosphoric acid is used for procuring phosphorus; it is obtained by mixing five parts of calcined and powdered bones with two of sulphuric acid; washing off the soluble matter, and evaporating it to dryness, and distilling the dry substance with charcoal.

(*b*) Pure phosphorus is of a light amber color, semi-transparent, and when broken exhibits a crystalline texture; it is tasteless, and when exposed to the air produces white acid fumes which have a fetid odor. Its sp. gr. is 1.77.

Phosphorus melts at about 109° in close vessels; heated to 140 or 150° and suddenly cooled it becomes black; at 550°, it boils and evaporates.

(*c*) Phosphorus combines readily with oxygene, and easily bursts into flame, by a moderate elevation of temperature, when exposed to the air; hence it is kept in water, and requires great caution in experimenting with it.

(*d*) When exposed to light under the surface of water, it effects a decomposition of the liquid.

It is soluble in oils, ether and alcohol.

It has been employed for aphrodisiac powers; in large quantities it is a virulent poison.

(*e*) It was discovered by KUNKEL.

177. *Phosphorus and oxygene.* When a piece of inflamed phosphorus is introduced into oxygene gas, a most vivid and brilliant combustion is produced; there are three acids produced by the union of phosphorus with different proportions of oxygene. The existence of a definite oxide of phosphorus is doubtful.

Hypophosphorus acid is procured by the action of phosphuret of barium on water; after the inflammable gas, which is produced, ceases to be given out, sulphuric acid is to be added to the *filtered* liquor as long as it causes a precipitate. The clear liquor then contains hypophosphorus acid. It is a colorless and transparent liquor, and by concentration becomes viscid; it absorbs oxygene, and combines with salifiable bases to form *hypophosphites*. It consists of

Phosphorus	2 primes=12X2=	24
Oxygene	1 prime 8 =	8

Its equivalent number is 32

178. *Hypophosphites* are all soluble in water, while many phosphites and phosphates are insoluble.

179. *Phosphorous acid.* This is procured by dissolving chloride of phosphorus in water, and heating the fluid to expel the muriatic acid which is formed by the decomposition of the water, and the union of its hydrogene with the chlorine.

The clear liquid by concentration yields a white crystaline solid of a very sour taste, and soluble in water. When heated in open vessels, a spontaneously inflammable gas is produced, and it is converted into phosphoric acid. It consists of

Phosphorus	1 prime	12
Oxygene	1 prime	8

And its equivalent number is 20

It was first obtained pure by DAVY.

180. Phosphorous acid forms, with the salifiable bases, a class of salts called *Phosphites*, very few of which have been examined.

Phosphite of ammonia is obtained by neutralizing the acid with ammonia; it is crystallizable in thin tables; decomposed by heat, and soluble in a small quantity of water.

181. *Phosphoric acid* is produced by combustion of phosphorus in pure oxygene gas, in the form of a white floculent solid, which is deliquescent, and by absorption of moisture passes to the state of liquid Phosphoric acid. Phosphoric acid may also be procured by adding to warm nitric acid in a retort,small pieces of phosphorus as long as they produce any action,and afterward exposing the liquid to heat in a pure platinum crucible. The phosphorus decomposes the nitric acid, and unites with part of its oxygene.

(*b*) Phosphoric acid is a liquid of an oily consistence, transparent and colorless, inodorous, and of a very sour taste. By exposure to heat, water is separated,and a solid glassy substance remains, called *Glacial phosphoric acid*, the sp. gr. of which is 2.85. Phosphoric acid possesses the usual properties of strong acids, but is hardly *corrosive*, like oil of vitriol. It is decomposed when heated with charcoal, or with some of the metals.

Phosphoric acid consists of

Phosphorus	1 prime		12
Oxygene	2 primes	8X2	16

And its equivalent number is 28

This acid exists in many substances. Combined with lime, it forms the principal portion of the earth of bones.

182. Phosphoric acid with the salifiable bases form *Phosphates.*

Phosphate of ammonia is procured by saturating the acid with ammonia. It crystallizes in 8 dra.; is soluble in water, and has a bitter saline taste. It is composed of

Phosphoric acid	1 prime	=28
Ammonia	1 prime	17

183. Phosphorus by slow combustion in the air produces white fumes which may be condensed in water and form an acid, which has been called *phosphatic acid.* It is probably a mixture of phosphorous and phosphoric acids. When neutralized by alkalies, it produces *phosphites* and *phosphates.* Its composition, however, according to DULONG is very uniform, consisting of

Phosphorus 3 primes=12X3=36
Oxygene 5 primes= 8X5=40; or

2 proportions of phosphoric acid=2phos+4 ox.=24+32=56 and
1 proportion of phosphorous acid=1 phos+1 ox.=12+ 8=20.

184. *Phosphorus and chlorine.* When phosphorus is introduced into chlorine gas, it takes fire spontaneously, and burns with a pale flame. A white substance is formed, which is volatile at 200°, fusible and crystallizable. When put in contact with water, *phosphoric* and *muriatic acids* are produced. It is decomposed at a red heat by oxygene gas. It consists of

Phosphorus	1 prime	=12
Chlorine	2 primes	36X2=72,

and is a *perchloride* of phosphorus.

The protochloride of phosphorus is procured by distilling phosphorus with corrosive sublimate (perchloride of Mercury.) It is a clear limpid liquor, which in contact with air exhales acid vapors, but it is not acid itself. It affords by the action of water, *phosphorous* and *muriatic acids.* It consists of

1 prime of phosphorus =12
1 prime of chlorine =36

185. *Phosphorus and Iodine* readily unite; they must be made

to act on each other in exhausted vessels: an iodide of phosphorus is thus formed. It is of reddish color, and decomposes water, affording phosphorous, and hydriodic acid. It consists of

Phosphorus	1 prime= 12
Iodine	1 prime=125

A periodide of phosphorus is formed by heating phosphorus with a great excess of iodine. It is a dark colored compound, which does not decompose water. It consists of

Phosphorus	1 prime	= 12
Iodine	2 primes	125×2=250 (THOMSON.)

186. *Phosphorus and Hydrogene.* These two substances unite and form two distinct gaseous compounds.

(*a*) *Phosphuretted hydrogene* is evolved in many processes. It may be procured for common experiment by boiling phosphorus in caustic potash, with a few small pieces of quicklime. The retort which contains these materials should be filled with hydrogene or nitrogene gas. It may be collected over water.

(*b*) It is colorless and transparent; of very nauseous odor, and a bitter taste.

100 cubic inches weigh 27.52 grs.; its sp. gr. is 13.

(*c*) Phosphuretted hydrogene takes fire spontaneously in the air. A bubble of the gas, passing through water, breaks in the air, and burns with a bright flash. A wreath of white vapor ascends, and enlarging as it rises, forms a beautiful object. In oxygene, chlorine, and nitrous oxide gas it burns with splendor. In a *small* tube it may be mixed with oxygene without explosion. It is soluble in water, and communicates to it its taste and smell.

(*d*) It consists of

Phosphorus	1 prime=12
Hydrogene	1 prime 1

The hydrogene suffers no change of volume by combination with phosphorus.

(*e*) The properties of this gas have been successfully studied by THOMSON.

(*a*) *Subphosphuretted hydrogene* is procured by heating concrete phosphorous acid in a small retort: a gas is evolved which must be collected over mercury.

(*b*) It is colorless, and of a fetid odor. 100 cubic inches weigh 29.64 grs. Its sp. gr. is 14.

(*c*) It is not spontaneously inflammable; it detonates when heated with oxygene, and burns spontaneously in chlorine.

It consists of

Phosphorus	1 prime=12
Hydrogene	2 primes= 2

It was first procured by DAVY.

187. *Phosphorus and sulphur* may be united in several proportions. A combination of 16 sulphur with 12 of phosphorus, will bear a high temperature with decomposition: it is a crystalline solid.

OF CARBON. (5)

188. Lampblack, well heated in close vessels, and the pure inflammable part of well burnt charcoal, consist of *carbon*. There is no chymical difference between them,and the *diamond*. Both, afford the same products by combustion in oxygene gas, and both equally convert iron into steel. *Anthracite*,and *Plumbago* are also nearly pure carbon.

The diamond is *crystallized* carbon. Its crystals are bounded by 12, 24 and 48 facets, whose edges are rounded. It is often colored,and its colors are various. Those which are most valuable are colorless. It is transparent; has a very high lustre, and refractive power, and its hardness exceeds that of any other body. It is not altered by heat in close vessels, but burns with flame in contact with air. It is phosphorescent, and a non-conductor of electricity.

Charcoal varies in its appearance according to the vegetable from which it is procured. It is a black, shining, glossy, inodorous, brittle body, with a smooth, close grained fracture and porous texture: its specific gravity is about 2. Recently ignited charcoal is capable of absorbing many times its volume of some gases. No intimate union, however, takes place between them. This property of charcoal depends on its mechanical structure. (*See gases. f.*)

Charcoal is a good conductor of electricity; and a very imperfect conductor of heat. Exposed to the highest furnace heats, it suffers no chymical change. Its volume only is diminished. Exposed to the action of Hare's *Deflagrator* it is fused and volatilized; a result first obtained by Silliman. (*Silliman's Jour. Vol.* 5 *and* 6.)

Charcoal possesses the remarkable property of removing the taste, smell, and color from many vegetable and animal substances, especially those of an oily or mucilaginous nature. This property was first noticed by Lowitz: hence it is employed as an antisceptic. The decoloring property is inherent in the charcoal, and depends on its physical condition. That which has the least aggregation, and consequently presents the greatest surface, is best; and that, which is so much heated as to be hard and brilliant, has no perceptible decoloring power. The coloring matter is precipitated upon, and adheres to the charcoal, and increases its weight. (Bussy. *Brande's Jour. No.* 26.)

Charcoal is insoluble in water, and is almost unalterable by common agents.

All animal and vegetable bodies, and many minerals, contain carbon. It constitutes the coloring matter of the ink of the cuttle fish, and the pigmentum nigrum of the eye.

Charcoal is applied to a variety of purposes in the arts, besides that of producing heat. It is employed for reduction of oxides, and preservation of meats. It is the basis of all black paints, and forms an ingredient in gunpowder.

189. *Carbon and oxygene* combine in two proportions.

(*a*) *Carbonic oxide.* When chalk, or carbonate of barytes is heated with iron filings in an iron or earthen bottle, a gas is evolved, which is carbonic oxide. After being passed through lime water, it may be considered pure. It may be collected over water. (191.*c*.)

(*b*) Carbonic oxide possesses the mechanical properties of common air.

100 cubic inches weigh 29.64 grs. Its sp. gr. is 14.

(*c*) *Carbonic oxide* is inflammable. It burns at comparatively low temperatures, and produces but little heat during its combustion; of this, carbonic acid is the only product. Two volumes of the gas require one of oxygene, for its combustion, and afford one volume of carbonic acid.

It is slightly absorbed by water, and is decomposed by the bases of the alkalies.

(*d*) It consists of

1 prime of carbon	6
1 „ of oxygene	8

(*e*) Its action on the animal system is sedative.

It was first distinguished from hydrogene, and its properties examined by Mr. CRUICKSHANKS.

190. *Carbonic oxide* and *chlorine* unite and form a compound called *chloro-carbonous acid.* The union may be effected when equal volumes of the two gases, deprived of moisture, are exposed to the direct rays of the sun. It is a colorless, transparent gas, of a pungent odor. 100 cubic inches weigh 105.8 grains. Its specific gravity is 50.

It unites with ammonia, and is decomposed by water, forming muriatic and carbonic acid gases.

It was discovered by Dr. JOHN DAVY; and called by him Phosgene gas, because it requires the agency of light for its formation

191. (*a*) *Carbonic acid* is formed when the diamond or charcoal is burned in oxygene gas; and is obtained when coarsely powdered marble is dissolved in dilute sulphuric acid. The gas may be collected over water.

(*b*) It is colorless and transparent; without smell, and of a pungent taste.

100 cubic inches weigh 46.57 grs. Its sp. gr. is 22.

(*c*) Carbonic acid instantly extinguishes combustion, and renders lime water turbid. When passed through an iron tube containing ignited charcoal, it is converted into carbonic oxide. Iron, zinc, and some other substances, decompose it at high temperatures, and depriving it of a portion of its oxygene, converted it into carbonic oxide.

Water absorbs twice its volume of carbonic acid, and acquires a brisk and agreeable taste, and an increased specific gravity.

The gas is evolved from the liquid by freezing, or boiling, or exposure to the air. The artificial soda water, consists of water highly charged with carbonic acid gas, by the aid of machinery.

(*d*) Carbonic acid gas exists in the atmosphere. Hence the formation of a pellicle on lime water which is exposed to the air; it is produced in combustion of wood, &c. and also in respiration, and in vinous fermentation. From its gravity, it is sometimes found in deep pits and caves. It is the choak damp of the coal miners.

(*e*) It is not respirable, and is speedily fatal to animal life.

(*f*) It consists of

Carbon	1 prime	6
Oxygene	2 primes	16

And its equivalent number is 22

The volume of oxygene is not altered by combination with carbon, in forming carbonic acid.

(*g*) It is the *first* gas which was certainly distinguished from common air, and its examination, by Dr. BLACK, laid the foundation for Pneumatic Chymistry.

192. *Carbonic acid*, with the salifiable bases, forms carbonates; they all effervesce in diluted nitric acid.

Carbonic acid unites with ammonia in two proportions.

(*a*) *Carbonate* of ammonia, is formed when the two gases come in contact with each other; it may be procured by passing a current of carbonic acid through water of ammonia; it is a white, crystalline solid, having the smell of ammonia, and consists of

Carbonic acid	1 prime	=22
Ammonia	1 prime	17

(*b*) *Bicarbonate* of ammonia is formed by exposing the carbonate to the air; it loses the ammoniacal odor, and perhaps absorbs a small quantity of carbonic acid. It consists of

Carbonic acid	2 primes	44
Ammonia	1 prime	17

The common carbonate of ammonia of the shops consists of

3 primes carbonic acid	66
2 primes of ammonia	34

193. *Carbon and Chlorine.* These two bodies have not been made to act directly on each other; but they may be obtained in combination by mixing olefiant gas (194) with a great excess of chlorine; a white crystalline salt is formed, which, after washing in water, is a *perchloride of carbon*; it has a slight taste, and an odor like that of camphor; its sp. gr. is nearly 2; it does not conduct electricity, and when exposed to heat in a close vessel it boils, and is converted to vapor at 360°; it is decomposed by some of the metals, and burns in a flame; it is soluble in water and alcohol, and some other fluids. It consists of

Carbon	2 primes	12
Chlorine	3 primes	108

Proto-clhoride of carbon is procured by passing the perchloride through a red hot tube; it is a liquid, clear and colorless; sp. gr. 1.55; combustible in flame; boils at 165°, is insoluble in water and alcohol; and consists of

Carbon	1 prime	6
Chlorine	1 prime	36

These chlorides are not affected by acids or alkalies; they were discovered by Faraday.

194. *Carbon and hydrogene.* It is doubtful whether there exists more than one compound of these two bodies, viz. olefiant gas, or carburretted hydrogene; the other gases, supposed to be compounds of carbon and hydrogene, are probably mixtures of olefiant gas and hydrogene.

(*a* Olefiant gas is obtained by heating four parts of suphuric acid, with one part of alcohol in a retort; it may be collected over water.

(*b*) It is colorless, transparent and inodorous.

100 cubic inches weigh 29.63; its sp. gr. is 14.

(*c*) It is inflammable, and burns with a splendid flame; when mixed with thrice its volume of oxygene, and an electric spark passed through the mixture, or when a flame is applied to it, a violent detonation ensues; carbonic acid and water are the only products of its combustion. When exposed to a high temperature it is decomposed, and is deprived of nearly all its carbon. Sulphur heated in this gas decomposes it; two volumes of sulpurretted hydrogene are produced, and carbon is deposited.

This gas is abundantly produced by the decomposition of many bodies, and its combustion as in *gas lights*, and in common lamps, is an illustration of its practical use.

(*d*) It consists of

Carbon	2 primes	12
Hydrogene	2 primes	2

Two volumes of hydrogene in this combination are condensed to one.

195. *Carburetted Hydrogene and Chlorine* when mixed in equal volumes over water, unite and form a fluid of an oily consistence which has the properties of ether; it has been called chloric ether or hydrochloride of carbon. It has a limpid, colorless oily fluid, of a fragrant odor and agreeable taste.

Its specific gravity at 45° is 1.22, it boils at 152°, and the specific gravity of its vapor is 3.47. air being 1. It burns with a green flame, and the odor of muriatic acid is evolved; at a red heat it is decomposed. It consists of

Chlorine	1 prime	36
Carburetted Hydrogene	1 prime	14

196. The *Fire damp*, of coal mines, is probable a mixture of carburetted Hydrogene with variable proportions of hydrogene. (Brande.)

197. Carbon united to nitrogene forms *cyanogene*, which see. (205.)

198. *Carbon and Sulphur*; when sulphur is passed in vapor over charcoal ignited in a porcelain tube, a liquid is procured, which by distillation, affords pure sulphuret of carbon; it is colorless, transparent, of a pungent taste, and fetid odor; its sp. gr. is 1.27.

It is very volatile, boils at 105°; and does not freeze at 60°. It is inflammable, and affords carbonic acid and sulphurous acid by its combustion; it is not soluble in water.

It consists of

1 prime of carbon = 6
2 primes of sulphur =32.

199. When Sulphuret of carbon is added to an alcoholic solution of a fixed alkali, a peculiar play of affinities takes place, and an acid, consisting of carburet of sulphur and hydrogene is formed, (hydro-carbo-sulphuric acid,) and combines with the alkali present. The sulphur and carbon probably do not exist in the proportions to constitute carburet of sulphur,but form, without hydrogene a substance, called *Xanthogene*, because it forms *yellow* compounds with some metals; the new acid is called hydroxanthic acid; it has the appearance of an oil, is of a pungent odor and an acid taste, reddens litmus paper, and is obtained by the decomposition of xanthate of potash by muriatic or sulphuric acid, and subsequent washing with water.

If sulphuret of carbon be mixed with an alcoholic solution of ammonia, two new compounds may be procured according to ZEISE, viz. a *hydro-carbo-sulphuret* of ammonia, and a *hydro-sulphuretted-hydrosulpho-cyanate* of ammonia. The properties of this new class of compounds, produced by the action of sulphuret of carbon on alcoholic solutions of alkalies, have not been completely examined. (ZEISE, *Brande's Journal, Nos.* 28, 30 *and* 35.)

200. *Carbon and Phosphorus.* Phosphuret of carbon is produced by adding an excess of muriatic acid to phosphuret of lime and water, after the former has ceased to evolve any gas, and afterwards filtering the liquid; it is a soft yellowish powder, without taste or smell, exposed to the air it absorbs moisture, and when heated, the phosphorus takes fire and carbon remains.

It consists of

Carbon one prime = 6
Phosphorus one prime = 12 THOMSON.

It probably exists in the phosphuret of lime, as it is commonly prepared.

BORON (40 ?)

201. Heat two parts of potassium in a copper tube, with one of fused and powdered boracic acid; the latter is decomposed and yields oxygene to the former. Wash out the contents of the tube, filter and dry; *Boron* is thus procured; its sp. gr. exceeds that of water; it is a greenish brown, insipid, inodorous powder, insoluble in water, and a non-conductor of electricity, by combustion it produces *boracic acid.* When borax is heated with charcoal, an impure boron is obtained. (Thenard *Traite de chem. T.* 1.)

202. *Boracic acid* is usually procured from borax, in which it is combined with soda, by the action of sulphuric acid; it is in white silvery scales, which look and feel like spermaceti, and nearly tasteless; fusible by heat, difficultly soluble in water, and acts on *turmeric* paper like an alkali; it is soluble in alcohol, and the solution burns with a green flame; by affusion of sulphuric acid it gives a transient smell of musk. It probably consists of

Boron	1 prime	40
Oxygene	3 primes	24
		64

Its true composition is very uncertain. It has been found native. It forms *borates* with the alkalies; and enters into the composition of false gems or pastes.

203. Boron burns in chlorine, and the compound formed is a permanent gas, which is decomposed by moist air, and water, giving rise to muriatic and boracic acids. (Berzelius. *Brande, No.* 36.)

SELENIUM. (41 ?)

204. (*a*) Selenium is prepared from a substance found adhering to the walls of lead-houses, in which sulphur, from the pyrites of Fahlun, has been burnt; by a very complicated process, *seleniate of potash,* is procured, and this is heated with muriate of ammonia; a mutual decomposition of the salts takes place, and at the same time the selenic acid is decomposed by the hydrogene of the ammonia, and selenium is produced.

(*b*) Selenium at common temperatures is of a deep brown color, and metallic lustre, it has a conchoidal fracture, and internally appears like lead; it is brittle and easily powdered; in thin plates, it is transparent; it is a *non-conductor* of electricity, and an inferior conductor of heat. It melts at a temperature a little higher than 212°, and while cooling, remains for a long time soft and ductile like wax; in this state it may be drawn out into thin, transparent threads; it boils, and evaporates at a heat below redness; its vapor is of a yellow color.

(*c*) When selenium is heated in the air before the blow pipe, it is oxidized; the oxide is volatile, and has the odor of horseradish; by peculiar management, to prevent the volatizing of selenium, it may be burned in oxygene gas, and converted into *selenic acid*, which sublimes and crystallizes; it is more easily prepared by digesting selenium in nitro-muriatic acid; it has a purely acid taste, is soluble in cold water, and very soluble in warm water. It appears to be composed, according to the experiments of BERZELIUS, of

Selenium, 1 prime	41 ?	71.261
Oxygene, 2 primes	16	28.739
	57	100.000

Selenic acid unites with salifiable bases, and forms a class of salts called *seleniates*.

Selenium absorbs chlorine gas, heat is evolved, and a brown liquid, which, by an additional quantity of chlorine, is converted into a white solid; it has not yet been accurately examined.

Selenium unites with hydrogene; this compound is evolved, when the compound produced by fusing selenium and potassium together, is thrown into water acidulated with muriatic acid.

Selenuretted hydrogene has a strong fetid odor, and is absorbed by water; the solution reddens litmus paper, and stains the cuticle of a permanent brown.

Selenuretted hydrogene produces violent effects on the organs of respiration, and a sharp, tingling, painful sensation in the nostrils; this is followed by a mucous discharge, which continues many days. It is composed of

Selenium 1 prime	41	97.4
Hydrogene1 prime	1	2.6
	42	100.0

Selenium combines with sulphur and phosphorus, and unites with some of the metals.

(*d*) Selenium was discovered by BERZELIUS, and has been procured in very small quantities only. It seems to connect the inflammable non-metallic bodies with the metals, and to be entitled to a place in the class with sulphur, but its nature is not yet satisfactorily ascertained.—(THENARD, *Traite de Chem.tom.* 1 & 2. URE's *Dic.* HENRY's *Chym. 9th ed.*)

CYANOGENE. (26)

205. Cyanogene is a compound of carbon and azote, (197) and the simple name is given to it to serve as a convenient radix, from which the names of the compound it forms may be conveniently derived; it comports itself like many undecompounded bodies.

(*a*) Cyanogene is easily procured by heating dry and pure *cyanide* of mercury (prussiate of mercury) in a small retort; a gas is evolved which is to be collected over mercury.

(*b*) Cyanogene is colorless and transparent, has a strong, pungent odor; it supports a high temperature without decomposition.

100 cubic inches weigh 55 grains, and its sp. gr. is 26.

(*c*) Cyanogene is inflammable, and burns with a purple flame; its azote is evolved, and its carbon forms carbonic acid. Phosphorus, sulphur, iodine and hydrogene do not combine with cyanogene by heat. Potassium, when heated in it, burns with the usual phenomena of combustion. Water dissolves 4.5 its volume of cyanogene, and acquires a pungent taste and smell; the solution reddens the vegetable blues, and suffers spontaneous decomposition, and carbonic and hydrocyanic acids and ammonia are produced.

When one volume of cyanogene is mixed with two volumes of oxygene and an electric spark passed through the mixture, a violent detonation ensues, and one volume of azote and two volumes of carbonic acid are produced.

Hence cyanogene consists of

Carbon	2 primes	12
Azote	1 prime	14
		26

(*d*) Cyanogene is always a product of art; it was discovered by Gay Lussac, and his memoir on the subject contains a full history of this interesting compound.

206. *Cyanogene and oxygene; cyanic acid.* An acid exists, combined with oxides, in the fulminating compounds of silver, mercury, &c. It has not been procured in a separate form; but its compounds, have examined by Gay Lussac and Liebeg.

It presents a very close analogy to the tartaric acid, in many of its habitudes; the fulminating compounds are analogous to the neutral tartrates, being only *half* decomposed by potash; and the *cyanic* (or *fulminic*) *acid*, also forms double salts with bases like the double tartrates. The presence of a metal does not appear to be essential to the constitution of this acid; the fulminating compounds are *cyanates*, or *bicyanates*, or salts with double bases.

Cyanic acid is composed of

Cyanogene	1 prime	26
Oxygene	1 prime	8
		34

(Brande's *Jour. No.* 36.)

207. (*a*) *Cyanogene and chlorine.* Chloro-cyanic acid is procured by passing a current of chlorine through hydro-cyanic acid; the excess of chlorine being separated by agitation with mercury, and the remaining liquid slowly and cautiously distilled into a receiver surrounded with ice, or a freezing mixture.

(*b*) Chloro-cyanic acid is a colorless, limpid liquid, of a very strong and pungent odor, very volatile, and changes vegetable blues to red.

(*c*) It consists of equal volumes of chlorine and cyanogene.

1 prime of cyanogene=26 or 1 volume
1 prime of chlorine =36 or 1 volume
62 2

208. *Cyanogene and iodine* may be obtained in combination with each other by heating cyanuret of mercury and iodine together; it has an acrid taste and pungent odor. It was discoved by Davy.

209. (*a*) *Cyanogene and hydrogene.* Hydro-cyanic acid (prussic acid) is obtained easily by moistening cyanuret of mercury with muriatic acid, and distilling at a low temperature; the vapors produced being made to pass into a receiver surrounded with ice, through a glass tube containing fragments of marble and fused chloride of calcium; the former, to abstract any vapor of muriatic acid; the latter, to absorb moisture.

(*b*) Hydro-cyanic acid is a colorless, transparent liquid, having a strong odor of bitter almonds, and a taste at first cooling and then acrid.

Its sp. gr. is 0.69 at 64°F. It is very volatile, boils at 81° and freezes at 3°. Its volatility is so great, that it freezes itself when exposed to the air. It feebly reddens litmus paper, but the blue color is restored by the evaporation of the acid.

(*c*) The vapor of hydro-cyanic acid is colorless and transpaparent.

(*d*) Hydro-cyanic acid is a virulent poison; when its vapor is incautiously inhaled, it excites nausea and fainting; in a diluted state it it employed in medicine, and for this purpose it is best prepared according to formulæ given in dispensatories (*see U.S.Pharmacopœia*) It is very liable, even when diluted, to suffer decomposition, and it should be kept secluded from the light.

100 cubic inches weigh 28.579 grs.; its sp. gr. is 13.5.

When detonated with oxygene, it affords carbonic acid,hydrogene and azote, and consists of

Cyanogene 1 volume, or 1 prime=26
Hydrogene 1 " 1 " 1
and its equivalent number is 27

210. Hydro-cyanic acid combines with bases and forms *hydrocyanates.* They do not appear to be neutral compounds; are readily decomposed by weak acids, such as the carbonic, and have no useful properties.

Hydro-cyanate of ammonia crystallizes in cubes and prisms; it is very volatile; the proportion of its constituents is not known.

211. Cyanogene when mixed with an equal volume of sulphuretted hydrogene combines with it and forms a yellow crystallized compound; this has been regarded by Dr. THOMSON as a compound of sulphur and cyanogene; and called by him *sulpho-cyanic* acid; it was discovered by PORRETT; and again noticed by GAY LUSSAC; its properties have been imperfectly studied, and its composition is not yet accurately settled.

OF FLUORIC ACID. (17 ?)

212. (*a*) The true nature of this substance is unknown; it is procured by heating two parts of sulphuric acid and one part fluor spar together, in a leaden or silver retort; the acid passes over, and is collected in a metallic receiver surrounded by a freezing mixture (SILLIMAN'S *Journal Vol.* 6.)

(*b*) Fluoric acid, resembles sulphuric acid; is volatile and emits white fumes when exposed to the air, is of a very pungent odor,and,when much diluted with water, of a pleasant sour taste; it possesses the usual properties of acids.

Its sp. gr. is 1.0609.

At 80° F. it becomes gaseous: it has not been congealed.

(*c*) Fluoric acid has a strong attraction for water; when dropped into it, a hissing noise is produced. It acts with intense energy on the living system; a drop of it falling on the skin instantly destroys it, and produces very painful and extensive ulcerations, and a rapid formation of pus. It dissolves silex, and glass.

Potassium and Sodium, and some other metals, act on this acid with great energy, and hydrogene gas is evolved.

(*d*) The nature of fluoric acid is involved in obscurity; it may be regarded as an acid, composed of oxygene and a bases, and its combinations with salifiable bases as salts; the probable opinion, however, is, that it is a compound of hydrogene with a basis, analagous to *muriatic acid*, and the compounds it forms, by acting on oxides, are combinations of this bases with the metal; this supposed basis has been called *Fluorine*, and its compounds *Fluorides*; the acid under examination,*Hydrofluoric acid;* but new investigations are required to elucidate this subject. (URE'S *Dic.* THENARD. *T. de Chem.*)

(*d*) From the property which fluoric acid possesses of dissolving silex, it is employed for etching and engraving on glass; the glass is covered with a thin coat of wax, and the figures drawn upon it with a style, and then exposed to the action of the acid.

It was first procured pure by GAY LUSSAC and THENARD.

213. *Fluate* or *Hydrofluate* of *ammonia* is formed by adding carbonate of ammonia to the acid; there should be a slight excess of acid; it is not crystallizable; and is a very delicate test of lime.

214. (*a*) *Fluoric* acid and *Boron ; Fluoboracic acid ;* is procured by distilling in a glass retort, fluor spar, in fine powder, mixed with half its weight of fused boracic acid and twelve parts of sulphuric acid; it is gaseous and must be collected over mercury.

(*b*) It is colorless and transparent, of a pungent odor, and forms dense vapors when exposed to the air; its attraction for moisture is so great, that it is advantageously employed to detect the presence of it in other gases; however little they may contain, it produces in them very perceptible vapors.

100 cubic inches weigh 73.5. (Davy.) Its sp. gr. is about 34.

(*c*) Water absorbs 700 times its volume of this gas; a limped, fuming and caustic liquid is formed; about one fifth of the gas may be expelled by boiling. This solution according to Brande consists of *fluoric* and *boracic* acids.

Fluo-boric gas acts with energy on animal and vegetable bodies, an effect arising probably from its attraction for water. Potassium burns in this gas, boron is deposited, and fluate of potash or fluoride of potassium is produced.

(*d*) Fluoboric gas is to be considered, either as a compound of fluoric and boracic acids, or of *Fluorine* and *Boron*, according to the view entertained of the nature of fluoric acid.

215. *Fluoboric acid* unites with salifiable bases and forms fluoborates, none of which have been examined but the fluoborate of *ammonia*, of which there appears to be three varieties. (*See Silex.*) John Davy.

OF THE METALS.

216. The metals are a class of substances distinguished by peculiar characteristics. They are very important in their chymical relations, and in their applications to the arts. They are all undecompounded bodies, and possess the following general characters:

(*a*) They have a splendent lustre, which continues in the streak and in their minutest fragments.

(*b*) They are, with the exception of gold, perfectly opaque, even when in very thin leaves.

(c) They are fusible by heat, and retain their opacity and lustre while in fusion. Their fusing points are very various:

Mercury fuses	at	-39.5 F.
Potassum	at	150
Iodium	at	200
Arsenic	at	350
Lead	at	600
Zinc	at	700
Antimony	at	800.

Silver, copper, and gold, melt at a cherry red heat; nickel, cobalt, and iron at a white heat; while others can be softened in the strongest furnace heat, and can be fused only in the Voltaic circuit, or by the compound blowpipe of Hare; in the latter they may all be vaporized.

(*d*) In their melted state, metals are capable of combining with each other and of forming *alloys*, in which the metallic characters are preserved. In returning to the solid state different metals present different phenomena; some expand, as iron, antimony and bismuth: others contract, as mercury. In congealing, many metals assume a crystalline arrangement; the crystals are nearly of the same figure in different metals.

(*e*) The metals are all conductors of heat, and of electricity; and they evolve or generate electricity by contact, in galvanic arrangements, more remarkably than any other substances.

(*f*) *Tenacity* is a distinguishing property of some of the metals; it gives rise to two other properties, malleability and ductility. These properties are not always proportional to each other; ductility is the capacity of being drawn out into wire, and iron; platina and silver are the most ductile metals. Malleability is the capacity of being extended into thin leaves, under the hammer, and gold, silver, and copper are the most malleable metals. These properties seem to be connected with the hardness and softness of metals, the harder metals being more ductile, the softer, more malleable.

The qualities of hardness and softness are dependent on the state of aggregation, produced by temperature, and by its slow, or rapid reduction. It is remarkable that the state of aggregation is liable to be affected, by other causes, which do not so obviously change the arrangement of parts; thus brass is liable to become brittle from exposure to damp air, and steel to change its elasticity by friction on its surface. The elasticity and hardness of metals may be increased by hammering and by wire drawing.

Tungsten, palladium, manganese and iron are the hardest metals; tin, arsenic and lead are among the softest; the hardest metals are the most sonorous.

(*g*) When metals are exposed to the action of oxygene, chlorine or iodine at elevated temperatures, they combine with them and are converted into oxides, chlorides or iodides; compounds which are destitute of the metallic characters. The combination is often accompanied with the phenomena of combustion.

(*h*) When some metals are exposed to heat and atmospheric air, they begin to suffer more or less obvious changes; the surface becomes dull, and the lustre is lost; the color is changed, and scales or a powder formed, which was called by the older chymists, a *calx*, and the process itself, *calcination*. These phenomena were explained by STAHL by assuming the metals to be compound bodies, consisting of an earth and *phlogiston*, and that by exposure to heat, the latter was driven off, while the former remained. This hypothesis did not explain the necessary presence of air, or the increase of weight which the metal experienced; 100 pounds of lead affording, e. g 110 pounds of calx.

BAYEN and LAVOISER proved the fallacy of the phlogistic hypothesis, and first gave the true explanation of the facts; calcination cannot occur unless oxygene be present, and oxygene disappears during the process; the weight which the metal gains, is equal to that of the oxygene which disappears; and oxygene may be again recovered from the calx and the metal revived. The terms *calx* and *calcination* are discarded, and *metallic oxide*, and *metallic oxygenation* or *oxydation* are substituted.

Some metals combine with oxygene at comparatively low temperatures with the phenomena of combustion; others require an intense temperature for this effect, although they may be oxygenated at a lower heat.

Each metal is capable of combination with oxygene in different proportions forming distinct compounds (§122. *a*) and offering constant illustrations of the laws of *Definite Proportions*. (§ 26.)

(*i*) The *metallic oxides* are of an earthy appearance, and destitute of the metallic lustre, brilliancy, opacity, and specific gravity; they are uninflammable, tasteless, and insoluble in water. Many of them however are capable of combining with water, forming *Hydrets*, in which the relative proportion of water is definite. Some Hydrets are decomposed with facility by exposure to heat; others resist decomposition very strongly.

(*k*) There are several other methods of oxydating metals beside exposure to air and heat; these consist in exposing the metals to the action of substances containing oxygene, and with or without the aid of heat, as occasion may require. In this way some metals, which are not oxydated in the ordinary method, may be converted into oxides; as in heating gold with nitre.

(*l*) The process by which a metallic oxide, or other metallic compound, is decomposed, and the metal restored to its original state, is called *Reduction*. Some oxides are reduced by mere exposure to heat; others by this means are partially decomposed, but not reduced. The reduction is generally effected by the operation of affinities, in presenting some substance to the compound, whose attraction for some of its constituents is superior to that of the metal.

The reduction of oxides is generally effected by the action of carbon; charcoal is generally employed for this purpose, and it is capable of reducing every oxide when aided by a high temperature. In practical chymistry some additions are usually made to the mixture of oxide and charcoal, both (*a*) to bring the oxide into fusion, in order to facilitate the action of carbon on it, and (*b*) to afford a thin liquid medium through which the particles of the reduced metal can easily pass, and be collected at the bottom of the crucible,or furnace. These substances are called *Fluxes ;* the one most commonly employed in the laboratory is called *black-flux*, an intimate mixture of finely divided charcoal and sub-carbonate of potash, obtained by projecting into a red hot crucible, a mixture of equal parts of nitre and tartar, or of two parts of flour and one of nitre, by small portions at a time. Lime is employed as a flux in the large way.

(*m*) Metallic oxides unite with acids and form metallic salts; and the different oxides of the same metal form different salts with the same acid.

(*n*) *Chlorine* unites with metals, and the compounds are called *chlorides*. The attraction of chlorine for some of the metals is superior to that of oxygene. Many of the metallic chlorides are soluble in water, and resemble salts. Their physical and chymical properties are extremely various. A metal sometimes combines with more than one definite proportion of chlorine.

(*o*) *Iodine*, by the aid of heat, combines with many of the metals, and produces *Iodides ;* some of them are soluble in water, and others effect its decomposition.

(*p*) There are some metals which may be combined with hydrogene ; the compounds are solid, or gaseous.

(*q*) *Sulphur* unites with the metals and forms *sulphurets*. Sulphurets may be procured by various methods, other than the direct combination of the two bodies. Their properties are various ; many of them have the metallic lustre. Different compounds are formed by the union of different proportions of sulphur with the same metal.

(*r*) Many metals combine with phosphorus, and form *phosphurets*. These generally retain the metallic lustre and brilliancy.

(*s*) Carbon unites to one metal only, iron ; carburet of iron is steel.

(*t*) The metals are acted upon by some of the acids, either with or without the aid of heat. The acids are active agents in affording metals oxygene, either from their own decomposition, or by determining the union of the metals with the oxygene of some other body.

(*u*) Alkalies are capable of dissolving some metals, and of combining with their oxides.

217. Metals are found either pure, or in various states of combination, in the earth, viz.

(*a*) *Native metals* are such as occur pure.

(*b*) *Metals* combined with *oxygene* or with *chlorine*.

(*c*) *Metals* combined with *sulphur*, *phosphorus* and *carbon :* the former is the most common mineralizer.

(*d*) *Metallic oxides* combined with acids, or *native metallic salts.*

The physical and chymical properties of metals have each been made the foundation of their classification by different philosophers.

A classification of metals founded on their chymical relations alone, appears to be peculiarly proper for their chymical history; but there are difficulties connected with such an arrangement in consequence of the gradual transition of metals from one class to another. They may conveniently be arranged in four groups, according to the characters presented by their combinations with oxygene.

1. Metals producing alkalies = 7
2. Metals producing acids = 5
3. Metals producing oxides =24
4. Supposed metals or earths = 5

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I. OF THE METALS PRODUCING ALKALIES.

The metals whose combinations with oxygene afford bodies possessing the properties of alkalies in a greater or less degree are seven, viz.

Potassium, *Sodium*, *Lithium*, *Calcium*, *Barium*, *Strontium*, and *Magnesium.*

OF POTASSIUM. (40.)

218. Potassium is the metallic basis of potash. It may be procured (*a*) by subjecting potash to the action of the Voltaic battery. The metal is then slowly evolved at the negative pole; or, (*b*) by subjecting potash to the action of ignited iron filings in the apparatus of Gay Lussac and Thenard, or of Dr. Gorham; or, (*c*) by distilling sub-carbonate of potash, or cream of tartar with charcoal or oil, in the apparatus of Prof. Brunner. (*Silliman's Jour. Vol.* 8. *Brande's Jour. No.* 30.)

219. (*a*) Potassium is of a white color and brilliant lustre; is ductile and of the consistence of soft wax at common temperatures.

Its specific gravity is 0.85.

At 32° F. it is a hard brittle solid; it fuses at 150°, and at a bright red heat is vaporized.

It is a good conductor of heat, and of electricity.

(*b*) Potassium has a very strong attraction for oxygene, and is capable of separating that substance from its combinations with other bodies; it instantly tarnishes in the air, and by a gentle heat burns with a bright white flame. It must be preserved under the surface of naptha.

(*c*) When potassium is thrown into water, or upon ice, it instantly takes fire; hydrogene gas is evolved, and the water is found to contain oxide of potassium, or potash, in solution. The quantity of hydrogene evolved indicates the quantity of oxygene transferred to the metal, and the composition of the protoxide of potassium or potash. It consists of

Potassium	1 prime	=40
Oxygene	1 prime	= 8
And its equivalent number is		48

(*d*) The protoxide of potassium, forms an *Hydret* of *potash* by combination with water; it is under this form, that it is usually met with in laboratories, and called pure potash.

Hydret of potash may be prepared in the following way:—Dissolve pearlash (an impure sub-carbonate of potash) in twice its weight of hot water; add to it, while hot, its own weight of quicklime, slaked in four times its weight of hot water: boil the mixture in a clean iron vessel, for twenty minutes, with frequent stirring; the lime deprives the potash of its carbonic acid: filter the liquor through linen, and evaporate the solution to dryness in a silver bason. During this evaporation a portion of carbonic acid is absorbed,and carbonate of potash formed: pour on the dry mass a quantity of pure alcohol, sufficient to dissolve it; put the solution into a bottle, and let it stand a few hours—the impurities will subside, and the alcohol dissolves the pure potash only: decant the clear alcoholic solution into an alembic of pure silver, furnished with a glass capital, and distil off the alcohol. The alkali may now be fused, and poured on a clean silver plate, and when cold, broken into pieces and preserved in well stopped bottles. If the whole of the alcohol be not distilled off, the potash may be obtained in crystals.

(*e*) Hydret of potash is of a white or greyish white color; it is very acrid and corrosive; deliquescent and easily soluble in water; it absorbs carbonic acid from the air, and, when touched with moist fingers, has a soapy feel in consequence of its action on the skin. When exposed to a bright red heat, it evaporates in a white acrid smoke. It is an important agent in chymical researches. It is composed of

Potash	1 prime	48
Water	1 prime	9
		57

220. When potassium is heated in an excess of oxygene gas,

it burns with great brilliancy, and an orange colored body is formed. This is the *peroxide* of potassium, and it consists of

Potassium	1 prime	40
Oxygene	3 primes	24

When this substance is thrown into water, it is decomposed; oxygene gas is evolved, and a solution of potash obtained.

221. When potassium is heated in chlorine, an energetic action ensues, and *chloride of potassium* is obtained; it is procured also by dissolving pure sub-carbonate of potash in muriatic acid, and evaporating the solution; it was formerly called *muriate of potash.* It is a white crystalline solid, of a bitter saline taste, soluble in water, and crystallizable in cubes.

It is composed of

Potassium	1 prime	=40
Chlorine	1 prime	=36

222. When potassium is heated in iodine, it burns with the evolution of heat and light, and an *iodide of potassium* is formed; it is a white, fusible, and crystalline compound, consisting of

Potassium	1 prime	= 40
Iodine	1 prime	=125

223. Potassium combines with hydrogene, and forms two compounds; the one, a grey solid, highly inflammable; the other, a spontaneously inflammable elastic fluid, called *potasiuretted hydrogene gas.*

224. Potassium unites with sulphur, with the phenomena of combustion; the same compound may be obtained by heating sulphate of potash with charcoal, or by exposing a mixture of potash and sulphur to an high temperature; sulphuret of potassium is a grey compound, which decomposes water, and evolves sulphuretted hydrogene gas. It consists of

Potassium	1 prime	40
Sulphur	1 prime	16

Liver of sulphur is an impure sulphuret of potassium.

225. *Phosphuret of potassium* is produced by heating phosphorus and potassium together, in vessels exhausted of air; it is a brown colored compound, which decomposes water and evolves phosphuretted hydrogene gas.

226. *Cyanide of potassium,* is procured by heating the metal in cyanogene gas; and by the action of water it affords a hydrocyanate of potash.

227. Potassium was discovered in 1807 by Davy; it is a very important agent in chymical investigations, owing to its strong attraction for oxygene.

SALTS OF POTASH.

228. (*a*) SALTS of potash are generally soluble in water.

(*b*) If a solution of tartaric acid be dropped into a solution of any salt of potash, a white granular precipitate is soon deposited.

(*c*) When a solution of platinum is dropped into a solution of a salt of potash, an orange yellow precipitate is produced.

(*d*) When they are added to sulphate of alumine, they enable it to crystallize and to form alum.

229. The protoxide of potassium, or potash, unites with acids and produces a class of salts. Many of these are of great importance in the arts.

(*a*) *Chlorate of potash.* This salt is formed by passing a current of chlorine gas through a solution of potash. Chloride of potassium, and chlorate of potash are obtained. Five sixths of the potash are decomposed forming chloride of potassium, and yield their oxygene to convert the remainder into chlorate of potash.

This salt is in white silvery scales, and of a cooling unpleasant taste; it is soluble in water. When fused it gives out *pure oxygene gas*, and chloride of potassium remains.

It acts on many inflammable substances with great violence. When triturated with sulphur or phosphorus, it produces explosions. Its action on phosphorus is dangerously violent. These phenomena depend on the decomposition of chloric acid.

When sulphuric acid is dropped on mixtures of this salt with combustibles, they instantly burst into a flame ; and similar mixtures may be inflamed under water by conveying sulphuric acid upon them through a long glass funnel, or dropping tube. It enters into the composition of the patent fire matches.

It consists of

Potash	1 prime 48 =	Potassium	1 prime	Ultimate Elements.
		Oxygene 1	= 6 primes	
Chloric acid	1 prime 76 =	Oxygene 5		
		Chlorine	1 prime	
	124			

(*b*) *Oxychlorate of patash* is formed, when one part of chlorate of potash is moistened with three parts of sulphuric acid, and the yellow mass thus obtained cautiously heated till it becomes white. The bi-sulphate of potash produced, may be separated by solution and crystallization; the oxychlorate being much less soluble in cold water than the bi-sulphate. It is a white crystalline salt, which, when mixed with its own weight of sulphuric acid and distilled at 270 or 280°, affords pure oxychloric acid which distils over. It affords oxygene on exposure to heat, and the chloride of potassium remains.

It is composed of

Potash	1 prime 48=	Potassium	1 prime	Ultimate elements.
		Oxygene 1	8 primes	
Oxychloric acid	1 prime 92=	Oxygene 7		
		Chlorine	1 prime	

(*c*) *Nitrate of Potash—Nitre.*—This abundant natural product, which is procured from lixiviation of certain soils, may be formed by neutralizing nitric acid with potash, and subsequent evaporation. Nitrate of potash crystallizes in six sided prisms with dihedral summits; it has a sharp, peculiar, cooling taste.

When exposed to heat it fuses, and oxygene gas is evolved; it is entirely decomposed by a strong white heat, and dry potash remains. One pound of nitre will afford 12000 cubic inches of oxygene gas sufficiently pure for common experiments. Nitre is rapidly decomposed at a red heat by charcoal, sulphur and phosphorus. It is from the violent action of charcoal and sulphur on nitre, that its use in the manufacture of gun powder depends. Gun powder is an intimate mixture of these substances in certain proportions. Nitre is of extensive use in some chymical arts and manufactures; it is the source from which is procured nitric acid, and it is employed in the manufacture of sulphuric acid. It consists of

Potash	1 prime 48=	Potassium	1 prime	Ultimate elements.
		Oxygene 1	6 primes	
Nitric acid	1 prime 54=	Oxygene 5		
		Nitrogene	1 prime	

It will be seen on comparing their ultimate elements, that this salt and chlorate of potash do not differ, excepting that one contains one prime of nitrogene, the other one prime of chlorine.

It is found native in Georgia (CORNELIUS,) and in Kentucky and Ohio. (CLEAVELAND.)

(*d*) *Sulphate of potash.* This salt, which is a residuum of many processes in the chymical arts, may be obtained by neutralizing sulphuric acid with potash. It crystallizes in short hexangular prisms, terminated by six sided pyramids. It is of a bitter taste and difficult solubility. It is fused by heat, but not decomposed, unless heated with charcoal, when sulphuret of potassium is formed. It is composed of

Potash	1 prime 48=	Potassium	1 prime	Ultimate elements.
		Oxygene 1	4 primes	
Sulphuric acid	1 prime 40=	Oxygene 3		
		Sulphur	1 prime	

(*e*) *Bi-sulphate of Potash* is procured by boiling sulphate of potash in sulphuric acid, or by heating equal parts of sulphuric acid and nitre together. It is a white, silky looking salt, of an acid taste, and is soluble in twice its weight of water at 60°.

It consists of

Potash	1 prime	48=	Potassium	1 prime	Ultimate elements.
			Oxygene 1	7 primes	
Sulphuric acid	2 primes	40X2=80=	Oxygene 6		
			Sulphur	1 prime	

(*f*) *Carbonate of Potash;*—(*sub-carbonate of potash.*)—This salt may be obtained by burning *tartar*, or by passing carbonic acid through a solution of potash, evaporating to dryness, and heating the residue to redness. It is a white salt, of an alkaline taste, and capable of rendering the green vegetables, blue. It is very soluble in water, and a hot solution sp. gr. 1.6; when placed in deep jars affords long rhomboidal, tabular crystals. (Brande's *Jour. No.* 33.) It is very deliquescent, and when exposed to the air absorbs moisture and forms a dense liquid, formerly called *oil of tartar per deliquium.* Carbonate of potash is fused, but not decomposed by a red heat. It consists of

Potash	1 prime 48=	Potassium	1 prime	Ultimate elements.
		Oxygene 1	3 primes	
Carbonic acid	1 prime 22=	Oxygene 2		
		Carbon	1 prime	

The carbonate of potash is of very great importance in the arts and in commerce; it constitutes the alkaline matter of *potashes* and *pearl-ashes*, in which it is mixed with many impurities. Potashes owe their dark color to the presence of vegetable matter, which is *burnt off* in the process of "*pearling;*" the green and purplish parts in pearl-ashes derive their color from oxides of iron and manganese.

(*g*) *Bi-carbonate of Potash*, is formed by exposing a solution of the carbonate of potash to a current of carbonic acid; the liquid on evaporation affords primitive four-sided crystals with dihedral summits. They are white; of a slightly alkaline taste, and are soluble in four times their weight of water at 60°. When exposed to a red heat, they lose half their carbonic acid, and are converted into carbonate of potash; they are composed of

Potash	1 prime 48=	Potassium	1 prime	Ultimate elements.
		Oxygene 1	5 primes	
Carbonic acid	2 primes 44=	Oxygene 4		
		Carbon	2 primes	

Bi-carbonate of potash	92	crystallized salt.
Water of crystallization	9	

Sal æratus is an impure bicarbonate of potash, and enters into the composition of *soda* powders.

(*h*) There are many other salts having potash for their basis; some of these are of little importance, and some others will be noticed under the history of the acids they contain.

OF SODIUM (24.)

230. (*a*) Sodium, the metallic basis of soda, is procured by a process similar to that for obtaining potassium; soda, being substituted for potash.

(*b*) Sodium is a white, solid metal of the appearance of silver; it is soft, malleable, and sectile: its specific gravity is 0,97.

Sodium fuses at 180°—and is converted into vapor at a white heat. It possesses the property of *welding*, like iron, at common temperatures.

231. (*c*) When sodium is thrown on water a violent action ensues; hydrogene is evolved and a solution of soda, protoxide of sodium, is obtained. It consists of

Sodium 1 prime	24
Oxygene 1 prime	8
Its equivalent is	32

Pure soda, as it occurs in laboratories, is an *hydret of soda* or protoxide of sodium; it is procured by processes similar to those used for procuring pure potash, (219 *d*) and it possesses the same general characters as potash; it is distinguished from that alkali, by its greater power of neutralizing acids, and by the characters of its salts. *Soda*, when exposed to the air, forms an efflorescent paste, *potash* forms an oily liquid. Its consists of

Soda 1 prime	32
Water 1 prime	9

232. Sodium, when heated in oxygene, burns brilliantly, and an orange colored body is formed, which is *peroxide of sodium*; this, like the peroxide of potassium, is decomposed by water, and one half its oxygene is evolved. It consists of

Sodium 1 prime	24
Oxygene 2 primes	16
	40

233. When sodium is heated in chlorine gas, it burns, and a white compound is formed called *chloride of sodium*; it is the important substance, *common salt*, and was formerly called *muriate of soda*. Chloride of sodium is of a white color and a purely saline taste; fusible by heat; soluble in 2.5 parts of water at 60° and scarcely more soluble in hot water. It crystallizes, from its solution, in cubes. It is a non-conductor of electricity; chloride of sodium exists abundantly in nature, both in a solid form, and in solution in water. It consists of

Sodium 1 prime	24
Chlorine 1 prime	36
	60

Chlorine has an affinity for sodium, superior to that of oxygene; when *soda* is heated in chlorine, oxygene is evolved and the chloride is formed. The use of chloride of sodium as a condiment, &c. is well known; it is employed in the manufacture of muriatic acid; when sulphuric acid is poured on *chloride of sodium*, *muriatic acid* is evolved, and sulphate of soda formed; results which depend on the decomposition of water.

Sodium and Iodine act on each with phenomena similar to those presented by potassium and iodine. Iodide of sodium is a deliquescent body, whose solution yields four sided prisms.

234. Sodium unites with sulphur; the sulphuret has the same characters as sulphuret of potassium; and may be procured by similar processes.

SALTS OF SODA.

235. (*a*) Salts of soda are generally more soluble in water than salts of potash.

(*b*) They give no precipitate with tartaric acid, or with muriate of platinum.

(*a*) *Chlorate of soda* is procured by the same processes as chlorate of potassa. It resembles that salt in appearance, taste, and other properties.

(*b*) *Nitrate of soda* may be obtained, by distilling common salt and nitric acid in a retort, dissolving the residue and evaporating: or by direct combination of the nitric acid and soda. Its crystals are rhombs; of a cooling sharp taste, and soluble in water; they are sometimes found in crude nitre, and possess the general properties of that substance. It was formerly called *cubic nitre*. It consists of

$$\left.\begin{array}{l}\text{Soda } 1 \text{ prime} = \left\{\begin{array}{ll}\text{Sodium} & 1 \text{ prime}\\ \left.\begin{array}{l}\text{Oxygene } 1\end{array}\right\} & \end{array}\right.\\ \text{Nitric acid } 1 \text{ prime} = \left\{\begin{array}{ll}\left.\begin{array}{l}\text{Oxygene } 5\end{array}\right\} & =6 \text{ primes}\\ \text{Nitrogene} & 1 \text{ prime}\end{array}\right.\end{array}\right\}\text{ Ultimate Elements.}$$

(*c*) *Sulphate of soda*—(*Glauber's Salts*)—may be procured by neutralizing sulphuric acid by soda, or by acting on common salt with sulphuric acid, as in the manufacture of muriatic acid. Sulphate of soda is white and transparent, of a bitter taste, soluble in water, and crystallizable from its solution in long four sided prisms, the sides of which are deeply channelled. These crystals contain more than fifty per cent. of water; they are very deliquescent, and fall into a white powder on exposure to the air, but suffer watery fusion when heated.

Sulphate of soda consists of

Soda	1 prime =32	Sodium		1 prime	Ultimate Elements.
		Oxygene	1	4 primes	
Sulphuric acid	1 prime =40	Oxygene	3		
		Sulphur		1 prime	

The crystallized salt contains

Sulphate of soda	1 prime	=72
Water	10 primes=9X10=90	

Sulphate of soda is used in medicine, and sometimes as a source of pure soda in the large way.

(*d*) *Bi-sulphate of soda*, obtained by the addition of sulphuric acid to a hot solution of sulphate of soda, forms rhomboidal efflorescent crystals.

It contains 1 prime of soda=32, and two primes of sulphuric acid=80.

(*e*) *Phosphate of soda* may be obtained by the direct combination of its constituent parts; it is procured by saturating with carbonate of soda, the impure phosphoric acid obtained by acting on calcined bones with sulphuric acid. It has a purely saline taste; soluble in water, and forms rhomboidal efflorescent crystals. It consists of

Soda	1 prime =32	Sodium		1 prime
		Oxygene	1	3 primes
Phosphoric acid	1 prime =28	Oxygene	2	
		Phosphorus		1 prime

It is employed in the practice of medicine.

(*f*) *Carbonate of soda* is procured by the combustion of marine plants, as potash is by the combustion of land vegetables, and subsequent solution and crystallization. It has the general properties of carbonate of potash; a strong alkaline taste, and power of rendering green the vegetable blues; it is soluble in water, and forms efflorescent crystals, which are octaëdra with rhombic bases and deeply truncated summits. It consists of

Soda	1 prime 32=	Sodium		1 prime
		Oxygene	1	3 primes
Carbonic acid	1 prime 22=	Oxygene	2	
		Carbon		1 prime

The impure alkali, which corresponds to the *black salts of potash*, is called *barilla*, or *kelp;* the latter sometimes contains only 5 per cent. of the pure carbonate of soda. They are employed in glass works and by soap-boilers to form hard soap.

(*g*) *Bi-carbonate of soda* is obtained by passing a current of carbonic acid gas through a solution of the carbonate, and subsequent evaporation.

It consists of soda 1 prime=32+carbonic acid 2 primes=44.

(*h*) A salt, composed of soda and carbonic acid, is found native in abundance in Africa; it consists of a mixture of the carbonate, and bi-carbonate of soda.

Carbonate of soda	1 prime	Soda	32	
		Carbonic acid		22
Bi-carbonate of soda	1 prime	Soda	32	
		Carbonic acid		44

Soda 64 + 66 Carb. acid.

or, 3 primes carbonic acid and 2 primes of soda. It has been called Sesqui-carbonate of soda.

(*i*) *Borate of soda* has not been examined; *Borax* is a

(*k*) *Sub-borate of soda;* it is brought in an impure state from the East-Indies under the name of *Tinkal.* The purification consists in solutions and crystallizations, and the processes are conducted in leaden vessels. *Pure borax* is of a white color and of an alkaline and somewhat styptic taste. It renders the vegetable blues, green. It is soluble in water, and forms crystals in irregular six sided prisms, which are slightly efflorescent. When heated, it swells up, and forms a porous frothy mass called calcined borax. On exposure to high temperatures it melts into a transparent glass, called glass of borax.

The precise composition is not accurately settled; according to Gmelin it consists of

Boracic acid	35.6	2	3 primes boracic acid	66 ?
Soda	17.8	1	1 prime of soda	32 ?
Water	46.6			

Borax is used by glass makers and workers in metals; it is also employed in the practice of medicine.

OF LITHIUM. (10 ?)

236. (*a*) Lithium is a white highly combustible metallic body, procured by subjecting Lithia to the Voltaic battery.

(*b*) *Lithia*, or *oxide of Lithium*, has been procured only in small quantities from certain minerals. It was discovered by M. Arfwedson in petallite. It may be procured by mixing the mineral *spodumene* in powder, with twice its weight of powdered fluor spar, and with sulphuric acid. Then heat the mixture, and the fluoric acid is evaporated and carries with it the silex of the mineral; the sulphate of lithia remains, and may be separated by solution; (Berzelius.) The solution, on the addition of a strong solution of carbonate of potash, affords a precipitate of carbonate of lithia, from which the carbonic acid may be separated by lime water or barytic water.

(*c*) Pure lithia is of an acrid, alkaline taste, soluble in water, and acts instantly on the vegetable colors like potash and soda. It is sparingly soluble in alcohol. There are no direct experiments on the composition of lithia. It probably consists of lithium 1 prime=10?+oxygene 1 prime=8.

237. *Chloride of lithium* is procured by evaporating to dry ness and fusing the muriate of lithia, procured by dissolving carbonate of lithia in muriatic acid; it is a white translucent body; very deliquescent; readily soluble in alcohol, but crystallizes with difficulty; when heated in open air it loses chlorine and absorbs oxygene, and is converted into lithia. These properties distinguish it from potash and soda.

238. The compounds of this substance, owing to the small quantity in which it is found, have not been completely investigated.

SALTS OF LITHIA.

239. (*a*) SALTS of lithia afford precipitate on the addition of strong solutions of carbonate of potash?

(*b*) They afford a floculent precipitate on the addition of phosphate of ammonia?

(*c*) They give no precipitate with platinum or with tartaric acid.

(*a*) *Nitrate of lithia* is formed by adding carbonate of lithia to nitric acid; it is a very deliquescent salt, of a sharp pungent taste, and crystallizes in oblique four sided prisms; it is soluble in absolute alcohol.

(*b*) *Sulphate of lithia* is a white salt, of a strong lustre; soluble in water; of a saline taste, and crystallizes in small prisms.

It consists of

Lithia	1 prime	10?
Sulphuric acid	1 prime	40

There is a *bi-sulphate* of Lithia.

(*c*) *Carbonate of lithia*, procured by adding carbonate of potash to solution of sulphate of lithia, is of a white color; is fusible; alkaline, and sparingly soluble in water. 100 parts of water at 60° F. dissolve one part of lithia.

(*d*) Some other salts of lithia are known: they have been principally examined by VAUQUELIN, and GMELIN; but do not appear to be yet applied to any practical use.

OF CALCIUM. (20.)

240. (*a*) CALCIUM is the metallic bases of *lime*, and is procured by electrizing mercury negatively, in contact with lime; an amalgam is thus procured, which by distillation affords a white metal. It has been procured in small quantities only. When this metal is gently heated in the air it burns and *lime* is formed.

(*b*) Lime, oxide of calcium, or calcia, consists of

Calcium	1 prime	20
Oxygene	1 prime	8
And its equivalent number is		28

241. Lime may be obtained quite pure by calcination of pure crystallized limestone, or powdered white marble, at a red heat. It is of a grey color, and a caustic taste, and turns vegetable blues to green.

It is of very difficult fusion, yet it powerfully promotes the fusion of many other earthy bodies. In common with all other earthy bodies, it was considered as infusible, until the experiments of SILLIMAN and HARE, with the compound blowpipe of the latter philosopher, proved its fusibility.

When a small portion of water is thrown upon lime, there is a great rise of temperature resulting from the solidification of the water and extrication of its latent heat. The lime soon splits and falls into a fine powder, and forms *slacked lime*. It is an *hydret* of lime consisting of

Lime	1 prime	28
Water	1 prime	9

Lime, when exposed to the air, gradually passes to the state of an hydret, and absorbs a little carbonic acid. It is then said to be air slacked. Lime is an indispensable ingredient in mortar and cements used in building and masonry.

Lime is soluble in water; and more soluble in cold than in hot water. Lime water is a limpid colorless fluid, of a sub-nauseous and alkaline taste; it converts the vegetable blues to green. When it is exposed to the air, it absorbs carbonic acid and a pellicle of carbonate of lime is formed; this when broken is succeeded by another, and eventually the whole lime is thus separated. Lime water is used in medicine; and as a test of the presence of carbonic acid.

When lime water is placed over a surface of sulphuric acid under the exhausted receiver of an air pump, the water evaporates and the hydret lime crystallizes in imperfect hexagonal crystals.

(c) Lime is capable of combining with an additional quantity of oxygene, and is converted into a peroxide of calcium; this may be formed by passing oxygene over heated lime.

242. *Chloride of calcium* may be obtained by evaporating a solution of lime in muriatic acid, to dryness, and heating the dry mass to redness, or by heating lime in chlorine gas. In the latter case, oxygene is expelled from the calcium by the superior affinity of the chlorine.

Chloride of calcium has a hot, bitter taste; it is soluble in 1-4 its weight of water at 60° F., and may be obtained in crystals by exposing this solution to low temperatures. It is very deliquescent and strongly attractive of moisture, and is used in its fused state for absorbing hygrometric water from gases. It is soluble in alcohol; when fused it becomes phosphorescent, and is called HOMBERG's *phosphorus*. It was also called *Fixed sal ammoniac* by the old chymists, being abundantly produced in the manufacture of carbonate of ammonia, from sal ammoniac and carbonate of lime; from erroneous views respecting its nature, it was called *muriate of lime* It is employed, mixed with snow, for producing an intense degree of cold.

243. Chlorine unites with lime; when chlorine is brought in contact with hydret of lime it is absorbed, and *chloride of lime* is formed. The composition of this body is not perfectly understood; its solution in water possesses great bleaching powers; and it is manufactured for that purpose, and constitutes bleaching powder, and bleaching salts. Chloride of lime, of a superior quality, is manufactured for Bleaching-houses, at Waltham, by S. L. DANA, M. D.

244. *Iodide of calcium*, procured by evaporating to dryness the hydriodate of lime, is a white fusible substance, soluble in water.

245. *Sulphuret of calcium* is obtained when sulphur and lime are heated together; it is soluble in water, and evolves sulphuretted hydrogene during its solution. (*See* BERTHIER *on sulphurets. Brande's Jour. No.* 36.)

246. *Phosphuret of calcium*? When phosphorus in vapor is passed over red hot lime, a chesnut brown substance is produced, which rapidly decomposes water, and evolves the spontaneously inflammable gas, phosphuretted hydrogene.

SALTS OF LIME.

247. When a solution of oxalate of ammonia is dropped into a solution of any salt of lime, a white precipitate is produced; but more of them are altered by a solution of pure ammonia.

(*b*) If the salt be not soluble in dilute nitric or muriatic acid, it may be boiled in water with carbonate of potash; a white powder will remain, soluble in those acids; and to this solution the tests may be applied.

(*a*) *Nitrate of lime* is prepared by the direct union of its constituents. It is very soluble, and deliquescent; fuses by heat, and a phosphorescent substance is formed, called Baldwin's *phosphorus*. At a strong red heat it is totally decomposed and pure lime remains; it is found in old plaster, and mortar, and is formed in artificial nitre beds. It consists of

Lime	1 prime=28=	Calcium		1 prime
		Oxygene	1	6 primes
Nitric acid	1 prime=54=	Oxygene	5	
		Nitrogene		1 prime

(*b*) *Sulphate of lime*, (*gypsum*, *selenite*, *alabaster*, *plaster stone*;) occurs abundantly native. It may be formed by the direct union of its component parts, and obtained in small acicular silky crystals. When exposed to heat it falls into a white powder, which, made into a paste with water, soon becomes solid, and is employed for stucco work and plaster casts. It is soluble in water, and is generally found in all *hard* well waters. It is also soluble in dilute nitric and muriatic acids. It consists of

Lime	1 prime 28=	Calcium		1 prime
		Oxygene	1	4 primes
Sulphuric acid	1 prime 40=	Oxygene	3	
		Sulphur		1 prime

There are several localities of the sulphate of lime in the United States.

(*c*) *Phosphate of lime.* This salt constitutes the principal part of the bones of animals, and it is also found among minerals. It is readily formed by mixing a solution of phosphate of soda with one of chloride of calcium; it is a white, insipid powder, not soluble in water, but easily dissolved in nitric or muriatic acid. From these solutions it is precipitated unaltered by pure liquid ammonia.

It consists of

Lime	1 prime=28=	Calcium		1 prime
		Oxygene	1	3 primes
Phosphoric acid	1 prime=28=	Oxygene	2	
		Phosphorus		1 prime

It is found in many parts of the United States. (*See* CLEAVELAND's *Mineralogy.*)

There is a bi-phosphate of lime, produced by digesting the phosphate of lime in phosphoric acid. It is uncrystallizable, and deliquescent.

(*d*) *Carbonate of lime* is a most abundant natural product, and forms the principal part of all limestones, and marbles. The crystallized calcareous spar is pure carbonate of lime. It is soluble in a solution of carbonic acid, and when exposed to a red heat carbonic acid is driven off and pure lime remains. It is soluble with effervescence in most acids. It consists of

Lime	1 prime	28
Carbonic acid	1 prime	22

It is abundant in the United States.

Fluate of lime? Fluoride of calcium? This is also a natural product, and when pure, is white, insipid, and insoluble in water. It crystallizes in cubes whose solid angles are easily truncated. It often presents rich shades of green, olive and purple; but the nature of the coloring matter is not known. It may be formed artificially by adding lime to fluoric acid, or any soluble fluate to a soluble salt of lime. When acted on by sulphuric acid, fluoric acid is evolved. It is phosphorescent by heat. The nature of this compound is not certainly known.

It is easily wrought and turned in a lathe into a variety of ornamental forms. It is found at Putney, Vt., and in several other places in the United States.

OF BARIUM. (70.)

248. (*a*) BARIUM is the metallic basis of barytes, or baryta, and is procured in the same manner from that substance, that calcium is from lime. It is of a dark grey color, and more than twice as heavy as water. (DAVY.)

(*b*) When heated in the air, it rapidly absorbs oxygene, and burns with a deep red light. The product of this combustion is oxide of barium or baryta. It is composed of

Barium	1 prime	70
Oxygene	1 prime	8=78

Baryta is best obtained by exposing nitrate of baryta to a full red heat; the nitric acid is thus decomposed and driven off. It is of a greenish grey color, and of an acrid, caustic, alkaline taste, and absorbs water with the same phenomena as lime, and is converted into an hydret, which consists of

Baryta	1 prime	78
Water	1 prime	9

Hydret of baryta is soluble in hot water, and the solution deposites crystals as it cools. The solution possesses the same characters as lime water; absorbs carbonic acid; changes the vegetable blues to green, &c. Baryta and its compounds are powerful poisons.

(*c*) When baryta is heated in oxygene gas, it absorbs oxygene, and is converted into peroxide of barium; a substance of a pale grey color, which falls into powder on the addition of a small quantity of water, without evolving heat. It is the substance employed by THENARD in procuring oxygenized water, and oxygenized acids.

249. (*d*) *Chloride of barium* is procured by dissolving baryta or its carbonate in muriatic acid, and evaporating the solution till a pellicle appears on its surface. It forms tabular crystals of a sharp acrid taste, soluble in water and fusible by heat.

It consists of

Barium	1 prime	70
Chlorine	1 prime	36

It was formerly, but erroneously, called *muriate of barytes*; and it is employed in medicine. It is a violent poison, when incautiously used.

250. *Iodide of barium* is procured by using hydriodic acid, in the same way that muriatic acid is used in procuring the chloride.

251. *Sulphuret of barium* may be procured by heating sulphur and baryta together, or by heating the sulphate of baryta with charcoal. It decomposes water, and evolves sulphuretted hydrogene.

252. *Phosphuret of barium?* is procured when phosphorus is passed over ignited baryta: a vivid action ensues, and a metallic looking body is obtained, which acts with energy on water and decomposes it.

SALTS OF BARYTA.

253. A SOLUTION of sulphate of soda dropped into any soluble salt of barytes instantly produces a white precipitate, which is insoluble in nitric acid.

(*a*) *Chlorate* of *baryta* is formed by passing a current of chlorine gas through barytic water, in the same way as chlorate of potash is formed; it crystallizes in four sided prisms, and is soluble in water. It consists of

Baryta	1 prime	78
Chloric acid	1 prime	76

And it is employed to obtain chloric acid by the action of sulphuric acid.

(*b*) *Nitrate of baryta* is formed by neutralizing nitric acid with baryta, or by dissolving the native carbonate in that acid, and subsequently purifying the crystals by repeated solution and crystallization. It is a white solid, of an acrid and austere taste; soluble in water, and capable of forming octaëdral crystals. When exposed to heat, it is decomposed and pure baryta remains. It consists of

Baryta	1 prime =78=	Barium		1 prime
		Oxygene	1	6 primes
Nitric acid	1 prime 54=	Oxygene	5	
		Nitrogene		1 prime

(*c*) *Sulphate of baryta.* This is produced when the solution of any sulphate is added to a soluble salt of baryta; it is also an abundant natural product, and is totally insoluble in water.

It consists of

Baryta	1 prime 78=	Barium		1 prime
		Oxygene	1	4 primes
Sulphuric acid	1 prime 40=	Oxygene	3	
		Sulphur		1 prime

When the native sulphate is made into a thin cake with mucilage and heated to redness, it becomes phosphorescent, and it is called the BOLOGNA phosphorus. The artificial sulphate is useful as a pigment, and is called a *permanent white.*

Sulphate of baryta heated with charcoal is converted into sulphuret of barium; this by the action of nitric acid is converted into nitrate of baryta, which affords pure baryta by heat.

The native sulphate of baryta is found in many parts of the United States. (CLEAVELAND'S *Min.*)

(*d*) *Carbonate of baryta* is found native in Kentucky (RAFINESQUE. *Silliman's Jour. Vol.* 2.) and in some parts of England. It is a white insoluble powder, when prepared artificially by adding carbonate of ammonia to a solution of chloride of barium; and consists of

Baryta	1 prime 78=	Barium		1 prime
		Oxygene	1	3 primes
Carbonic acid	1 prime 22	Oxygene	2	
		Carbon		1 prime

The artificial carbonate is more easily decomposed by heat than the native. The latter is a most virulent poison; the former, not so active.

OF STRONTIUM. (44?)

254. STRONTIUM is the metallic basis of strontia, and is procured from that body by the same process as barium from baryta. It very much resembles barium.

Strontia or oxide of strontium is procured, like baryta, from the pure nitrate by ignition. It is of a grey color, and resembles baryta in many of its properties. It is soluble in water and crystallizable from its solution. With a smaller portion of water it forms an hydret.

Strontia water is clear and colorless, of an acrid styptic taste, and produces the effect of alkalies on vegetable colors.

Strontia consists (by theory) of

Strontium	44
Oxygene	8
Its equivalent number is	52

255. *Chloride of strontium*, formerly called muriate of strontia, may be procured by processes similar to those for procuring chloride of barium. It is of a greyish color, and soluble in alcohol. The solution burns with a carmine colored flame.

It consists of

Strontium	1 prime	44
Chlorine	1 prime	36

The attraction of *chlorine*, for strontium, is stronger than that of oxygene.

256. *Iodide of strontium* resembles iodide of barium, and may be formed in a similar manner.

257. *Sulphuret of strontium* (253. c.) is like sulphuret of barium in its general characters and habitudes.

OF THE SALTS OF STRONTIA.

258. (*a*) SALTS of strontia do not give a precipitate with succunate of ammonia like salts of baryta.

(*b*) A paper dipped into a solution of salts of strontia burns with a red colored flame.

(*c*) They are not poisonous.

(*a*) *Nitrate of strontia* is procured by dissolving the carbonate of strontia in nitric acid; it crystallizes in hexaëdral tables or in eight sided prisms; its taste is cooling and pungent; it is decomposed by heat, and pure strontia remains.

It consists of

Strontia	1 prime 52=	Strontium		1 prime
		Oxygene	1	4 primes
Nitric acid	1 prime 54=	Oxygene	3	
		Sulphur		1 prime

It is used in compositions for producing *red* fire.

(*b*) *Sulphate of strontia* is procured by dropping sulphuric acid into strontia water. It is a white, tasteless and nearly insoluble powder, consisting of

Strontia	1 prime 52=	Strontium		1 prime
		Oxygene	1	6 primes
Sulphuric acid	1 prime 40=	Oxygene	3	
		Sulphur		1 prime

When heated with charcoal it is decomposed, and sulphuret of strontia remains; from which strontia may be procured by the action of nitric acid. Sulphate of strontia is a natural product, and is found on Strontian island, lake Erie, (Delafield. *Silliman's Jour.*) and in other places.

(*c*) *Carbonate of strontia* is formed by adding carbonate of ammonia to a solution of chloride of strontium. It is a white, tasteless powder, nearly insoluble in water, consisting of

Strontia	1 prime	Strontium		1 prime
		Oxygene	1	3 primes
Carbonic acid	1 prime	Oxygene	2	
		Carbon		1 prime

Carbonate of strontia is a natural product; but it is of rare occurrence.

OF MAGNESIUM. (12 ?)

259. Magnesium has not yet been obtained insulated from other bodies. When mercury is electrized in contact with magnesia, an amalgam is obtained, which decomposes water, and gives rise to the formation of magnesia. Magnesium appears to have an intense attraction for oxygene. (Davy, *Chym. Phil.*) Magnesia, there is no doubt, is a metallic oxide, and consists probably of

Magnesium	1 prime	12
Oxygene	1 prime	8
Its equivalent number is		20

Magnesia—(*calcined magnesia*)—is procured by calcining the white lump magnesia of the shops. It is a very light, tasteless, inodorous powder, insoluble in water, and rendering green the delicate blue of the violet. It is nearly insoluble: SILLIMAN, with HARE's blowpipe, fused it, and it was afterwards fused by Clarke. Magnesia is a rare natural product, and is found at Hoboken, New-Jersey, combined with water, forming an hydret of magnesia, which, according to the analysis of the late Dr. BRUCE, consists of

Magnesia	70
Water	30
	100

It is probably a compound of

Magnesia	1 prime=20	or per cent.	69 magnesia
Water	1 prime 9		31 water.
			100

Magnesia is slightly soluble in water, and less soluble in warm than in cold water.

260. *Chloride of magnesium* may be procured by heating magnesia in chlorine; oxygene gas is expelled, and the chloride formed. It is soluble in water. The solution forms the muriate of magnesia? It is of a saline bitter taste, and is crystallized with difficulty from its solution. It is very deliquescent.

The crystals consist of

Chlorine	1 prime	36
Magnesium	1 prime	12
Water	1 prime	9

When these are heated the water suffers decomposition; muriatic acid flies off and pure magnesia remains. It exists in sea water, and in some mineral springs.

SALTS OF MAGNESIA.

261. WHEN phosphate of soda is dropped into any salt of magnesia, no precipitate is produced, until a solution of neutral carbonate of ammonia is added, when an immediate precipitate, consisting of the triple phosphate of ammonia and magnesia, is produced. (WOLLASTON.)

(*a*) *Sulphate of magnesia*—(*Epsom salts.*)—It is an abundant natural product, and exists in some mineral waters and in sea water. It is a white crystalline salt, of a silky lustre, and of an intensely bitter taste; soluble in water, and may be obtained from its solution in quadrangular prisms. It effloresces on exposure to the air, but suffers watery fusion when exposed to heat, and loses 50 per cent. of its weight. It consists of

	Magnesia	1 prime	20	
	Sulphuric acid	1 prime	40	crystallized
with	Water	7 primes=9X7=63		

It is used as an aperient medicine.

(*b*) *Phosphate of magnesia* is an insoluble salt produced by adding magnesia or its carbonate to phosphoric acid.

(*c*) *Phosphate of magnesia and ammonia* is formed when phosphate of soda, and bicarbonate of ammonia, are added to sulphate of magnesia. It is a white crystalline powder, insoluble in water, and tasteless; soluble in muriatic acid; 100 parts of salt contain about 20 parts of magnesia. It consists of

Magnesia	1 prime	20
Ammonia	1 prime	17
Phosphoric acid	2 primes	56
Water	1 prime	9
		102

This triple salt is frequently found in urinary calculi, and in gravel.

(*d*) *Carbonate of magnesia.* This is the substance sold in the shops as magnesia; it may be procured by adding carbonate of potash or soda to sulphate of magnesia in solution; it is a white, tasteless powder, which is decomposed by a full red heat.

It consists of

Magnesia	1 prime	20
Carbonic acid	1 prime	22
		42

(*e*) Carbonate of Magnesia is soluble in water containing carbonic acid; it then forms a *bi-carbonate of magnesia* which may be obtained in crystals. This is the *magnesia water* (Super carbonated magnesia water of the United States Pharmacopœia) sold at fountains; and has been employed with advantage in some calculus disorders.

(*f*) Magnesia forms many triple salts, but none of any practical use or importance except those already mentioned.

II. OF THE METALS FORMING ACIDS.

The metals which, by combination with oxygene in certain proportions, are capable of forming acids, are five, viz. *arsenic, molybdeum, chromium, tungsten, and columbium.*

OF ARSENIC. (76.)

262. Arsenic has the color and lustre of steel; is very brittle, and when broken it exhibits a laminated structure. Its specific gravity has been variously stated: 3.31. (Henry.) 8.3. (Brande.) 5.763. (Ure.) 5.235. (Thomson.) 8.31. (Davy.)

Arsenic readily fuses; and in close vessels is vaporized, before it melts, at 360° F. Its vapor has a strong aliaceous odor. When exposed to the air it tarnishes and becomes covered with a brownish coating : heated in the air it burns with a blue flame and is converted into an oxide. It occurs native in some parts of the world.

There are two combinations of arsenic with oxygene.

263. *Protoxide of arsenic*, (*arsenous acid—white arsenic*) is readily formed by combustion of the metal; it is procured abundantly in working certain ores ; and is found native. It is a white crystalline solid body, brittle, and has a vitreous fracture; easily reduced to powder, in which state it usually occurs. It has a sweetish sub-nauseous taste; it is sublimed by heat of 380, and condenses in tetraëdra. Its vapor, when unmixed with the metal, has no smell. It is soluble in water; 100 of water at 212° dissolve nearly 8 of this oxide, and retain about 3 in solution; the solution is of a nauseous taste, and reddens vegetable blues.

It consists of

Arsenic	1 prime	76
Oxygene	3 primes	24
		100

When the oxide is heated to redness with half its weight of black flux in a flask, it is decomposed, and pure metallic arsenic sublimes. It is by this process that metallic arsenic is artificially procured. The virulent poisonous properties of this substance are well known. It is employed in medicine.

264. *Arsenic acid* is procured when a mixture of 4 parts of muriatic acid and 24 of nitric acid are distilled off from 8 parts of the protoxide of arsenic in a retort: the dry residuum is to be gradually heated to redness. It is a solid white body, of a sour taste, deliquescent and soluble in 6 parts of cold, and in 2 of boiling water, but is uncrystallizable. It consists of

Arsenic	1 prime	76
Oxygene	5 primes	40

When metallic arsenic is thrown into chlorine gas, it takes fire spontaneously, and forms a white, volatile, deliquescent compound.

265. *Chloride of arsenic* when mixed with water is decomposed. Muriatic acid, and oxide of arsenic are formed.

It consists of

Arsenic	1 prime	76
Chlorine	3 primes	

266. *Iodide of arsenic* is formed when arsenic is heated with excess of iodine. It is a deep red, volatile compound, which, mixed with water, forms by their mutual decomposition, hydriodic and arsenic acids.

267. *Arsenic*, or *oxide of arsenic*, when added to the usual mixture for producing hydrogene, combines with a portion of the gas, forming *arsenuretted hydrogene gas.* This gas has a strong garlic odor; it does not support combustion, but burns with a pale blue flame, and arsenic, or oxide of arsenic, is deposited. It has not probably been obtained perfectly pure, and hence its specific gravity has been found to be variable. BRANDE found it 12 or 14 times heavier than hydrogene.

168. *Sulphur and arsenic* unite when they are fused together and form sulphuret of arsenic; it is a red colored compound, having a conchoidal fracture and vitreous lustre. It is called *realgar ;* both this, and the lemon colored sulphuret, called orpiment, are found native ; the former consists of

Arsenic	1 prime	76
Sulphur	2 primes	48

and the latter of

Arsenic	1 prime	76
Sulphur	3 primes	48

Orpiment is employed in calico printing to deozygenate indigo ; realgar for dyeing wool, silk, or cotton of a fine yellow.

269. *Phosphuret of arsenic* is obtained by heating the metal or its oxide with phosphorus. It is a grey, brittle compound.

TESTS OF ARSENIC.

270. (*a*) WHEN it becomes necessary to examine a substance supposed to be arsenic, mix a small portion of it with two parts of black flux, and heat the mixture in a glass tube to redness by the flame of a spirit lamp ; if it contain arsenic a *steel colored* sublimate will be found adhering to the cool part of the tube.

(*b*) If this steel colored sublimate be heated in the air, a white smoke having a strong alliaceous odor will be produced.

(*c*) Boil a small portion of the suspected substance in pure distilled water ; and add to the cold solution, or to the liquid supposed to contain arsenic, first a drop of the solution of carbonate of potash (salt of tartar) and then a drop of the solution of sulphate of copper ; if arsenic be present, a *grass green* precipitate will appear.

(*d*) Add to the solution suspected to contain arsenic a drop of ammonia, and then a drop of the solution of nitrate of silver; if arsenic be present, a yellow precipitate occurs.

(*e*) Boil the suspected matter in nitric acid to dryness, and repeat the operation, and dissolve the dry residuum in pure water; then add the ammonia and nitrate of silver as before, and a *brick red* precipitate occurs.

(*f*) Add to the solution supposed to contain arsenic a drop of the solution of sulphurretted hydrogene; if arsenic be present, a lemon yellow precipitate occurs.

(*g*) Mix the suspected substance with two parts of black flux, and heat the mixture between two polished copper plates; they will be *stained white*, if arsenic be present.

(*h*) Add a drop of the solution of chromate of potash to the solution supposed to contain arsenic or to an atom of the supposed white arsenic in substance; if it be arsenic, a bright grass green color will be produced in about 30 minutes. (*President* COOPER.)

The first test (*a*) is the only unequivocal proof; the rest are liable to give fallacious results, especially in the hands of unexperienced experimenters. For excellent practical instructions and observations on the tests of arsenic, and the cautions to be used in their application, I refer to BECK's valuable work on *Medical Jurisprudence*, vol. 2, page 202 et sequent.

OF SALTS CONTAINING ARSENIC.

271. Arsenious acid, and arsenic acid unite with salifiable bases, the former producing arsenates, the latter arsenates.

Arsenite of potash is the active ingredient in the "*Liquor Potassæ Arsenitis*" of the *U. S. Pharmacopœia.*

The arsenites and arsenates have been but little examined, and none except that above mentioned—and the arsenate of copper—are applied to any practical use.

OF MOLYBDENUM. (47?)

272. Molybdenum is a greyish white metal; very refractory and difficult of fusion. Specific gravity, about 8.

Molybdenum is not soluble in any acid but the nitric acid and nitro-muriatic.

When molybdenum is heated in the air, it unites with oxygene and a white crystalline substance is produced called *molybdic acid.* Besides this, there are two other combinations of this metal with oxygene.

273. *The Protoxide* is procured by heating molybdic acid with charcoal; it is of a blackish color, and consists of

Molybdenum	1 prime	47
Oxygene	1 prime	8

The *Deutoxide* is produced when tin is immersed in a solution of molybdic acid; it is of a blue color and consists of

Molybdenum	1 prime	47
Oxygene	2 primes	16

The molybdic acid is prepared by reducing the native sulpuret of molybdenum to powder, and boiling it repeatedly to dryness in nitric acid, until it is converted into an uniform white mass; the nitric and sulphuric acids which it contains may be expelled by exposing the mass to heat in a platinum crucible; the remaining matter, repeatedly washed in boiling water, is molybdic acid. It consists of

Molybdenum	1 prime	47
Oxygene	3 primes	24

It is a white powder; forming a solution in water of a yellow color, which has not a sour taste, but reddens litmus; one part of the acid requires 960 of boiling water for its solution.

The molybdates, formed by the union of this acid with salifiable bases, are not an interesting class of bodies.

274. *Sulphuret of Molybdenum* occurs native; it is soft, sectile, and resembles in some degree plumbago or black lead.

It is from this compound that the metal is procured, by first driving off the sulphur; then digesting it in pure ammonia; filtering the solution and evaporating to dryness; dissolving the dry mass in nitric acid, and again evaporating to dryness; and lastly heating this dry mass to an *intense temperature* with charcoal for one hour.

OF CHROMIUM.

275. Chromium has been obtained by igniting a mixture of its protoxide and charcoal, only in agglutinated grains; it is of a whitish grey color, and of a sp. gr. 5.9.

No acid but boiling nitro-muriatic acid acts on this metal.

When chromium is heated in the air it unites with oxygene; and forms the

276. *Protoxide of Chromium.* It is of a dark green color; soluble in acids; and is sometimes employed in painting of porcelain and enamel; it is usually obtained by heating chromate of mercury in a small retort. It is found native; and gives the exquisite green to the emerald.

Deutoxide of Chromium is a brilliant brown colored powder produced by heating the nitrate of chromium; it is not soluble in acids.

277. *Chromic acid* is of a red color, and sour metallic taste, soluble in water and crystallizable in ruby red prisms; it is the coloring matter of the ruby; when exposed to heat, it is decomposed, and the green protoxide remains. It is procured by decomposing the chromate of lead by potash; and adding sulphuric acid to this orange colored chromate of potash; on evaporation, crystals of chromic acid and of sulphate of potash are formed.

278. Chromic acid unites with salifiable bases, and forms salts: some of them are important in the arts as pigments; but little is known of their chymical habitudes.

Chromate of Potash, may be procured by heating equal weights of nitre and chromate of iron together; by subsequent solution and crystallization, the salt is procured in small crystalline prisms of a lemon yellow color, soluble in water, affording a yellow solution.

OF TUNGSTEN.

279. Tungsten is of an iron color, and has considerable lustre; it is very hard, and brittle. Specific gravity is 17.2.

Protoxide of tungsten is formed when hydrogene gas is passed over tungstic acid ignited in a glass tube; it is of a brown color, and when heated in the air takes fire, burns like tinder, and reproduces tungstic acid.

280. Tungstic acid is procured by complicated process from native tungstate of iron and manganese. It is of a yellow color; tasteless, insoluble in water, and forms, by uniting with salifiable bases, a class of salts called tungstates. When mixed with charcoal and exposed to a violent heat, it is reduced; but reduced with great difficulty.

281. Tungsten burns in chlorine with a deep red light, and forms an orange colored chloride of tungsten; when this is put into water they mutually suffer decomposition, and tungstic and muriatic acids result. (Davy. *Chym. Phil.*)

The combinations of tungstic acid, and of tungsten, have been but little examined, and appear to be of little importance.

OF COLUMBIUM.

282. Columbium was first recognised as a distinct body by Hatchett in a mineral, the columbite, from the United States; it is found at Haddam, Conn.(Torney.) Berzelius first procured it in its metallic state; it is, according to that philosopher, hard, brittle, and of the color of iron; burns at a red heat into a white oxide; it is not acted on by nitric, muriatic or nitro-muriatic acids.

This white oxide is soluble in potash; and from its readily combining with this alkali, was considered by its discoverer as an acid. Infusion of galls added to the columbate of potash gives a yellow precipitate; acids precipitate columbic acid from the solution of columbate of potash; the recently precipitated acid is soluble in tartaric, oxalic and nitric acids.

Very little is known respecting this metal, or its combinations.

III. OF THE METALS FORMING OXIDES ONLY.

OF MANGANESE. (28.)

283. Manganese is a metal of a blueish white color, and of very difficult fusion; it is hard and brittle; tarnishes on exposure to the air and is converted into an oxide.

There are two oxides of manganese.

284. The *protoxide* may be obtained by dissolving the manganese of commerce in sulphuric or nitric acid with a small quantity of sugar, and precipitating by potash; or, heat an excess of manganese of commerce with muriate of ammonia in a crucible; add water and filter the solution, it is pure muriate of manganese and may be decomposed by potash; (Faraday.) A white hydrated protoxide is separated; it is to be washed with hot water and dried out of contact of the air: it is of a dark olive color; absorbs oxygene when exposed to the air, and when heated takes fire. It consists of

Manganese	1 prime	28
Oxygene	1 prime	8
		36

When mixed with charcoal and exposed to an intense heat, it is reduced and affords the metal.

285. *The peroxide* is of a black color: when heated it suffers partial decomposition, and yields oxygene gas. This oxide is not soluble in any acid, without decomposition. It consists of

Manganese	1 prime	28
Oxygene	2 primes	16

The peroxide is an abundant natural product, and occurs often in fine crystalline masses. It is abundantly used for the production of chlorine in the manufacture of bleaching powder; and it is used also by glass-makers, and in potteries; and in the laboratory, as a source of oxygene gas. The fine amythestine color of glass is produced by this oxide of manganese.

It is found abundantly at Monkton, and Bennington, Vt. (Gibbs. Hall.)

When the peroxide of manganese is heated to redness with its own weight of nitre, a singular compound is formed, which dissolves in water, and produces several changes of color; it has been called *Cameleon Mineral;* from recent experiments of Chevillot and Edwards, it appears that the oxide of manganese has absorbed an additional portion of oxygene, and acquired the property of an acid, and united with potash forms the red cameleon, which is a neutral *manganesate of potash.*

286. *Chloride of manganese* is formed by the combustion of the metal in chlorine, or by dissolving the black oxide in muriatic acid, evaporating to dryness and igniting the residuum. It is a pink colored, semi-transparent substance, in brilliant crystalline scales. It consists of

Manganese	1 prime	28
Chlorine	1 prime	36

The salts of manganese do not require particular notice.

OF IRON.

287. Iron, the most common and most useful metal, has a blueish white color and a high degree of lustre; it melts at a strong white heat; is very ductile; and capable of being welded; its sp. gr. is 7.8.

It is found native in the United States and in other countries; a magnificent specimen is in the cabinet of Col. Gibbs from Louisiana; its weight exceeds 3,000 pounds; it is also found in meteoric stones.

There are several varieties of iron used in the arts; principally *cast iron, wrought iron and steel.*

(*a*) *Cast iron or pig iron* is the metal when first extracted from the ores; it is a very compound body, and contains, besides iron, its principal ingredient, portions of other metals, especially the metallic bases of the earths, and also sulphur, oxygene, &c. Manufacturers distinguish several kinds of *cast iron* according to its color and other qualities, viz:

White cast iron appears to be of a highly crystalline texture; is very hard and brittle, and cannot be wrought with tools; it is liable to crack on sudden changes of temperature.

Grey or mottled cast iron, so called from its color, is of a granulated texture, softer and more tough than the white variety, and can be turned in a lathe. Artillery is made of it.

Black cast iron is very fusible, and unequal in its texture, and has less cohesive force than the others.

Cast iron is converted into soft or wrought iron by the process of *puddling* and *blooming*; in which the extraneous matters are separated from the iron by fusing and hammering, or passing the metal while soft between heavy rollers.

288. Iron combines with oxygene in two proportions, and perhaps in more than two. The

(*a*) *Protoxide* is obtained by adding potash to a solution of green vitriol, washing, and drying the precipitate at a red heat out of contact of the air, or by burning iron wire in oxygene gas; it is of a black color, and consists of

Iron	1 prime	28
Oxygene	1 prime	8
		36

This oxide was formerly used in medicine and called Martial Ethiops.

(*b*) *Pertoxide* of iron is obtained by boiling the protoxide in nitric acid, and igniting the dry mass, or by drying and igniting green vitrol. (*U. S. Pharmacopœia.*) It is of a reddish brown color; it exists native in many ores of iron, and was formerly known by the name of *crocus martis*, and *colcothar;* it is used in giving a fine polish to silver wares, &c. It consists of

Iron	2 primes	56
Oxygene	3 primes	24

Peroxide of iron mixed with muriate of ammonia and heated, affords a yellow sublimate, called *ens veneris;* it is the "ammoniæ et ferri murias" of the U. S. Pharmacopæia. (Biglow's *Sequel.*)

There are two chlorides of iron.

289. The *Proto-chloride* may be obtained by dissolving the

protoxide in muriatic acid and evaporating the solution to dryness, and igniting the dry mass out of the contact of air; it has a greyish, variegated color, and metallic lustre; it is fusible at a red heat, and soluble in water. It consists of

Iron	1 prime	28
Chlorine	1 prime	36

The solution of this substance in water forms the *proto-muriate of iron.*

The *Per-chloride of Iron* is formed by burning iron in chlorine gas; it is a redish brown substance, of a brilliant metallic lustre, and is volatile; when acted on by water it affords permuriate of iron. It consists of

Iron	2 primes	56
Chlorine	3 primes	108.

290. *Iodide of Iron* is a fusible compound, of a brown color, produced by heating iron with iodine: when acted on by water, an hydriodate is produced by their mutual decomposition.

291. (*a*) *Proto-sulphuret of Iron* is formed by heating sulphur with iron filings; it is of a black color, but when broken frequently exhibits a yellowish hue with a slight metallic lustre. It consists of

Iron	1 prime	28
Sulphur	1 prime	16.

(*b*) The *Bi-sulphuret of Iron* is always a natural product; it is the very common mineral called *iron pyrites*, so often supposed to be a more valuable substance from its golden yellow color and high metallic lustre; it usually crystallizes in cubes, and consists of

Iron	1 prime	28
Sulphur	2 primes	32.

292. *Phosphuret of Iron* is a grey, brittle substance, of a metallic lustre, obtained by dropping phosphorus on red hot iron wire or filings, in a crucible.

293. *Carburet of Iron* (Plumbago, Graphite or black lead) is generally regarded as a carburet of iron. It is an abundant natural product, and is found of an excellent quality at Bristol, N. H. It contains

$$\text{Carbon } 95+\text{Iron } 5=100.$$

Its uses in making pencils, crucibles, anti-attrition paste, and in covering cast iron, are well known. It has been considered as an infusible body; but it yields to the action of HARE's *Deflagrator;* and was first fused by SILLIMAN. (*Silliman's Journal, Vol.* 6.)

294. *Steel* is a compound of iron and carbon, in variable proportions. There are several kinds of steel, distinguished by the names of *natural steel, steel of cementation, or blistered steel,* and *cast steel.*

Natural steel is much inferior to the other kinds, and is made directly from cast iron by exposing it to a violent heat under the surface of melted scoriæ. Part of the carbon of the cast iron, and other impurities are thus driven off; the remainder combined with the iron constitutes natural steel. It is not uniform in its texture.

Steel of cementation or *blistered steel* is made by stratifying pure bar iron with finely powdered charcoal, in an earthen, or crucible ware box, and carefully closing every aperture, and exposing the whole to an intense heat for 10 or 12 days. When this species of steel is drawn down into small bars, by the *tilt-hammer*, it is called *tilted-steel.* When it is broken into short bars, and repeatedly heated and welded so that the fibres may interlace with, and cross each other in various directions, and again drawn into bars, it forms *Shear steel* or *German steel.*

Cast steel is made by fusing blistered steel in a close crucible, with certain proportions of pounded glass and powdered charcoal. Cast steel is more valuable than the other kinds; it has a finer and closer grain, and is susceptible of an exquisite polish. When steel is heated to a cherry red heat, and suddenly plunged into cold water,it becomes so very hard and brittle, as to be unfit for almost any practical purpose; it is softened by again heating it to a certain point, a process called *tempering.*

295. *Iron and Cyanogene.* These two bodies have not yet been obtained insulated, in combination with each other in the proportions in which they exist together, and united with some other substances. It seems probable that there is an acid, in which iron and cyanogene form the basis, and hydrogene the acidifying body; and that it is analogous to hydro-chloric and hydriodic acids; it is called *ferro-cyanic* or *ferro-prussic* acid.

To procure it, add to the ferro-prussiate of baryta (see 296) (triple prussiate of baryta) just sulphuric acid enough to precipitate the baryta, and decant the clear liquid; or dissolve 56 grains of crystallized tartaric acid in alcohol, and add it to a solution of prussiate of potash dissolved in 2 or 3 drams of warm water; the potash is precipitated, leaving a clear solution of ferro-prussic acid, which, by spontaneous evaporation, affords crystals; when in solution, it has a pale lemon color, but no smell; when exposed to heat, or strong light, it is decomposed; it is capable of expelling some other acids from their combination with bases; it combines with alkalies, oxides and earths, and forms the compounds long known by the name of *triple prussiates.* It has been proved by Mr. PORRETT, who discovered it, to consist of iron, carbon, azote and hydrogene; and when a soluble *ferro-prussiate* is decomposed by the Voltaic battery, the acid with its constituent *iron*, goes to the positive pole. Many of the compounds produced by the union of this acid with oxides, contain neither hydrogene or oxygene; these have united, probably, to form water,while the metal of the oxide and the basis of the acid, iron and cyanogene, remain in combination; so that such compounds are *ferro-cyanides.* Thus the precipitate procured by adding *triple prussiate of potash*, to a solution of lead consists of

$$\left.\begin{array}{lll}\text{Cyanogene} & \text{2 primes} & =78 \\ \text{Iron} & \text{1 prime} & =28\end{array}\right\} =106$$

Lead 2 primes =208

The other *triple prussiates* have an analogous composition, and consist of

Cyanogene 3 primes+iron 1 prime, united to 2 primes of the basis.

Now the lead, and other bases, in solution, must have been combined with oxygene; and consequently, since the ferro-cyanides do not contain oxygene or hydrogene, the *ferro-prussic* acid, which contains hydrogene, must have contained a sufficient quantity to unite with the two primes of oxygene in the basis, viz. two primes; so that the acid obtained by Mr. Porrett is a *hydro-ferro-cyanic* acid, and is probably constituted of

Hydrogene 2 primes= 2
Cyanogene 3 primes=78
Iron 1 prime =28

108

or

Hydro-cyanic acid 2 primes=54
Cyanide of iron 1 prime =54

This acid, probably in some cases, unites to bases without relinquishing its hydrogene, and further researches may develope its basis in a separate form. The subject is not yet fully elucidated. (Gay Lussac. Brande's *Jour. No.* 31.)

296. *The Ferro-cyanides* (*Ferro prussiates, Triple prussiates*) of the alkaline bases are readily obtained by boiling the alkalies in water with prussian blue. Thus the ferro-cyanide of potassium, is formed by adding prussian blue, previously deprived of its alumine by sub-dilute sulphuric acid, in fine powder to a hot solution of potash, as long as the blue color is discharged. This compound is of a peculiar taste, is soluble in water, from which it crystallizes in fine yellow colored tables and cubes; it is insoluble in alcohol; and when decomposed in a retort by ignition affords hydro-cyanate of ammonia, carbonic acid, charcoal, potash and metallic iron; products which result, in part, from the decomposition of the water of crystallization.

The constitution of this compound is stated above (295.) In the large way the ferro-cyanide of potassium (*triple prussiate of potash*) is made by heating a mixture of pearlash and dried blood, or hoofs and horns, in an *iron* vessel, and constantly stirring the materials with an iron instrument; when the materials have acted upon each other, allow them to cool; then add water, filter and evaporate; crystals of ferro-cyanide of potassium will be deposited. (Ure's *Chym. Dic. Ed.* 2, *Lond.* p. 92.)

Probably when potash and animal matter are heated together in an earthen vessel, a cyanide of potash is formed. (Ure's *Dic. Ed.* 2. *Lond.* p. 653.)

SALTS OF IRON.

297. (*a*) Solutions of salts of iron give, with a solution of the ferro-cyanide of potassium, a precipitate which is of a deep blue color, or becomes so on exposure to the air.

(*b*) Infusion of nut-galls produces a black, or purple precipitate.

(*a*) *Nitrate of iron.* There are two nitrates of iron, produced by dissolving the protoxide, or peroxide of iron in nitric acid; concentrated nitric acid has not a rapid action on iron, but when diluted with a certain portion of water, a very violent action ensues, and an immense quantity of gas and vapor burst forth.

The *protonitrate*, consisting of nitric acid, and the protoxide of iron, readily obsorbs oxygene, and is converted into the

Pernitrate, which consists of peroxide of iron and nitric acid —its solution is of a brown color, and does not afford crystals by evaporation; by exposure to heat the acid is driven off, and the peroxide of iron remains.

(*b*) *Protosulphate of iron* is obtained by acting on the sulphuret of iron with diluted sulphuric acid; it consists of

Protoxide of iron	1 prime	36
Sulphuric acid	1 prime	40

Sulphate of iron is of a fine green color, soluble in water; its solution affords crystals in transparent rhombic prisms. It suffers changes on exposure to the air, and is converted into persulphate and peroxide of iron. When exposed to heat its acid is driven off, and it absorbs oxygene, and is thus converted into the peroxide of iron. Its green color is owing to water; when deprived of it, it becomes white.

Green vitriol, or *copperas*, is an impure *protosulphate* of iron; it is formed by exposing the native sulphuret of iron to the action of the air; oxygene is absorbed, the sulphur converted into sulphuric acid, and the iron into an oxide. It is extensively manufactured at Thetford, Vermont.

(*c*) *Persulphate* of iron is obtained by heating the moist red oxide in diluted sulphuric acid; it is of a reddish brown color; does not crystallize. It consists of

Peroxide of iron	1 prime	80
Sulphuric acid	3 primes	120

(*d*) The *protophosphate* is produced when a solution of phosphate of soda is added to a solution of protosulphate of iron; it is of a blue color, and insoluble in water; it is found native.

The *perphosphate* is formed when solutions of persulphate of iron, and of phosphate of soda are mixed: it is a white, insoluble powder.

The phosphates of iron have been employed in medical practice and the *protophosphate* is an officinal preparation. (*U. S. Pharmacopœia.*)

(*e*) *Carbonate of iron* is produced by adding to a solution of sulphate of iron, a solution of carbonate of potash; a greenish colored precipitate is thrown down which becomes brown on exposure to the air; it is found native.

Rust of iron is an impure carbonate of iron.

(*f*) *Chromate of iron* occurs native in small crystalline grains, or in amorphous masses of a black color and metallic lustre. When chromate of potash is dropped into a solution of protosulphate of iron, a fawn colored precipitate falls which contains oxide of chromium.

Chromate of iron is found near Baltimore; it promises to be a valuable source of pigments.

(*g*) *Ferro-cyanate of iron.* (*ferro-prussiate of iron.*) Ferro-cyanic acid, unites with the oxides of iron; the compounds are formed by adding ferro-cyanide of potassium to solutions of the sulphates of iron.

The *Proto-ferro-cyanate of* iron, is of a white or blueish white color.

The *Per-ferro-cyanate* (*prussian blue*) is of rich deep blue color, tasteless and inodorous; insoluble in water, or in alcohol. The prussian blue of commerce contains also a portion of alumine, which gives *body* to the pigment. It is usually made by adding a solution of ferro-cyanide of potassium (296) to a solution of 1 part of copperas and 4 of alum; the precipitate is to be well washed and dried. It is manufactured of a superior quality at the extensive works of Mr. WHITE, near Troy, New-York, and Watertown, Mass.

OF ZINC. (34.)

298. ZINC is of a white color with a distinct shade of blue, and of highly crystalline texture; its sp. gr. is 7. At common temperatures it is not malleable; at 300 it becomes so, and is then capable of being hammered, and drawn into wire; at a more elevated temperature it falls into powder, when struck with a hammer. Zinc is much employed in the construction of Voltaic instruments, and recently for covering roofs of buildings.

299. *Oxide of zinc* is produced when zinc is heated to redness in the air; the metal, burning with a bright flame, unites with oxygene, and a white, flocculent, wooly substance is formed, consisting of

Zinc	1 prime	34
Oxygene	1 prime	8

It is tasteless, and is soluble in acids and alkalies. It is employed in medicine, and for this purpose is best obtained by adding aqua ammonia to a solution of white vitriol, (*sulphate of zinc*) and washing and drying the precipitate.

300. *Chloride of zinc* is produced by heating thin plates of zinc in chlorine gas; it is a very deliquescent compound, soluble in water; the solution was formerly called muriate of zinc; it is very acrid and corrosive.

301. *Iodide of zinc* is a crystalline compound fusible, and volatile; it is readily formed when its two constituents are made to act on each other.

302. *Sulphuret of zinc* is formed by heating zinc and sulphur together; it consists of zinc 1 prime 34+sulphur 1 prime=16. It occurs native, and is a common ore of zinc called *blende*.

SALTS OF ZINC.

303. SOLUTIONS of salts of zinc afford white precipitates with ferro-cyanide of potassium; hydrosulphuret of potash and sulphuretted hydrogene.

(*a*) *Sulphate of zinc*—(*white vitriol*)—is a white salt, soluble in water and crystallizable in quadrangular prisms; it is prepared from the native sulphuret, or by dissolving zinc in dilute sulphuric acid; it consists of

Oxide of zinc	1 prime	42
Sulphuric acid	1 prime	40

It is a violent emetic, and occurs native.

(*b*) *Carbonate of zinc*—(*calamine*)—is a white tasteless powder, produced by adding carbonate of potash to sulphate of zinc in solution. It occurs native.

OF TIN. (59.)

304. TIN is of white color, malleable, not very ductile, of a specific gravity 7.3. When bent it produces a peculiar crackling sound.

Block tin is nearly pure tin; *tin foil* consists of nearly pure tin, cast in very thin sheets; *granulated tin*, or *grain tin*, is pure tin reduced to fine powder by pouring melted tin into water, or agitating the melted metal in a box chalked on the inside.

305. (*a*) *Protoxide of tin* is obtained by adding ammonia to a solution of proto-chloride of tin; (*muriate of tin;*) an hydret falls, which is of a grey color when dry; it is soluble in the alkalies. It consists of

Tin	1 prime	59
Oxygene	1 prime	8

Its equivalent is 67

(*b*) *Peroxide of tin* is formed by the action of nitric acid on tin; it is of a white color, soluble in alkalies and acids, fusible by heat, and is then insoluble in acids. This oxide forms the basis of white enamel. It consists of

Tin	1 prime	59
Oxygene	2 primes	16.

306. (*a*) *Protochloride of tin* is formed when one part of tin is boiled to dryness in a retort with two parts of muriatic acid; it is a crystalline body, translucent and of a grey color, and soluble in water; its solution rapidly absorbs oxygene from the air, and from other bodies. The solution is much employed by dyers. Protochloride of tin consists of

Tin	1 prime	59
Chlorine	1 prime	36

(*b*) *Perchloride of tin* is formed by heating tin in chlorine gas; or indirectly, by heating seven parts of an amalgam of tin, consisting of 6 of tin and 1 of mercury, with 30 parts of corrosive sublimate in a retort to which a large receiver is attached; a gentle heat is then to be applied; a transparent colorless fluid is distilled over, which is volatile and produces copious fumes when exposed to moist air. It consists of

Tin	1 prime	59
Chlorine	2 primes	72

This compound when added to a certain quantity of water forms a solid compound, which is probably a hydret of the perchloride; this is fusible and soluble in water.

307. *Iodide of tin* is formed by heating tin and iodine together; it is of an orange color.

308. (*a*) *Sulphuret of tin* is formed when tin and sulphur are heated together; it is a blueish black crystalline compound, containing

Tin	1 prime	59
Sulphur	1 prime	16

(*b*) *Bi-sulphuret of tin* is formed when equal weights of peroxide of tin and sulphur are heated together. It is of a golden yellow color and scaly structure, soft and unctuous to the touch; and consists of

Tin	1 prime	59
Sulphur	2 primes	32

It is employed in artificial *bronzing* of plaster casts, &c. and called aurum musivum, or mosaic gold. (AIKIN'S *Dic. Art.* TIN. URE'S *Dic. Art.* AURUM MUSIVUM.)

309. *Tin plate* is an imperfect alloy of iron and tin, made by dipping clean iron plates into melted tin. The tin which adheres to the surface crystallizes as it cools, and the crystalline structure is developed by the action of a weak acid, and the beautiful appearance called *moiré metallique* is produced. (17.)

THERE are no soluble compounds of tin which require particular notice, except the *chlorides.* (306. *a. b.*)

OF CADMIUM. (56.)

310. CADMIUM has a very close resemblance to tin: its sp. gr. is 8.6. It is fusible and volatile; when melted in contact with air, it absorbs oxygene and is converted into

311. *Oxide of cadmium*, which is of an orange color, is soluble in acids and precipitable from these solutions in the state of a white *hydret.* It consists of

Cadmium	1 prime	56
Oxygene	1 prime	8

It is soluble in ammonia, but not in the fixed alkalies.

Chloride of cadmium consists of cadmium 56, chlorine 36; it is a grey fusible compound, volatile, and condenses in micaceous plates.

312. This metal was discovered in 1817, by STROMEYER; it exists in certain ores of zinc. Its presence may be detected by dissolving zinc or ore in muriatic acid and evaporating the solution to dryness; re-dissolve and filter. From this solution all the metals present that iron will precipitate may be thrown down by a bar of bright soft iron. Filter again, and introduce a clean piece of zinc; the cadmium will be precipitated in its metallic state.

OF COPPER. (64.)

313. **Copper** is of a rose color, and high lustre. When heated, or rubbed, it evolves a peculiar odor. Its specific gravity is 8.89. or 9.00; it melts at a bright red heat. It occurs native in considerable quantities on the south shore of lake Superior. (Schoolcraft. *Silliman's Jour. Vol.* 8.)

314. (*a*) *Protoxide of copper* is formed by digesting copper filings and peroxide of copper in muriatic acid, and adding a solution of potash to the liquid. A hydret of copper falls, which is of an orange color. When quickly dried out of contact of the air, it becomes of a brownish red color. It consists of

Copper	1 prime	64
Oxygene	1 prime	8

It occurs native, and crystallized, forming a beautiful ore called *ruby* copper.

(*b*) *Peroxide of copper* is formed by adding potash to a solution of nitrate or sulphate of copper. A green hydretted peroxide falls, whch, when heated to redness, affords the black peroxide of copper. It consists of

Copper	1 prime	64
Oxygene	2 primes	16
Its equivalent number is		80

When the peroxide of copper is heated below ignition, and plunged into hydrogene gas, it becomes ignited and is reduced, and water is formed.

This oxide is soluble in pure ammonia. The solution is of a rich azure color; it has been called *cuprate of ammonia.*

315. (*a*) *Protochloride of copper* is formed by the action of an excess of copper filings on chlorine gas; or by heating to dryness the protoxide of copper and the metal in muriatic acid, in a vessel having a small orifice; it is of a dark brown color, fusible, and when slowly cooled is a yellow, semi-transparent, crystalline substance, insoluble in water, soluble in muriatic acid, and precipitable from its muriatic solution unaltered. Protochloride of copper consists of

Copper	1 prime	64
Chlorine	1 prime	36

When the solution of protochloride of copper in muriatic acid is exposed to the air, the acid suffers decomposition, oxygene is absorbed, and the

(*b*) *Perchloride of copper* is formed. It may also be produced by dissolving the peroxide of copper in muriatic acid, and evaporating to dryness at the temperature of 375°. It is of a yellow color, but changes its hue on exposure to heat and moisture. It is soluble in water, and when heated to redness in a tube with a small aperture, chlorine gas is evolved. It consists of

Copper	1 prime	64
Chlorine	2 primes	72

316. (*a*) *Sulphuret of copper* is formed when copper and sulphur are heated together. The action between them is energetic, and they become ignited when the sulphur is melted, presenting the phenomena of combustion, even in vessels exhausted of air. The sulphuret of copper is a black and brittle compound, consisting of

Copper	1 prime=64	
Sulphur	1 prime	16

(*b*) *Bi-sulphuret of copper* is of a golden yellow color and consists of

Copper	1 prime	64
Sulphur	2 primes	32

Both compounds of sulphur and copper occur native; the bisulphuret is the most common ore of copper.

317. Some of the alloys of copper are of great importance in the arts.

Brass, *Prince's metal*, *Pinchbeck*, and *Tombac*, consist of copper with various proportions of zinc. *Dutch leaf* or *brass leaf* is a compound of copper and zinc, very malleable; the leaves are about five times as thick as gold leaf, or 1-60 thousandth of an inch in thickness.

Bell metal and *bronze*, are alloys of copper and tin; in small sharp sounding bells there is a small portion of zinc.

An alloy of copper and tin is used for specula in reflecting telescopes. A very beautiful and perfect compound of these two metals for this purpose, has been made under the direction of Dr. OLIVER of Salem.

SALTS OF COPPER.

318. SALTS of copper have the peroxide for their basis.

(*a*) They all afford a blue solution when acted on by ammonia.

(*b*) They afford a chocolate colored precipitate on the addition of a solution of the ferro-cyanide of potassium.

(*a*) *Nitrate of copper, or pernitrate of copper.* Nitric acid acts with great energy on copper; nitrous acid gas is evolved, and a blue solution is obtained. This, by cautious evaporation, yields crystals of nitrate of copper. These crytals are of a fine blue color, and of an acrid and metallic taste; deliquescent, and soluble in water, and act as a caustic on the skin. Exposed to heat, they suffer watery fusion, and by a more elevated temperature are decomposed. When they are moistened with water and wrapped up in a sheet of tin foil, they are decomposed with violence; steam and red vapors are evolved, and sometimes ignition, or sparks of light may be noticed. Nitrate of copper consists of

Peroxide of copper	1 prime=	80
Nitric acid	2 primes=	108

Sulphate of copper, or *persulphate of copper*—(*blue vitriol*)—may be formed by heating peroxide of copper in sulphuric acid. The solution affords fine blue, rhomboidal, doubly refracting crystals, of a styptic metallic taste, and offen employed as a caustic. They effloresce on exposure to dry air, and when heated, lose their water of crystallization, and their color; when exposed to higher temperatures they are decomposed, and peroxide of copper remains. The sulphate of copper, in the large way, is made either by partially decomposing sulphuret of copper, by heat, and exposure to the air; or by the direct action of the acid on copper, which is effected in a peculiar manner at the Chymical works in Salem, Mass. where blue vitriol of an excellent quality, is extensively manufactured. It is composed of

Peroxide of copper	1 prime =	80
Sulphuric acid	2 primes	80

It occurs native, and is used in medicine as a prompt emetic.

Phosphate of copper is formed when a solution of phosphate of soda is mixed with one of sulphate of copper; it is a blueish white powder, insoluble in water, and fusible by heat.

It consists of

Peroxide of copper	1 prime =	80
Phosphoric acid	2 primes=	56

Carbonate of copper is formed when carbonate of potash is added to sulphate of copper, or nitrate of copper. It has a fine green color, and is insoluble in water. It consists of

Peroxide of copper	1 prime	80
Carbonic acid	1 prime	22

It is used as a pigment.

It occurs native, either of a green, or blue color, and constitutes a mineral of great beauty and elegance.

Blue verditer is a carbonate of copper, which contains a greater proportion of carbonic acid than the above mentioned salt. A very inferior verditer is made by adding whiting to a solution of blue vitriol.

Arsenite of copper—(*Scheele's green*)—is a grass green powder, insoluble in water, formed by adding a solution of arsenite of potash to one of sulphate of copper. It is sometimes used as a pigment.

OF LEAD. (104.)

319. Lead is of a blueish white color, soft, ductile, and malleable; its sp. gr. is 11.4. and it fuses at 600° F.

When lead is heated in contact with the air, its surface becomes dull, and it is converted into an oxide of lead.

320. (*a*) *Protoxide of lead*—(*massicot*)—may be obtained easily, by heating the nitrate of lead in a vessel having a small orifice, until all the acid is expelled; or by drying the precipitate produced, by adding potash to a solution of nitrate of lead. It is of a yellow color, fusible by heat into a glass. It is volatile at a bright red heat, and forms the bases of the salts of lead. It is soluble in potash, and soda. It consists of

Lead	1 prime	104
Oxygene	1 prime	8
Its equivalent number is		112

Litharge consists of this oxide partially vitrified.

(*b*) *Peroxide of lead.* When red lead is digested in nitric acid, a brown insoluble powder remains, which is the peroxide of lead. When this oxide of lead is heated, it gives off half its oxygene, and is converted into the protoxide. It consists of

Lead	1 prime=	104
Oxygene	2 primes	16

Minium or red lead is an oxide of lead whose nature admits of doubt. It consists of

Lead	1	prime	104	or	2 primes	208
Oxygene	1 1-2	prime	12	or	3 primes	24
			116			232

Or of

Protoxide of lead	1 prime	112
Peroxide of lead	1 prime	120
		232

It is formed by exposing lead to heat and air, with constant stirring.

321. *Chloride of lead* is formed by the direct union of lead with chlorine, or by adding muriatic acid to nitrate of lead. It is a white substance, fusible at moderate temperatures, and vol-

atile at higher temperatures in open vessels. After fusion, it is a semi-transparent substance like horn. It is soluble in water, and in nitric acid. It consists of

Lead	1 prime	104
Chlorine	1 prime	36

Patent yellow is an impure chloride of lead.

322. *Iodide of lead* is also a yellow insoluble body, produced by heating the metal in thin leaves with iodine.

323. *Sulphuret of lead* may be formed by heating sulphur and lead together. It has the color and lustre of the metal, and consists of

Lead	1 prime	104
Sulphur	1 prime	16

It is an abundant natural product; the galena of mineralogists.

324. *Phosphuret of lead* is formed by dropping phosphorus on melted lead. It has a metallic lustre and brilliancy, which it soon loses on exposure to the air.

325. *Common pewter* is an alloy of lead and tin, in the proportion of 1 of the former to 4 of the latter metal.

Soft solder, or *plumber's solder*, consists of equal parts of tin and lead.

SALTS OF LEAD.

326. (*a*) THE soluble salts of lead have more or less of a sweet astringent taste.

(*b*) Solutions of sulphuretted hydrogene, and of hydrosulphurets, produce in solutions of salts of lead a black precipitate.

(*c*) A plate of zinc immersed in a solution of lead produces a white precipitate; or reduces the lead to its metallic state.

Nitrate of lead is formed by digesting lead in diluted nitric acid; by evaporation, the salt is obtained in opaque white crystals, of an octaëdral or tetraëdral form and a silvery lustre. Alkalies added to a solution of this salt precipitate the protoxide of lead. It consists of

Protoxide of lead	1 prime=112
Nitric acid	1 prime 54

The crystals of nitrate of lead heated with charcoal afford the pure metallic lead.

Sulphate of lead is readily formed by adding a solution of sulphate of soda to any solution of lead. The sulphate of lead precipitates in a white powder. It is tasteless, and nearly insoluble in water, requiring for its solution 1200 parts of water. It is sparingly soluble in dilute sulphuric acid. When this salt is dried at 400° F. it may be heated to redness without suffering any diminution of weight; it is reduced on charcoal before the blowpipe; and consists of

Protoxide of lead	1 prime	112
Sulphuric acid	1 prime	40

Phosphate of lead is a yellowish white insoluble powder, produced by adding a solution of phosphate of soda to a solution of lead. It is soluble in a solution of soda, with which it forms a triple salt. It is fusible before the blowpipe and crystallizes on cooling. It consists of

Protoxide of lead	1 prime	112
Phosphoric acid	1 prime	28

It occurs native.

Carbonate of lead—(*ceruse—white lead*)—may be formed by adding a solution of carbonate of potash, or soda to any solution of lead. It is a white, insoluble, tasteless powder. It is prepared by exposing plates of lead to the action of vapor of vinegar. The metal is corroded and becomes converted into a carbonate; the perfection of the color depends on the purity of the lead employed. It occurs native, and constitutes a mineral of great beauty. It consists of

Protoxide of lead	1 prime	112
Carbonic acid	1 prime	22

Chromate of lead—(*chrome yellow*)—is formed by adding a solution of chromate of potash to a solution of lead; an orange colored precipitate falls, which becomes yellow on drying. It is insoluble in water, and is decomposed by sulphuric and nitric acids. It occurs native, and has been obtained in artificial crystals.

OF ANTIMONY. (48?)

327. **Antimony** is a brittle, white metal, of a crystalline texture; it melts at a dull red heat, and is volatile at higher temperatures. Its sp. gr. is 6.71.

328. There are several combinations of antimony with oxygene, two of which are well defined, the others are of a doubtful composition.

(*a*) *Protoxide of antimony* is a greyish white powder, procured by dissolving the metal in muriatic acid, and pouring the solution into potash water. It fuses at a moderate heat, and forms a crystalline mass as it cools. This oxide contains

Antimony	1 prime	48
Oxygene	1 prime	8
Its equivalent number is		56

It is the basis of all the active antimonial preparations used in medical practice ; mixed with its weight of tartar, and heated, it affords pure metallic antimony.

(*b*) *Peroxide of antimony* is procured by boiling the metal repeatedly in nitric acid, and exposing the residue to a red heat; another process is found in the United States Pharmacopœia. The peroxide of antimony is of a yellowish white color, and possesses, in a degree, the properties of an acid. It consists of

Antimony 1 prime 48+oxygene 2 primes 16.

It combines with bases producing a class of compounds called *antimoniates.*

329. *Chloride of antimony* is readily formed by introducing powdered antimony into the gas. The compound, at first liquid, becomes a solid of a soft consistence. It is easily fusible, and deliquescent; it is an energetic caustic. It affords protoxide of antimony, and muriatic acid by the action of water; and the protoxide dissolved in muriatic acid, and evaporated to dryness, affords the chloride. It consists of

Antimony	1 prime	48
Chlorine	1 prime	36

329. *Iodide of Antimony* is procured by heating the metal with iodine; it it is of a dark reddish color. When the iodide and water come in contact, they suffer mutual decomposition.

330. *Sulphuret of Antimony*—(*crude antimony*)—is formed by heating sulphur with the metal; it is of a blackish grey color and metallic lustre, and of a crystalline texture. It is found native.

Glass of antimony is procured by heating to redness the sulphuret on a muffle. Sulphur is expelled, and oxygene is absorbed, and thus a mixture of the sulphuret and oxide of antimony is procured, which,by a more elevated temperature, is fused into a blackish or brownish yellow glass.

331. *Phosphuret of antimony* is a white brittle body, formed by heating oxide of antimony and phosphoric acid with charcoal.

332. Some of the alloys of antimony are of great importance. The white and hard metal used for the manufacture of articles of table furniture, is an alloy of tin, antimony, bismuth and copper. Printers' types, are an alloy of lead and antimony with a little copper, or brass; and plates, for engraving music upon, are formed of lead and antimony. It is requisite that good type metal should run freely into the mould, and possess hardness without brittleness. The smaller letters are harder

than the large ones. A perfectly uniform alloy, possessing the requisite properties for good types, is yet a desideratum. Out of the same parcel of metal some types are very hard and brittle, and others, soft and sectile.

333. *Hydrosulphuret of antimony*—(*Kermes mineral*)—is a compound of protoxide of antimony with sulphuretted hydrogene, procured by boiling sulphuret of antimony with carbonate of soda in an iron vessel. The liquor is to be filtered, and very slowly cooled; the precipitate is to be washed in recently distilled water and dried slowly. It is a fine light velvety powder, of a deep purplish brown color.

The liquid from which the *kermes* is deposited affords on the addition of dilute acids an orange yellow precipitate, which is an hydroguretted sulphuret of antimony, or sulphuretted hydrosulphuret of antimony.

Both the last mentioned bodies contain oxide of antimony and sulphuretted hydrogene, and may without impropriety be considered as salts.

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334. The salts of antimony are not of great importance. They afford orange colored precipitates on the addition of a solution of sulphuretted hydrogene.

OF BISMUTH. (72.)

335. Bismuth is a reddish white brittle metal of a highly crystalline texture; its sp. gr. is 9.8. At 476 it melts, and may be procured in crystals of great beauty by slow cooling. (8.)

336. By exposure to heat and air bismuth unites with oxygene, forming a *white oxide*, which consists of

Bismuth	1 prime	=72
Oxygene	1 prime	8
Its equivalent is		80

This oxide may also be procured by affusion of a large portion of water on the nitrate of the metal. It is used in medicine, and as a cosmetic, and called *magestery of bismuth*.

337. *Chloride of bismuth* is formed by heating the metal in chlorine, or by dissolving it in muriatic acid and evaporating the solution to dryness. On raising the temperature, a volatile deliquescent body is sublimed, which consists of

Bismuth	1 prime	72
Chlorine	1 prime	36

338. *Iodide of Bismuth*, procured by heating the constituents together, is of an orange color, and insoluble in water.

339. *Sulphuret of bismuth* occurs native and may be formed artificially. It consists of

Bismuth 1 prime 72+Sulphur 1 prime 16.

340. Bismuth enters into the composition of soft solders, and forms very fusible alloys. An alloy of 8 parts of bismuth, five of lead and three of tin, fuses at about 212°.

SALTS OF BISMUTH.

341. The salts of bismuth have been imperfectly examined. The *nitrate* is easily formed by adding the metal to the acid. A rapid action ensues; the solution affords crystals of a quadrangular form, white, and transparent, consisting of

Oxide of bismuth	1 prime	80
Nitric acid	1 prime	54

They are instantly rendered opake by the action of water' and the liquid nitrate is decomposed by that fluid.

OF COBALT. (30?)

342. Cobalt is a brittle metal, of a reddish gray color with little lustre. It is somewhat soft, but is fused with difficulty. Its sp. gr. is 8.6.

Cobalt is susceptible of feeble magnetism.

343. (*a*) *Protoxide of cobalt* is procured by gently igniting in a retort, the precipitate procured by adding potash water to nitrate of cobalt. When recently precipitated it is blue; if left in contact with water, it becomes of a rose color, but when heated it becomes of a blueish black. It consists of

Cobalt	1 prime	= 30?
Oxygene	1 prime	8

(*b*) When the protoxide of cobalt is heated in the air, it passes to the *peroxide* by absorbing oxygene.

It consists of Cobalt 1 prime 30+Oxygene 2 primes 16 ?

When violently heated with charcoal and a flux, it is reduced to pure cobalt.

344. *Chloride of cobalt* is formed by heating the metal in chlorine, where it takes fire; or by dissolving it in muriatic acid, and

evaporating the solution to dryness, and heating the residue. It is of a Camellar texture and blue color. It is soluble in water, and its solution, which is of a pink color, is used as a *sympathetic ink.* Characters written with it are hardly visible when cold, but when heated become green.

It consists of Cobalt 1 prime = 30 + Chlorine 1 prime = 36.

345. The iodide, sulphuret and phosphuret of cobalt have been formed, but not much examined.

Cobalt is employed for painting, and printing the blue figures on the common earthen ware, and for staining glass.

Zaffre is an impure oxide of cobalt fused into a blue glass with some vitrifiable substance.

Smalt is made by fusing zaffre with glass, which while hot, is dropped into cold water, and reduced to a fine powder.

SALTS OF COBALT.

346. (*a*) The salts of cobalt have the protoxide for their bases; they give a precipitate on the addition of ammonia, and are soluble in an excess of that alkali.

(*b*) The solution of ferro-cyanide of potassium produces in them a grass green precipitate. (BRANDE.)

1. *Nitrate of cobalt* is formed by digesting the metal in nitric acid. The solution is of a rose color, and affords on evaporation, red crystals, deliquescent, and decomposable by heat.

2. *Phosphate of cobalt* is an insoluble, reddish purple powder, produced by adding prosphate of ammonia or soda to a solution of nitrate or of chloride of cobalt. When heated with alumine, it produces a beautiful blue pigment called *Thenard's blue*, which has been employed as a substitute for ultramarine. It is considered as a combination of oxide of cobalt and alumine. (BRANDE's *Jour. No.* 30.)

OF URANIUM.

347. URANIUM is a grey, brittle and difficultly fusible metal, first discovered by KLAPROTH in a mineral called pechblend. Its

combinations and characters have not been investigated sufficiently to present a satisfactory history of the metal.

Oxide of uranium is of a yellow color, and is procured by the addition of potash to the nitrate of the metal.

347. The saline combinations of uranium have a yellowish color, and a metallic acerb taste. Potash produces in them a yellow precipitate, and carbonate of potash a white precipitate; both precipitates are soluble in carbonate of potash.

OF TITANIUM.

348. **Titanium** has not been obtained in agglutinated masses; it is of very difficult fusion. Its color is red, like copper; it is obtained from the nitrate of titanium.

It appears to form three oxides, viz. *blue*, *red* (native), and *white* (hydret.) The latter is probably an acid.

349. The solutions of oxide of titanium are colorless. The white oxide is precipitated from them by alkalies. They afford a red precipitate with infusion of galls, and a green one with a solution of ferro-cyanide of potassium.

OF CERIUM.

350. **Cerium** is said to be a white, brittle metal; it is of very difficult reduction. It appears to be susceptible of forming two oxides, viz. a *white*, and a *reddish colored oxide.* The latter oxide is soluble in acids.

351. The saline combinations of cerium are white, or yellowish; of a sweetish taste, and yield a white precipitate with hydro-sulphuret of potash, but none with sulphuretted hydrogene.

OF TELLURIUM. (39.)

352. **Tellurium** is a greyish white metal, of considerable lustre; brittle, easily fusible, and volatile; sp. gr. 6. Its ores have been found in Siberia.

353. When heated, it exhales a pungent odor, burns, and forms a cream colored oxide, which consists of

Tellurium	1 prime	39
Oxygene	1 prime	8

354. *Chloride of Tellurium* is a white, fusible body, formed by heating the metal in chlorine gas.

355. *Iodide, and sulphuret of tellurium* have been formed, but not particularly examined.

356. *Teluretted hydrogene gas* is disengaged when the mixture of potash and oxide of tellurium, previously ignited with charcoal, is acted upon by diluted sulphuric acid. The gas is to be collected over mercury. It has a strong, pungent odor; is inflammable, and burns with a blueish flame, depositing oxide of tellurium. It dissolves in water, and forms a claret colored solution.

There appears to be a solid hydruret of tellurium.

SALTS OF TELLURIUM.

357. The oxide of tellurium is soluble in several acids, but the combinations have not been particularly examined. They are decomposed by the alkalies, and the precipitate is soluble in excess of them. They afford a brown precipitate on the addition of hydro-sulphuret of ammonia, and metallic tellurium, when a plate of iron, zinc or tin is immersed in them.

OF NICKEL. (30.)

358. Nickel is a white metal of great hardness, and uniform texture, malleable, and susceptible of magnetism with polarity. Its sp. gr. is 8.27.

359. When nickel is exposed to heat, it is readily converted into an oxide.

(*a*) The protoxide is procured by adding potash-water to nitrate of nickel; a green hydret falls, which becomes grey when heated, and then consists of

Nickel	1 prime	30
Oxygene	1 prime	8

This oxide is soluble in ammonia, and forms an azure blue solution, like that of copper.

The oxide, when heated with the black flux, affords pure nickel.

(*b*) When chlorine gas is passed through water holding the protoxide of nickel in solution, a black peroxide is obtained.

360. Very little is known respecting the chloride, iodide and sulphuret of nickel.

361. This metal is very interesting, from the fact that it always exists in meteoric stones or ærolites. In these it is alloyed with iron; and meteoric iron contains nickel.

SALTS OF NICKEL.

362. (*a*) Salts of nickel form fine green colored solutions, which present appearances with ammonia, similar to those of copper. (318.)

(*b*) Ferro-cyanide of potassium produces in them a greenish white precipitate. The individual salts of this metal, being of no importance in the arts, do not require particular notice.

OF MERCURY. (200.)

363. Mercury is a brilliant white metal, fusible at 39°, and of course fluid at all common temperatures; boils and evaporates at 656°F. and is capable of forming vapor at common temperatures, as was proved by Farraday. Its sp. gr. is 13.5. It occurs native.

364. (*a*) *Protoxide of mercury* is a black, tasteless powder, insoluble in water; it is decomposed by heat, oxygene is evolved and the mercury revived. It is procured by acting on calomel with warm potash water, and subsequent edulcoration; or by long continued agitation of mercury in contact with oxygene.

It consists of

Mercury	1 prime	200
Oxygene	1 prime	8

It is the basis of some mild mercurial medicines.

(*b*) *Peroxide of mercury*—(*red precipitate*)—is formed by adding potash water to corrosive sublimate, and subsequent washing, or by exposing mercury, heated nearly to its boiling point, to the action of the air, or by decomposing the nitrate of mercury by heat. Its color varies with its state of mechanical aggregation, and by heat; the brilliant scales of the red precipitate form an orange colored powder when rubbed in a mortar, and pass through various shades of crimson, and maroon color, to dark steel grey, when the temperature is raised, but regain their original hue as the temperature is again reduced. Peroxide of mercury is acrid, and an escharotic; sparingly soluble in water; it is decomposed by a red heat, and consists of

Mercury	1 prime	200
Oxygene	2 primes	16

365. (*a*) *Protochloride of mercury*—(*calomel*)—is generally formed by triturating metallic mercury with corrosive sublimate, and afterward subliming the protochloride thus formed. It was formerly the custom to sublime it repeatedly; but a portion of corrosive sublimate is formed at each repetition of the process. It may be formed by adding a solution of common salt to protonitrate of mercury.

Protochloride of mercury, when slowly sublimed, forms acicular crystals of considerable beauty. It is tasteless, and insoluble in water; and when two pieces are rubbed together in the dark, they phosphoresce. It consists of

Mercury	1 prime	200
Chlorine	1 prime	36

(*b*) *Perchloride of mercury*—(*corrosive sublimate*)—may be formed directly by heating mercury in chlorine gas, in which it burns with a reddish flame; or, indirectly, by mixing chloride of sodium (common salt) with persulphate of mercury, and subjecting the materials to a subliming heat. The perchloride rises and concretes into a translucent, white, crystalline mass. It has an acrid and astringent metallic taste, eminently disagreeable. It is soluble in water. The solution, after a time, suffers partial decomposition by the action of light, and the protochloride is precipitated. A little common salt, or sal ammoniac added to it, prevents this decomposition. It is soluble in alcohol. It is decomposed by the alkalies, potash and soda, and peroxide of mercury is produced. It consists of

Mercury	1 prime	200
Chlorine	2 primes	72

366. *Protiodide of mercury* is a yellow compound, consisting of 1 prime of each of its constituents; and periodide of mercury is a red compound containing 1 prime of mercury and 2 of iodine. It is procured by heating mercury and iodine together.

367. (*a*) *Protosulphuret of mercury*—(*Ethiop's mineral*)—is a black, tasteless, insoluble powder, obtained by rubbing sulphur and mercury together in a mortar, or by dropping mercury into melted sulphur. It consists of

Mercury	1 prime	200
Sulphur	1 prime	16

(*b*) When this substance is exposed to heat, a portion sublimes and is condensed into a steel grey solid called *cinnabar*. It is a persulphuret of mercury, and consists of

Mercury	1 prime	=200
Sulphur	2 primes	32

When this is levigated, it forms the pigment *vermilion*.

368. *Phosphuret of mercury* is a soft solid of a blackish blue color, formed by heating oxide of mercury and phosphorus.

369. *Cyanide of mercury*—(*prussiate of mercury*)—This compound is procured by boiling finely powdered peroxide of mercury with excess of powdered ferro-cyanate of iron (*prussian blue*) in water, and filtering the solution when hot. On cooling, it deposits yellowish white four sided crystals, of a peculiar unpleasant metallic taste, and which consists of

Mercury	1 prime	200
Cyanogene	2 primes	52

A solution of cyanide of mercury dissolves a portion of oxide of mercury, becomes alkaline, and crystallizes in small scales. This solution, when evaporated to dryness, is very easily charred.

Cyanide of mercury is decomposed by heat, and affords pure cyanogene gas, and by the action of sulphuretted hydrogene, or of muriatic acid, affords pure hydrocyanic acid, (*Prussic acid.*)

SALTS OF MERCURY.

370. (*a*) The salts of mercury are volatile at a red heat.

(*b*) Ferro-cyanide of potassium produces in them a white precipitate.

(*c*) A plate of copper immersed in their solutions is speedily coated with quicksilver.

371. (*d*) *Protonitrate of mercury* is formed by dissolving small portions of the metal at a time in cold diluted nitric acid, until the acid ceases to act on it. This salt is crystallizable, and affords the protoxide on the addition of alkalies. It is caustic, and tinges the skin black.

(*b*) *Pernitrate of mercury* is formed by dissolving mercury in nitric acid by the aid of heat. The solution is more acrid than the protonitrate. On the addition of water a precipitate falls consisting of supernitrate of mercury, and a bi-pernitrate remains in solution.

When either of these nitrates of mercury are heated to dull redness, the red precipitate is formed.

(*c*) *Protosulphate of mercury* is formed when the metal is boiled in its own weight of sulphuric acid; and a white deliquescent mass formed, which affords a very difficultly soluble salt by washing with cold water.

(*d*) *Persulphate of mercury* is formed when 3 parts of sulphuric acid are boiled to dryness on 1 of mercury. The salt is decomposed by hot water; a bright yellow insoluble sub-persulphate of mercury (*turpeth mineral*) is formed, and a bi-persulphate remains in solution. The sub-persulphate consists of

Peroxide of mercury	1 prime	216
Sulphuric acid	1 prime	40

(*e*) *Cyanate of mercury*—(*fulminating mercury*)—is prepared by making a solution of 100 grains of mercury in a fluid ounce and a half of nitric acid, with the aid of heat. The solution when cold is to be poured into two fluid ounces of alcohol, and the mixture cautiously heated till an effervescence appears. As soon as the precipitate is thrown down, it is to be immediately placed on a filter, and well washed with water, and carefully dried at a gentle heat. This is a greyish white compound; which, on the application of heat, produces a slight explosion, and by a blow, or friction, a violent detonation. The nature of this compound seems to have been elucidated by LIEBEG and GAY LUSSAC. (*Brande's Jour. No.* 34.) It consists of oxide of mercury united to *cyanic acid*. It was discovered by Mr. HOWARD.

OF OSMIUM.

372. OSMIUM was discovered by TENNANT in ore of platinum. It is of a blackish grey color; is not volatile in close vessels, and has not been fused. When exposed to heat and air, it absorbs oxygene, and forms a volatile oxide of a pungent smell. The oxide is soluble in water, and forms a colorless, sweet tasted solution, having the odor of the oxide, and capable of staining the cuticle black. The oxide yields its oxygene to all metals, except to gold and platina. When mercury is agitated in the solution of the oxide, an amalgam of osmium is formed, which by exposure to heat is decomposed, and pure osmium obtained. Infusion of galls produces a blue precipitate in the solution of the oxide. Osmium is readily soluble in alkalies, but is not acted on by acids. Its name is derived from the Greek word for *odor*.

OF IRIDIUM.

373. **This** metal was also discovered by Mr. **Tennant** in ore of platinum; it is of a whitish color, fuses with extreme difficulty, and has a sp. gr.=18. Its solution in muriatic acid presents a variety of colors, and hence the name Iridium. The muriatic solution is decomposed by a plate of zinc and metallic iridium is precipitated.

OF RHODIUM.

374. **This** metal was discovered by **Wollaston** in ore of platinum. It is of a white color, difficult of fusion ;—sp. gr. 10.6; soluble in nitro-muriatic acid; the solution affords, on evaporation, a red substance, soluble in water and in alcohol; the name *Rhodium* was suggested by the rose color of this compound.

OF PALLADIUM.

375. **This** metal was discovered by **Wollaston** in ore of platinum. It is of a greyish white color, and with little lustre. It is malleable, ductile, and hard. Its sp. gr. is 11. It exists native in ore of platinum. When exposed to heat it tarnishes; but afterwards becomes bright. If touched while hot with sulphur, it melts at once, and a sulphuret is formed. When muriatic acid is boiled on palladium, it acquires a red color, and sulphuric acid a blue color. It is soluble in nitric acid and nitro-muriatic acid. From the solutions the alkalies throw down orange colored precipitates; and a solution of cyanide of mercury, a yellowish floculent precipitate, which on exposure to heat affords pure palladium.

OF SILVER. (110.)

376. **Silver** is of a white color, and has considerable lustre. It is very malleable, and ductile; its sp. gr. is 10.5. It fuses at a bright red heat, and when in fusion appears very brilliant. It

tarnishes in the air, not from oxidizement, but from the action of sulphurous vapors.

377. *Oxide of silver* is procured, when lime water is added to a solution of nitrate of silver. It has a dark olive color, is insipid, and insoluble in water; decomposed by heat, and pure silver remains. It consists of

Silver	1 prime	110
Oxygene	1 prime	8

And its equivalent is 118

378. This oxide is soluble in ammonia, and the solution affords fulminating silver; a black compound of oxide of silver, and ammonia, which detonates with extreme violence on the slightest touch, even when moist. Water, azote and pure silver are the results of its decomposition. It was discovered by BERTHOLLET, and differs from *cyanate of silver*, or *detonating silver.*

379. *Chloride of silver* is easily formed by adding a solution of common salt to one of nitrate of silver; a curdy precipitate is formed, which is at first white, but on exposure to light becomes purple and ultimately black.

Chloride of silver is fusible at a dull red heat, and is volatile at a white heat. It is soluble in pure ammonia, and the solution sometimes affords *fulminating silver.* It is decomposed when placed in contact with nascent hydrogene, and metallic silver in very fine powder is obtained. When rubbed with zinc filings and moistened, the heat is so great as to fuse the resulting alloy of silver and zinc. It consists of

Silver	1 prime	110
Chlorine	1 prime	36

380. *Iodide of silver* is formed when hydriodates are added to a solution of silver. It resembles chloride of silver, but is insoluble in ammonia.

381. *Sulphuret of silver* is easily formed by heating its constituents together. It is a fusible grey crystalline compound. It consists of

Silver 1 prime 110+Sulphur 1 prime 16.

SALTS OF SILVER.

382. THE saline solutions of silver all afford a precipitate with a solution of chloride of sodium, which blackens on exposure to light, and is dissolved by pure ammonia.

383. (*a*) *Nitrate of silver* is readily formed by dissolving the metal in the acid. The solution is colorless, acrid and caustic; tinges the skin black, and on evaporation affords crystals of nitrate of silver. These have a very disagreeable metallic taste, and are decomposed by light, and the silver reduced. The solution is decomposed by copper, and pure metallic silver separated. When crystals of nitrate of silver are mixed with sulphur or phosphorus, and struck a heavy blow with a hammer, explosion is produced. It consists of

Oxide of silver 1 prime 118+nitric acid 1 prime 54.

Lunar caustic is fused in nitrate of silver; by a strong heat, it is decomposed. It is used as the basis of indelible ink.

(*b*) *Hyposulphate of silver* is produced when chloride of silver is dissolved in any hyposulphite. It is *intensely* and *purely sweet to the taste.*

(*c*) *Sulphate of silver* is formed when a solution of sulphate of soda is added to nitrate of silver, or by the direct action of boiling sulphuric acid on clippings of silver. It is soluble in water, and affords small acicular crystals. It consists of oxide of silver, and sulphuric acid each 1 prime.

(*d*) *Cyanate of silver*—(*detonating silver*)—was discovered by **Brunatelli**. It may be prepared by dissolving silver or lunar caustic in nitric acid, and mixing the solution with alcohol. Effervescence soon occurs, and a white crystalline powder is separated. It explodes with a sharp report on contact of strong sulphuric acid, or by heat, or friction, or by the electric spark.

It consists of

Oxide of silver	**1 prime**	**118**	
Cyanic acid	**2 primes=68**	**Oxygene Cyanogene**	**2 primes 2 primes.**

Gay Lussac and Liebeg.

OF GOLD. (200.)

384. **Gold** is of a yellow color, soft, and more malleable than any other metal; fuses at a bright red heat, and appears green when in fusion. It is not altered by exposure to heat. Its specific gravity is 19.3.

385. (*a*) *Protoxide of gold* is formed by washing with potash water, the matter which remains after heating chloride of gold; it is of a greenish purple color. It is also probably formed when an electric discharge is passed through a small gold wire.

It consists of

Gold	**1 prime**	**200?**
Oxygene	**1 prime**	**8?**

(*b*) *Peroxide of gold* is precipitated from a solution of the chloride by adding magnesia or potash; it is of a brownish yellow color, and consists of

Gold	1 prime	200 ?
Chlorine	3 primes	24 ?

386. *Perchloride of gold* is formed when the metal is heated in chlorine gas, or in nitro-muriatic acid, or in an aqueous solution of chlorine. It is of a yellow color, soluble in water.

It consists of

Gold	1 prime	200
Chlorine	3 primes	108

There appears to be a proto-chloride, consisting of one prime each of its constituents.

When ammonia is added to a strong solution of chloride of gold, a yellowish brown precipitate is formed, which consists of oxide of gold united to ammonia. It is *fulminating gold*, and explodes by a gentle heat.

The solution of chloride of gold stains the skin purple, and is decomposed by a solution of proto-sulphate of iron, and pure metallic gold is precipitated. Phosphorus also precipitates pure gold from this solution. The solution, on the immersion of a plate of tin, affords a beautiful purple precipitate of the mixed oxides of tin and gold, called purple powder of Cassius.

When ether is added to the solution of the chloride, it combines with the oxide of gold, and forms the ethereal solution of gold.

387. *Iodide of gold* is a yellowish brown powder, formed by the addition of Hydriodate of potash to a solution of chloride of gold.

388. *Sulphuret of gold* is formed by passing a current of sulphuretted hydrogene through a solution of chloride of gold; it is a black powder.

SALTS OF GOLD.

389. Salts of gold afford a precipitate of metallic gold on the addition of proto-sulphate of iron to their solutions. They have been very little examined.

OF PLATINUM.

390. Platinum is a white metal, possessing little lustre, is malleable and ductile, and by the ingenious process of Wollaston may be drawn into a very fine wire; its sp. gr. is 21.5. It is

not fusible in any furnace heat; but pieces of it may be united by welding to each other, or to iron.

391. There is great uncertainty respecting the composition of the oxides of platinum. A black oxide is formed when proto-nitrate of mercury is added to a solution of platinum; and another oxide exists in the salts of platinum.

392. *Chloride of platinum* is formed by digesting platinum in nitro-muriatic acid; evaporated to dryness at a heat below redness, it forms a brown powder, not very soluble in water. When partially concentrated, the solution affords crystals, deliquescent and soluble in water.

The nitro-muriatic solution of platinum affords a yellow precipitate of muriate of ammonia and platinum on the addition of muriate of ammonia. This yellow precipitate, when ignited, affords the *spongy platina*, whose curious property of determining the combination of oxygene and hydrogene was discovered by DOBEREINER. (129*f.*) It may also be ignited in vapor of alcohol or ether. (*Silliman's Journal, Vol.* 8.)

A very dilute solution of the chloride of platinum becomes of a claret color, on the addition of proto-chloride of tin.

393. *Sulphuret of platinum* is formed by heating spongy platina and sulphur together. Another sulphuret is obtained by passing a current of sulphuretted hydrogene into the nitro-muriate of the metal; and a third sulphuret is formed according to Mr. E. DAVY, by heating the ammonio-muriate of platina with sulphur.

SALTS OF PLATINUM.

394. SALTS of platinum have been but little examined. They afford an orange-yellow precipitate with potash, and ammonia; and black precipitate with sulphuretted hydrogene. Hydriodic acid is a delicate test of the metal, and gives a deep wine red color, to colorless solutions of platina. (SILLIMAN.)

395. *Sulphate of platinum* is formed by boiling the sulphuret in nitric acid. It is of a brown color and very soluble in water. It forms triple salts on the addition of potash, soda, or ammonia. The precipitate, which is formed by adding a slight excess of ammonia, when boiled in potash water and dried, forms fulminating platinum.

When a strong solution of the sulphate is mixed with its own volume of strong alcohol, the color of the former gradually disappears, and a black substance is formed which possesses some remarkable properties. It may also be formed when the sulphate is boiled in alcohol. When it is plunged into ammoniacal gas, it becomes red hot, and it also becomes ignited when in vapor of alcohol. The platinum is reduced; when it is introduced into liquid ammonia, it forms a detonating compound. The nature of this singular compound is not yet known; it was discovered by Mr. E. **Davy**.

III. OF SUPPOSED METALS, OR EARTHS.

396. The earths bear a very close resemblance to metallic oxides, and the evidence that they are compounds of oxygene and a basis, is becoming daily more strong; yet it is hardly demonstrated that the nature of the basis is metallic, rather, than like carbon. They have by no means an equal degree of evidence respecting their compound nature; and while some of them might, from various circumstances, be so considered, others have only analogy to support their claims to this rank.

OF SILEX, AND ITS BASIS SILICIUM.

397. It has been supposed that this body was a compound of oxygene and a basis in equal weights; and recently, **Berzelius** has stated that he has procured the basis with all ease, by acting on fluo-silicate of potash, previously ignited, with potassium; after washing with water an *hydruret* of silicium is procured, which by being slowly heated to redness in a covered platinum crucible affords pure silicium.

Pure silicium does not decompose water, and is incombustible even in oxygene gas; nor is it acted upon by any acid, except the fluoric. It decomposes carbonate of potash with the evolution of carbon and carbonic oxide. Sulphur passed in vapor over silicium heated to redness, combines with it, and the selicum becomes incandescent. The sulphuret is a white earthy mass, which decomposes water with rapidity, and an *aqueous solution of silica is obtained*, while sulphuretted hydrogene is evolved. Silicium takes fire in chlorine at a red heat, and a liquid, nearly or quite colorless, results, which has a pungent odor. This liquid decomposes water. Silicium unites with 0.52 of oxygene to form silex or silicia, according to **Berzelius**. (*Brande's Jour. No.* 35.)

398. *Silica* exists pure in rock crystal, and nearly pure in many other minerals. It may be procured by heating white quartz to redness, and plunging it into cold water; it is then ea-

sily reduced to powder. Fuse this powder with three times its weight of potash, and dissolve the mass in water; add to the solution a slight excess of muriatic acid, and evaporate to dryness; wash the dry mass with hot water, and the resulting white powder is silica.

It is white and tasteless; is infusible in water unless recently separated from some other combination, and in the state of a gelatinous hydret. It is also soluble slightly in this form in some acids; it unites readily with the alkalies, and forms readily fusible compounds; it is fusible before Hare's blow pipe.

399. Silex is dissolved by fluoric acid; and a peculiar gas is the result of this action, called *Fluo-silicic acid gas.* It is obtained easily by mixing powdered fluor spar with pounded glass or quartz, and pouring on it, sulphuric acid. The gas must be collected over mercury. It is colorless and transparent. It is very heavy; 100 cubic inches weigh 110.77 grs. hence its sp. gr. is about 50, hydrogene being 1. When this gas comes in contact with water, white hydret of silica is deposited. It instantly forms a white vapor in the air, from the action of moisture.

Potassium burns in this gas when strongly heated; a fawn colored substance is produced, which decomposes water with effervesence, and contains a combustible body.

The nature of this gas is unknown; it may be regarded as a compound of fluoric acid and silex, or of the bases of silex and fluoric acid; but until these *are* known, we can only form conjectures respecting the nature of *fluo-silicic acid gas.*

400. *Glass* is a compound procured by the fusion of silex and an alkali; other substances are occasionally added to these two, either to communicate or destroy color, or to render the glass more highly refractive. Glass, which is suddenly cooled, is very brittle.

Enamel is opaque glass; the *white* is produced by the addition of oxide of tin to glass. Glass and enamel are colored by the addition of various metallic oxides.

ALUMINE, AND ITS BASIS ALUMINUM.

401. Alumine or pure clay is supposed to be a compound of oxygene and a basis. Certain kinds of steel and cast iron, which have a perfectly metallic aspect, afford on analysis a portion of alumine, and it is conceived that its basis must have been *alloyed* with the other metals.

402. Pure alumine is procured by adding carbonate of ammonia to a solution of alum; a precipitate falls, which is to be washed and ignited. It is a white, tasteless powder; sp. gr. 2; forms a plastic paste with water, and retains water even when heated to redness. It is the basis of all natural clays; when

mixed in certain proportions with silex, it is employed for the manufacture of pottery and porcelain. For a brief, but comprehensive account of the process of the art see CLEAVELAND's *Mineralogy, p.* 466 *et seq. Ed. 2d.*

Alumine has a very strong attraction for coloring matter, and forms the basis of the pigments called *lakes.*

403. Alumine combines with acids; the most important compound is the triple salt, sulphate of alumine and potash, or alum. It is usually prepared by roasting and lixiviating certain kinds of slate, and adding potash to the solution, and separating the alum by crystallization. It is made of a superior quality at Salem, Mass. by the direct union of its constituents.

Alum has a sweet astringent taste; is soluble in water, and reddens vegetable blue colors. It consists of

Bi-sulphate of potash	128 =	1 prime
Sulphate of alumine	123 =	2 primes
Water	198 =	22 primes.

Alum loses its water of crystallization and parts with its acid when exposed to an intense heat. When heated with charcoal, it forms a spontaneously inflammable substance, called HAMBERG's *pyrophorus.* Its inflammability depends on the presence of potassium. (GORHAM. *New Eng. Jour.*)

OF ZIRCONIA, AND ITS BASIS ZIRCONIUM.

404. ZIRCONIUM was obtained by BERZELIUS in a manner similar to that by which silicium was procured. (197.) It is as black as carbon; it is not oxidized by water; it decomposes fluoric acid, and evolves hydrogene. When heated, it burns with brilliancy. It combines with sulphur; the sulphuret burns brilliantly, producing sulphurous acid gas and Zirconia.

405. Zirconia is obtained, by complicated processes, from certain minerals, in which it exists. It is a fine, white, tasteless powder, insoluble in water; it is not soluble in the pure alkalies, but dissolves in the alkaline carbonates, and is soluble in acids.

OF GLUCINA, AND ITS BASIS GLUCINUM.

406. GLUCINA is supposed to be a compound of oxygene and a basis. It is a white, insipid body, soft to the touch, and adhesive to the tongue; it is soluble in potash and soda, and in carbonate of ammonia; this distinguishes it from alumine. It unites

with acids and forms *sweet* astringent salts. It was discovered by **Vauqueline** in the emerald and beryl. Glucina has recently been discovered in the chryso-beryl, by Mr. H. **Seybert**. (*Silliman's Journal*, *Vol.* 8.)

OF YTTRIA AND THORINA, AND THEIR BASES, YTTRIUM AUD THORINUM.

407. **Yttria** and Thorina are supposed to be metallic oxides. They are white, insoluble in water, and tasteless.

Yttria is insoluble in pure fixed alkalies; but dissolves in their carbonate. It forms salts, having sweet austere taste. Thornia is not soluble in potash; it forms salts, which taste astringent, but not sweet. These bodies have been but little investigated. Yttria was discovered by **Gadolin**, and Thorina by **Berzelius**.

OF COMBUSTION AND FLAME.

407. **In** all cases in which chymical changes occur with rapidity and energy, whether in combination or decomposition, heat and light are manifested. Where the combination of bodies with each other is accompanied with these phenomena, they are said to undergo *combustion*. This term, however, is often restricted to the combination of certain bodies, called *combustibles*, with oxygene, chlorine or iodine, which are called *supporters of combustion*, because heat and light generally accompany their chymical actions. But these actions are the consequence of the agency of general powers or forces, (1) and the phenomena of heat and light, the common results of the vivid and energetic exercise of such powers among bodies. The distinction, therefore, between combustibles and supporters of combustion, is grounded on a partial view of the phenomena. Some bodies are combustibles, and supporters of combustion. Thus sulphur and potassium, with oxygene and chlorine, have been called combustible bases; but potassium in vapor of *sulphur*, burns with brilliancy; and arsenic, uniting with potassium, presents all the phenomena of combustion. It is needless to multiply examples to prove "that no *peculiar* substance, or form of matter is necessary for the effect; it is a general result of the actions of any substances possessed of strong chymical attractions or different electrical relations." (**Davy**. *Elem. Chym. Phil.*)

408. Inflammation is the result of the rapid combination of gases or vapors with each other. Flame is gaseous matter, or

vapor, heated to ignition; no bodies but gases, or such as readily assume that form, will burn with flame. Iron burns brilliantly in oxygene gas, but no flame appears, for the iron is not vaporized. Zinc, which at high temperatures is volatile, burns with a brilliant *flame.* Phosphorus, at low temperatures, burns without flame; at elevated temperatures, with a vivid one. Substances which unite with inflammation, if brought gradually in contact with each other, will burn slowly and silently; but if they are previously mixed together and then exposed to heat, combustion pervades every part of the mixture at once, and the union of the bodies is accompanied with a more or less sensible explosion and report. This is rendered evident by the experiment of BOYLE's philosophical candle, and by the inflammation of a mixture of hydrogene and oxygene gases. (129. *c.*) The fact explains the roaring of fires and of furnaces.

409. The violence of the combustion and inflammation depends on the rapidity with which the combining bodies act on each other. Iron, by rapid oxidation, is ignited; but when slowly oxidized, there is no ignition. Hydrogene and chlorine unite slowly, without combustion, when exposed to light; but violent detonation, and vivid inflammation accompany their rapid union in the direct solar ray. Charcoal, heated red hot and plunged into oxygene gas, burns vividly; but heated to a point a little higher than that of boiling mercury, it unites with oxygene without the evolution of light. A mixture of oxygene and hydrogene, exposed to a heat little below redness, unites slowly and silently; but if to a strong heat, vivid combustion, and inflammation occur.

In the above examples, the same product results, both from the slow and the rapid union of the bodies; and there are many similar examples, in some of which, however, *different* products are afforded by the rapid and slow combination.

410. Although no flame appears in the gradual combination of bodies, yet heat accompanies their action, and it may be rendered sensible by the ignition of solid bodies. If a heated platina wire is introduced into an explosive mixture of fire-damp and air, it continues to glow for some time, in consequence of the gradual combination of the substances present; and when the wire ceases to be luminous, the inflammability of the mixture is entirely destroyed. It occasionally happens, that a small wire is so intensely ignited by this invisible union of the ingredients of the mixture, that it inflames the gases, and explosion follows. The aphlogistic, or the glowing lamp, and the ignition of wire in vapor of ether, depends on the heat which accompanies this secret and invisible combination of the acting bodies.

411. The temperature of flame, or of ignited gases, must be very elevated, since their capacity for heat is so great; and since gases, not luminous, are capable of igniting solid bodies to whiteness. WEDGEWOOD found that gold was ignited in air which was not luminous itself; and a filament of asbestos, or fine wire of

platinum is ignited when held near, but not in, the flame of a candle, or lamp; and is actually fused in the flame itself.

412. Davy, to whom we are indebted for most of our knowledge respecting flame, has made a happy practical application of the facts offered by invisible combustion. It consists in fixing a coil of platina wire above the wick of the *Safety Lamp*—which continues to glow in mixtures where the flame itself is extinguished, and its ignition ceases only when the air is unfit for respiration; when the lamp, with its glowing wire, is carried again into a better atmosphere, the flame is re-kindled. Thus the glowing wire supplies the miner with light when the flame of his lamp is extinguished, and the relative brightness of it, points out the state of the atmosphere in different parts of the mine.

413. The light which is emitted by the flames of different bodies, and by the same body under different circumstances, is very different. The flame of hydrogene is hardly perceptible, while that of olefiant gas is very brilliant. When the safety lamp is introduced into a very inflammable mixture of coal gas, its cylinder becomes filled with a pale flame; yet when the same coal gas is made to issue from a small orifice, and is there inflamed, it mixes in explosive proportions with the air, but the flame is very bright; here the same substance, during combustion, presents very different appearances. The brilliancy and density of flame depends, *cæteris paribus*, on the production and ignition of solid matter. Thus olefiant gas gives a very bright light, because, as we learn, from the experiments of Berthollet, it readily suffers decomposition at high temperatures, and deposits carbon, which, first by *ignition*, and afterwards by combustion, increases the intensity of the light. This fact is illustrated by a simple experiment:—hold a piece of wire gauze of 900 meshes to the square inch, over the orifice from which a stream of coal gas issues,and inflame the gas above the gauze; it will burn with its usual bright flame. Raise the wire tissue so as to cause the gas to be mixed with more atmospheric air before it inflames, and the light becomes feeble, and at a certain point becomes pale, and presents the precise character of the flame burning within the wire cylinder. The heat, however, of this pale flame is so great as instantly to ignite platinum wire to whiteness. Reverse this experiment, and pass a piece of wire gauze gradually from the apex of the flame to the orifice of the pipe; and it will be found that the apex of the flame intercepted by the wire gauze, will not afford solid charcoal; but lower down much lampblack is deposited; and still lower, where the blue flame is, no sensible deposition of carbon will be noticed; for here, indeed, the carbon is burned in its gaseous combinations, which have not yet suffered decomposition by passing through an ignited tube of flame.

414. This principle, that the light of flames depends on the production and ignition of solid matter, explains the appearances which the different parts of a flame present, and of a flame urged by the blow pipe; in the latter, the heat is the greatest

at the point of the inner blue flame, where the gases are burned without previous decomposition. The flames of phosphorus, of zinc, and of potassium in oxygene,are very brilliant, and so are all flames, where, as in these instances, *fixed* solid matter is produced; but the flame of phosphorus in chlorine, of sulphur in oxygene, and of hydrogene, where no solid matter is produced, is feeble; but the intensity of the light they afford, is wonderfully increased by introducing into them solid bodies; a fact easily illustrated by holding a coil of platina wire in the flame of a spirit lamp.

415. The light of flames is much modified by the presence of incombustible substances. Thus chloride of strontium, of sodium, of copper, &c. dissolved in alcohol, give distinct and different hues to the light of its flame.

416. There is a great difference in the temperature produced by the combustion of different bodies. The following table, constructed from the experiments of different philosophers, shows the relative quantities of heat disengaged during the combustion of different bodies.

Substances burned, 1 lb.	pounds of oxygene consumed.	Pounds of Ice melted according to			
		Rumford.	Dalton.	Lavoiser.	Crawford.
Hydrogene	8		320	295.6	480
Olefiant gas	3.5		80		
Carbonic oxide	0.58		25		
Olive oil	3.00	94.7	104	149	89
Wax	3.00	126.24	104	133	97
Tallow	3.00	111.58	104	96	
Alcohol	2.0 ?	67.47	58		
Charcoal	2. ?		49	96.5	69

There are discrepancies in the above results, which destroy our confidence in them; but they establish the fact, that different bodies during combustion produce different quantities of heat.

Davy, in some experiments conducted with his accustomed accuracy, found the relative heating powers of some gases, as follows;

Hydrogene	21
Olefiant gas	9.66
Sulphuretted hydrogene	6.66
Coal gas Carbonic oxide	} = 6.00

These ratios cannot be considered as exact, for carbon was deposited from the olefiant gas, and sulphur from the sulphuretted hydrogene.

417. The origin of heat in combustion and inflammation has been referred to a change in the capacity of the combining bodies. But the researches of Petit and Dulong prove that the "quantity of heat developed at the instant of the combination of bodies has no relation to the capacity of the elements." In many instances the evolution of heat is not accompanied by a corresponding change of capacity. "The combination of oxy-

gene and hydrogene, and of sulphur with lead, occasions a great evolution of caloric, but produces no greater change in the capacity of water, or of sulphuret of lead, than the combination of oxygene with copper, silver, lead, or of carbon with sulphur, produces, in the oxides of those metals, or in sulphuret of carbon." The capacity of water for heat is greater than the mean capacities of its constituents, and *cold*, therefore, on this hypothesis, ought to accompany the combustion of hydrogene.*

The relations, which have been pointed out between the specific heats of simple bodies and their compounds, seem to preclude the idea, that the heat developed in chymical action is derived merely from change of capacity, or from combined caloric. It is conceived that the same causes which occasion the intense ignition, in vacuo, of charcoal points connected with the Voltaic pile, also occasion the evolution of heat in chymical action. It has been satisfactorily established, that bodies, at the instant of their combination, are in the same electrical conditions as the two poles of the battery. (70.)

418. The temperature required for the combustion and inflammation of different bodies is very different. This is so obvious as hardly to require illustration. Sulphur and phosphorus burn by a gentle elevation of heat, while iron and zinc require very elevated temperatures to produce that effect. A mixture of oxygene and hydrogene explodes in tubes of glass or metal when heated to dull redness; a mixture of hydrogene and chlorine explodes at lower temperature.

The combustibility of different gaseous substances is, to a certain degree, as the masses of heated matter required to inflame them; thus an iron wire, 1-40th of an inch in diameter, heated to full redness, will inflame hydrogene gas, but not olefiant gas; although a wire 1-8th of an inch in diameter, heated to the same degree, will produce that effect; a wire 1-500 of an inch in diameter, must be heated to whiteness, to inflame hydrogene; although at a low red heat, it will inflame phosphuretted hydrogene. A wire 1-40th of an inch diam. will not inflame *fire-damp* (impure carburetted hydrogene) even when heated to whiteness; a wine red heat will inflame carbonic oxide gas, but it must be heated so as to burn with sparks before it will inflame carburetted hydrogene.

419. The combustibility of gases, and of other bodies, is not altered by rarefaction from removal of atmospheric pressure. This is illustrated by a simple experiment:–let hydrogene gas be slowly produced from a proper mixture and inflamed, as in Boyle's philosophical candle, at the point of a glass tube, so as to make a flame about 1-6th of an inch high. Introduce this under the receiver of an air pump, and the flame will at first be increased,

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* Capacity of water is 1.000; of hydrogene 3.2936; of oxygene 0.2361; and the capacity of the constituents of water in the ratio they unite is $\frac{3.2936}{8}+0.2361=0.6478$.

as the pressure of the air is removed, but soon begins to diminish, and when the pressure is 7 or 8 times less than that of the the air, it is extinguished. This effect is not produced by deficiency of oxygene, for a larger flame, which renders the point of the glass tube, from which it issues, red hot, will burn till the pressure is diminished 12 or 13 times; an effect, produced by the heat which the ignited glass tube communicates to the gas. A similar effect is produced by a small coil of platina wire so placed as to be ignited within the little flame; the gas then continues to burn as long as the wire is visibly red hot, and is inflamed in contact with the wire, although it is extinguished below, until the pressure is reduced 12 or 13 times. When the heat, which the inflammation of the gas produces, is insufficient to keep up the combustion, the flame is extinguished, and that heat, for hydrogene under ordinary pressure, is that which is capable of communicating visible ignition to metals. (218.) This temperature will maintain its combustion in rarefied air. In conformity to this view of the subject, it will be found that those bodies, which produce most heat by their combustion, and which require but little for that effect, will burn in the most rarefied medium. Thus

Phosphorus will burn in air rarefied to			$\frac{1}{60}$	nearly.
Sulphur	"	..	$\frac{1}{20}$	
Hydrogene	"	"	$\frac{1}{13}$	
Olefiant gas	"	"	$\frac{1}{10}$	
Flame of wax, or alcohol	"		$\frac{1}{7}$	
Fire damp (tube furnished with platina wire)			$\frac{1}{4}$	

Fire damp requires a higher temperature for its combustion than any other gas, and excepting carbonic oxide, produces less heat during combustion; and hence it is extinguished in atmospheres but little rarefied. Carbonic oxide, which produces less heat by its combustion than any other gas, but is nearly as inflammable as hydrogene, burns in atmospheres so rare as to extinguish the flame of fire-damp; and phosphuretted hydrogene produces a flash of light in the most perfect vacuum which a good air pump can produce. A mixture of chlorine and hydrogene, which inflames at a lower temperature than a mixture of oxygene and hydrogene, and produces great heat during its inflammation, will bear exhaustion to 1-24th without losing its explosive powers; whereas a mixture of oxygene and hydrogene will not explode if rarefied 18 times.

420. Rarefaction, or expansion by heat, seems to increase the explosive powers of gases, or to enable them to explode, apparently, at lower temperatures. If a mixture of oxygene and hydrogene be slowly passed through a thick glass tube, 1-6th of an inch in diameter, curved so as to be gradually heated in a char-

coal furnace, and having spirit lamps placed underneath it, where it passes into the charcoal fire, the mixture, rarefied by passing through the part heated by the spirit lamps, will explode *before* the tube becomes red hot. A mixture of oxygene and hydrogene rarefied 18 times does not explode by the electric spark, but if previously heated, it readily explodes by that means. A mixture of fire-damp and air in the proportion of one to eight, when passed through an ignited capillary tube, into the flame of a spirit lamp, will burn with its own peculiar light beyond the flame of the lamp, notwithstanding the great rarefaction it must have experienced in passing through the tube; and if it be withdrawn, the gas will continue to burn, even though the aperture of the tube be white hot; and it has been shown, that fire-damp requires a very high temperature for its combustion. (218.)

421. It has been supposed that the compression, in one part of an explosive mixture, produced by the sudden expansion of another part by heat, or by the electric spark, is the cause of its combustion by these agents. The idea however, is not countenanced by the facts above stated, nor by experiments on the direct condensation of explosive mixtures, to a degree equal to that which they must have experienced, by the passage of the electric spark. It appears that when gases are suddenly compressed, heat is evolved, and it is the *heat* which is given out by compression, or occasioned by the electric spark, which is the real cause of the inflammation produced.

422. Condensation does not considerably increase the heat of flame in atmospheric air, but the intensity of the light seems to be augmented. More particles, capable of emitting light, existing in denser atmospheres.

423. Those substances which rapidly abstract heat from burning bodies extinguish combustion and flame, and arrest explosion. Place a wire across the flame of a candle, and its light is diminished; bring two or three other wires near to, and parallel with the first, and there will be a greater diminution of light, and more carbonaceous smoke will be evolved; and farther, place three or four more wires across the flame, and upon, and at right angles with the first set, so as to leave small square apertures, and the flame will be quite intercepted, or only a few dark red streaks of it will pass through. The temperature of the flame is, in this instance, reduced by the cooling power of the wire, an effect which depends on its ability to abstract heat, and on its conducting power. A piece of wire gauze exhibits the effect in the most perfect manner; bring a tissue of this kind over the flame of a spirit lamp, and the upper part of the flame will be cut off, while the lower part continues to burn, and exhibits a *cup of flame*. When the wire gauze has become warm, the combustible gases which pass through it may be inflamed, and will burn above the wire gauze, exhibiting an inverted hollow cone of flame, shaped like the cap of Liberty, and by careful management another

piece of wire gauze may be introduced a little above the first, and a hollow cylinder of flame remain between them. This experiment seems to prove that a flame is a mere shell, luminous only at its surface. The wire gauze not only intercepts the light of the flame, but the heat also, for a piece of linen or paper may be held on it over a flame for a long time without being scorched, and the same fact is proved by holding a thermometer above the wire gauze over a flame; it rises on removing the tissue from 90° ? to 150 or 200°.

424. If two vessels, filled with an explosive mixture of fire-damp and air, be connected with a long, and small glass tube also filled with the same mixture, and a flame be applied to one of them, the explosion will not be communicated through the tube to the other, or, if it be, the flame will appear to crawl slowly through the connecting tube like a glow worm. If the tube be so large as to permit the passage of the flame, it will completely intercept it, when a short portion of it is filled with small iron wires. If a very small tube be used, it may be quite short, and if a metallic one be employed, it may be still shorter, and yet prevent the communication of the explosion, or the passage of the flame. The reason of this is obvious: the temperature of the flame is so much diminished by the cold tube that it is incapable of communicating sufficient heat to the contiguous portions of mixed gases to continue the combustion. The more perfect the conducting power of the materials of which the tube is made, the shorter it may be; and the length of a metallic tube 1-60 in. diameter, need not exceed its diameter,to arrest the progress of the combustion of *some explosive* mixtures through it. Let a very small flame be made by a single thread of cotton in oil, and burning at the surface of the oil, and then bring over it a small ring of iron wire 1-10 inch diameter, and the flame will be extinguished; but let the little ring be heated, and it no longer produces that effect. A ring of glass, of the same size and diameter as the iron, will not produce the effect,although a small ring of large glass will extinguish the combustion. These facts are obviously explained on the principles above stated; and the principle may be farther illustrated by the effect which bodies of different conducting powers have on flames. Bring a small bar of silver near to, but not in contact with the little flame made by the single thread of cotton in oil, and the flame will be extinguished; but the metal previously heated will not cause its extinction. An inferior conductor of caloric will only diminish the flame, and charcoal, the worst solid conductor known, will produce no visible effect.

425. It is upon the principle now illustrated, that the operation of the SAFETY LAMP is explained. In this lamp, the flame burns within a cylinder of wire gauze. When it is introduced into an explosive mixture of fire-damp and air, the whole cylinder may become filled with flame, which, by the explosive force, attempts to pass through the meshes of the wire gauze

cylinder, and is then divided into many little flames, each of which is extinguished by the metallic sides of the small aperture, through which the passage is attempted, precisely as the small flame of the single thread of cotton is extinguished by the single ring of wire. (223.)

426. The wire gauze tissue, which arrests the explosive flame of one inflammable gâs, may not, however, produce the same effect with that of another gas. The flame of those bodies which produce much heat by their combustion, and require but little for that effect, easily passes through a tissue, which at once intercepts the flame of less inflammable bodies, and those which produce less heat in combustion; and a tissue which, when cold, intercepts the passage of a flame, will suffer it to pass when heated; the most inflammable substances, and those producing the most heat, passing with the greatest facility through heated tissues. Thus a wire gauze which arrests the flame of a spirit lamp only, will permit the flame of hydrogene to pass; and a tissue which intercepts the flame of the spirit lamp, when cold, will suffer it to pass when heated; and the heated tissue, which permits the flame of hydrogene to pass, intercepts that of a gas which produces less heat during its combustion, or requires more for that effect. Hence it requires a tissue with very fine meshes, to arrest the explosive flame of mixed oxygene and hydrogene gases.

427. When rapid currents of inflamed explosive mixtures act upon wire gauze, it becomes rapidly heated, and the same aperture which arrests the flame of an explosive mixture when at rest, will permit its passage when in motion. But by increasing the length, and diminishing the size of an aperture, the most rapid currents may be arrested; very minute apertures, when they are few in number, permit the passage of flames, which are arrested by much larger orifices, filling the whole surface. This fact is illustrated by a simple experiment:—drill a small hole, less than 1-18th of an inch in diameter, through the brass ring which confines the wire gauze cylinder in the safety lamp; light the lamp and introduce it into an explosive mixture of fire-damp and air, and the explosion will be transmitted through this small hole; because the whole explosive force of the thin stratum of the mixture within the ring, drives the flame rapidly through the aperture; but if the whole ring had been filled with such apertures separated by small partitions of metal, it would not have transmitted the explosion.

428. The power of extinguishing flame, or of preventing explosion, is not confined to solid bodies alone; gases also produce this effect, as in the common method of extinguishing a lamp or candle. Even gases, the presence of which is ordinarily necessary in combustion, will prevent the occurrence of explosion, and of combustion, on the principles above stated. A mixture of oxygene and hydrogene, in the proportions in which

they form water, easily explodes by the electric spark; but the explosion is prevented when mixed with

8	times its volume of	hydrogene
9	"	oxygene
11	"	nitrous oxide
2	"	sulphuretted hydrogene
1	"	carburetted hydrogene (fire-damp)
2	"	muriatic acid
0.5	"	olefiant gas
5-6th	"	silicated fluoric acid gas.

These results evince that something else than density, or capacity for heat of gases, interferes with combustion. Nitrous oxide gas has a greater density, and capacity for heat, than oxygene, but its powers of preventing explosion are less in the inverse ratio of 11 to 9; and oxygene is more dense than olefiant gas, but it has less power of preventing explosion in the inverse ratio of 9 to 0.5 or 18 to 1. The effect, which gases have in preventing explosion, depends on a power similar to that possessed by solids, viz. of rapidly abstracting heat from the contiguous particles; an effect which may depend on the agency of two circumstances, viz. on their simple abstracting power, whereby they become more or less rapidly heated; and on their capacity for heat, which will be greater or less in proportion as they are more or less rapidly heated by this abstraction.

429. Different gases operate uniformly with respect to different species of combustion. Those bodies which produce much heat during combustion, and require but little for that effect, are those which require the largest admixtures of different gases to prevent explosion. Thus chlorine and hydrogene require but little heat to effect their combination, and they will explode when mixed with 18 times their volume of oxygene; but a mixture of fire-damp and oxygene, in the proportion by volume of 1 to 2, will not explode if mixed with *thrice* its volume of oxygene. The flame of a wax candle is immediately extinguished in air containing 1-10 silicated fluoric gas or 1-6 muriatic acid gas; but hydrogene readily burns in such a mixture, and sulphur will burn after the hydrogene is extinguished. The general principle is illustrated with ease: introduce a lighted taper into a long bottle with a narrow neck, and let it burn till it is extinguished; cautiously withdraw it, stop the bottle; and soon after introduce the relighted taper. It will be soon extinguished; then, introduce a small tube, containing the proper mixture for producing hydrogene, at the orifice of which, the gas is inflamed, and it will be found that the gas will burn in any part of the bottle. When the hydrogene ceases to burn, introduce burning sulphur; and after this has ceased to burn, phosphorus will appear in it, as luminous as in atmospheric air, and on the application of heat will burn with a pale yellowish flame.

430. When the temperature required for chymical union is low, a mixture which prevents combustion, will not prevent combination. Thus if two volumes of fire-damp be mixed with one volume of a mixture of chlorine and hydrogene, muriatic acid gas will still be found in every part, and heat be produced; as the expansion which occurs during the passage of the electric spark through the mixture, evinces; but the heat is so rapidly carried off by the fire-damp,that no flash appears. No known admixture of gases will prevent the luminous appearance of phosphorus in oxygene. There is reason to believe that every particle of acid formed, by the union of phosphorus with oxygene,is heated to whiteness, and that the light, which is emitted by phosphorus in oxygene, is limited to the solid particles of acid formed; but to produce flame, a certain volume of vapor must be ignited.

431. Those gases which are not concerned in combustion, acids, steam and vapors, which require a high temperature for their production, probably have less power in preventing inflammation, particularly in gases requiring but a low heat for their combustion, than gases at common temperatures. Thus a greater quantity of steam is required to prevent the combustion of sulphur, than of hydrogene. Oxygene and hydrogene require five times their volume of steam to prevent inflammation, and fire-damp and air, the least explosive of all mixtures, require 1-3 their volume of steam, and 1-5 of nitrogene, to produce that effect.

432. Steam appears to promote the perfect combustion of some vapors. Thus vapor of tar,or of spirits of turpentine, when burned, evolve dense volumes of smoke, and the wick of a common lamp when supplied with an excess of oil throws off much carbonaceous matter; but if steam be previously mixed with the vapors, or be thrown in proper quantities into the flame of the lamp, the flame is enlarged, and evolves more light and heat. This fact was first noticed by Mr. Morey, and is the foundation of his invention, the "*American water burner*," and of a lamp, of peculiar construction, for the combustion of spirits of turpentine mixed with common whiskey. (*North American Review, and Silliman's Jour. Vol.* 1.) The steam, it is obvious, suffers decomposition in these instances; and hence also water sometimes increases, instead of diminishing combustion, and green wood, in large fires, produces the greatest heat.

433. The phenomena of secret combustion explain why so much more heat is evolved when fuel is rapidly consumed than when slowly burned, and show that the temperature of the substances acting on each other should be as high as possible, not only because the heat is greater, but those combinations which take place at low temperatures without considerable production of heat, are prevented; the best fire places, and the argand lamp are sufficient illustrations of this principle. Rumford has shown that the quantity of light emitted by burning bodies, is, *cæt: par:*

proportional in some high ratio to the elevation of temperature. A lamp having many wicks near each other, so as mutually to increase the heat of their flames, burns with much more brilliancy than the argand lamp; a double wicked lamp gives more light than two single wicked lamps, the wicks being of the same size and similarly supplied with oil.

END OF PART I.

AN EPITOME

OF

CHYMICAL PHILOSOPHY.

PART II.

CONTAINING THE CHYMISTRY OF ORGANIC SUBSTANCES.

I. VEGETABLE CHYMISTRY. II. ANIMAL CHYMISTRY.

AN EPITOME, &C.

CHYMISTRY OF ORGANIC BODIES.

434. The compounds which result from the chymical actions occurring in animal and vegetable bodies, under the influence of vitality, are distinguished by peculiar characteristics, from those which occur inorganic bodies. The composition of vegetable and animal substances, with regard to the undecompounded substances of which they are composed, is more simple; but with regard to the proportions, and to the number of elements in simultaneous combination, and perhaps, also, to their mode of union, they are more diversified than inorganic compounds.

435. Organic bodies are formed by the union of different compounds, which exist, either insulated, or mixed, or combined with each other in their various parts. These different compounds may be separated from each other, by various methods founded on their chymical habitudes. If *e. g.* a leaf, or a muscle be macerated in water, the entire substance is not dissolved, but only a certain portion; another portion may be separated by alcohol, and another by heat, &c. and by multiplied operations of this kind, a number of distinct substances called *Proximate Principles* may be obtained, as starch, sugar, gum, &c. from vegetables, and fibrin, albumen, &c. from animals.

436. The proximate elements, which are all compounds, may be separated by appropriate methods, into their *ultimate elements*, or constituent parts, viz. carbon, hydrogene and oxygene; to these, uniformly in animal substances, and occasionally in vegetable bodies, is added azote or nitrogene.

437. When organic substances are subjected to a temperature of 212° F. they are deprived of their superfluous moisture. If the heat be raised, a reaction of the ultimate elements ensues, decomposition commences, and new compounds are produced by the union of the elements in new proportions; a blackish empyreumatic oil is formed and evaporated; an acid is produced, and carbonic oxide and carburetted hydrogene gases are disengaged: if azote exists in the substance,

ammonia is formed; the excess of carbon, mixed with some earthy, saline and metallic matter, remains. Phosphorus, and sulphur in minute quantities, exist in organic products.

438. Very few products of organic bodies can be formed by the artificial processes of the Laboratory. Their elements are united by a power which subverts and controls the ordinary laws of chymical affinity; they are united and retained in union by VITAL AFFINITY, a term happily introduced by Prof. J. JACKSON, M. D. of Boston. As soon as life ceases, under ordinary circumstances, the elements of organic bodies become subjected to the influence of the usual laws of affinity. They react on each other. The organic compounds are decomposed, and inorganic combinations are formed.

I. OF THE VEGETO-ALKALIES, OR VEGETABLE SALIFIABLE BASES.

I. MORPHIA.

439. MORPHIA constitutes the narcotic principle of opium; it was discovered in 1817 by SETÜRNER.

(*a*) It may be procured by adding caustic aqua ammonia to a strong infusion of opium. A brownish precipitate falls, which is to be separated by a filter. The liquor on concentration affords another precipitate of impure *morphia* by addition of more ammonia. The precipitates are to be washed with cold water, and then with a small quantity of cold alcohol, and afterwards dissolved in acetic acid. This solution is rendered colorless by animal charcoal (188) and is again filtered and decomposed by ammonia. A white precipitate falls, which by digestion in warm alcohol affords a solution of *pure morphia*, and by slow evaporation crystals of morphia are obtained.

(*b*) Morphia is colorless and transparent, crystallizes in double four sided pyramids. It is soluble in 82 parts of boiling water and in 36 parts of boiling alcohol, and 46 parts of cold alcohol. These solutions possess the general properties of alkalies. Morphia melts by a gentle heat, and appears like melted sulphur. On cooling, it again assumes a crystalline form; it burns easily.

(*c*) Morphia acts with great energy on the animal system, and in minute quantities produces powerful narcotic effects. It exists in opium combined with a peculiar acid called the *meconic acid.*

(*d*) Morphia, according to Brande, consists of

Carbon	72
Nitrogene	5.50
Hydrogene	5.50
Oxygene	17

and its prime equivalent, according to the same authority, is 325. (*Journal, No.* 32.)

440. *Morphia* combines with acids and forms salts, all of which have a bitter taste.

(*a*) *Muriate of morphia* is a white crystallizable salt, and soluble in about 10 parts of water.

(*b*) *Nitrate of morphia* is a very soluble salt, and affords fine acicular crystals.

(*c*) *Sulphate of morphia* is a soluble crystalline salt.

(*d*) *Carbonate of morphia* forms prismatic crystals, soluble in water.

2. STRYCHNIA.

441. Strychnia is a peculiar vegeto-alkali existing in the *nux-vomica*, from which it may be procured by infusing the powdered vegetable in hot water in close vessels. The infusions, mingled together, are to be reduced by cautious evaporation to the consistence of syrup, and a slight excess of powdered lime is to be added; a precipitate or glutinous magma is formed, which is to be digested in hot alcohol; a solution of *strychnia* and of some coloring matter is thus procured. By cautiously distilling the alcohol away, the alkali is obtained in crystals, which, by repeated solutions and crystallizations, is rendered pure. (M. Henry.)

(*a*) Strychnia is a white crystalline solid of a very bitter taste; it is not fusible or volatile; it is not easily dissolved in cold water, but with hot water it readily forms a very bitter solution.

(*b*) Strychnia is a virulent poison, and speedily induces the locked jaw and death.

(*c*) It is composed of carbon, hydrogene, oxygene and nitrogene (Brande) and its equivalent number is 380.

442. Strychnia forms with acids, intensely bitter tasted salts.

3. CINCHONIA.

443. **Cinchonia** is a peculiar alkaline principle on which the virtues of the *cinchona condaminiæ* or grey Peruvian bark depend, and it is procured by a complicated process from that substance by acting upon it with very diluted sulphuric acid, so as to form a sulphate of cinchonia; to this, lime is to be added, and the alkali, thus precipitated, is to be separated from the other substances by alcohol, and again converted into a sulphate. From this last, it is procured pure by the addition of an alkali.

(*a*) Cinchonia is a white crystalline solid, of bitter taste, and of sparing solubility in water; it forms with alcohol a bitter solution. When exposed to heat it decrepitates and fuses, a portion sublimes and condenses on cooling, into brilliant acicular crystals. When subjected to high temperatures it affords ammonia.

(*b*) Cinchonia consists of carbon, hydrogene and nitrogene; the mean result of two experiments of **Brande**, is

Carbon	79.3	
Nitrogene	13.775	
Hydrogene	7.175	(*Journal No.* 32.)

and its equivalent number, according to that Chymist, 315.

444. Cinchonia unites with acids and forms very bitter salts.

(*a*) *The sulphate of cinchonia* is a white crystalline salt, soluble in water; its febrifuge virtues are believed to be very great.

(*b*) *The muriate of cinchonia* is a very voluble salt; it may be obtained in crystals.

(*c*) *The nitrate of cinchonia* is a soluble and uncrystallizable salt.

4. QUINIA.

445. **Quinia** is procured from pale Peruvian bark by processes analogous to those described under Cinchonia. (443.)

(*a*) Its properties are analogous to those of cinchonia; but it is not crystallizable, but separates from its hot alcoholic solution, as it cools, in a viscid pasty mass.

(*b*) It affords a large quantity of ammonia during its destructive distillation, and consists, according to **Brande**, of

Carbon	73.8
Nitrogene	13
Hydrogene	7.65
Oxygene	5.55

(*c*) Quinia may be separated from cinchonia by ether, in which it alone is soluble.

446. The most important salt of quinia is the *sulphate;* it is in greyish white acicular crystals, of a very bitter taste, and is employed as a febrifuge.

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447. There are several other vegeto-alkalies, which are procured from active vegetables by complicated processes, which, however, are analogous to those above described. The activity of powerful articles of the materia medica appears to reside in these newly discovered bodies, and some of them will no doubt be of great importance to the science of medicine.

(*a*) **Veratria** is an alkaline body, which has been obtained from several vegetables, and among them *colchicum autumnale.* It is a white pulveralent solid, without odor, but of an acrid taste; it excites violent sneezing, and produces, in small doses, excessive vomiting. It forms salts with acids.

(*b*) **Atropia** is the alkaline and narcotic principle of the *atropa belladonna.* It is intensely poisonous, and forms salts with acids; the vapor of the salts produces giddiness, and merely testing them, a dilatation of the pupil, which remains several hours. It was discovered by Dr. **Brandes**, who suffered severely in his experiments upon it from its poisonous effects.

(*c*) **Brucia** is an exceedingly bitter and acrid vegeto-alkali procured from the false angustura, *brucia antidysenterica;* it is very poisonous, and affects animals like strychnia, but much less violently.

(*d*) **Delphinia** is a vegeto-alkali procured from the seeds of the Stavesacre, *delphinium staphysagria;* it is white and transparent when wet; opaque when dry. It fuses by heat, and when cold breaks with a resinous fracture; it is sparingly soluble in water, and very soluble in alcohol and in ether.

(*e*) **Hyosciama** is a vegeto-alkali in which the narcotic properties of the henbane, *hyosiamus niger*, reside. It forms long prismatic crystals; its vapor is very prejudicial to the eyes; and it is very poisonous even in very small quantities.

(*f*) **Picrotoxia** is a white granular powder procured from the *cocculus indicus*, which is fruit of the *memspereum cocculus;* it is an acrid narcotic.

II. OF THE VEGETABLE ACIDS.

448. **There** are several substances, proximate principles of plants, which possess the properties of acids in an eminent de-

gree. These are not however found in all plants, or in all parts of plants, and some of them may be formed by artificial processes.

1. ACETIC ACID.

449. Acetic acid is found as a proximate principle of several plants. It is, however, an abundant product of fermentation, and from that source it is generally procured for the purposes of the arts. It is also a product of the destructive distillation of green wood; it is the acid of vinegar. Pure acetic acid may be procured by pouring one part of strong sulphuric acid on two parts of fused acetate of potash in a retort, and slowly distilling the acid into a receiver surrounded by a freezing mixture; or by distilling the substance called *verdigris*, which is an impure acetate of copper.

(*a*) Acetic acid has a fragrant and pungent odor, and an acrid and acid taste; it is colorless and transparent; at 38° F. it becomes a crystalline solid, if it be perfectly pure. Its sp. gr. is 1.062. Its vapor is inflammable.

(*b*) Acetic acid is decomposed at a strong red heat. It is composed of

Carbon	46.83	
Hydrogene	6.35	
Oxygene	46.82	(Berzelius.)

Its equivalent number is 50. (*Brande's Jour.*)

450. When concentrated vinegar is purified (*U. S. Pharmacopœia.*) and subjected to distillation an acid liquor is obtained, which is clear, colorless and limpid, and of a pleasant acid taste, and a very fragrant odor. It has been called *acetous acid*, or *distilled vinegar.* It differs from acetic acid only in being more dilute.

451. *Pyroligneous acid* is merely acetic acid procured by the destructive distillation of wood, and contaminated with empyreumatic oil and bitumen, from which it derives its peculiar taste, smell and color; it has the property of preventing the decomposition of animal substances, and retards or prevents putrefaction. It may be purified by appropriate processes, and converted into pure acetic acid.

452. Acetic acid by combination with salifiable bases forms a class of salts called *acetates*, some of which are very important.

(*a*) *Acetate of ammonia* has been employed in medicine under the name of *Spirit of Mindererus;* it does not form crystals, but only a deliquescent mass, and is easily formed by adding carbonate of ammonia to acetic acid.

(*b*) *Acetate of potash* is procured by neutralizing acetic acid with potash; it is white and deliquescent, soluble in its own weight of boiling alcohol. When exposed to destructive distillation it is resolved into pyro-acetic ether, carbonic acid and carburetted hydrogene gases; its solution suffers spontaneous decomposition. It is composed of

Acetic acid	1 prime	50
Potash	1 prime	48

(*c*) *Acetate of soda* is formed by the neutralization of acetic acid with soda; it is a crystallizable salt, and does not deliquesce in the air. It is soluble in less than its own weight of cold water and in twice its weight of boiling alcohol; it is composed of

Acetic acid	1 prime	50
Soda	1 prime	48

(*d*) *Acetate of Lime* is used in the preparation of acetate of alumine, and may be prepared by adding chalk, or lime to acetic acid. It is readily soluble and not easily crystallizable. It has a bitter saline taste. It is composed of

Acetic acid	1 prime	50
Lime	1 prime	28

(*e*) *Acetate of baryta* is formed by adding pure, or carbonated baryta to acetic acid; it crystallizes, and has a bitter saline and subacid taste. It is sometimes employed as a test.

(*f*) *Acetate of iron.* Both oxides of iron combine with acetic acid. The *protacetate* is formed by digesting the protosulphuret of iron in acetic acid. This by exposure to the air absorbs oxygene and passes to the *peracetate;* which may readily be formed by digesting peroxide of iron in acetic acid; or for the purposes of the art, by digesting rusty iron scraps in vinegar or pyroligneous acid. It is used by curriers and calico printers.

(*g*) *Acetate of zinc* is formed by adding oxide of zinc to acetic acid, or by adding acetate of lead to sulphate of zinc, so as to produce a mutual and total decomposition. It crystallizes in thin brilliant tables which have a bitter metallic taste. It is used as a colyrium.

(*h*) *Acetate of copper—verdigris.*—Verdigris is formed when copper is exposed to the vapor of vinegar. This green substance is resolved by the action of water into two portions; the one soluble, the other insoluble in water. The former is an *acetate*, the latter a *subacetate* of copper; by distillation, the acetate affords acetic acid.

(*i*) *Acetate of lead—sugar of lead*—is formed by digesting the carbonate of lead in acetic acid. It is generally in crystalline masses, of a white color and a sweetish taste. It is soluble in water, and by cautious evaporation may be procured in four sided prisms. It is a delicate test of carbonic acid, and is used in pharmacy and in the arts. It consists of

Acetic acid	1 prime	50
Protoxide of lead	1 prime	112

A *sub-acetate* of lead is formed by boiling a solution of acetate of lead or acetic acid on litharge. It is not so sweet or so soluble as the acetate. It is a very delicate test of carbonic acid, and has a strong attraction for coloring matter. It consists of

Acetic acid	1 prime	50
Protoxide of lead	3 primes	336

It is used in pharmacy and called GOULARD's *extract*, or *vegeto mineral.*

(*k*) *Acetate of silver* may be formed by digesting oxide of silver in acetic acid, or by the decomposition of acetate of potash by nitrate of silver, and subsequent crystallization; it is sometimes employed as a test.

(*l*) *Acetate of alumine* is procured by digesting recently precipitated alumine in acetic acid; or by the mutual action of acetate of lead or of lime on sulphate of alumine or alum. When a solution of acetate of alumine is heated, even in vessels hermetically sealed, it is decomposed, and alumine is deposited, which is again re-dissolved as the solution cools. It is much employed by dyers and calico printers.

2. TARTARIC ACID.

453. TARTARIC acid is procured from the substance called cream of tartar, in which the acid is combined with potash; by the addition of chalk to a solution of it, an insoluble tartrate of lime is formed, which is to be decomposed by sulphuric acid, and the tartaric acid separated by subsequent filtrations and crystallizations. It forms white needle shaped crystals of an intensely sour taste. It is soluble, and its solution becomes mouldy. When exposed to heat, tartaric acid fuses, and on cooling, concretes again. Its nature is altered, and it now deliquesces when exposed to air.

Tartaric acid is composed of

Carbon	31.42	
Hydrogene	2.76	
Oxygene	65.82	(URE.)

and its equivalent number is

454. Tartaric acid combines with salifiable bases and forms tartrates.

(*a*) *Tartrate of potash* is a neutral salt formerly called soluble tartar, and may be procured by neutralizing the acid with potash; it is soluble, saline, and bitter. It exists in some fruits, and when exposed to the action of carbonic acid it is partially decomposed; carbonate of potash is formed, and bi-tartrate of potash produced.

Bi-tartrate of potash. This is deposited on the inside of wine casks mixed with coloring matter, and is then called *argol*, or *crude tartar*. By solution, the action of pure clay, and crystallization, it is procured in hard gritty crystals of a white color, which, when reduced to powder, form *cream of tartar*.

It is composed of

Tartaric acid	2 primes
Potash	1 prime

(*b*) *Tartrate of soda* is formed by neutralizing tartaric acid with soda. It is a white crystalline salt.

(*c*) *Tartrate of potash and soda—Rochelle salts*—is formed by neutralizing the acid of the bi-tartrate of potash by the addition of carbonate of soda. It is composed of

Tartaric acid	2 primes
Potash	1 prime
Soda	1 prime

(*d*) *Tartrate of antimony and potash—Tartar emetic*—may be prepared by boiling equal parts of bi-tartrate of potash and finely levigated glass of antimony; the liquid after filtration should be evaporated to one half and suffered to deposit crystals. This salt is of a white color; efflorescent in the air; partially decomposed by the light; soluble in 2 parts of boiling water and 14 parts of cold water; and when mixed with astringent or bitter vegetable infusions, it is decomposed.

It consists of

Tartaric acid	2 primes
Protoxide of antimony	2 primes
Potash	1 prime

(*e*) There are many other tartrates, but none of them are of any practical importance. Tartaric acid is disposed to form salts with double bases.

3. OXALIC ACID.

455. Oxalic acid is a proximate principle of some plants; but it may be formed artificially by distilling nitric acid and sugar.

(*a*) Oxalic acid is a white, crystalline solid, of a very sour taste, soluble in water. Crystals of oxalic acid when dried lose above one third of their weight, and fall into powder; they effloresce in dry air.

(*b*) When exposed to a red heat, they are entirely decomposed; they consist of

Oxalic acid	1 prime	36
Water	4 primes	36

Oxalic acid contains the same constituents as carbonic acid; but in different proportions. It consists of

Carbon	2 primes	12
Oxygene	3 primes	24
		36 (Ure.)

Oxalic acid is employed for removing iron stains, for cleaning boot tops, and in calico printing.

It is an active poison, and it has sometimes been taken for Epsom salts; but its acid taste, when a drop of the solution is applied to the tongue, will easily distinguish it from that substance.

456. Oxalic acid unites with salifiable bases and forms oxalates.

(*a*) *Oxalate of ammonia* is formed by adding carbonate of ammonia to oxalic acid; it crystallizes in long transparent silky needles. When slowly crystallized rhomboidal prisms terminated by dihedral summits are formed. It is employed as a test of lime.

(*b*) Oxalic acid and potash unite in several proportions.

Oxalate of potash is formed by neutralizing oxalic acid with potash; it forms flat rhomboidal prisms, soluble in water, and consists of oxalic and potash of each 1 prime.

Binoxalate of potash is formed by dissolving the oxalate in oxalic acid. It consists of

Potash	1 prime	=48
Oxalic acid	2 primes	=76

Quadroxalate of potash is formed when the binoxalate is digested in nitric dilute acid; one half of the alkali is dissolved by this acid; and a salt remains, consisting of

Potash	1 prime	48
Oxalic acid	4 primes	152

These combinations of potash with oxalic acid offer beautiful illustrations of definite and multiple combinations.

The *essential salt of lemons* is an impure quadroxalate of potash.

(c) *Oxalate of lime* is formed by the addition of oxalic acid to lime water, or by the mixture of the solution of any oxalate with any solution of lime. It is a white insoluble powder, which by exposure to heat is converted into pure lime. It consists of oxalic acid and lime, of each 1 prime.

(*d*) There are many other oxalates, but none of them require distinct notice.

4. MALIC ACID.

457. Malic acid exists in the juice of apples, of the houseleek, and in the berry of the mountain ash; in this latter substance it was discovered by Mr. Donovan. It may be procured by adding acetate of lead to the juice of the ripe berries. Separate the precipitate which falls, and wash it with cold water; then pour hot water upon it, and the solution, as it cools, deposites crystals, which are to be boiled with dilute sulphuric acid. A precipitate of sulphate of lead appears; and the remaining portion of lead is to be separated by sulphuretted hydrogene; the filtered liquor, after boiling to expel the gas, contains the pure vegetable acid. It was called *sorbic acid* by Donovan.

458. (*a*) Malic acid is a colorless, transparent, uncrystallizable liquid, of a very sour taste; it forms crystallizable salts with many salifiable bases; but its habitudes and its compounds have been imperfectly examined. It was discovered by Scheele in 1787.

5. GALLIC ACID.

459. Gallic acid is procured from the gall-nut. There have been various processes proposed for procuring it pure. It is said that it may be procured by boiling one ounce of the powdered galls in 16 ounces of water, to one half. Then precipitate two ounces of alum dissolved in hot water with carbonate of potash, and after washing the precipitate thoroughly, add it to the decoction, and digest the mixture for 24 hours with frequent agitation. The filtered solution by gentle evaporation yields gallic acid in crystals. To obtain them perfectly pure, they must be sublimed.

(*a*) Gallic acid is in transparent tables, of an acid and astringent taste. They are soluble in water, and in alcohol. It precipitates most metals from their solutions.

460. Gallic acid forms *gallates* with salifiable bases; and the solutions of these salts are prone to decomposition.

The impure gallic acid, as it exists in nut-galls, is of important use in the arts.

6. CITRIC ACID.

461. Citric acid is the acid constituent of lemons. It may be obtained from them by neutralizing their acid with pulverized chalk, and subsequently decomposing the citrate of lime thus formed, with sulphuric acid. The citric acid is then to be separated by crystallization on cautious evaporation.

(*a*) Citric acid is in white crystals of a very sour taste, soluble in water. In damp air it partially deliquesces. It is not so easily decomposed by heat as the other vegetable acids.

It is composed of

Carbon	33	
Hydrogene	4.63	
Oxygene	62.37	(Ure.)

462. The combinations of this acid have not been much examined, and are of little importance. The acid, mixed with a little sugar and a drop of the oil of lemons, when dissolved in water, forms a very perfect substitute for lemon juice.

7. BENZOIC ACID.

463. Benzoic acid exists in several balsams. It may be procured by subjecting them to heat. The acid rises and condenses in delicate crystals.

(*a*) Benzoic acid is in fine white delicate crystals, soft to the touch; of a fragrant odor, and of an acrid subacid taste. It is soluble in boiling water, and much less so in cold water; it is soluble in alcohol. It combines with salifiable bases and forms *benzoates*. The benzoate of ammonia is sometimes used as a precipitant of iron.

464. There are several other acids extracted from vegetables. They have been procured in very small quantities only, and their properties have been but partially investigated. They do not require particular notice in this place.

III. OF OTHER VEGETABLE PRINCIPLES.

1. GUM.

465. **Gum arabic** may be taken as an example of pure gum. It is in transparent nodules or tears, of a yellowish white color; brittle, breaking with a vitreous fracture; inodorous and tasteless. It is soluble in water, and the solution is called mucilage; it is insoluble in alcohol, and may be precipitated from water by that liquid. When the water of mucilage is evaporated, the gum is procured again unaltered.

Gum is not altered by exposure to air. Its solution does not ferment, but after a long time it becomes sour. A solution of silicated potash produces a precipitate in very dilute mucilage, and is considered as a delicate test of the presence of gum.

Gum is soluble in dilute muriatic and sulphuric acids; by the action of nitric acid, it is converted into *mucic* or *saccholactic acid*, and chlorine converts it into citric acid. (Thomson.)

Gum is composed of

Carbon	35.13	
Hydrogene	6.08	
Oxygene	55.79	
Azote ?	3	(Ure.)

Gum is a nutritious food; it is employed to give a lustre to linen and calicoes, and enters into the composition of ink, &c.

466. There are several varieties of gum, procured from different vegetables, each of which present some peculiarities.

467. *Saccholactic or mucic acid* is procured by the action of nitric acid on gum. It was discovered by Scheele. It is a white pulverulent substance, soluble in 60 parts of hot water. It combines with salifiable bases.

2. STARCH.

468. **Starch** or *fecula* exists in a great variety of vegetables, and may be extracted from them by diffusing the powdered grain

or rasped wood in *cold* water, and separating the grosser parts by a strainer.

Pure starch is a white pulverulent substance without taste or smell. It is insoluble in alcohol, ether, or cold water; but is easily dissolved in boiling water. The solution forms a jelly, when cold, which soon becomes mouldy and sour on exposure to the air. Infusion of nut-galls produces a precipitate in solutions of starch, which is again re-dissolved at the temperature of 120°; this is considered as characteristic of starch by THOMSON. The production of a *blue color* by the action of iodine is a distinguishing property of starch. Starch is soluble in potash ley.

469. When starch is exposed to a temperature of 600° or 700° F. it becomes brown, swells up and exhales a peculiar odor, and is changed in its nature; it no longer is insoluble in cold water, nor does it produce a blue color with iodine. It possesses the properties of gum, and is employed as such by calico printers.

470. When starch is boiled in very dilute sulphuric acid, it is converted into sugar. 100 pounds of starch affords one hundred and ten pounds of sugar.

Starch is composed of

Carbon	38.55
Hydrogene	6.13
Oxygene	55.32

471. There are several varieties of starch, of which the following are the principal:

(*a*) *Indian arrow root* is procured from the roots of the *maranta arundinacea*, by beating them to a pulp and separating the fibrous portions by cold water, and afterward washing and drying the white insoluble powder.

(*b*) *Sago* is a kind of starch prepared from the pith of the palm tree; it is granulated when partly dry by being forced through proper apertures, and its brown color is occasioned by the heat employed in drying.

(*c*) *Cassava and Tapioca* are prepared from the roots of a plant, which grows in South America, the *Jatropha Manihat*; they are there mixed with a very poisonous juice, which is washed out by cold water, and the insoluble portion forms *cassava*, a nutritious and perfectly innoxious substance. *Tapioca* is the same substance under a different form, which it assumes in drying.

(*d*) *Salop* or *saloop* is the starch obtained, by processes similar to those already mentioned, from the roots of several species of *orchis*, particularly from the *O. Mascula*.

(*e*) *Potato* starch is prepared from the potato, by reducing it to pulp and washing it with cold water on a searce. It is heavier than common starch, and is more friable, and more soluble.

3. SUGAR.

472. **Sugar** is obtained from many vegetables, and particularly from the sugar cane. When pure, it is a white crystalline substance, of a purely sweet taste, and without odor. Sugar is easily soluble in cold water, and in almost any proportion in hot water. The solution constitutes *syrup*, which by long repose deposits crystals of sugar. Alcohol dissolves it, and large crystals of sugar may be obtained from the alcoholic solution. Sugar is very soluble in lime water, and, reciprocally, lime is very soluble in syrup. A similar remark applies to baryta and strontia. Alkalies combine with sugar and destroy its taste. Its taste is again restored by the addition of an acid. When sugar is triturated with oil, a mixture is formed which is diffusible through water, producing a milky fluid called an *emulsion*. When sugar is exposed to the action of nitric acid, it affords oxalic acid.

473. Sugar, by destructive distillation, yields acetic acid, carburetted hydrogene, carbonic acid and charcoal.

It is composed of

Carbon	40.00
Hydrogene	6.66
Oxygene	53·33

According, however, to **Ure**, it contains more than 40 per cent of carbon.

473. *Manna*, *sugar of grapes*, of the *maple*, of *beets*, and *honey* are varieties of sugar, and possess the same general properties. Honey consists principally of a crystallizable and an uncrystallizable sugar. *Molasses* is an uncrystallizable sugar.

474. Sugar, starch, and gum, are composed of the same elements united nearly in the same proportions.

4. GLUTEN.

475. **Gluten** may be obtained from wheat flour by making it into a paste, and kneading it under a very small stream of water. The fluid, becoming milky, carries off the starch, and gluten remains. It is a very peculiar body, of a greyish white color, tough, and elastic, and when stretched into thin pieces, appears like animal membrane. When dried it become brown, and brittle ; it is soluble in acids, and in alkaline solutions. When dried gluten is exposed to heat, it evolves in offensive odor, swells and burns precisely like horn, and affords by destructive distillation, the same products as animal substances do. When kept moist, it ferments, and putrefying, exhales the odor

of putrid animal substances, and is eventually converted into a substance resembling cheese, and is then full of holes and cells, which are partially filled with a liquid like that existing in some kinds of cheese. Gluten is precipitated from water by an infusion of nut-galls. It is insoluble in ether. It is nearly allied to animal substances.

476. There are several varieties of Gluten; or rather several plants afford a juice which contain a principle analogous to gluten.

477. When fresh gluten is kneaded in successive portions of alcohol, it is resolved into two principles, one, soluble in alcohol, called *gliadine*, the other insoluble and called *zimome;* they were first recognized as distinct principles by Taddei.

478. (*a*) *Gliadine* is procured by slow evoporation of the alcohol in which gluten has been washed. It is, when dry, of a straw yellow color, translucent, of a slight balsamic odor, and when heated smells like boiled apples. In the mouth it becomes adhesive and has a sweetish aromatic taste. It is insoluble in water, and is precipitated by it from its alcoholic solution. It is insoluble in ether.

(*b*) *Zimome* forms a shapeless mass of small globules, hard, tough, of a greyish color, and without adhesion; it becomes somewhat viscid when put into water. It putrefies on exposure to damp air, and exhales a fetid animal odor. It is soluble in acids, and forms a kind of soap with alkalies.

479. The principal nutritive ingredients of the vegetables employed as food are constituted of gum, starch, sugar and gluten.

		Gluten.	Starch.	Sug'r.	Gum.	Woody fibre and water.
100	Wheat contain	18 to 24	76 to 82	0	0	trace
100	Rye	5	61		-	34
100	Barley	6	80	7	-	7
100	Oats	6	59	2	-	33
100	Peas	4	50	3 extract. &c.		43
100	Potatoes	0	20 to 25		-	80 to 75
1000	Turnips	0	0	34	7	959
1000	Carrots	0	0	95	3	902
1000	Parsnips	0	0	90	9	901

5. TANNIN.

480. **Tannin** is the astringent principle contained in oak bark, hemlock bark, and in many other vegetables. It is difficult to procure it pure and free from all other vegetable matter. It may be advantageously procured by infusing powdered catechu in cold water, filtering and boiling the solution, and filtering a second time; (**Brande**) on evaporation tannin nearly pure is obtained.

Tannin is soluble in cold water. It has a purely astringent taste. When dry it is of a blackish brown color, and has a close grained texture and resinous fracture. Its distinctive character is the production of an insoluble precipitate with gelatine or glue. This precipitate is chymically the same as leather, and has the properties of overtanned leather. It is upon this property of tannin, that the art of tanning is founded; and the comparative utility of barks and woods in the manufacture of leather depends on the relative proportions of tanning, they afford.

481. A very important fact in the history of tannin is its artificial production; a discovery made by **Hatchett**. It may be formed by digesting charcoal in dilute nitric acid for several days. 100 of charcoal afford 120 of artificial tannin; artificial tannin resists the action of nitric acid, while all the varieties of natural tannin are decomposed by it, an effect however which may be referable to the impurity of native tannin, as obtained by the methods employed for procuring it. (*Phil. Trans.* 1805. 1806.)

6. WAX.

482. **Wax** exists in many vegetables, and may be procured from them by appropriate processes, as by boiling them in water. The wax separates and concretes on cooling; it is thus that the Bayberry wax is procured.

Pure wax is a white insipid and inodorous substance, insoluble in water, and but sparingly soluble in boiling alcohol. It is soluble in the fixed oils and the compound forms a *cerate.* Some volatile oils dissolve wax. The alkalies form a species of soap with wax, but the acids hardly act upon it.

At 150° of F. wax fuses; at higher temperatures it is vaporized, and at a red heat burns with a bright flame.

Bees-wax is of a yellowish color, balsamic taste, and a fragrant odor. It is bleached by being cautiously melted and cast into thin plates, sheets or ribbands, and by exposure to dew and light; nitric acid and chlorine bleach it.

The berries of the *myrica cerefera* afford about 32 per cent. of wax. (*Silliman's Jour. Vol.* 1.)

A peculiar kind of wax has been procured from cork by Chevreul and called *cerine ;* it is not so fusible as common wax, but is more soluble in alcohol.

7. FIXED OR EXPRESSED OILS.

483. Fixed oils are procured by subjecting certain seeds to pressure. They are generally viscid, and nearly tasteless; at temperatures a little above the freezing point of water they congeal, and some of them constitute soft solids at common temperatures, and are called *vegetable butters*—they boil at elevated temperatures, as 600° F. With the exception of castor oil they are sparingly soluble in alcohol or ether, and insoluble in water ; they burn with a bright flame.

When oils are exposed to the air, they suffer peculiar changes and become *rancid ;* this change has been supposed to depend on the mucilage they contain ; in this state they contain a free acid.

Fixed oils dissolve sulphur and form a kind of balsam ; they also dissolve phosphorus and form a compound which is luminous in she dark, and is called *liquid phosphorus.*

484. Some fixed oils when exposed to the air, or spread thinly on a surface, do not remain greasy but become hard and dry ; these are called *drying oils*, to distinguish them from the other fixed oils which are called *fat oils.* Oils are rendered drying by boiling ; and occasionally by setting them on fire while boiling, and extinguishing it by covering the vessel ; in this way oil is prepared for making printer's ink.

485. A singular property is possessed by fixed oils, which has occasioned serious accidents. When mixed with lamp-black, or light charcoal, or with cotton thread, flax, wool, &c. the mixture after sometime grows hot, and at length bursts out into a flame. This has sometimes occurred in the oily waste cotton of carelessly managed cotton mills.

486. Oils are not homogeneous substances, but like gluten, are capable of being separated into two distinct substances, called *Stearine*, and *Elaine.*

When an oil is rendered solid by congelation, and exposed to pressure between folds of filtering paper, the *Elaine* soaks into the paper, and the *stearine* remains; or by digesting oil in very pure and hot alcohol, the *Stearine* will be deposited in crystals during cooling, and the *elaine* may be procured by evaporation of the spirit. *Elaine* is fluid at common temperatures; *stearine* is solid and crystalline. *Elaine* is of a yellowish color, and generally of the odor of the fats or oils from which it is derived; *stearine* is colorless, tasteless, inodorous, and is fused at about 120° F. They both afford soaps when acted upon by alkalies and at the same time suffer some peculiar changes in constitution. The relative proportions of these two principles are different in different oils and fats; and their degree of consistence depends on these proportions.

486. The principles, *Elaine* and *Stearine*, which constitute fat and oils, probably experience a change in the proportion of their elements when they are acted upon by alkalies; this change developes at least three new bodies, and this change is not accompanied with the evolution or absorption of any gaseous, or other foreign matter. These principles are *Margaric acid*, *Oleic acid* and a *sweet principle*, whose nature is not well known.

The two acid bodies, agree in their general properties with other acids. They redden vegetable blues; neutralize alkalies, and decompose alkaline carbonates.

487. *Soaps* are compounds of these two acid bodies with potash and soda. The margarate and oleate of potash form soft soap; and the oleate and margarate of soda form hard soaps. These acids combine with some oxides; the *lead plaster* is a combination of this kind.

VOALTILE OR ESSENTIAL OILS.

488. VOLATILE oils contain the peculiar aromatic properties of plants; they may be obtained from vegetables by distillation with water in common stills; the water passes over, and after due repose the oil separates.

(*a*) Volatile oils have a pungent and penetrating taste, and a strong odor; they are seldom limpid and colorless; oil of wormwood is green; oil of laurel is brownish; but generally they have a yellowish tint; they are very soluble in alcohol, and these solutions constitute *Essences;* they are sparingly soluble in water, and these solutions constitute *Distilled waters*. They boil at about 212° F.

(*b*) Volatile oils differ in their specific gravity from each other and from water. Oil of sassafras is 1.094; of cloves 1.035; of oranges 0.888; of turpentine 0.792.

(*c*) Some of the volatile oils take fire when dropped into chlorine gas, and detonate when rubbed with chlorate of potash; they also take fire when nitric acid, mixed with a fourth or a sixth of sulphuric acid, is poured upon them. Volatile oils absorb oxygene and become thick and resinous.

489. **Camphor** very much resembles volatile oils; it is volatile, inflammable, soluble in alcohol, and sparingly so in water; as it is found in the shops it is in white solid hemispherical cakes, of a sp. gr. of 0.98. It fuses at about 300 in close vessels, and is soluble in oils; some acids dissolve it, others decompose it. Nitric acid, when distilled from camphor, converts it into a peculiar acid called *camphoric acid* which is a solid crystalline substance, efflorescent, soluble in water and in alcohol, and, uniting with the alkalies and earths, forms *camphorates.* When camphor is mixed with clay and repeatedly distilled it is almost entirely converted into a volatile oil.

490. A curious compound resembling camphor in many of its properties is formed by passing a current of muriatic acid gas through oil of turpentine; the latter absords the gas and becomes thick, and deposits a white crystalline body, volatile at a moderate heat, and has the odor of camphor. It has been supposed by **Thenard** to be a compound of the acid with the oil, and from analogy he infers that camphor is a similar compound of a volatile oil and a vegetable acid.

RESINS.

491. **There** are many substances obtained from natural fissures or artificial wounds on certain plants which are called resins. They are generally of a yellowish color; translucent, dry, brittle and very inflammable; and of a sp. gr. greater than water. They are soluble in oils, alcohol and ether, and insoluble in water; water precipitates them from their solutions. The alkalies dissolve them; nitric acid by long digestion converts them into artificial tannin, and sulphuric acid decomposes them; acetic acid dissolves them. Resins form the basis of varnishes.

(*a*) *Common resin or rosin* is procured by the distillation of the juice which flows from various kinds of fir; spirits of turpentine passes over, and rosin remains.

(*b*) *Guiacum* is the resin obtained from the hard and dense wood *lignum vitæ.* It presents some curious properties; its sp. gr. is 1.229. It has a yellowish color, but becomes green when exposed to light. Its powder, mixed with water and swallowed, excites a burning sensation in the sauces and stomach. It is soluble in alcohol, and water, digested upon it, dissolves an extractive matter. Nitric acid and chlorine produce some peculiar changes of color in this substance; the former converts it to oxalic acid. Guiacum produces a blue color with gluten, but not with starch. (**Taddei.**)

(*c*) *Mastic* is a resinous body which flows from some firs; it has a little odor, and a slight taste; it is not totally soluble in alcohol, a portion, resembling caoutchouc remains.

(*d*) *Sandarach* is a very transparent resin in yellowish white globules.

(*e*) *Dragon's-blood* is an absurd name given to a brownish red resin imported from India; it is soluble in alcohol, and the solution gives a fine red tint to hot marble.

(*f*) *Elemi* is a resin which exudes in dry weather from wounds made in a South American tree; it has a faint but agreeable odor.

(*g*) *Labdanum* is a blackish resin, often greatly adulterated by the addition of iron sand; it has been employed in pharmacy and in perfumery.

(*h*) *Copal* agrees with resin in some of its properties. It is not soluble in alcohol as the other resins are. If the copal be rubbed with a little camphor it softens and becomes soluble in alcohol; it is soluble in linseed oil, and rendered drying by quick lime.

(*i*) *Amber* is probably a vegetable product and may be considered as a resin possessing peculiar properties; it agrees with copal in being sparingly soluble in alcohol: when submitted to distillation it affords a peculiar acid body called *succinic acid;* this, by solution and crystallization is purified, and affords white shining tabular crystals. They possess the general characters of acids, and with salifiable bases form *succinates.* The succinate of ammonia is employed in the analysis of mineral waters to separate iron.

492. BALSAMS are resins which contain benzoic acid, and derive their fragrance from admixture of essential or volatile oil; some balsams are liquid, as *balsam of copaiba; opo-balsam,* the most precious of the balsams, and called *balm of Gilead;* this precious substance is often adulterated. The genuine balsam, when dropped into water, spreads over its surface and forms a thin irised pellicle, so tenacious as to be taken up entire by the point of a needle. This property is said to be possessed also by some other balsams.

Benzoin and *storax* are concrete balsams; the latter, however, is sometimes liquid.

493. GUM RESINS are native mixtures or combinations of gum and resin, and possess properties more or less analogous to gum or resin, in proportion as they contain more or less of either substance.

Frankincense, ammoniacum, gamboge, assafœtida, scammony and aloes are gum resins.

INDIGO AND COLORING MATTER.

494. INDIGO is the coloring matter of the Anil or indigo plant, from which it is procured by steeping and fermentation of the

vegetable. Indigo is of a fine blue color, and contains about half its weight of coloring matter. When subjected to heat, a fine violet vapor arises which condenses into acicular crystals, of a metallic lustre; these have been called *indigogene;* (GORHAM. *N. E. Journal.*) Indigo is soluble in sulphuric acid; the solution forms the *Saxon blue.* The nitric acid converts it into a peculiar bitter principle. Indigo contains oxygene in its natural state; when deoxodized, it has a green color, and is then soluble in alkalies, and may be fixed on cloth. Cloth when taken from the indigo vat has a green color, but by exposure to the air it absorbs oxygene and becomes blue

495. *Coloring matter of vegetables* does not appear to reside in any peculiar principle, and it is therefore differently affected by solvents. By the affinity of certain solvents, coloring matter is separated from vegetables, and by the superior attraction of wool, silk, cotton, &c. it is separated from the solvents and fixed on the fibres of the fabric.

Colors which are fixed and durable by the simple attraction of the fibres of cloth, without the intervention of any other substance, are called *substantive colors.* Those which require the intervention of a third body, which possesses an attraction both for the cloth and the coloring matter, and thus links them together, are called *adjective colors;* the substance which possesses the property of fixing colors is called a *mordant.* Preparations of alumine, of tin and of iron are generally employed as mordants. The peculiar tint of color is frequently produced by the action of the mordant.

Alumine has a very strong attraction for coloring matter, and form the basis of pigments called *lakes.* (BANCROFT *on Phil. Perm. colors.*)

CAOUTCHOUC.

496. CAOUTCHOUC, or India rubber, is obtained from many plants which yield a milky juice. The most remarkable property of this substance is its elasticity. It is inflammable, and burns with a bright flame; it is not soluble in water or in alcohol, but may be dissolved in pure ether and in some essential oils. By the action of the alkalies it loses its elasticity. By destructive distillation it affords a portion of ammonia. It is employed in forming elastic varnishes.

497. BIRDLIME is analogous in its properties to caoutchouc; it is a tenacious, gluey substance, of a grey color and of the odor of linseed oil; it loses its viscidity when dry, and regains it on the application of moisture; it is not soluble in water, or in alcohol, but dissolves in ether.

It is prepared from the bark of the Holly, and from some other vegetables.

ZEINE.

498. This is a peculiar principle discovered by Prof. Gorham in the *zea mays* or Indian corn. It may be procured by infusing the grain in water, filtering, and digesting the insoluble residue in alcohol; on evaporating the alcoholic solution, a substance remains which is *zeine.* It is of a yellowish color, and the appearance of wax; it is insipid, soft, ductile, tough and elastic, and has a faint odor; it resembles gluten, but yields no ammonia by decomposition by heat. (Gorham. *N. E. Jour.*)

499. A number of other proximate principles of plants has been examined, some of which appear to be possessed of peculiar and interesting properties; but they have not yet been thoroughly examined.

(*a*) Sarcocoll is an uncrystallizable substance of bitterish sweet taste; soluble in water and in alcohol, and yields oxalic acid when heated with nitric acid. It resembles sugar in some of its properties.

(*b*) Inulin is a white powder procured from the roots of elecampane; like starch, it is insoluble in cold water, but dissolves in hot water, but as the solution cools the inulin is precipitated; it is insoluble in alcohol.

(*c*) Ulmin is a substance which exudes from the bark of the elm; it is of a brown color, without taste or smell; very soluble in weak solutions of carbonate of potash. It is generally combined with carbonate of potash as it exudes from the tree.

(*d*) Hematin is a peculiar substance obtained from logwood, and is probably the pure coloring matter of that wood; it is a reddish crystalline substance, of a bitter taste, forming a yellowish solution in cold water, and an orange red one in boiling water.

(*e*) Polychroite is the extract of saffron, of a deep yellow color, deliquescent, soluble both in water and in alcohol, but insoluble in ether; it is rendered blue by sulphuric acid, green by nitric acid, yellow by lime or baryta.

(*f*) Asparagin is a crystalline substance, of a cooling nauseous taste, procured by evaporating the juice of asparagus; it is soluble in hot water, but insoluble in alcohol; when heated it emits acrid vapors.

(*g*) **Nicotin** is the poisonous principle in tobacco. It is procured in small quantities only by complicated processes; it is acrid, volatile, soluble in water and alcohol, and is highly poisonous.

(*h*) **Emetin** is the emetic principle in ipecacuana, from which it is extracted by a circuitous and complicated process; it is in brownish crystalline scales which have an acrid taste. They are without smell, and are insoluble in ether. Alcohol and water dissolve it; it operates with violence as an emetic in doses of half a grain.

(*i*) **Suber** or cork, is a light elastic substance; easily combustible, which by the action of nitric acid yields a peculiar acid called *suberic.*

(*j*) **Lupulin** is a yellow powder obtained from the female flower of the hop. It contains in a concentrated form the virtues of the hop. It was discovered by Dr. Ives of New-York. (*Silliman's Jour. Vol.* 2.)

(*k*) **Woody fibre,** which remains after the action of water and alcohol on wood, has been called *lignin.* It is insipid and inodorous. By the action of sulphuric acid it is converted into a substance like gum; and by diluted sulphuric acid this is converted into sugar. Lignin, by destructive distillation, affords pyroligneous acid, and a light brittle shining charcoal remains. Different woods afford different quantities of charcoal.

Beech	15. per cent.		Oak	17.40 per cent.
Mahogany	15.75 "		Fir	18.17 "
Lignum Vitæ	17.25 "		Box	20.25 "

OF FERMENTATION AND ITS PRODUCTS.

500. **Certain** vegetable juices and decoctions or infusions which contain a sensible quantity of sugar, when exposed to a temperature of 60° or 70° F., begin to suffer changes from the reaction of their principles on each other; this reaction constitutes *fermentation.* When these changes terminate in the production of an intoxicating liquor, they constitute *vinous fermentation;* when an acid is the result, *acetous fermentation.*

501. *Vinous fermentation.* The principal substance concerned in vinous fermentation is sugar. When one part of sugar is dissolved in five parts of water, and a little yeast added, fermentation quickly occurs if the mixture be placed in a proper temperature. A brisk intestine motion ensues and the liquor becomes turbid. Some impurities are separated, and a frothy scum rises to the surface. A hissing noise is heard, carbonic acid gas is evolved, and the bulk of the liquid is augmented, and

its temperature is increased. After sometime the phenomena subside, the liquor becomes clear, and having lost its sweet taste, has acquired a spirituous taste and smell; and when subjected to distillation, affords a liquid of less sp. gr. than water, and of a strong spirituous taste. This is *spirit of wine*, and when properly purified constitutes *alcohol* or pure spirit.

502. The presence of yeast is not absolutely necessary to the process of fermentation. The juices of many vegetables naturally contain the saccharine principle essential to fermentation, together with many other substances, some of which promote the process. From the fermented juice of the grape, or wine, *brandy* is procured by distillation; *rum* is procured by distilling the fermented juice of the sugar cane; *whiskey* from the fermented decoction of grain, and *arrack* from the fermented rice. Sulphurous acid, procured for this purpose by the combustion of sulphur, has the property of arresting the progress of vinous fermentation; it has long been employed for this effect in wine countries. Its mode of operation has not been thoroughly investigated.

ALCOHOL.

503. Alcohol may be obtained by slowly distilling proof spirit until one third has passed over; this is to be mixed with one fourth its weight of dry and warm pearlash, which deprives it of another portion of water, and again slowly distilled. Chloride of calcium may be substituted for pearlash, and the process may be several times repeated if necessary.

(*a*) *Alcohol* is a limpid and colorless liquid, of a fragrant odor and pungent taste. Its specific gravity varies with its purity. It has been obtained of a sp. gr.$=0.791$; it is generally 0.820. Alcohol boils at about 175° F.; it has not yet been frozen. It is combustible and yields carbonic acid and water only. It is decomposed when transmitted through an ignited tube.

(*b*) *Alcohol* exists ready formed in fermented liquors; it is an *educt*, not a *product*, of distillation, as is satisfactorily established by the experiments of Brande.

(*c*) *Alcohol* mixes in all proportions with water. The volume of the mixture is less than the volumes of the substances before mixture.

(*d*) *Alcohol* is a powerful solvent; many vegetable principles, many saline substances, and hydrets are soluble in this fluid.

(*e*) An interesting relation subsists between the composition of sugar, and of the products of its fermentation:

Sugar	appears to contain 3	primes of	carbon	3 of hydro.	& 3 of	oxygene.
Alcohol	contains 2	"	carbon	3 hydro.	& 1	oxygene.
Carbonic acid	contains 1	"	carbon	and	2	oxygene.

· So that by abstracting from sugar 1 prime of carbon and 2 of oxygene which form carbonic acid, we leave the elements of alcohol. Dr. Ure has stated a different result for the composition of sugar and alcohol, which needs confirmation. From 100 parts of sugar Lavoisier obtained 50.776 of pure alcohol; from the same quantity, Thenard procured 51.453; and by the theoretical deductions of Gay Lussac there should be 51.55.

The coincidence of these three results seems perfectly decisive. (Ure.)

It will be noticed that alcohol contains the elements of water and of olifiant gas, and it may be perhaps considered as a combination of

$$\begin{array}{l}\text{Olifiant gas 1 prime}=\left\{\begin{array}{ll}\text{Carbon} & 2\text{ primes}\\ \text{Hydrogene} & 2\text{ primes}\end{array}\right.\\ \text{Water 1 prime}=\left\{\begin{array}{ll}\text{Hydrogene} & 1\text{ prime}\\ \text{Oxygene} & 1\text{ prime}\end{array}\right.\end{array}\left.\begin{array}{l}=2\\=3\\=1\end{array}\right\}\text{Alcohol.}\left\{\begin{array}{l}2\\3\\1\end{array}\right.$$

Or of one volume of olifiant gas + 1 volume of vapor of water condensed by combination into one volume; this would give the specific gravity of vapor of alcohol 1.603 by theory; now, it comes out 1.613 by experiment; a difference too slight to be noticed.

504. When alcohol is acted upon by certain acids, a peculiar product is afforded called *ether;* and ether is named according to the acid employed in its production.

(*a*) Sulphuric ether is the most important of these liquids. It may be prepared by mixing equal weights of alcohol and sulphuric acid. The mixture should be made gradually, and subjected to slow distillation, into a receiver surrounded by ice, by a carefully regulated heat; the ether first distilled is not pure. It is contaminated with alcohol and with sulphurous acid. By mixing it with water and agitating it, many of the impurities are carried off; and by re-distilling this *washed* ether from dry carbonate of potash, or from chloride of calcium, it is obtained extremely pure.

Sulphuric ether is a limpid transparent fluid, of a fragrant odor, and a pungent taste; it produces a degree of intoxication when its vapor is inhaled. It is extremely volatile, and produces a great degree of cold during its evaporation; it boils at about 98° under ordinary pressure, and at—20° F. in the exhausted receiver of an air pump, and hence it would appear in the state of gas at common temperatures, were it not for atmospheric pressure; at—48° it freezes. It is very inflammable, and its vapor burns with a bright flame; by slow combustion (410) it affords an acid called *lampic;* which is probably the *acetic acid.* The specific gravity of ether, like that of alcohol, varies with its purity; common sulphuric ether has a sp. gr. of 0.730 to 0.760. It is said to have been procured as low as 0.632.

Ether dissolves several bodies; as sulphur, phosphorus, fixed oils, caoutchouc, and some volatile oils; it also dissolves several oxides.

Ether is composed of

$$\left.\begin{array}{ll}\text{Hydrogene} & 6\text{ primes}\\ \text{Carbon} & 5\text{ primes}\\ \text{Oxygene} & 1\text{ prime}\end{array}\right\} = \left\{\begin{array}{ll}\text{Olifi. gas 5 prs.} = \Big\{ & \text{Carbon 5 primes} = 5\\ & \left.\begin{array}{l}\text{Hydro. 5 primes}\\ \text{Hydro. 1 prime}\end{array}\right\} = 6\\ \text{Water 1 pr.} = \Big\{ & \text{Oxygn. 1 prime} = 1\end{array}\right.$$

Or of vapor of water 1 volume + olifiant gas 2 volumes. It appears that when we deprive alcohol of all its water we convert into olifiant gas (194. *a.*) and if of half of it, we form ether.

Alcohol = olifiant gas 100 + water 50.
Ether = olifiant gas 100 + water 25.

(*b*) Nitric ether is obtained by the action of alcohol and nitric acid. When these two liquids are mixed a very violent action ensues, and a great quantity of ethereal vapor is evolved. They should be mixed in small quantities only at once. A convenient mode of effecting this, without hazard, has been proposed by Hare. (*Silliman's Jour. Vol. 2.*)

Nitric ether has a light yellow color, a fragrant odor, and of a pungent taste. It is very volatile and boils by the heat of the hand; it suffers spontaneous decomposition, and is converted into nitric and acetic acids. It contains nitrogene in its composition, or

4 primes olifiant gas + 1 prime nitric acid.

(*c*) Muriatic ether is procured by acting on strong alcohol with concentrated muriatic acid; and Hydriodic ether by distillation of strong *hydriodic acid* with *alcohol;* the former appears to contain 2 primes olifiant gas + 1 prime muriatic acid: the latter has not been thoroughly examined. Acetic ether is formed by the distillation of acetic acid and alcohol. Some other acids have been employed in the formation of ether; but they do not produce them unless a mineral acid be present.

ACETOUS FERMENTATION.

505. When wine, cider, or beer is exposed to a temperature of about 80° F. and to the contact of air, they gradually become thick. The temperature is increased, a hissing noise is perceived, and filaments appear to be moving in the liquid in all directions. When the liquor becomes transparent, it has lost its spirituous taste, and a sour taste has been acquired, and acetic acid formed. Pure alcohol, or alcohol and water, do not suffer acetous fermentation; but strong wine, beer or cider affords the strongest vine-

gars. During this fermentation a portion of carbon is extracted from the liquor by the oxygene of the air, and carbonic acid is formed; and this circumstance constitutes the principal difference in the phenomena presented by vinous and by acetous fermentation.

Vinegar in this country is generally procured from cider. When the acetous fermentation is completed, the whole of the alcohol and of the malic acid have disappeared. The product of acetous fermentation has already been referred to.

506. Vegetable bodies, when left to themselves, are gradually destroyed and decomposed, provided moisture be present and the temperature be about 50°. This spontaneous decomposition, called *putrefaction*, is in many instances attended with a nauseous and fetid odor. Various gases are evolved; a portion of the oxygene of the air is converted into carbonic acid, and a carbonaceous residue is left. We are not yet able to trace the various complicated processes which constitute putrefaction. The chymical action is probably, in some instances, very energetic, since light is evolved by putrescent wood, and it becomes phosphorescent. (430.)

II. OF THE CHYMISTRY OF ANIMAL SUBSTANCES.

507. The general differences in the chymical constitution o animals and vegetables has already been alluded to. The former derive their peculiarity from the presence of azote, and this element frequently exists in them in large quantities. Hence when animal substances are exposed to heat, they afford ammonia in abundance. Some animal substances contain carbon, hydrogene and oxygene in the proportions which constitute water, and hydrogene and nitrogene in the proportions which form ammonia; and such substances are analogous in some respects to starch, sugar, gum, &c. There are some other animal products which contain oxygene and azote in excess relatively to the hydrogene, and these are acid bodies. And again there are others in which the hydrogene is in excess, as in fat, oils, &c. Phosphorus is generally found in animal bodies; and to this

body and to sulphur is due some of the peculiar chymical properties which they present. The charcoal afforded by the destructive distillation of animal bodies is more porous than that from vegetables, and is more efficacious in destroying color and odor than that from vegetables; it is more difficult of incineration than vegetable charcoal, an effect depending on the formation of a glaze by the fusion of the common salt and phosphate of lime which it contains.

1. OF THE BLOOD AND ITS CONSTITUENTS.

508. The blood of the higher order of animals appears, when fresh drawn, like a homogeneous fluid, smooth and unctuous to the touch, of a red color, a faint odor, and a saltish maukish taste; it is heavier than water, being of a sp. gr. from 1053 to 1126. After a few minutes a thin film appears on its surface, and the whole mass soon becomes a soft solid; a spontaneous analysis of the fluid soon commences, drops of a yellowish fluid ooze out, and the whole is at length resolved into two portions, a firm red colored portion called *clot*, *cruor* or *crassamentum*, and a light yellowish liquid called *serum;* the relative proportion of these two parts depends on the state of vigor and health of the animal.

(A) Of the serum. This fluid has a yellowish or greenish tinge; a soapy feel, and a saltish taste; its sp. gr. is about 1.029. When heated it becomes coagulated and forms a white pearly mass; and if it now be cut into thin slices and subjected to pressure it yields a small portion of a whitish liquor, having an alkaline taste and peculiar odor; this liquor is called *serosity*, a liquid which probably differs from the serum in containing a greater quantity of alkaline matter. The coagulation of the serum is due to the presence of a peculiar principle called *albumen;* a principle which exists in many animal products, and which possesses the following characters, viz.

(*a*) *Albumen* exists sufficiently pure in the white of an egg for the exhibition of its properties; in its natural uncoagulated state it is a glairy liquid without taste or smell; exposed to a low heat, it dries and forms a transparent solid; and when spread thinly on a surface, forms a kind of varnish.

(*b*) *Albumen* is soluble in water; the solution is effected by agitation, and a viscid liquid is obtained. This solution as well as the liquid albumen renders the vegetable blues, green; indicating a portion of an alkali, which is *soda*. A solution of perchloride of mercury dropped into a solution of one grain of albumen dissolved in 2000 of water produces a cloudiness, and hence it is a useful test of albumen. (Bostock.)

(c) *The distinguishing characteristic of albumen is its coagulability by heat.* When it is exposed to the temperature of about 135° it becomes partially solid, and at 160° it forms a white opaque solid mass; and if now it be dried on a water bath, it shrinks and assumes the appearance of horn. It is now scarcely soluble in water, and is not liable to spontaneous decomposition; by dilute nitric acid it is converted into gelatine. A solution which contains 1-10 of dry albumen forms a solid coagulum when heated; if it contains 1-15 it forms a glairy liquid, and a solution containing $\frac{1}{1000}$ is rendered opalescent by heat. Voltaic electricity has been found by Brande to be a delicate test of the presence of albumen. When two platina wires from a small battery are introduced into liquids containing albumen, a rapid coagulation will take place about the negative pole. Solutions of albumen, so diluted as not to be changed by heat or corrosive sublimate, afford a coagulum with the Voltaic battery. When liquid albumen is agitated with ten or twelve times its weight of alcohol it is coagulated, and precipitated in white flocks or filaments, and after being well washed with water appears like *fibrin.* Strong acids coagulate albumen, and a similar effect is produced by some salts and by some oxides. The pure alkalies dissolve albumen even after it has been coagulated. Liquid albumen is probably a compound of albumen and soda dissolved in water, and its coagulation by heat, alcohol, acids and electricity depends on the removal of the alkali by those agents. A solution of soda oozes from albumen coagulated by heat, which re-dissolves a portion of the coagulum; this liquid, which does not give indications of albumen by common agents, constitutes the *serosity* of the serum, and has been called *mucus* and *muco-extractive* by some chymists. Brande has shown that it affords a coagulum of albumen by Voltaic electricity.

(d) *Albumen* by destructive distillation affords a large quantity of ammonia. It is composed of

Carbon	52.883	
Oxygene	23.872	
Hydrogene	7.54	
Nitrogene	15.705	(Gay Lussac & Thenard.)

In addition to the albumen which exists in the serum of the blood there are found water and some saline bodies; the serum of human blood contains,

	According to Berzelius.	According to Marcet.	
Water	905.0	- -	900.00
Albumen	80.0	- -	86.80
Muriates of potash and soda	6.0	- -	6.60
Lactate of soda and animal matter	4.0	Muco-ex. (Lac. of soda)	4.00
Soda, phos. soda and animal matter	4.1	Sub. car. soda pot. & phos.	2.60
Loss	0.9		
	1000		1000

These analyses agree remarkably well; the muco-extractive matter of MARCET is doubtless impure lactate of soda; and the sulphate of potash, &c. formed by combustion. It has been contended that *sulphur* exists in the serum; but if it does it is probably in a state of intimate combination. Serum or albumen when heated in a vessel of silver renders it black.

(B) OF THE CLOT, CRUOR OR CRASSAMENTUM. This is the firm coagulating portion of the blood, and has a specific gravity of about 1.245; it may be resolved into two portions by careful washing under a small stream of water; the coloring matter, called red globules, is gradually dissolved and washed out, and a white fibrous substance, called coagulable lymph or fibrin, remains.

(*a*) *Fibrin* possesses the essential characters of coagulated albumen, and is considered as being chymically the same; like the fibrous albumen procured by the action of alcohol, it is white, insipid, inodorous, heavier than water and produces no effect on vegetable blues; it is soluble in pure alkalies, but with more difficulty than albumen; but in acetic acid it dissolves with more ease. When the blood is a long time in coagulating, the red globules subside, leaving a portion of this coagulated albumen without coloring matter; this forms the *buffy coat* of the blood.

(*b*) The *red globules* may be discovered by the aid of a microscope; their diameter varies from $\frac{1}{6000}$ to $\frac{1}{4000}$ of an inch; they have been supposed to be soluble in water; but this fluid simply dissolves out the coloring portion, leaving the globule colorless; the colorless portion of the globule has the properties of albumen.

(c) The *coloring matter* appears from the experiments of BRANDE to be a peculiar animal principle; it may be obtained according to VAUQUELINE, by digesting the crassamentum in dilute sulphuric acid at 160° F. for several hours; to the solution, filtered while hot, ammonia, nearly sufficient to neutralize it, is to be added; a precipitate falls, which is to be washed and dried. The dry coloring matter thus procured is black and has the appearance of jet. When diffused through water it has a wine red color. It is soluble in several acids and alkalies, and solutions having reddish tints by reflected light, and greenish by transmitted light, are formed. The coloring matter is decomposed by nitric acid, and does not contain iron in any state of combination which can be detected by the usual tests. The coloring matter when incinerated, leaves a very small residuum, in which a small quantity of oxide of iron exists. From the experiments of BRANDE, it appears that the coloring matter may be fixed by mordants, and will probably be useful in the art of dyeing.

(*d*) The crassamentum consists of

Albumen and fibrin	39
Coloring matter	64

When the blood is exposed to the action of different gases, it suffers some changes in its appearance. *Nitrogene gas* renders arterial blood black, and is said also to have that effect on venous blood; *Oxygene gas* restores the florid hue to blood changed by nitrogene. Atmospheric air produces a similar change in blood owing to the oxygene it contains. Venous blood becomes of a deep purple when exposed to *nitrous gas*, and of brighter purple when exposed to *nitrous oxide*. *Carburetted hydrogene* renders it of a fine red color; chlorine renders blood black. *Carbonic acid* gas is disengaged from blood placed under the exhausted receiver of the air pump. The blood of the fœtus contains no phosphoric salts, nor any fibrin; it is of a darker color than the blood of adults.

2. OF THE SOFT PARTS OF ANIMALS.

510. (*a*) *The skin* has been separated by anatomists into three parts. The external, called the *cuticle*, beneath which is the *rete mucosum*, which separates the cuticle from the *cutis* or true skin.

The cuticle possesses the chymical properties of coagulated albumen. It is that part of the skin which is raised in blisters. It possesses a great degree of elasticity. It is soluble in alkalies, and is tinged yellow by nitric acid, and some other colors, by other agents.

The composition of the *rete mucosum* has not been determined with accuracy. It is known that the color of negroes depends on a black pigment situated in this part; and that it is partially destroyed for a limited time by the bleaching powers of chlorine.

The *cutis* is composed principally of GELATINE, which is a peculiar animal principle possessing the following characters: When pure, it is transparent, colorless, inodorous and insipid. When immersed for some time in cold water it becomes softened, and it readily dissolves in hot water. The solution, when concentrated, forms on cooling, a tremulous mass called jelly; jelly is readily soluble in water, and when dry presents the original appearance, and has the properties of gelatine. Dry gelatine suffers no changes; but when moist, it soon becomes mouldy and putrescent.

Dilute acids and alkalies dissolve gelatine; sulphuric acid converts it to a peculiar saccharine matter. Solution of tannin produces a precipitate with gelatine, and on the affinity existing between these is founded the art of tanning. *Glue*, *size*, and *isinglass* are more or less pure forms of *gelatine.*

(*b*) Membranes are thin transparent textures which envelope certain parts of the body. When macerated in water they swell and soften; they are soluble in hot water; the solution, if concentrated, concretes and forms jelly on cooling; and it gives a precipitate with tannin. They may, like skin, be converted, by tanning, into leather; hence they possess the characters of gelatine.

(*c*) Muscles constitute that part of the animal called the flesh. When red muscular flesh is repeatedly washed in cold water, a white fibrous substance remains, which has the properties of the coagulating albumen of the blood. A small portion of gelatine is obtained from them, and they yield a peculiar substance of an aromatic flavor, called *osmazome.* It is of a brownish yellow color, and of taste and smell of soup. Muscles are converted in a substance bearing an analogy both to spermaceti and to fat, when they are exposed to running water, or when buried in moist ground, it has been called *adipooiere;* the same substance is formed by the action of diluted nitric acid on muscle. Muscles usually terminate in strong white cords or membranes, called

(*d*) Tendons, or sinews. They are strong, pearl colored shining bodies. When digested for a long time in warm water they soften, and are ultimately dissolved; they exhibit all the chymical properties of gelatine, and are a peculiar modificatio nof that body.

(*e*) Ligaments are strong bands which bind the bones to each other; they are dense, strong, fibrous, somewhat elastic bodies. When these bodies are boiled they yield a portion of gelatine, but still retain their form and strength, in a great degree. They are a modification of coagulated albumen.

Glands are organs for forming or altering different fluids in the animal system. Their chymical composition is not known.

Brain. A very elaborate analysis of the brain by Vauquelin, shows that about 80 per cent. of it consists of watery matter. It contains albumen, salty matter, acids, sulphur and phosphorus. Brain kept in close vessels secluded from the air does not suffer decomposition for a long time; but it very soon becomes putrid when exposed to the air. Solution of pure potash dissolves it and gives rise to the production of a large quantity of ammonia. The *spinal marrow* and the *nerves* have the same chymical properties and composition as the brain.

Fat of animals is separated from the cellular membrane by heat and pressure; it has various degrees of consistency and hardness, as tallow, lard, oil; and which depend on the relative proportions of Elaine and Stearine, of which they are constituted.

Fat has the same general chymical habitudes as vegetable oils. *Marrow* is a peculiar fat found in the hollows of long bones; it resembles butter.

Spermaceti or *cetine* is a peculiar substance which concretes from the oil of the spermaceti whale. It is of a white color, crystalline texture and soft unctuous feel; melts at about 110°; and at higher temperatures is volatile. By repeated distillation it forms a fluid oil; its nature is changed by potash, and it forms an acid body by uniting with that alkali to form soap, which differs from oleic, or margaric acid, and has been called by CHEVREUL, *Cetic acid.*

3. OF THE HARD PARTS OF ANIMALS.

511. (*a*) BONES are composed of an intimate combination or mixture of earthy and of animal matter; when exposed to heat for sometime, the animal portion is destroyed, and a brittle white matter remains, which consists of *phosphate of lime*, with a small portion of *carbonate of lime*, *phosphate of magnesia* and *sulphate of lime.* The latter, however, is produced by the process of calcination; the earthy part of human bones constitutes about 63 per cent., of which the phosphate of lime forms about 82 per cent.; the remainder consists of other saline and earthy matter. The relative proportion of earthy and animal matter in bones of different animals is very different.

Bones when broken in small pieces and boiled in water afford a portion of *fat*, and of *gelatine.*

When bones are digested in dilute nitric or muriatic acid, the earthy and saline portions are dissolved out; and when deprived of their gelatine and fat, by boiling in water, and of their earthy portions by dilute acids, a soft white elastic substance remains, which retains the form of the bone, and is called *cartilage;* it possesses all the properties of coagulated albumen. The cartilaginous portion of the bone appears to be first formed, and the earthy matters afterward gradually deposited in them give the requisite firmness. The toughness and strength of bones appears to be derived from the gelatine and the fat; for when these are removed, they become brittle.

(*b*) *Teeth* contain more earthy and less animal matter than bone; and the *enamel* of teeth is entirely destitute of cartilage.

(*c*) *Ivory* is analogous in its composition to bone; the principal difference seems to be in its texture.

When bones are subjected to destructive distillation, the usual product of animal matter is obtained, and the charcoal which remains, mixed with the earthy and saline matter, constitutes *ivory black.*

512. *Shells.* The only complete set of experiments on the chymical nature of shells was made by Mr. HATCHETT, and there is a foundation for distinguishing them into two classes.

Porcellanous shells have a compact texture, smooth surface, and are brittle; they are often beautifully colored and variegated. When heated they lose their color; crackle and split without evolving much smoke or odor; they effervesce vigorously in dilute muriatic and nitric acid. They are composed of carbonate of lime with a very little animal matter, which is gelatine.

Mother of pearl shells are more tough, and glossy, and exhibit a play of colors on their surface; when heated to redness they evolve an odor like that of burning horn. By the action of diluted nitric acid or of muriatic acid they partially dissolve, leaving a series of lamina of cartilaginous matter; and the shell appears to be composed of alternate layers of coagulated albumen and of carbonate of lime.

Pearls have a structure and composition like mother of pearl shells.

513. *Horns* consist of coagulated albumen, and contain but a trace of earthy matter and of gelatine; the horns of the buck and the hart, are intermediate in their composition between bone and horn. Horn may be softened by heat and squeezed into moulds; it is rendered more translucent by being heated and pressed between heated iron plates.

Hoofs have the same composition as horn, and also *nails, claws,* and beaks of birds. Tortoise shell is a peculiar form of coagulated albumen.

Quills, feathers, horn, wool and *bristles* are only modifications of coagulated albumen, and differ rather in their texture and structure than in their composition. Some of these parts yield a trace of gelatine.

In *hair,* VAUQUELINE found traces of silex, sulphur, iron and manganese, and a peculiar oil, which is nearly colorless in white hair, blackish green in dark hair, and red in red hair.

514. *Crusts* or shells of lobsters, &c. are intermediate between shells and bone; they consist of coagulated albumen, carbonate and phosphate of lime.

Scales of fish are like mother of pearl; scales of serpents like *nails.*

Zoophytes present some differences in their chymical composition. Some, like the common white coral, consist almost totally of *carbonate of lime* with a trace gelatine. Others are like pearl in composition, as the madrepores. The red coral contains phosphate and carbonate of lime united to cartilage; and sponges consist chiefly of albumen.

4. OF SECRETIONS.

515. **Secretions** are fluids separated from the blood to serve some ulterior purpose in the animal economy.

Milk is the fluid secreted by certain animals for the nourishment of their young. The milk of different animals presents some differences in composition. It is white, opaque, of a sweetish grateful taste, and of a peculiar odor. Its color and taste vary in some degree with the food of the animal; its sp. gr. is greater than water, but is variable. It freezes at 32° and its boiling point is a little above that of boiling water.

When milk is allowed to rest a few hours a thick unctuous portion collects on the surface, and a thin bluish white liquid remains beneath the former, called *cream*. The liquid portion when heated with a little *rennet*, which is the inner coat of a calf's stomach preserved with salt, digested with water, it separates into two portions, a thick coagulum, and a thin watery part. The former called *curd*, the latter *whey;* thus milk may be readily separated into three parts, *cream*, *curd* and *whey*.

Cream has a yellowish color; its consistence gradually increases when exposed to the air, and it is at length converted into a very fat cheese, called *cream cheese*. Cream is a kind of oil, and when agitated, as in churning, it separates into two portions, viz: *butter* and *butter-milk*. The former is a true animal oil, consisting of variable proportions of elaine and stearine; mixed with a little curd and whey, the latter consists principally of whey with a little curd. Butter becomes rancid by keeping; a change owing to the presence of these foreign ingredients.

Curd consists principally of albumen, and is used in making cheese; and the cheese which contains most of that oily principle which constitutes cream is the best. Good cheese melts at a moderate heat; bad cheese dries and curls like horn. Cheese is said to contain a peculiar acid which has been called *caseic* by **Proust**. When milk is boiled a pellicle forms on its surface which consists of coagulated albumen.

Whey is of yellowish green color, and of sweetish pleasant taste, having the flavor of milk; it generally contains a portion of curd which may be separated by boiling. After a few hours repose the whey becomes quite clear and nearly colorless; and if slowly evaporated, affords a white crystalline deposit of a sweet taste, called *sugar of milk*. Sugar of milk, when heated, gives nearly the same products of common sugar, but it is insoluble in alcohol, and when acted upon by nitric acid, affords *saclactic* acid, and not oxalic acid. Whey contains an acid, called *lactic acid*, and several saline substances in small quantities. The *lactic acid* is supposed to be acetic acid.

Woman's milk is more sweet than cow's, and furnishes an abundant cream of a white color, leaving a very thin whey. When boiled, pellicles form on its surface, but it does not afford a curd by the usual methods which produce it in cow's milk;

the cream affords no butter by churning. It affords a greater quantity of sugar of milk than cow's milk does.

Ass' milk very nearly resembles woman's milk in color, consistence and taste, but it affords much less cream, and the cream yields a soft, white, tasteless butter; a very little curd is afforded by it, but it yields much sugar of milk.

Goat's milk has greater consistence than cow's milk, but is otherwise very much like it; it affords an abundant cream which readily yields butter, and the milk itself affords a great quantity of curd.

Ewe's milk is like cow's milk; its cream is rather more abundant, but it never affords a firm, solid butter like cow's milk; it makes excellent cheese.

Mare's milk is thinner than cow's milk, but not so thin as woman's. It does not afford butter, but may be made into cheese. Mare's milk is fermented by the Tartars, and a vinous intoxicating liquid is procured from it, called *koumiss*. All the varieties of milk are susceptible of vinous fermentation.

516. *Eggs.* The shell of eggs is composed principally of carbonate of lime with a little animal matter. The white consists of albumen; the yolk consists principally of albumen and an oil which possesses properties analogous to those of fixed oil, and which may be separated from the other portions by boiling the egg; putting the yolk into a pan and softening it by the fire, and pressing it in linen, drops of oil exude. The yolk serves as food for the chick before it bursts the shell.

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517. *Tears.* This liquid is secreted for the purpose of lubricating the eye; it is colorless, transparent and perceptibly salt to the taste. It tinges the vegetable blues, green, and is soluble in water. The animal matter contained in it is albumen; but is not detected by the usual tests, and from some peculiarities has received the name of *mucus* from Dr. Bostock. The remaining constituents of the liquid are water, soda, chloride of sodium and some salts.

Tears absorb oxygene and suffer some changes in appearance very obvious in some persons laboring under fistula lachryamalis.

518. *Mucus of the nose* has the same composition as tears; being more exposed to the air, it suffers with more rapidity, those changes which arise from the absorption of oxygene; hence its greater viscidness and consistence; and hence the greater consistence it acquires during colds.

519. The mucus from other parts of the great mucous membranes probably does not differ much in its composition from that of tears; the proportion of animal matter is probably much greater.

520. *Saliva* is the fluid secreted by the salivary glands, and is poured into the mouth during mastication. It is a transparent, colorless and slightly viscid fluid. It consists of albumen and some saline substances dissolved in water. The liquor secreted by the Pancreas has not been minutely examined; it has probably nearly the same constitution as saliva.

521. The *gastric juice* is a fluid poured out on the the mucous coat of the stomach; and appears to be possessed of extraordinary powers as a solvent. It has not yet been examined with accuracy owing to the difficulty of procuring it pure. It probably acts an important part in the process of digestion. In the purest form in which it has been procured, it is transparent and colorless; of a bitter saline taste, and affords on evaporation, a solid, deliquescent residuum of an unpleasant odor; the gastric juice coagulates milk; its peculiar powers cannot be explained upon any known chymical principle.

522. The *bile* is a liquid secreted from venous blood by the liver; it is a yellowish green soapy fluid, of a greater specific gravity than water. It has an intensely bitter taste, and easily putrefies and exhales a detestable smell. Bile contains about 90 per cent. water, some saline substances, some peculiar animal matter and albumen. A peculiar substance has been separated from ox-bile by Thenard, and called *Picromel*. It may be procured by adding dilute sulphuric acid to recent bile; a yellow precipitate falls formerly called *resin of bile*, but which is a compound of the acid with the animal principle. The compound, after washing, may be digested with carbonate of barytes; the acid is separated and the picromel is dissolved in the water. It is the peculiar substance which characterizes bile, and has an intensely bitter taste. By destructive distillation it affords no trace of ammonia, and hence the absence of azote is inferred.

523. *Synovia*, the liquor which lubricates the surfaces of the joints, consists of water holding in solution albumen and some phosphates.

524. The fluid which lubricates the pleura, pericardium and peritonium, has the characters of dilute serum, or water holding small quantities of albumen and saline substances in solution.

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525. The *aqueous humor* of the eye is composed principally of water, with some saline matter and a trace of albumen. The crystalline lens contains more than half its weight of water, and the remainder is a peculiar coagulated albumen with a trace of salts. The pigmentum nigrum affords a large proportion of iron according to Berzelius.

Cerumen of the ear is a yellowish colored secretion, of a slight odor and bitter taste; it is partially dissolved in alcohol, and affords traces of albumen, soda, resin, oil, and phosphate of lime.

Poisons. Some animals are furnished with glands for secreting peculiar liquids, which, infused into fresh wounds, produce painful or fatal effects.

The poison of the viper is a yellowish liquid which by exsiccation affords a solid resembling gum. FONTANA made experiments upon this substance and upon gum, and obtained similar results from both.

The poisonous fluid which is forced through the stings of insects has a hot acrid taste, and bears in its other properties a strong resemblance to that of the viper.

Formic acid. This is doubtless a secretion, and is obtained from *red ants* by subjecting the insects to distillation, or by infusing them in warm water; the acid is occasionally emitted by the insects. It is a transparent colorless fluid, of a very sour taste, and slight odor. Its sp. gr. is 1.1168 at 68° It combines with salifiable bases and forms *Formiates.* It has recently been discovered by DOBEREINER, that it may be formed artificially.

6. OF THE EXCRETIONS.

526. Under this term we include those substances which are thrown out of the system as useless.

The urine is one of the most complicated animal fluids, and contains

1 Water
2 Phosphoric acid
3 Phosphate of lime
4 " of magnesia
5 Fluoric acid
6 Uric acid
7 Benzoic acid
8 Lactic acid
9 Urea
10 Gelatine
11 Albumen
12 Lactate of ammonia
13 Sulphate of potash
14 " of soda
15 Fluate of lime
16 Chloride of sodium
17 Phosphate of soda
18 " of ammonia
19 Sulphur
20 Silex
21 Carbonic acid

These various substances do not perhaps exist in every portion of this excretion, and their relative proportions also vary with the varied states of health and disease. The substance which stamps peculiar characters on this liquid is an animal product called *Urea.* It may be obtained by slowly evaporating urine to the consistence of syrup; on cooling, a crystalline mass is formed from which pure alcohol dissolves *urea ;* by careful evaporation of the alcohol, brownish crystals are deposited, which may be purified and rendered colorless.

(*a*) *Urea* is very soluble in water and in alcohol. Nitric acid when dropped into its aqueous solution produces a crystalline precipitate. It very readily suffers decomposition.

(*b*) *Uric acid* is another substance from which the excretion derives some peculiarities. When obtained pure it is a greyish solid, of very difficult solubility, and combines with salifiable bases and produces *urates ;* it has been called *lithic acid.* When uric acid is heated with nitric acid, it dissolves and on evaporation a beautiful pink colored residuum is procured which possesses distinct acid properties, and has been called *purpuric acid* by PROUT. Uric acid frequently composes the substances formed in the gravel and stone.

Sweat is an excretion consisting principally of water; an acid, supposed to be the acetic, by THENARD, exists in this excretion, together with some saline bodies. *Carbon* is also evolved by the skin.

A more minute account of excretions, and of some secretions is inconsistent with the nature of this work. A full abstract of the present state of knowledge respecting them may be found in THOMSON's system.

6. OF THE CHYMICAL CHANGES PRODUCED BY THE FUNCTIONS OF ANIMALS.

527. THESE changes have in part been referred to in the preceding pages, and it remains briefly to notice the functions of digestion and respiration.

Digestion. When food is properly masticated and mixed with saliva, it passes into the stomach, where, in a short time, and in a manner wholly inexplicable, it is reduced to an uniform pulpy mass called *chyme ;* this is apparently homogeneous, and the different substances constituting the food can hardly be recognized in it. The gastric juice probably exerts considerable influence in producing this change; the consistency of the chyme, when it reaches the pyloric orifice of the stomach, appears to be the same whether much liquid has been swallowed with the food or not. Chyme formed from vegetable food alone does not appear to contain any albumen. Chyme passes from the stomach to the small intestines, where it becomes mixed with the bile, and is separated into two portions: one is a milky fluid called *chyle;* the other passes on through the canal. The bile has been supposed to perform an important part in effecting the change which separates the chyle from the remaining portion, and to act as a precipitant; but this view of the subject appears to be too exclusively chymical. The chyle is absorbed by appropriate vessels called *lacteals*, which unite in a common tube, the *thoracic duct*, by which they communicate with the sangineous system.

Chyle has a very near resemblance to the blood. It is deficient in coloring matter. It is an opaque white fluid, sweet, and somewhat salt to the taste; coagulates and afterwards separates into a firm white portion and into a thin transparent colorless serum. There does not appear to be any essential difference between the chyle of granivorous and carnivorous animals. Brande obtained from the serous portion of the chyle a substance analogous to sugar of milk.

Chyle is mixed in the thoracic duct with variable proportions of *lymph*, which will probably account for some of the differences between its properties and those of blood. Lymph has the general characters of a weak solution of albumen, but it has not been satisfactorily examined.

Chyle mixes with venous blood at the entrance of the thoracic duct into the venous system. The blood in the veins is of a dark color; that in the arteries is of a florid red or vermilion color. This change of color is produced by respiration.

528. *Respiration* is a function which is intermediate between the functions of animal and of organic life; it consists of two actions, *inspiration*, by which a portion of air is taken into the lungs and retained there for a short time; and *expiration*, by which it is again thrown out of the lungs. Some gases cannot be respired; others may be taken into the lungs without producing an immediate deleterious effect. Atmospheric air is the only gaseous mixture which will support life. A given quantity of common air can support life a limited time only, and it therefore suffers some change in its properties. The volume of the air does not appear to be altered in healthy natural respiration; the weight of the expired air is greater than that of the inspired portions. This arises from two causes; a portion of moisture is exhaled, and a portion of oxygene gas disappears and is replaced by an equal portion of carbonic acid, and probably the atmospheric oxygene is converted into carbonic acid, by abstracting carbon from the blood.

529. The quantity of carbonic acid varies considerably during the day. It is greatest about noon, and least at midnight, according to Prout. The quantity is diminished by the use of fermented liquors and a vegetable diet. Its average quantity is about 4 per cent.

The blood in passing through the lungs loses its dark color and becomes of a fine florid red; this change is effected by the air which does not act directly on the blood. Venous blood contains more carbon than arterial blood. The mode by which the carbon is combined with the atmospheric oxygene is unknown; but the lungs perhaps may be considered as a great gland whose function it is to secrete carbon. The production of animal heat is closely connected with respiration; and as intimately dependant on nervous action. Its production is a very recondite process of which we at present only know the effects.

7. OF PUTREFACTION AND MORBID PRODUCTS.

530. Urinary calculi, and sand or gravel are formed in certain states of disease when some of the ingredients of urine are secreted in excess. The formation of calculi gives rise to one of the most excruciating diseases to which the human system is subjected.

The substances which have been detected in urinary deposits and calculi, are *uric* or *lithic acid*, *phosphate of lime*, *triple phosphate of ammonia and magnesia*, *oxalate of lime*, *urate of ammonia and cystic oxide.*

Calculi are classed, according to the predominance of one or more of the above named constituents, as follows:

1. Lithic acid calculus,
2. Bone earth calculus,
3. Triple phosphate calculus,
4. Fusible calculus,
5. Mulberry calculus,
6. Urate of ammonia calculus,
7. Cystic oxide calculus,
8. Alternating calculus,
9. Compound calculus.

Some correct notions of the constitution of a calculus may be formed from its external appearance. Lithic acid generally composes those which have a brownish or mahogany color, with a smooth or a finely tuberculated surface. The earthy phosphates compose those which are of a white or greyish white color, and this is especially characteristic of the fusible calculus, which also soils the fingers like chalk. Urate of ammonia generally composes those calculi which have a fine earthy fracture and a clay color. The bone earth calculus often presents a smooth and polished surface; and the triple phosphate calculus is composed of, or covered with small crystals.

The following chymical characters of calculi will serve to identify them when their external characters are not decisive.

1. *Lithic acid calculus* blackens when heated before the blowpipe and emits a vapor having a strong and peculiar odor. It gradually evaporates leaving a very small quantity of white alkaline ashes. When digested in a solution of pure potash the acid is dissolved, and the other substances remain. The alkaline solution, on the addition of any acid, affords a white precipitate, which is pure uric or lithic acid. When a small fragment of a calculus containing lithic acid is boiled in nitric acid to dryness, a beautiful pink or carmine colored residuum is obtained.

2. *The bone earth calculus* blackens before the blowpipe, and afterwards becomes white, and retains its form without suffering fusion unless a most intense heat be applied. When this calculus, which consists of phosphate of lime, is digested in weak muriatic acid, it is dissolved, and may again be precipitated by pure ammonia.

3. *The triple phosphate calculus* exhales a strong smell of ammonia when exposed to heat or when acted upon by caustic potash. When exposed to the flame of the blowpipe it is decomposed, the phosphate of magnesia remains, and is very difficult of fusion. Diluted muriatic or nitric acid dissolves this calculus with facility, and the crystals of the triple salt are again precipitated by the addition of pure ammonia.

4. *The fusible calculus* is recognized by the property from whence it derives its name. Before the blowpipe it froths and runs into a globule, which is either perfectly transparent or of a pearly whiteness. It consists of a mixture of the phosphate of lime, and triple phosphate of ammonia and magnesia.

5. *The mulberry calculus* is named from its resemblance, in its rough tuberculated surface, to the fruit of the mulberry. It consists of *oxalate of lime* as WOLLASTON first ascertained. When exposed to the flame of the blowpipe it becomes black, and afterwards white; and on continuing the heat a white residuum of *pure lime* is obtained, which, placed on moist turmeric paper, changes the yellow to brownish red. This calculus is sometimes smooth; and when mixed with lithic acid it becomes more refractory, and decrepitates before the blowpipe.

6. *The urate of ammonia calculus* gives the strong odor of ammonia, like the triple phosphate calculus, when treated with caustic potash; but it is totally volatile before the blowpipe. Water which has been boiled on this calculus, affords a precipitate by the addition of nitrate of silver, which on exposure to heat gives pure metallic silver. (*Silliman's Jour. Vol.* 4.)

7. *The cystic oxide calculus* is very rare. It resembles the triple phosphate calculus, but is more compact. Before the blowpipe it evolves a very fetid smell. It is readily soluble in almost all acids, and in the alkalies. It is insoluble in alcohol, water, acetic, tartaric or citric acids, or in solutions of neutral carbonate of ammonia. It is composed of animal matter.

8. *The alternating calculi* are composed of alternate layers of two or more of the substances already mentioned as constituting calculi; a fragment of each of the layers may be broken off, and its nature determined by the application of the blowpipe, and other tests abovementioned.

9. *The compound calculi* may be known from the equivocal results presented when they are subjected to chymical examination. They are composed of an intimate mixture of the ingredients of other calculi.

Some other substances have been detected in calculi, but they are of very rare occurrence. (MARCET *on Calculous Disorders.*)

The sediments which constitute gravel may be examined in the same manner as calculi or stones.

The urine is altered very materially by disease. In inflammatory diseases it is red and contains an excess of albumen. In *jaundice* it is rendered green by the action of muriatic acid. In *hysteric affections* it is abundant in quantity, but contains very little urea. In some species of *dropsy* it is loaded with albumen. In *dyspeptic complaints* it is highly putrescent and affords a precipitate with tan. In *rickets* it contains much phosphate of lime. In *chronic hepatitis* it contains no urea, and in *diabetes* it contains more or less sugar.

531. BILIARY CALCULI are solid concretions formed in the gall bladder called gall-stones; their composition differs in different animals. There are two kinds occurring on the human gall bladder. One resembles inspissated bile, and differs from it in not being soluble in alcohol or water. The other is a fatty crystalline substance, which nearly resembles spermaceti. It is soluble in hot alcohol and separates again, on cooling, in bright crystalline plates; ether dissolves them; when heated, they melt, and are inflammable. They do not form a soap with alkalies, and hence CHEVREUL considers them as consisting principally of a peculiar animal principle which he calls *cholesterine.* This substance fuses at about 280° F. and forms a crystalline mass on cooling. It does not dissolve in cold alcohol or in water. When heated with its own weight of strong nitric acid it affords a peculiar acid called *cholesteric*, which separates on cooling. This acid is hardly soluble in water, but it is easily dissolved in alcohol, from which it may be obtained in crystals by evaporation; it is easily decomposed by heat. Some of the *cholesterates* are very soluble.

Some biliary calculi appear to be composed of a mixture of the two kinds abovementioned.

532. Gouty concretions are formed in the joints of those long subjected to this disease. They are white and friable and are hence called *chalk-stones.* Wollaston ascertained that they were composed of *urate of soda..* They afford the sulphate of soda when acted upon by sulphuric acid, and give the pink colored residuum when treated with nitric acid. (527. *b*)

Concretions in the pineal gland, in the salivary glands, in the tonsils, and in the pancreas, in the liver and in some other parts, consist principally of bone earth or phosphate of lime and animal matter. Pulmonary concretions frequently contain carbonate of lime.

Concretions of various kinds are found in the intestines of animals. *Ambergris* is a concretion found in the intestines of unhealthy whales. It has a peculiar odor and is employed as a perfume. It is partially soluble in alcohol and some specimens afford benzoic acid.

Pus is the liquid secreted by ulcers. It is of a yellowish white color, of the consistence of cream, and of a peculiar odor when warm. Under the microscope it appears to be composed of solid globules swimming in a translucent fluid; hence its optical properties are peculiar, and have been proposed to distinguish it from mucus, which, containing no globules, does not produce a similar effect on transmitted light. (Young's *Med. Lit.*)

Pus produces no change on vegetable blues. By repeated agitation with water it is partially dissolved, and the solution affords a precipitate with solutions of nitrate of silver and chloride of mercury.

The pus of the hospital sore is distinguished by its odor, which is supposed to be produced by an alteration of some of the constituents of true pus.

Pus from cancer changes delicate vegetable blues to green, and evolves the odor of sulphuretted hydrogene on the addition of sulphuric acid. (Crawford.)

The pus from small pox, venereal ulcers, &c. is matter *sui generis*, whose peculiar properties cannot be explained on any chymical principle.

The liquor of dropsy contains albumen and saline substances dissolved in water, and the liquor of blisters has a similar composition.

533. PUTREFACTION of animal bodies is the spontaneous decompositions to which they are liable after the extinction of life. Complex animal substances, when exposed to a certain degree of moisture and heat suffer decomposition with great rapidity and evolve gaseous matters which have a very offensive smell. The organization of the parts is destroyed and broken down into a brownish or greenish matter of a soft consistence, of a faint nauseous smell and of qualities virulently poisonous. After a long time a friable earthy matter remains. Putrefaction occurs more slowly in bodies buried in the earth; if the earth in which the body is buried is dry and warm, the carcase dries and is converted into a mummy. In certain circumstances the body is converted into a soapy matter or rather into a substance resembling spermaceti, called *adipocere.* It is of the consistence of tallow, but is more fusible. Boiling alcohol dissolves it; the alkalies form a species of soap with it. The formation of adipocere is facilitated by moisture; and it may be procured by digesting muscle in dilute nitric acid. The gases which are exhaled at a certain stage of putrefaction have a very deletereous influence on the brain and nervous system, causing faintness and dizziness and even more distressing effects when in a concentrated form. Many substances, as salt, sugar, aromatics, resins, &c. have the property of retarding putrefaction. The chymical changes which occur during putrefaction are very complicated and have not yet been satisfactorily traced.

THE END.

A TABLE OF PRIME EQUIVALENT NUMBERS.

HYDROGENE 1.

Acid acetic	50
arsenic	116 ? 62 ?
arsenious	100 ? 54
benzoic	120
boracic	64 ? 22 ?
carbonic	22
chloric	76
chloriodic	161
chloro-carbonic	50
chloro-cyanic	62
chromic	52
citric (dry)	58
" crystallized (2 water)	76
columbic	156
cyanic	34 ?
ferro-cyanic	108 ?
fluoboric	22
fluoric	17
fluosilicic	24
formic	?
gallic	63 ?
hydriodic	126
hydrocyanic	27
hyposulphurous	24
hyposulphuric	36
iodic	165
malic	70
molybdic	72
molybdous	64
muriatic	37
nitric (anhydrous)	54
" liquid (sp. gr. 1,50)	72
nitrous	46
oxalic	36
oxyodic	165
oxychloric	92
phosphoric	28
phosphorous	20
saccholatic	105
selenic	57?
succinic	50
sulphuric (anhydrous)	40
liquid (sp. gr. 1.85)	49
sulphurous	32
Acid tartaric	76
tungstic	120
uric, or lithic	45 ? 36 ?
Alum (dry)	260
crystallized (25 water)	485
Alumina	26
acetate	
sulphate	66
Ammonia	17
acetate	67
carbonate	39
bicarbonate	61
chlorate	93
fluate	34 ?
hydriodate	143
hydrocyanate	44
iodate	182
muriate	54
nitrate	71
oxalate	53
phosphate	45
succinate	67
sulphate	57
Antimony	45
chloride	81
iodide	170
oxide	53
peroxide	61
sulphuret	61
tartrate of, and potash	288
Arsenic	76 ? 38 ?
chloride	184 ? 100 ?
iodide	206 ? 288 ?
sulphuret	108 ?
persulphuret	124 ?
Barium	70
chloride	106
iodide	195
oxide	78
peroxide	86
phosphuret	82
sulphuret	86
Baryta	78
acetate	128

Baryta carbonate	100
chlorate	154
hydret	87
nitrate	132
sulphate	118
Bismuth	71
chloride	107
iodide	196
nitrate	137
oxide	79
sulphuret	87
Boron	40 ?
Cadmium	56
chloride	92
oxide	64
Calcium	20
chloride	56
fluoride	36
iodide	145
oxide	28
phosphuret	32
sulphuret	36
Carbon	6
chloride	42
perchloride	130
hydrochloride	50
oxide	14
phosphuret	18
sulphuret	38
Cerium	46
Chlorine	36
oxide	68
hydret of (10 water)	126
Chromium	28
oxide	36
Cinchonia	115
Cobalt	30
chloride	66
iodide	155
nitrate	92
peroxide	46 ?
phosphate	66
phosphuret	42
oxide	38
sulphuret	46
Columbium	?
Copper	64
acetate	130
bi-sulphuret	96
chloride	100
carbonate	102
nitrate	188
oxide	72
perchloride	136
peroxide	80
phosphate	136
phosphuret	76
sulphate	160
sulphuret	80
Cyanogene	26
Fluorine ?	16
Glucina	26
Glucinum	18
Gold	200
chloride	236
iodide	325
oxide	224 ?
sulphuret	248 ?
Hydrogene	unity, or 1
Iodine	125
Iron	28
acetate	
chloride	64
perchloride	82
carbonate	58 ?
chromate ?	
ferro-cyanate ?	
iodide ?	
nitrate ?	
per oxide	80 ? 40 ?
phosphate	
phosphuret	40 ?
sulphate (dry)	76
" crystallized	139
sulphuret	44
bi-sulphuret	60
Lead	104
acetate	162
carbonate	134
chloride	140
chromate	164
deutoxide	116
iodide	229
nitrate	166
peroxide	120
phosphate	140
phosphuret	116
protoxide	112
sulphate	152
sulphuret	120
Lime	28
bi-phosphate	84
carbonate	50
hydret	37
oxalate	64
phosphate	56
sulphate	68
Lithia	18
carbonate	40
nitrate	72
sulphate	58
Lithium	10
chloride	46
oxide	18
Magnesia	20
bi-carbonate	64
carbonate	42
hydret	29

Magnesia			
	phosphate		48
	" of, and ammonia,		93
	sulphate	(dry)	60
	crystallized(7 water)		123
Magnesium			12
	chloride		48
	oxide		20
Manganese			28
	chloride		64
	oxide		46
	peroxide		44
Mercury			200
	bi-sulphuret		232
	chloride		236
	cyanate	?	
	perchloride		272
	cyanide (1M.X2C)		252
	nitrate		324
	oxide		208
	peroxide		216
	sulphate		248
	persulphate		296
	sulphuret		216
	persulphuret		232
Molybdenum			48
	oxide		56
	sulphuret		64?
Morphia			325
	carbonate		347
	muriate		362?
	nitrate		379
	sulphate		365
Nickel			30
	chloride		66
	oxide		38
Nitric oxide			30
Nitrogene			14
	chloride		158
	iodide	?	
	oxide (nitrous oxide)		22
	deutoxide (nitrous gas)		30
Olefiant gas		14?	7?
Osmium		?	
Oxygene			8
Palladium		?	
Phosphorus			12
	chloride		48
	perchloride		84
	iodide		167
	periodide		262
Phosphuretted hydrogene			13
Platinum			96
	chloride		142?
	oxide	?	112?
Potash	(dry)		48
	acetate		98
	arseniate	110?	
	arsenite	102?	
Potash			
	bi-carbonate		92
	binoxalate		120
	bi-sulphate		128
	bi-tartrate		182
	carbonate		70
	chlorate		124
	chromate	100?	
	hydret		57
	nitrate		102
	oxalate		84
	oxychlorate		140
	quadroxalate		192
	sulphate		88
	tartrate		115
Potassium			40
	chloride		76
	iodide		165
	peroxide		64
	phosphuret		52
	protoxide	(dry)	48
	sulphuret		56
Quinia		?	
Rhodium		?	
Selenium			41?
Silica			16?
Silicium			8?
Silver			110
	acetate		168
	chloride		146
	iodide		235
	nitrate		172
	oxide		118
	sulphate		158
Soda			32
	acetate		82
	bi-carbonate		76
	borate	?	
	carbonate	(dry)	54
	chlorate		108
	hydret		41
	nitrate		86
	sulphate	(dry)	72
	" crystallized (10 w)		162
	tartrate of, and potash		214
Sodium			24
	chloride		60
	iodide		149
	oxide		32
	peroxide		40
Starch			142?
Strontia			55
	carbonate		77
	hydret		64
	sulphate		95
Strontium			47
	chloride		83
	iodide		172
	oxide		55

Strontium	
sulphuret	63
Strychnia	380
Subphosphuretted Hydrogene	14?
Sugar	?
Sulphur	16
carburet	38
chloride	52
iodide	141
Sulphuretted Hydrogene	17
Tannin	71?
Tellurium	38
chloride	74
iodide	?
oxide	46
Tin	59
bi-sulphuret	91
chloride	95
iodide	184
oxide	66
peroxide	75

Tin	
perchloride	131
sulphuret	75
Tungsten	96
Titanium	?
Uranium	?
Water	9
Yttria	40
Yttrium	32?
Zinc	35
acetate	93
carbonate	65
chloride	71
iodide	160
oxide	43
sulphate (dry)	83
(crystallized 7 w)	146
sulphuret	51
Zirconia	45?
Zirconium	37

INDEX.

ERRATA.

Page:	Line:		
9	18 top	*for* substances	read substance
17	24 “	“ *Tracti*	“ *Traite*
17	28 “	“ stated on ot	“ state do not
23	15 bottom	“ vireous	“ vitreous
23	20 “	“ ido	“ idio
26	23 “	“ indentity	“ identity
54	11 top	“ (CANON)	“ (CANTON)
63	16 bottom *after*	facility *insert* with	
66	12 top	“ conductor	“ non-conductor
104	5 “	“ green	“ blue
“	5 “	“ blue	“ green
110	5 “	“ bases	“ basis
111	5 “ *after*	hydret *insert* of	
112	4 “	“ more	“ none
119	1 bottom	“ molybdeum	“ molybdenum
“	7 “	“ calculus	“ calculous
120	12 top	“ *arsenous*	“ *arsenious*
121	23 “	“ deozygenate	“ deoxygenate
125	6 “	“ (TORNEY)	“ (TORREY)
127	14 bottom	“ *Pertoxide*	“ *Peroxide*
129	19 “	56	58
“	18 “ *after*	solution *insert* of 50 grs.	
“	18 “	“ drams	“ drachms
145	2 top	Camellar	“ Lamellar
148	13 bottom	“ 39	“ 39°F
159	20,21 “	“ HAMBERG'S	“ HOMBERG'S
“	5 “	“ Clucinum	“ Glucinum
176	5 top *after*	occur *insert* in	
179	5 bottom	“ *memspereum*	“ menispermum
“	9 “	“ *hyosiamus*	“ *hyosciamus*
181	11 “	“ colyrium	“ collyrium
184	17 “ *after*	oxalic *insert* acid	
194		“ Guiacum	“ Guaiacum
209 & 201		“ Olifiant	“ Olefiiant