A syllabus of the courses of lectures on chemistry, delivered in King's College, London / [J. Frederic Daniell].

James Wilkes
1833

A

SYLLABUS

OF

THE COURSES OF LECTURES

ON

CHEMISTRY,

DELIVERED IN

KING'S COLLEGE, LONDON.

BY

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" Science is the knowledge of many, orderly and methodically digested and arranged, so as to become attainable by one."—HERSCHEL's *Discourse on the Study of Natural Philosophy*, p. 18.

"The foundations of chemical knowledge are observation, experiment, & analogy. By observation, facts are distinctly and minutely impressed on the mind: by analogy similar facts are connected: by experiment new facts are discovered. And in the progression of knowledge, observation, guided by analogy, leads to experiment, and analogy, confirmed by experiment, becomes scientific truth."

Davy's Elements of Chemical Philosophy

Compounds of which Oxygen forms a part are called acids or oxides as they do or do not possess acidity- The oxide of iron or [illegible] signifies a combination of those metals with oxygen which has no acid properties. If sulphur or any other body sh^d form two acids that which contains the least quantity of oxygen terminates in "ous" as sulphurous acid, while the other ends in "ic" as sulphuric acid. The termination "uret" denotes combination of simple non metallic substances with one another, or with a metal or metallic oxide. Protoxide signifies the 1^st degree of oxidation- binoxide the 2^nd Teroxide the 3^rd Peroxide is applied to the highest degree of oxidation. Salts are compounds of acids with alkalies earths, or metallic oxides. If the acidifiable substance contain a maximum of oxygen the name of the salt ends in "ate" if a minimum in "ite" Thus sulphate, & phosphate of potash are salts of sulphuric & phosphoric acids, while sulphite & phosphite of potash are formed by sulphurous & phosphorous acids -

A SYLLABUS,

&c. &c.

Of all the artificial aids to the acquirement and retention of knowledge, it cannot be doubted that a clear, methodical arrangement is one of the most efficacious; and in proportion to its importance, must be the care which the teacher is called upon to devote to its consideration. The pupil, also, cannot more surely promote the object of his study, than by endeavouring to attain to an accurate conception of the arrangement adopted, and to impress the plan upon his mind: he will thus be led to form an orderly distribution of the new ideas which he acquires; analogous to, and no less beneficial than, that species of arrangement by which confusion is avoided in large collections of material objects. It is with the view of assisting the chemical students in the formation of such a "Memoria Technica" that the following syllabus has been drawn up.

After mature consideration, the plan of these lectures has been so arranged as to comprehend, as a whole, the illustration of a complete and extended system of chemistry. The symmetrical order, however, of a regular system has not been the object aimed at; but rather to lead the mind of the beginner from the known to the unknown, and from the simple to the complex. The science, of late years, has become so enlarged by the accumulation of facts and the extension of theories; it has involved itself at so many interesting points with various collateral branches of natural philosophy, that a less comprehensive view would scarcely do justice to its present advanced position. For the purposes, however, of classification, as well as for the convenience of occasional students, who may wish to attend to different branches of the subject, they are divided into two courses, and each course into two parts.

THE FIRST COURSE

commences early in the month of October, and comprises in

Part I.

The Laws of Physics—so far as they are necessary for the proper comprehension of their connection with *Chemical Affinity*.

This part commences with a preliminary *mechanical* view of each branch of the subject, which is succeeded by their strictly *chemical* relation to each other.

Part II.

The Laws of Chemical Combination and Decomposition; illustrated chiefly by the *non-metallic* and *gaseous* elements and their compounds.

THE SECOND COURSE

Commences in the month of January following; and comprehends in

Part I.

The Principles, Processes, and Products of Inorganic Chemistry.

Part II.

The Principles, Processes, and Products of Organic Chemistry.

It is a primary object of these Lectures not only to verify the results of reasoning by experimental illustration, but to elucidate the phenomena of nature, and explain the combinations of art in the processes of the Pharmacopœia, of metallurgy, of the principal manufactures, and of domestic economy.

At convenient intervals of the courses, EXAMINATIONS are held; at which regular students, who require certificates, are expected to attend. They are not instituted so much for the purpose of exciting emulation, as of affording opportunities of familiar and conversational elucidations of the more difficult parts of the science, and of the explanation of points which may have been misunderstood. For this reason, the occasional students, also, are recommended to be present; and, although they will not be required to take a part in them, the names of such as wish to avail themselves of the full advantage which they offer, will be received by the Professor.

To enable the students of the mathematical and classical departments of King's College to attend these lectures, without interfering with their other studies, they have been fixed for 9 o'clock in the morning.

Matter though susceptible of motion has no power either to move itself or arrest its progress when an impulse is once communicated to it. This indifference to rest or motion has been expressed by the term vis inertiæ, as if it depended on some specific force resident in matter; but it may with greater propriety be regarded as a negative character in consequence of which matter is wholly given up to the operation of various forces which are constantly acting upon it.

All bodies descend in straight lines towards the centre of the Earth when left at liberty at a distance from its surface. The power which produces this effect is termed gravity, the attraction of gravitation, or terrestrial attraction and the force required to separate a body from the surface of the Earth, or prevent it from descending towards it is called its weight. Every particle of matter is equally affected by gravity and therefore the weight of any body will be proportional to the number of ponderable particles it contains. The tendency of cohesion is manifested by to bring the ultimate particles of bodies into immediate contact; if such were the result of its influence were it not counteracted by an opposing force, a principle of repulsion, which prevents their approximation. The form of bodies as to solidity & fluidity is determined by the relative intensity of these powers. Cohesion acts at insensible distances, & between similar particles, chemical attrac^{n} between dissimilar ones. Thus marble is an aggregate of smaller portions attached to one another by cohesion, but these integrant particles are composed of lime & carbonic acid which are united by affinity.

First Course.

Part I.

§ *THE LAWS OF PHYSICS.*

I. INTRODUCTORY REMARKS.

1. *Inertia of Matter.*
2. *Force.* (*a*) Origin of the idea. (*b*) Animal force. (*c*) Weight. (*d*) Elasticity. (*e*) Motion. (*f*) Equilibrium. (*g*) Attraction. (*h*) Repulsion.
3. *Gravitation.*
4. *Elasticity.*
5. *Cohesion.* (*a*) Capillary action.
6. *Heat.* (*a*) Sensation. (*b*) Expansion.
7. *Electricity.* (*a*) Attraction. (*b*) Repulsion.
8. *Magnetism.* (*a*) Attraction. (*b*) Repulsion.
9. *Chemical Affinity.*

II. GRAVITATION.

1. *Weight.* (*a*) Balances. (*b*) Mode of weighing. (*c*) Torsion balances.
2. *Specific Gravity.* (*a*) Of solids. (*b*) Liquids. (Hydrometers.)

III. ELASTICITY.

1. *Gases.* (*a*) Mechanical properties. (*b*) Barometer. (*c*) Air pump. (*d*) Air gun.
2. *Manipulation of Gases.* (*a*) Collecting. (*b*) Measuring. (*c*) Weighing. (*d*) Specific gravity.

IV. ATTRACTION OF COHESION.—V. REPULSION OF HEAT.

Physical state of Bodies.

1. *Solids.* (*a*) Hardness. (*b*) Elasticity. (*c*) Brittleness. (*d*) Malleability. (*e*) Ductility. (*f*) Tenacity.
2. *Liquids.* (*a*) Slight compressibility. (*b*) Viscosity. (*c*) Limpidity.
3. *Aeriform Fluids.* (*a*) Gases. (*b*) Vapours. (*c*) Condensation.

V. HEAT.

1. *Conduction.* (*a*) Of solids. (Sensation of heat and cold) (*b*) Of liquids. (*c*) Of aeriform fluids.

Attraction is exerted at sensible & insensible distances, and among the similar and dissimilar particles of matter, the former is termed homogeneous attract: the latter heterogeneous
When acting at sensible distances it constitutes Gravitation; at insensible, chemical attract: or affinity -

The force of the attraction of gravitation accords to Newton is greatest at the surface of the earth, decreasing downwards as the distance, & upwards according to the square of the distance inversely: thus a piece of lead on the surface weighs 1lb 2000 miles below the circumference being half the way to the centre it will weigh only 1/4 lb at the centre it will weigh nothing. Carry it 16000 miles above the circumference & it will weigh 1/16 of a lb for it is 4 times the distance of the circumference from the centre, & the square of 4 being 16 when inverted it will be 1/16

The specific gravity of a body is the relative weight of any body of a given size when compared with another body of the same volume, the standard of solids & fluids being water, of gases & aeriform fluids air. E.g. 1 cubic foot of water weighs 1000 ounces the same volume of gold weighs 19000. the Sp. grav: of gold is therefore 19.

The specific gravity of a body heavier than water is thus obtained. First weigh it in the common way, then weigh it in water & observe the loss it sustains: its weight in the air is then divided by its loss when weighed in water & the product is the Sp: gravity. Thus suppose a piece of tin weighs in air 480 ozs. in water 430 the loss being 50 ozs. 480 ÷ 50 = 9 3/5 Sp. gr. of tin. The tin displaces a quantity of fluid equal to its bulk & is buoyed up by a weight of 50 ozs. If the solid is lighter than water first weigh it in air, then add a sufficient

weight to cause it to sink entirely below the surface of the water; then divide the weight of the substance by the weight added to the weights required to sink it and the quotient is the sp. grav. E.g. a piece of cork weighs 30 grs. & requires 150 grs. of water to sink it, then 30 ÷ (150 + 30 =) 180 = .166 sp. gr. of cork —
The sp. gr. of fluids is generally taken by the hydrometer: the lighter the fluid is the deeper does the instrument sink; thus in brandy it sinks to 25, therefore if water be 1000 brandy will be 975 — 60° is the temperature at which bodies are usually taken — By substituting spirits of wine or any liquid for water in the 1st experiment its sp. gr. may be ascertained: thus if spirit of wine takes 149 grs. to suspend the glass while in water it took 177 6/10 we say then as 177.6 : 149 :: 1 = 837 — Divide the loss of weight in the other fluid by the loss of weight in water & the quotient is its sp. grav:
The sp: gr. of elastic fluids is thus obtained: exhaust the air from a thin flask & weigh it accurately: fill it or a receiver on which the cubic inches are marked: fill the flask with the gas & ascertain the quantity which enters it, and then again weigh it. The density of the atmosphere is of importance in weighing gases, & it is necessary to a standard elasticity, & that fixed upon is 30 inches — If you want to know the sp. gr. of a gas at a different state of the atmosphere, say if the gas were 31 ins of the barometer 29 ins state, as 30 : 29 :: 31 = 29 9/10 —
The pressure of the atmosphere is 15 lbs on every square inch: it is this pressure which prevents liquids assuming the elastic form or boiling & we can retain them in its liquid state — Water just under the receiver of the air pump boils on the atmospheric pressure being removed

Heat. The most general effect of heat is repulsion or expansion by which heat separates the particles of bodies It is the antagonist power of attraction. Some suppose that it is a peculiar fluid, others that it is merely produced by the motion of the particles of bodies upon each other. The sources of heat are The sun, percussion & friction, the mixture of bodies, combustion of bodies & Electricity. Heat & cold when referred to our sensations depend on the temperature of our bodies at the time of the experiment. The different conducting powers of bodies cause different sensations of heat or cold; a good conductor conducts heat rapidly from the hand & causes coldness: the best conductor is silver then gold, copper, brass, iron, tin, cast iron, Zinc, lead, dense stones, brick, pottery, glass charcoal. the latter is a very bad conductor. Diamond is better than glass, & so on applying the tongue to it it may be distinguished from glass from its greater coldness. Glass is a bad conductor of heat & thus causes the fracture of glass on applying hot water: if hot water be poured into a glass of moderate thickness the inner surface expands while the outer remains unaltered & fracture necessarily takes place. Liquids are very bad conductors of heat: in the usual mode of heating liquids the heat is applied to the bottom of the fluid & is diffused over the whole mass in consequence of the successive changes of density in the particles, the specific gr. of the heated particles being decreased relative to the rest of the fluid & a complete circulation is established. If heat be applied to the surface of water it can only be propagated by its conducting power but interchange of particles takes place. This is proved by an air thermometer in a vessel of water not being influenced by heat being applied to the surface by means of a double copper basin containing inflamed ether, although the surface is at the boiling point. Air & gaseous bodies are also very bad conductors of heat. A stratum of confined air is a very bad conductor hence the advantage of double doors to rooms, furnaces, ice houses &c. Air may be heated to 300° & yet a person may remain in it with

The intensity of radiated heat diminishes according to the squares of the distance from the radiating point.

2. *Expansion.* (*a*) Of solids. (*b*) Liquids. (*c*) Aeriform fluids.

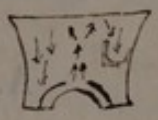
A. THERMOMETERS. (*a*) Air thermometer. (*b*) Differential. (*c*) Mercurial. (*d*) Spirit. (*e*) Graduation. (*f*) Register.

B. PYROMETERS. (*a*) Wedgwood's. (*b*) Daniell's.

C. Standards of Specific Gravity. (*a*) Correction for Expansion.

3. *Exceptions to the Law of Expansion.* (*a*) Congelation. (*b*) Max. density of water.

4. *Equilibrium of Heat.* (*a*) By conduction in solids. (*b*) Circulation in fluids. Perkins's boiler



A. Circulation of the Atmosphere.

B. ———————— Ocean.

C. Ventilation of Apartments

D. Warming of Apartments.

VI. CRYSTALLIZATION. (*a*) Formation of crystals. (*b*) Nuclei. . (*c*) Peculiar forms. (*d*) Primitive forms. (*e*) Secondary forms. (*f*) Structure. (*g*) Cleavage. (*h*) Goniometers.

1. *Hypothesis of Polyhedral Atoms.* (*a*) Primitive forms. (*b*) Secondary forms. (*c*) Decrements upon edges. (*d*) Decrements upon angles. (*e*) Octohedral and tetrahedral atoms.

2. *Hypothesis of Spheroidal Atoms.* (*a*) Spheres, octohedral and tetrahedral arrangement identical. (*b*) Oblate spheroids. (*c*)

The sources of Caloric are 1. The Sun - 2 Combustion 3 Electricity - 4 The bodies of animals during life - 5 Chemical action - 6. Mechanical action

oblong spheroids. (*d*) Dr. Wollaston's structure of the cube.

A. Dissection of Crystals.

(*e*) More probable structure of the cube. (*f*) Octohedral structure of the cube. (*g*) Cubic structure of the octohedron.

B. Unequal Expansion of Crystals.

3. *Hypothesis of the Atmospheres of Atoms.* (*a*) Explanation of unequal expansion.

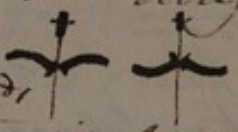
VII. ELECTRICITY. A. Electricity of Tension. B. Current Electricity.

A. Electricity of Tension. (*a*) Attraction. (*b*) Repulsion.

1. *Electrical Theories.* (*a*) Du Fay's. (*b*) Priestley's.
2. *Conduction.* (*a*) Conductors. (*b*) Non-conductors. (*c*) Electrics. (*d*) Non-electrics.
3. *Electrical Apparatus.* (*a*) Machines. (*b*) Electroscopes. (*c*) Electrometers, &c.
4. *Electrical Light.* (*a*) Spark. (*b*) Brush. (*c*) Lightning. (*d*) Aurora Borealis.
5. *Situation of Charge.* (*a*) Surface. (*b*) Influence of form. (*c*) Points. (*d*) Lightning conductors.
6. *Induction.* (*a*) Polar arrangement. (*b*) Action of machine. (*c*) Electrophorus. (*d*) Condenser. (*e*) Leyden Jar. (*f*) Battery.

very little inconvenience. The best conductors of heat have the weakest attraction for it & part with it more readily than bad conductors. It is painful to touch metal at 120°. Water boils at 150°. but as we have seen air heated to 250 or 300 may be borne without injury.

Different substances undergo different degrees of expansion. The same quantity of heat which expands air 5 times more than alcohol, 20 than mercury, 160 than platina, 580 more than glass. In solids the expansion is comparatively small, in liquids it is more obvious, in gases very apparent. Commencing with Platinum which expands the least follows steel, iron, copper, brass, tin, lead, zinc. In constructing iron bridges &c. it is necessary to make allowance for the contraction & expansion of the metal. If a bar of iron & one of brass be riveted or soldered together it will warp in one direction or other by change of temperature. Bar compound plate of silver & platinum is remarkably susceptible of this change & is employed in instruments for the measurement of temperature, & also in forming a compensating pendulum for clocks: the action of heat or cold on the pendulum is obviated by the contrivance of the plate to which the pendulum is attached is suspended between two compensating bars of the description: the warping of which according to the difference counteracts the elongation & shortening of the pendulum



The expansion of different liquids is liable to much variation. Ether is more expansible than alcohol, alcohol more than water & water than mercury. Generally speaking their rate of expansion increases with the temperature. Under the common atmospheric temperature water boils at 212 Alcohol 173 - Ether 96 - Mercury 660, Sulphuric acid 590 - Lead melts at 594 - Hence sulphuric acid cannot be concentrated in leaden vessels. The only exception to the general rule of expansion & contraction is in water which unlike other fluids expands when cooled below a certain point. It begins to expand at 40° so that it will be of the same bulk at 32 as at 48°. This is of the utmost importance in nature

if water went on increasing in density till it froze lakes & rivers instead of only being superficially frozen wd be solid masses of ice. The earth being warmer in winter than the air, the heat is withdrawn from the surface of the water by the cold breeze & the water is reduced to 40° which is the point of its greatest density. The cold continues to operate on the surface of the water but instead of rendering it heavier than the warmer water beneath it expands it & makes it lighter so that a stratum of ice cold water at 32° is found floating on water at 40°.

Water is found to freeze & boil at nearly the same temperature on all occasions & from this the thermometer has been graduated & is used in England. in the centigrade a hundred degrees is marked on the scale. The freezing point being 0°. The boiling 100°. in Reaumur the freezg. point is 0°. the boiling 80. in Fahrenheit the freezg. point is 32 & the boiling 112 & the intermediate space is divided into 180°. One degree of Fahrenheit equals 4/9 of Reaumur. & 5/9 Centigrade.

Pyrometers are used to measure high degrees of temperature. Wedgwood invented one which consisted of pieces of clay fitted into a piece of metal. Mr. Daniell has invented one by which the expansion of a bar of platinum inclosed in a case of black lead is capable of measuring high degrees of temperature with great nicety.

Aeriform bodies undergo much greater relative changes of bulk than the other forms of matter the force of cohesion being almost wanting the expansive power of heat meets with no opposition. All pure aeriform bodies contract & expand alike. The same kind of circulation takes place in Elastic fluids as in liquids & thus an equilibrium of climate is maintained.

Chrystallization.

Attraction gives to bodies their peculiar form & figure. Every compound substance assumes when left alone to crystallize a form peculiar to itself. Electricity, light, & motion exert a great influence on the formation of crystals. Dr. Wollaston believed that all forms of crystals may be produced by the different modes of arranging a sphere. He invented a very delicate instrument for measuring the angles of crystals, the goniometer: it is so fine that it will measure the angle of the finest grain.

Different substances possess different crystalline forms. Calcareous spar crystallizes in rhomboidrons, fluor spar in cubes, quartz in 6 sided prisms &c. & these are never found under any other arrangement

Electricity.

On rubbing a piece of glass & a piece of sealing wax on cotton or silk they both become excited, but in different degrees. From this Dufay supposed that there were two electricities, the vitreous and the resinous. Dr. Franklin supposed that there was only one kind of fluid, & that bodies which are positively or negatively electrified on being excited took or part of their electricity, as sealing wax - but that glass acquires during the same operation more than its usual quantity of electricity & becomes positively electrified.

Bodies similarly electrified repel each other, while those dissimilarly electrified

attract each other. On rubbing a piece of glass with a silk handkerchief & putting it near a feather suspended by a piece of silk it will immediately attract it, but the moment the feather becomes saturated with electricity it is repelled: if however an excited stick of sealing wax is held near the feather when in this condition it is no longer repelled but by the glass but attracted. In these experiments the two substances rubbed together possess different Electricities, one positive the other negative. All bodies may be divided into conductors & non conductors, which pass by insensible gradations into one another. The following is a table of different conducting substances

1 All metals			
2 Charcoal	11 Rarefied air		
3 Acids	12 Vapour of alcohol		
4 Saline solutions	13 Do of Ether		
5 Animal fluids	14 Dry oxides	21 Jet	
6 Water	15 Oils	22 Wax	
7 Living vegetables	16 Baked wood	23 Sulphur	
8 — Animals	17 Dry air	24 Resin	
9 Flame	18 Moist air	25 Amber	
10 Steam	19 Silk	26 Shell lac	
	20 glass		

The 1st 13 may be called conductors the remaining non conductors. Fresh wood is a conductor, & its conducting power seems to depend upon the water it contains. Perfectly dry air is a non conductor but damp air conducts Electricity with facility. Dufay conceived vitreous electricity to be peculiar to some bodies & resinous to others. Symmer on the contrary maintained, that excited bodies contain both kinds of electricity in a state of combination; and as they then neutralize or counteract each others effects no electrical phenomena are apparent.

If a metallic rod be rubbed it will not exhibit the least sign of electricity, & this led to the division of bodies into Electrics and non-Electrics. But the distinction does not exist, for if the rod is supported by a glass handle & then rubbed it will evince strong signs of electrical excitement. In the former experiment the electric fluid passes with such facility along the metal, as it is in fact such a good conductor that it immediately passes into the hand & is dissipated. The electricity of a substance is influenced both by the state of its surface &

The sources of electricity are friction, chemical action, contact of different metals. Proximity to an electrified body -
All electrified bodies tend to produce in contiguous substances an electric state opposite to their own -

7. *Effects of Accumulation.* (*a*) Mechanical. (*b*) Heating. (*c*) Shock.
8. *Excitation.* (*a*) Friction of non-conductors. (*b*) Change of physical state. (*c*) Change of temperature. (*d*) Contact of conductors.

B. CURRENT ELECTRICITY. (*a*) Experiments of Galvani. (*b*) Galvanic circles.

1. *Voltaic pile.* (*a*) Courrone de Tasses. (*b*) Batteries. (*c*) Large plates. (*d*) Small plates.
2. *Theories.*
3. *Effects of Accumulation.* (*a*) Physiological. (*b*) Heating. (*c*) Light. (*d.*)Tension.

VIII. MAGNETISM. (*a*) Attraction. (*b*) Repulsion. (*c*) Polarity.

1. *Formation of Magnets.* (*a*) From the loadstone. (*b*) By percussion. (*c*) By position.
2. *Magnetism of the Earth.* (*a*) Compass needle. (*b*) Dipping needle.
3. *Hypothesis of two Fluids.*
4. *Induction.*

A. ELECTRO-MAGNETISM. (*a*) Phenomena of the closed Voltaic circuit. (*b*) Magnetic helices. (*c*) Formation of permanent magnets. (*d*) Formation of temporary magnets by induction.

1. *Magnetic Rotation.* (*a*) Pole round the

wire. (*b*) Wire round a pole. (*c*) Barlow's wheel. (*d*) Magnet upon its axis.

2. *Theory of Vertiginous Currents.*
3. *Electro-Magnetic Multipliers.*

B. Thermo-Electricity. (*a*) Deflection of the needle. (*b*) Rotation.

C. Magneto-Electricity.

1. *Induction of Electricity from closed Voltaic Circuit.*
2. *Induction of Electricity from a Loadstone or Magnet.* (*a*) Deflection of the needle. (*b*) Electric spark.
3. *Induction of Electricity from the Earth's Magnetism.*
4. *Magnetic and Electric Motion.* (*a*) A current of electricity causes a magnetic pole to rotate. (*b*) The rotation of a pole causes à current of electricity. (*c*) Rotation of metallic discs.

IX. RADIANT MATTER. (A.) Light. (B.) Radiant heat.

A. Light. (*a*) Propagation. (*b*) Photometry.

1. *Theories.* (*a*) Emission. (*b*) Undulation.
2. *Reflexion.* (*a*) Plane surfaces. (*b*) Curved surfaces.
3. *Radiation.*
4. *Refraction.* (*a*) Prism. (*b*) Curved Surfaces.

the body with which it is rubbed. Smooth glass is rendered positive by friction, while rough glass becomes negative. And smooth glass becomes positive on being rubbed with woollen cloth, and negative with cats skin. The electricity which is so freely evolved by a good machine is derived from the earth, for if the apparatus is insulated, the evolution immediately ceases, & is instantly restored when the communication with the earth is again established. The electric fluid resides in or near the surface of bodies, but is distributed in different ways: a sphere is the only shape in which there is an equality of distribution: Coulomb has invented an instrument by which the intensity of electricity can be measured on the surface of a body: in a cylinder the intensity is much greater at the poles than in the centre: if 2 spheres are brought together the intensity is likewise at the poles, while at their junction it is nil.

Galvanism. Discovered by Galvani in 1790

The excitation of Electricity by the contact of metals gives rise to what has been termed Galvanism, Voltaic or current Electricity. The original discoverer of a successful mode of accumulating Electricity generated by the metals was Volta, who constructed a pile consisting of a number of plates of two different metals arranged in regular order of succession with a piece of moistened flannel or pasteboard alternating. Various modifications of this have been used, & for convenience the Galvanic trough is now generally employed. In these arrangements there is a positive (Zinc) and a negative (Copper) pole & a central point which exhibits no Electricity. Electronic intensity varies according to the number of the plates employed, quantity according to the size of the plates. The wire connected with the copper end is the positive pole, the one with the zinc the negative. Volta supposed that the electricity was set in motion, and the supply kept up, solely by contact

a communication between the two metals. He regarded the liquid interposed merely as a conductor of the electricity. Dr. Wollaston assigned chemical action as the cause by which it is excited; the oxidation of the zinc he thought was the primary cause of the development of electricity. Sir H. Davy proposes a theory intermediate between these two. He thought that the action commenced by contact of the metals, & was kept up by the chemical phenomena.

The effects of galvanism may be classed under 3 heads, 1st. Electrical effects - 2d. Its chemical agency - 3d its action on the magnet.

1 The agent or power excited by the voltaic apparatus appears to be identical with that called into activity by the electrical machine: for not only may all the common electrical experiments be performed by galvanism, but the chemical effects of the galvanic battery may be produced by electricity -

2 When two gold or platinum wires connected with a battery are plunged by their free extremities into a cup of water, hydrogen gas is disengaged at the negative wire & oxygen at the positive - The galvanic action not only separates the elements of bodies, but suspends the operation of affinity so entirely, as to enable an acid to pass through an alkaline solution, or an alkali through water containing a free acid, without combination taking place.

Now in all instances of common electrical attraction the bodies attract one another in consequence of being in opposite states of excitement, and in like manner the tendency

& acids towards the zinc, and of alkalies towards the copper end of the Voltaic apparatus, can be explained consistently with our present knowledge, only on the supposition that the former are negatively, and the latter positively electric, at the time of being separated from one another. Sir H. Davy observed that a dry alkali is excited positively by contact with a metal, & that dry acids after having touched a metal are negative. & he further found that acids & alkalies in their dry state excite each other, the former the contact becoming negative & the latter positive. The two particles are thus rendered oppositely electric & if not prevented by cohesion to particles of their own kind, or other causes, they remain permanently attracted to each other by the force of electrical attraction & thus give rise to a new compound. The Chemists therefore term chemical attraction or affinity is therefore under this point of view, an Electrical force arising from particles of a different kind attracting each other, in consequence of being in opposite states of Electrical excitement. The Electric energies of a substance are ascertained by exposing compounds to a galvanic battery & observing the pole at which the Elements appear. Those that collect round the positive pole are said to have a negative electric energy, & vice versa. Oxygen, Chlorine, Iodine, Bromine, & Fluorine are regarded as negative Electrics, the others compose the list of positive Electrics.

The power of lightening in destroying & reversing the poles of a magnet & communicating magnetic properties to iron, was noticed at an early period, but Professor Oersted in 1819 first discovered that an electric current caused a magnetic needle placed near it to deviate from its Natural position & assume a new one. It not only determines the position of the needle, but renders steel permanently magnetic. Soft iron does not retain magnetism, but while under the influence of the current its magnetic properties are very surprising

Light is similar to Caloric in many of its properties. They are both emitted in the form of rays, traverse the air in straight lines, and are subject to the same laws of reflection. The intensity of each diminishes as the square of the distance from their source.

There are 2 Kinds of light, natural & artificial, the former proceeding from the sun & stars, the latter from bodies which are strongly heated. Solar light is capable of producing chemical changes, as for instance its power of darkening the white chloride of silver.

5. *Decomposition.* (*a*) Solar spectrum. (*b*) Artificial spectra. (*c*) Homogeneous light. (*d*) Thin plates and lines.
6. *Double Refraction.*
7. *Polarization.* (*a*) By refraction. (*b*) By reflexion. (*d*) Depolarization.

B. Radiant Heat.

1. *Solar.* (*a*) Reflexion. (*b*) Refraction. (*c.*) Absorption. (*d*) Polarization.
2. *Terrestrial.* (*a*) Reflexion. (*b*) Refraction. (*c*) Apparent reflexion of cold. (*d*) Influence of surface and colour. (*e*) Laws of cooling by radiation. (*f.*) Phenomena of dew.

X. CHEMICAL AFFINITY.

1. *Mixture.* (*a*) Diffusion of gases. (*b*) Endosmose. (*c*) Mixture of liquids. (*d*) Separation of mixtures. (Evaporation, Distillation, &c.)
2. *Solution.* (*a*) Of solids. (*b*) Of gases. (*c*) Saturation. (*d*) Separation.
3. *Composition.* (*a*) Definite proportions. (*b.*) Multiple proportions. (*c*) Change of properties. (*d*) Neutralization. (*e*) Single elective affinity. (*f*) Double elective affinity. (*g*) Antagonist forces. (*h*) Influence of quantity. (*i*) Influence of heat. (*k*) Decomposition.

XI. HEAT OF COMPOSITION.

1. *Specific Heat.* (*a*) Mixtures. (*b*) Heating

and cooling. (*c*) Condensation. (*d*) Rarification.

2. *Latent Heat.* (*a*) Congelation. (*b*) Boiling. (*c*) Steam engines. (*d*) Evaporation. (*e*) Hygrometry. (*f*) Oscillation of the barometer.

XII. CHEMICAL RELATIONS OF ELECTRICITY.

1. *Voltaic Electricity.* (*a*) Chemical action in the pile. (*b*) Affinity counteracted. (*c*) Affinity promoted. (*d*) Voltaic protection.
2. *Common Electricity.* (*a*) Decomposition.
3. *Theory.*
4. *Electro-Negative and Electro-Positive Elements.*

XIII. CHEMICAL RELATIONS OF MAGNETISM. (*a*) Alloys. (*b*) Crystallization.

XIV. CHEMICAL RELATIONS OF LIGHT.

1. *Composition.* (*a*) Decomposition. (*b*) Crystallization. (*c*) Vegetation. (*d*) Bleaching.
2. *Phosphorescence.*

Chemical Affinity –

Chem: attract: acts on the particles of dissimilar substances at insensible distances, & is distinguished from attract: of cohesion by the latter acting on homogeneous or similar particles. Chemical mixture can only take place between fluids in the same physical state. Between some liquids there is no attraction whatever: if ether & water are mixed no permanent combination can be produced & they do not depend on their different specific gravities, for we find sulphuric acid which is twice as heavy as water, readily combines with it in any proportion. All aeriform bodies have the property of mixing notwithstanding their difference of gravity: & this appears to arise from their want of cohesive attraction. If a small jar containing atmospheric air be placed under a larger one containing hydrogen, the former being covered with a piece of caoutchouc, the hydrogen will ultimately pass into the small one, through the covering which will be distended & bursted by it. The diffusion is effected by an interchange of position. The same takes place with regard to liquids: if a vessel covered with bladder or the cæcum of a fowl containing alcohol be immersed in a vessel of water, diffusion of the two fluids will take place! This was termed by M. Dutrochet Endosmose. Chemical mixture causes condensation in volume – If 2 bulbs joined together are filled one with water the other with sulphuric acid & then agitated, they will be found to diminish in bulk & not fill the bulbs.

Solution. Different bodies have different attractive powers, & accordingly if several are brought together those which have the strongest mutual attract: will enter first into union: resin is easily dissolved in spirit of wine, but if some of this solution is dropped into water the spirit having a greater affinity for the water than for the resin sets the latter free which is precipitated: this is termed elective attraction. Unlike mixture there is a limit to solution, it is limited by the power of cohesion. Thus water will take up half its weight of sulphate of ammonia but a very small quantity, not more than $\frac{1}{500}$ part of sulphate of lime. The union of Carbonic acid gas with water is an instance

of solution of gaseous bodies & its solution is only limited by its elastic power: if this is overcome by pressure it may be made to take up a very large proportion. Heat in solids considerably increases the power of solution, the attraction of cohesion is lessened & elasticity has a greater ascendency. Solution of some solids produces a diminution of temperature: in solution of nitrate of potass the temperature is reduced 17 degrees & in the case of nitrate of ammonia from 50°: to 4°.
Composition is the result of the highest degree of chemical attract: but the union of bodies takes place only in definite proportions produced under whatever circumstances. If carbonic acid gas is passed through lime water chalk is formed, which is a definite compound of carb: acid & lime & whether we examine it in this state or in the crystal, or in the animal product, egg shell, the combining proportion will be exactly the same.
The evolution of heat & light are common consequences of chemical action, & also changes in the physical properties of bodies: eg. 2 gaseous bodies may produce a solid as ammonia & muriatic acid in the form of gas produce sum. of ammonia: or 2 fluids may produce a solid, as a solution of muriate of lime & one of carbonate of potassa, or 2 solids may produce a fluid as by rubbing sulphate of soda & nitrate of ammonia together. If to a combination of 2 substances a 3rd be added a new compound will be produced. If to a solution of copper in sulphuric acid a piece of iron is added the copper is precipitated & the acid acts upon the iron. If to a solution of baryta in nitric acid a sufficient quantity of sulphuric acid be added it will combine with the baryta forming an insoluble precipitate, while the nitric acid will be set free. This is an instance of simple decomposition. If however a solution of sulphate of soda be added to one of nitrate of baryta a double decomposition will take place & sulphate of baryta & nitrate of soda will be the result.

Part II.

THE LAWS OF CHEMICAL COMBINATION AND DECOMPOSITION.

I. NON-METALLIC ELEMENTARY PRINCIPLES.

1. *Gaseous.* (*a*) Oxygen. (*b*) Hydrogen. (*c*) Nitrogen. (*d*) Chlorine.
2. *Volatile.* (*a*) Bromine. (*b*) Iodine. (*c*) Sulphur. (*d*) Phosphorus. (*e*) Selenium.
3. *Fixed.* (*a*) Carbon. (*b*) Silicon. (*c*) Boron.
4. *Hypothetical.* (*a*) Fluorine.

1. Gaseous Non-Metallic Elements.

II. OXYGEN. (*a*) Production. (*b*) Properties. (*c*) History.

A. *Combustion.* (*a*) Phlogistic hypothesis. (*b*) Lavoiserian hypothesis.

III. HYDROGEN. (*a*) Production. (*b*) Properties. (*c*) History.

1. *Water.* (*a*) Synthesis. (*b*) Analysis. (*c*) Weight. (*d*) Ice. (*e*) Steam.

A. *Definite Weights.* B. *Definite Volumes.*

2. *Deutoxide of Hydrogen.*

A. *Nomenclature.*

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IV. NITROGEN. (*a*) Production. (*b*) Properties. (*c*) History.

A. *Atmospheric Air.* (*a*) Eudiometry.

B. *Nomenclature.*

1. *Compounds of Nitrogen with Oxygen.* (*a*) Protoxide of nitrogen. (*b*) Deutoxide of nitrogen. (*c*) Hypo-nitrous acid. (*d*) Nitrous acid. (*e*) Nitric acid.
2. *Compounds of Nitrogen and Hydrogen.* (*a*) Ammonia. (*b*) Hypothesis of Ammonium.

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V. CHLORINE. (*a*) Production. (*b*) Properties. (*c*) History.

1. *Compounds of Chlorine and Oxygen.* (*a*) Protoxide of Chlorine. (*b*) Peroxide of Chlorine. (*c*) Chloric acid. (*d*) Perchloric acid.
2. *Compounds of Chlorine and Hydrogen.* (*a*) Muriatic acid.
3. *Compounds of Chlorine and Nitrogen.* (*a*) Chloride of nitrogen.

VI. PROXIMATE PRINCIPLES.

1. *Acids.*
2. *Alkalies.*
3. *Salts.* (*a*) Water of crystallization. (*b*) Hydrates.

VII. SCALE OF EQUIVALENTS. (*a*) Hydrogen scale. (*b*) Oxygen scale.

Oxygen - Discovered by Dr Priestley in 1774 & called by him dephlogisticated air & by Scheele Empyreal air - The most convenient way of obtaining it pure is by exposing chlorate of potash to heat & forming it - 100 grs. will give 95 from 110 to 115 cubic inches of pure gas. Black oxide of manganese yields it readily when exposed to red heat when quantity is required. It is constantly formed in nature by vegetables. Oxygen is colourless, has neither taste or smell. It is a most perfect negative electric, always appearing at the positive pole when any compound containing it is exposed to the action of galvanism. It may be breathed with impunity for some time & is necessary to respiration, but is ultimately injurious to animal life in a state of purity. It is rather heavier than atmospheric air - Sp. gr. according to Thomson is 1.111. 100 Cubic inches of common air weighs 30½ grs. The same quantity of gas 34½ grs. It refracts light very feebly. It is very sparingly soluble in water - It has a very powerful attraction for most simple substances and may be made to combine with all of them. Combustion is supported with far greater brilliancy in Oxygen than in common air. Oxidation gives rise to three compounds, acids, alkalies & oxides. If phosphorus is burned in oxygen an acid is formed, an alkali if potassium, and an oxide if iron - In the combustion of about oxygen gas invariably disappears and a new compound consisting of oxygen & the combustible is generated.

1

Hydrogen, inflammable air, or phlogiston is most readily obtained by pouring dilute sulphuric acid on iron or zinc filings in a glass retort. It is a colourless gas, if when perfectly pure has neither odour or taste. It is a powerful refractor of light. It is the lightest of all bodies, 100 cubic inches weighs about 2½ grs. It is speedily fatal to animal life, but appears to be so from deprivation of oxygen rather than from any noxious quality of the hydrogen, hence air atmospheres composed of due quantities of each may be respired without inconvenience. It is highly inflammable but will not support combustion. It burns when it is in contact with the air. When mixed with oxygen or common air violent explosion takes place on applying a taper. The proportion for this purpose is 2 measures of hydrog: to 1 of Oxygen. Sudden & violent compression will cause explosion. Spongy platinum explodes this mixture as soon as flame. A large quantity of caloric is evolved during the combustion of hydrogen gas, & its combustion in oxygen produces the most intense heat that is known.

2

Water is the sole product of the combustion of hydrogen. Oxygen & Hyd: unite in the proportion of 1 measure of the former to 2 of the latter to form it. When Hyd is in excess of either it is left behind after the explosion. It is obtained by decomposing water by passing it over iron at a red heat, the oxygen unites with the metal while the hydrogen is set free.

Nitrogen or Azote - First discovered by D. Rutherford in 1792. It is of the Electro positive class, & consti- -tutes 4/5 of atmospheric air. It is easily obtained by the combustion of phosphorus in common air. The strong affinity of phosph: for Oxygen causes it to burn like all that gas is consumed, & the residue is nitrogen - It may also be obtain- -ed by exposing a mixture of fresh muscle & nitric acid to a moderate temperature. It is a permanent colourless, incondensible gas, elastic, compressible, but cannot be condensed into a fluid, cannot support combustion, nor destructive to animal life. Specific gravity of Oxygen 100 cub: in. weighs 30.1593 grs. while atmos- -pheric air is 31.01179 grs. The pressure of the atmosphere is about 15 pounds on every sq. inch & is capable of supporting a column of water 34 ft. high & one of mercury 30 inches. i.e. a column of mercury 1 inc: square & 30 in. long has the same weight (nearly 15 lbs.) as the same sized column of water 34 ft. long, & one of air reaching from the level of the sea to the limit of the atmosphere. It is highly compressible & elastic. The atmosphere is supposed to extend about 45 miles from the sur- -face. It is composed of 21 parts of Oxygen & 79 of Nitrogen combined with a small proportion of Carbonic acid gas.

There are 5 Compounds of Nitrogen & Oxygen - - : viz.

		Nitrogen	Oxygen	equivalent
1	Protoxide (Nitrous oxide) of Nitrogen	14	8	22
2	Deutoxide (Nitric oxide) of Nitrogen	14	16	30
3	Hyponitrous Acid	14	24	38
4	Nitrous Acid	14	32	46
5	Nitric Acid	14	40	54

1st Protoxide of Nitrogen - 22

Is most readily obtained by fusing nitrate of ammonia in a retort. In this process water & protoxide of nitrogen are formed - Nitrate of Ammonia is formed of one equivalent of nitric acid, 54, & 1 of ammonia, 17, & each of these are then formed,

Nitrogen 14 or 1 eq.	Nitrogen - 14 or 1 eq.
Oxygen 40 - 5 eq.	Hydrogen - 3 or 3 eq.
Nitric acid 54 or 1 eq.	Ammonia 17 or 1 eq

By the action of heat these arrange themselves in a new order: Hydrogen takes as much oxygen as is sufficient to form water, & the residual oxygen converts the nitrogen of both the acid & ammonia into protoxide of nitrogen. It is soluble to a certain extent in water, but less so if warm than cold

It is colourless heavier than common air, of a sweet taste faint agreable smell & rekindles combustion like oxygen with an equal bulk of Hydrogen it forms an explosive mixture. The combustible matter in these cases unites with the oxygen & the nitrogen is set free. Animals confined in it die speedily, though it may be breathed for a short time with impunity & produces peculiar excitement in the system, laughter &c. Subjected to the pressure of 50 atmospheres Mr. Faraday obtained it in a liquid state.

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2. Deutoxide of Nitrogen is best obtained by the action of nitric acid on metallic copper. Effervescence takes place & the gas may be collected over water or mercury. One portion of nitric acid suffers decomposition; part of its oxygen oxidizes the copper, while another part is retained by the nitrogen of the nitric acid forming deutoxide of nitrogen. The oxide of copper united to some undecomposed nitric acid forms the blue nitrate of copper. It is a colourless gas, not so soluble as the protoxide; wholly irrespirable. It has no acid properties unless combined with oxygen when it gives off dense suffocating acid vapours of a red colour. It extinguishes a lighted taper but if phosphorous in a state of combustion be put into it, it burns with increased splendour, phosphoric acid being the product. It is a little heavier than atmospheric air. By exposure to zinc or iron it is decomposed, 1 vol of oxygen is absorbed, leaving a protoxide. It is absorbed in great quantity by green nitrous protosulphate of iron.

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3 Hyponitrous acid: it may be produced by an addition of oxygen to the Deutoxide. It cannot be obtained in a pure state

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4 Nitrous acid: This is the result of the red vapours formed by mixing oxygen with the deutoxide: heat & condensation takes place, & by the application of ice & salt to the tube it is produced in a liquid form. Increase of temperature produces increase of colour, making it nearly black. The liquid acid may be at once obtained by exposing nitrate of lead to a low red heat. The liquid anhydrous acid has a powerfully corrosive acid taste, pungent odour, & of a yellowish orange colour. On mixing it with a large quantity of water it is instantly resolved into nitric acid, & deutoxide of nitrogen, the former unites with the water, the latter escapes in the form of gas.

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5 Nitric acid, may be produced by passing deutoxide of nitrogen slowly over water into oxygen gas. It is generally produced by decomposing nitrate of potash with sulphuric acid by means of heat. It is a highly corrosive fluid & when pure almost colourless: when exposed to the air it emits dense white suffocating vapours. It attracts watery vapour from the air, & a rise of temperature is occasioned by its mixture with water. It oxidizes metals rapidly.

Nitrogen combining with Hydrogen gives rise to
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Ammoniacal gas. It is a colourless gas of strong

2. Volatile Non-metallic Elements.

VIII. BROMINE. (*a*) Production. (*b*) Properties. (*c*) History.

1. *Compounds of Bromine and Oxygen.* (*a*) Bromic acid.
2. *Compounds of Bromine and Hydrogen.* (*a*) Hydro-bromic acid.
3. *Other Binary Compounds of Bromine.*

IX. IODINE. (*a*) Production. (*b*) Properties. (*c*) History.

1. *Compounds of Iodine and Oxygen.* (*a*) Iodic acid.
2. *Compounds of Iodine and Hydrogen.* (*a*) Hydriodic acid.
3. *Other Binary Compounds of Iodine.*

X. SULPHUR. (*a*) Production. (*b*) Properties. (*c*) History.

1. *Compounds of Sulphur and Oxygen.* (*a*) Sulphurous acid. (*b*) Sulphuric acid. (*c*) Hypo-sulphurous acid. (*d*) Hypo-sulphuric acid.
2. *Compounds of Sulphur and Hydrogen.* (*a*) Sulphuretted hydrogen. (*b*) Bi-sulphuretted hydrogen.
3. *Other Binary compounds of Sulphur.*

XI. PHOSPHORUS. (*a*) Production. (*b*) Properties. (*c*) History.

1. *Compounds of Phosphorus and Oxygen.* (*a*) Phosphorous acid. (*b*) Phosphoric acid. (*c*) Hypo-phosphorous acid.
2. *Compounds of Phosphorus and Hydrogen.* (*a*) Per-phosphuretted hydrogen. (*b*) Proto-phosphuretted hydrogen.
3. *Other Binary Compounds of Phosphorus.*

XII. SELENIUM. (*a*) Production. (*b*) Properties. (*c*) History.

1. *Compounds of Selenium and Oxygen.* (*a*) Selenious acid. (*b*) Selenic acid.
2. *Compounds of Selenium and Hydrogen.* (*a*) Seleniuretted hydrogen.
3. *Other Binary Compounds of Selenium.*

3. Fixed Non-metallic Elements.

XIII. CARBON. (*a*) Diamond. (*b*) Plumbago. (*c*) Charcoal. (*d*) Production. (*e*) Properties. (*f*) History.

1. *Compounds of Carbon and Oxygen.* (*a*) Carbonic oxide. (*b*) Carbonic acid. (*c*) Oxalic acid.

A. Detection of Poisons.

2. *Compounds of Carbon and Hydrogen.* (*a*)

pungent odour, & when pure quite irrespirable. It extinguishes burning bodies. A mixture of ammoniacal gas & oxygen detonates by the electric spark, water being formed & nitrogen set free. It is most easily obtained by applying gentle heat to the concentrated solution of ammonia. The gas at the temperature of 50° & at the pressure of 6 atmospheres becomes liquid. Ammonia has all the properties of an alkali. It is formed of 3 equivalents of Hydrogen & 1 of Nitrogen. 17. Dito sp. gr. is 0.5902. It has a powerful affinity for water, & therefore must be collected over mercury. According to D^r Thompson water takes up 780 times its bulk. The concentrated solution is made by passing a current of the gas through distilled water as long as it continues to be absorbed. It may also be obtained from any salt of ammonia by the action of any alkali upon it, as muriate of ammonia & lime. The presence of ammoniacal gas may always be detected by its forming dense white fumes, muriate of ammonia, when a glass rod moistened with muriatic acid is brought near it.

36.

Chlorine - Discovered by Scheele in 1770 & called dephlogisticated marine acid, & by the French Oxymuriatic acid, & by Sir H. Davy Chlorine - It is obtained by taking 3 pts. of common salt & 1 of Black oxide of manganese per & pouring over them sulphuric acid diluted with an equal weight of water. It may also be obtained by uniting strong muriatic acid with half its weight of peroxide of manganese - Muriatic acid, composed of 1 eq. of chlorine & 1 of hydrogen, & peroxide of manganese of 1 eq. of manganese, & 2 eq. of oxygen, gives 1 eq. of oxygen to the hyd: of the acid, & generates 1 eq. of water & 1 eq. of chlorine disengaged; while the protox: of manganese unites with 1 eq. of undecomposed muriatic acid & forms 1 eq. of muriate of the protox: of manganese. The affinities which determine these changes are the attract: of oxygen for Hydrogen & protoxide of manag: for muriatic acid. In the 1st mode of procuring it muriatic acid is disengaged by the action of sulph: acid on the salt which reacts as in the last on the manganese, but the protox: of manag: unites with sulph: acid instead of muriatic & forms sulphate of manganese & soda. Chlorine is an electro negative substance, of a yellowish-green colour, astringent taste, & suffocating smell. Water takes up twice its volume of the gas & has also its properties. 100 cub. in weighs 76 3/10 grs - when strongly & suddenly compressed it unites both heat & light: & under the pressure of about 4 atmospheres it becomes liquid - It is not acted upon by heat, Electricity or Galvanism: Light does not act on dry chlorine but if water is present it is decomposed the chlorine uniting with the hydrogen to form muriatic acid & oxygen is set free

a lighted taper burns for a short time in it & emits a large quantity of smoke. Phosphorus takes fire in it & burns spontaneously - several of the metals in the state of powder or fine leaves, as tin, copper, zinc, antimony &c are suddenly inflamed in it. It has the property of destroying vegetable colours, this depends on the presence of water dry chlorine has not this effect. It is a powerful antiseptic & fumigator it destroys the volatile principle of putrefying animal matter. It possesses no acid properties -
chlorine combines with oxygen, hydrogen & nitrogen but has a very powerful attraction for hydrogen. The compounds of chlorine which are not acid are termed Chlorides or Chlorurets.

Compounds of Chlorine & Oxygen	Chlo:	Ox	By volume. Chlo	Ox
1 Protoxide of Chlorine	36	8	2	1
2 Peroxide of do	36	32	2	4
3 Chlorine Acid	36	40	2	5
4 Perchlorine Acid	36	56	2	7

These principles are never met with in nature in a state of combination, & have a very feeble affinity for each other.

1. Protoxide of chlorine discovered by Davy in 1811. It is formed by the action of muriatic acid on chlorate of potash. It is of a yellowish green colour & smells like burnt sugar. It readily combines with water & has bleaching properties. It is explosive in a high degree even by the heat of the hand or by passing from one vessel to another mixed with hydrogen & exploded by flame or the electric spark water & muriatic acid are formed.

2. Peroxide of chlorine, discovered 1815 by Davy. It is formed by the action of sulphuric acid on chlorate of potash. A dense gas is formed of a deeper colour than chlorine & so heavy that it may be poured from one vessel to another. It has no sensible action on mercury & may be collected over it. Its smell is not so noxious as chlorine. It explodes violently at 212°. & phosphorus when introduced into it takes fire & occasions explosion

3 Chlorine Acid. When to a dilute solution of chlorate of baryta a quantity of weak sulphuric acid is added the insoluble sulphate of baryta subsides & pure chloric acid remains in the liquid. It has acid properties, pungent smell, & forms neutral salts called chlorates, with alkaline bases.

4 Perchloric acid: obtained from perchlorate of potash and dilute sulphuric acid on application of heat. It is the most permanent of the compounds of Chlo & Ox:

Compound of Chlorine & Hydrogen - Muriatic acid gas.

It was discovered in 1772 by Priestley & was called hydro-chloric acid gas. It may be obtained either by heating pure muriatic acid, or by pouring sulphuric acid on common sea salt & collecting the gas over mercury. In the latter process the salt being composed of chlorine & sodium, by the action of sulphuric acid on it & equiv: of water is resolved into its elements; its hydrogen unites with chlorine forming muriatic acid which escapes in the form of gas, while soda is formed by the combination of its oxygen with sodium, which combines with the sulphu: acid forming sulphate of soda: the attractions are chlorine for Hydrogen, sodium for oxygen, & sulphu: acid for soda. By passing an electric shock through equal measures of hydrogen & chlorine muri: acid is found. The sp. gr. of muri: acid gas is 1.2697. It is composed of 1 eq. of each = 37. It is a colourless gas, of pungent odour & acid taste: under a pressure of 40 atmos: where it is liquid. It is quite irrespirable - It will not support combustion. Water at 40°. absorbs, 480 times its volume of the gas. It is not chemically changed by pure heat, but is readily decomposed by Galvanism, hydrogen appearing at the negative & chlorine at the positive pole. If a mixt: of oxyg: & muri: acid gas is electrified the ox: unites with the hydrog: to form water, & chlorine is set free. It has a powerful attract: for wat: & whenever the gas escapes into the air a dense white cloud is formed by its combination with the watery vapour.

Compounds of Chlorine & Nitrogen. Chloride of Nitrogen.

Chlorine & Nitrogen have a very slight affinity for each other. Chloride of Nitrogen is obtained by passing Chlorine through a solution of ammonia: the ammonia is decomposed its hydrogen unites with chlorine forming muriatic acid, while the Nitrogen & chlorine combine. It is one of the most explosive compounds yet known. Its Sp. gr. 1.653. it does not become solid at intense cold. It explodes at a low temperature & mere contact with substances of a combustible nature at common temperatures causes detonation: oils & fatty substances produce this effect. By the analysis of Sir H. Davy it is composed of 4 29. of Chlorine & 1 of Nitrogen.

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Bromine. This is the last of the Elementary substances which have been discovered. It is obtained in small quantities from sea water: it has been detected in the waters of the Mediterranean, Baltic, North sea, Pitts of Scotland, Dead sea, & in salt springs in Germany. In its chemical relations it bears a close analogy to Chlorine & Iodine. It is usually obtained by passing chlorine through bittern, the residue of the evaporation of sea water; the chlorine unites with hydrogen & bromine is set free. By adding sulphuric ether to the solution & agitating it, the ether dissolves the whole of the bromine. At common temperatures bromine is a liquid of a red colour & emits copious red fumes: its odour from which it derives its name, is very disagreeable & its taste powerful. Its Sp. gr. is 3. It is very volatile & boils readily (116°) It is electro negative. It readily dissolves in water, alcohol & ether. It bleaches rapidly like chlorine. It is highly destructive to animal life, one drop placed on the beak of a bird proves fatal. In its combinations & its action on the metals it is very analogous to chlorine antimony & tin take fire by contact with it, & its union with potassium is so vehement as frequently to burst the vessel in which the experiment is performed.

Sub-carburetted hydrogen. (*b*) Carburetted hydrogen.

A. Flame. (*a*) Artificial illumination. (*b*) Drummond's light. (*c*) Safety-lamp. (*d*) Blow-pipes.

B. Gas Lighting. (*a*) Coal gas. (*b*) Oil and rosin gas. (*c*) Portable gas.

C. *Other forms of Hydro-carbon.* (*a*) Naptha-line. (*b*) Sulpho-napthalic acid, &c.

3. *Compounds of Carbon with Chlorine.* (*a*) Per-chloride of Carbon. (*b*) Chloride of Carbon. (*c*) Sub-chloride of Carbon. (*d*) Chloro-carbonic acid.

4. *Compounds of Carbon and Sulphur.* (*a*) Sulphuret of carbon. (*b*) Xanthogen.

A. Compounds of Xanthogen. (*a*) Xanthic acid.

5. *Compounds of Carbon with Nitrogen.* (*a*) Cyanogen.

A. Compounds of Cyanogen with Hydrogen. (*a*) Hydro-cyanic acid. (*b*) Ferro-cyanic acid.

B. *Compounds of Cyanogen and Oxygen.* (*a*) Cyanous acid. (*b*) Cyanic acid. (*c*) Fulminic acid.

C. *Compounds of Cyanogen and Chlorine.* (*a*) Chloro-cyanic acid. (*b*) Per-chloride of cyanogen.

D. *Compounds of Cyanogen with Sulphur.* (*a*) Sulpho-cyanic acid.

XIV. SILICON. (*a*) Preparation. (*b*) Properties. (*c*) History.

1. *Compounds of Silicon.* (*a*) Silica. (*b*) Chloride of Silicon. (*c*) Sulphuret of silicon. (*d*) With metals.

XV. BORON. (*a*) Preparation. (*b*) Properties. (*c*) History.

1. *Compounds of Boron.* (*a*) Boracic acid. (*b*) Chloride of Boron.

4. Hypothetical Element.

XVI. FLUORINE.

1. *Compounds of Fluorine.* (*a*) Hydro-fluoric acid. (*b*) Fluo-silicic acid. (*c*) Fluo-boracic acid.

Hydro-bromic acid - No chemical action takes place between Hydrogen & the vapour of bromine at common temperatures, but on introducing a piece of red hot iron into the mixture combination ensues. The combination is readily effected by the action of bromine on some of the gaseous compounds of hydrogen, & hydro-bromic acid is generated. It is colourless, of an acid taste, pungent odour, & powerfully irritating when respired. Chlorine decomposes it immediately & muriatic acid is formed & bromine deposited. Water absorbs it readily. It is formed of 1 volume of bromine & 1 of hydrogen.

Bromic acid - is formed by the action of bromine on pure potash, when by decomposition of water, & union of its elements with separate portions of bromine bromic & hydrobromic acids are generated. Bromic acid has scarcely any smell, but is very acid, though not corrosive - it consists of 1 eq: of bromine & 5 of oxygen
+ 40 =

Bromine (Chloride of) Formed by transmitting chlorine through bromine - a volatile fluid of a reddish yellow colour is formed, soluble in water, & decomposed by the alkalies into muriatic & bromic acids.

Bromide of Iodine

Bromide of sulphur By pouring bromine on sublimed sulphur an oily fluid of a reddish tint is formed. If boiling water is poured on it slight detonation ensues & hydro-bromic, & sulphurous acids, & sulphuretted hydrogen are formed.

Bromide of Phosphorus - When bromine & phosphorus are brought into contact in a flask filled with carbonic acid gas they act suddenly on each other with evolution of light & heat & 2 compounds are generated, one a crystalline solid bi-bromide of phosphorus, the other a fluid pro-bromide - Chlorine has a greater affinity for phosphorus than bromine & decomposes both the bromides.

Bromide of Carbon is formed by the action of bromine on periodide of Carbon, when bromide of Carbon, & subbromide of iodine are formed

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Iodine was discovered in 1812 by M. Courtois. It is
from the mother liquor which contains hydriodic acid, which
is obtained from Kelp the ashes of sea weed, or by
separated by adding sulphuric acid
putting salt of the manganese in a flask & dropping
it in a little sulphuric acid. Iodine is a
non conductor of electricity, of great spec: gr 8.749
It is hot & acrid to the taste, sparingly soluble in
water, but abundantly in alcohol. Iodine is a soft
friable opaque solid of a bluish black colour & metallic
lustre, & when heated gives out rich violet coloured vapours
It destroys vegetable colours, though in a less degree
than chlorine: it has a strong affinity for most metals
& for simple non-metallic substances forming com-
pounds termed iodides or iodurets. In its constitu-
tion it is very analogous to chlorine. It has
never been decomposed. It is fused at 226° Cold
solution of starch is a very delicate test of the presence
of iodine, forming an insoluble compound of a deep
blue colour: according to Stromeyer a liquid containing
1–450,000 of its weight of iodine is coloured by starch.

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compound of Iodine and oxygen. Iodic acid.
Discovered by Gay Lussac & Davy. Formed by bringing
iodine into contact with peroxide of chlorine:
the chlorine unites with 1 portion of iodine, & its
oxygen with another, forming a volatile orange
coloured matter, chloride of iodine & a white solid
substance iodic acid. It is white semi-transparent
of a strong astringent sour taste, very soluble in
water. It fuses at about 500°. With charcoal
sulphur, sugar, &c. it forms mixtures which
detonate when heated. With metallic oxides
it forms iodates. It is decomposed by sul-
phurous, phosphorous, & hydriodic acids, &
by sulphuretted hydrogen. It is composed of
1 eq. iodine 126 + 5 oxygen 40 = 166.

127
Iodine & Hydrogen. Hydriodic acid gas
obtained by passing hydrogen & the vapour of
iodine through a red hot porcelain tube, or by
the action of water on iodide of phosphorus
assisted by gentle heat. Oxygen of the water unites
with phosphorus, & its hydrogen with iodine
forming phosphoric & hydriodic acids, the
latter of which passes over in the form of a
colourless gas. It has a sour taste & odour similar
to muriatic acid gas. It combines with alkalies
forming hydriodates. Water dissolves it in large
quantities. It is decomposed by several substances

oxygen when heated with its water unites with its hydrogen & liberates iodine. By adding Chlorine muriatic acid gas is produced & iodine set free in the form of vapour - 100 measures of this gas contain half their volume of hydrogen: Eq: 127. Water charged with hydriodic acid forms a colourless solution which emits white fumes: this is readily decomposed by exposure to the atmosphere, the oxygen uniting with the hydrogen forms water & sets iodine free. HI: acid is frequently met with in nature combined with potash or soda, eg. in many mineral springs, & in salt water.

Chlorides of Iodine. Chlorine is absorbed at common temperatures by dry iodine with evolution of caloric forming an orange yellow protochloride of iodine. It has acid properties, dissolves freely in water alcohol, & ether without change. Perchloride of Iodine is said to be resolved by water into muriatic & Iodic acids.

Iodide of Nitrogen formed by putting iodine into a solution ammonia: iodide of nitrogen & hydriodic acid are formed. This like chloride of nitrogen is characterized by its explosive property. It is formed by 1 eq. nitrogen, & 3 of iodine = 392?
Iodine also unites with Phosphorus & Sulphur.

15

Sulphur. It occurs as a mineral production. It is a brittle solid of a greenish yellow colour emits a peculiar odour when rubbed & has little taste. It exists abundantly in combination with some metals, as silver, copper, antimony, lead, & iron. It is excited negatively by friction. Sp. gr. 1.99. Fuses at 216° but afterwards thickens. It is very volatile. It is insoluble in water but dissolves in boiling oil of turpentine & in alcohol. It forms with oxygen the following compounds.

	Sulphur	Oxygen	
Hyposulphurous acid	16	8	= 24
Sulphurous acid	16	16	= 32
Sulphuric acid	16	24	= 40
Hyposulphuric acid	32	40	= 72

sulphurous acid gas: it is the sole product when sulphur is burned in air or dry oxygen gas. It may be prepared by depriving sulphuric acid of 1 eq. of its oxygen, as by heating chips of wood, cork, straw, or some of the metals in strong sulph: acid - This is a suffocating, fumigating gas, fatal to animal life & wife with support combustion - Recently boiled water dissolves about 33 times its volume of the gas - Sulphurous acid renders bitumen paler & the bleaches it: it is twice as heavy as oxygen 100 cu: in: weigh 68.918 grs. 100 cu: in: are composed of vapour of sulphur - 100 cu: in. - sp: gr. double that of oxygen 2.2222.

Sulphurous acid has a strong affinity for oxygen, uniting with it & forming sulphuric acid the presence of moisture is essential to this change. Many of its chemical properties depend on this affinity for oxygen. When mixed with peroxide of iron in solution by depriving it of part of its ox: it converts it into protoxide - nitric acid by yielding some of its ox: converts it into sulphuric acid. It is condensed more readily at the gases, a force equal to two atmospheres being sufficient. The anhydrous liquid acid boils at 14° & from the rapidity of its evaporation produces intense cold. With metallic oxides it forms sulphites

40

Sulphuric acid - oil of vitriol. It is obtained in Britain & most parts of the continent by burning sulphur previously mixed with 1/8 of its weight of nitrate of potash: the gaseous product is conducted into a leaden chamber containing a little water - The nitric acid yields oxygen to a portion of sulphur & converts it into sulphuric acid which combines with the potash, while the greater part of the sulphur forms sulphurous acid by uniting with the oxygen of the air. This is not quite pure, containing sulphate of potash & lead which must be separated by distillation. Pure sulp: acid is a dense colourless fluid, boils at 620°, sp: gr. 1.847 & freezes at 15° when diluted with water at 32°

Second Course.

Part I.

THE PRINCIPLES, PROCESSES, AND PRODUCTS OF INORGANIC CHEMISTRY.

In here recapitulating the properties of the non-metallic elements, a different arrangement has been adopted; and the experimental illustrations will be, as much as possible, varied. In the first course, they have been classed according to the agreement of certain of their physical properties; it being thought that the strong contrasts which the classes therein present to one another, may impress themselves strongly upon the mind, which has been supposed not yet prepared for a more scientific arrangement.

In this second course, the electro-polar arrangement has been adopted; and the students who attend during the whole session will, thus, have the advantage of examining the most interesting and

instructive department of the science, from different points of view: while they who enter only for this division are supposed to be already sufficiently acquainted with the connecting points of Physics, but will have the whole field of pure Chemistry displayed before them.

I. INTRODUCTORY REMARKS. (*a*) Chemical attraction. (*b*) Composition. (*c*) Decomposition. (*d*) Equivalents. (*e*) Influence of electrical forces.

1. *Electro-Negative Elements.* (*a*) Oxygen. (*b*) Chlorine. (*c*) Iodine. (*d*) Bromine. (*e*) Fluorine.
2. *Electro-positive Non-metallic Elements.* (*a*) Hydrogen. (*b*) Nitrogen. (*c*) Carbon. (*d*) Boron. (*e*) Silicon. (*f*) Phosphorus. (*g*) Sulphur. (*h*) Selenium.
3. *Metals.*

1. ELECTRO-NEGATIVE ELEMENTS AND THEIR BINARY COMPOUNDS WITH EACH OTHER.

II. OXYGEN. (*a*) Combustion. (*b*) Oxi-acids. (*c*) Bases. (*d*) Equivalent.

III. CHLORINE. (*a*) Preparation. (*b*) Properties.

1. *Compounds of Chlorine.* (*a*) Protoxide of chlorine. (*b*) Peroxide of chlorine. (*c*) Chloric acid. (*d*) Per-chloric acid.

It is the strongest of the acids - It decomposes animal & vegetable substances by the aid of heat setting carbon free. It has a strong affinity for water, uniting with it in every proportion By passing it through a red hot porcelain tube it is decomposed & is resolved into 2 measures of sulphurous acid & 1 oxygen - It is composed

sulphur - 16 — or 1 eq
Oxygen - 24 — 2 eq } = 40

Muriate of baryta is a sure test for this acid, sulphate of baryta being formed on adding the baryta to the acid, which is insoluble in acids & alkalies

48 (Thomson)

Hyposulphurous acid. Formed by passing a current of sulphurous acid through a solution of hydrosulphuret of lime or strontia. The acid is deprived of ½ of its oxy: by the hydrogen of the sulphuretted hydrog: & the other ½ unites with the sulphur of the sulph: hyd: forming hyposulphurous acid. It may also be obtained by the action of sulphurous acid on iron filings. The salts formed by it are termed hyposulphites. It appears to be formed of 2 atoms of sulphur & 2 oxygen = 48 instead of 24

72

Hyposulphuric acid, is formed by transmitting a current of sulphurous acid gas through water containing peroxide of manganese in fine powder. The manganese yields oxygen to the sulphurous acid, converting it into sulphuric, and unites into hyposulphuric acid. It has no odour & forms soluble salts with baryta, strontia lime &c. While sulphuric acid forms insoluble ones. It is formed of 2 eq: sulphur 32 and 5 of oxygen 40 = 72.

Compounds of Hydrogen & Sulphur.

Sulphuretted Hydrogen. May be formed either by heating sulphuret of antimony in a retort with 4 or 6 times its weight of muriatic acid, by which hydrogen attracts the sulphur, oxygen the antimony & muriatic acid the protoxide of antimony: or by the action of diluted sulphuric acid on protosulphuret of iron. It is a colourless gas, of very offensive smell & very injurious to animal life. It extinguishes flame, but burns at the mouth of the tube with a pale blue flame & sulphur is deposited. With oxygen it forms a mixture which detonates on the application of heat or the electric spark. It tarnishes metals. Water absorbs its own bulk. 100 cu. in. weigh 36.6074 grs. th. gr. 1.1805 Very minute quantities of lead, silver & mercury are detected by this gas. It is formed of 1 eq. sulphur & 1 hydrogen = 17. Has acid properties. The tendency it has to unite with oxygen & the latter unites with its hydrogen forming water & sulphur is deposited. Sulphur & hydrogen and sulphurous acid decompose each other & hydrosulphurous acid is formed. Chlorine, iodine & bromine also decompose it.

Bisulphuretted Hydrogen. Formerly sulphuret of hydrogen? (Thenard) formed by boiling equal parts of recently slaked lime & flowers of sulphur with 5 or 6 of water. The liquid is then poured into dilute muriatic acid, & the sulphur is deposited, & the sulphuretted hydrogen combining with its former persulph: hyd: At common temperatures it is a liquid of a yellow colour, th. gr. 1.769 - it has the odour & taste of sulphuretted hydrogen. According to Dalton it is formed of 2 eq. of sulphur & 1 of hydrogen - It is regarded as an acid

Phosphorus – Discovered 1669. Originally prepared from urine, but afterwards from bones. The object is to bring phosphoric acid in contact with charcoal at a strong red heat. The charcoal takes ox: from the phosphoric acid, carbonic acid is disengaged, & phosphorus set free. Calcined bones should be used, & digested for a day or two with ½ their weight of sulphuric acid, a little water being added so as to form a thin paste. The phos: of lime is decomposed by the acid & 2 new salts generated, the neutral sulphate, & soluble super phosphate of lime: by adding boiling water & filtering the latter is separated. The solution is then evaporated to the consistence of syrupe, mixed with ¼ its weight of powdered charcoal & heated in a retort the beak of which is put into water & the phosphorus as it passes over in the form of vapour collected. Pure phosph: is transparent & almost colourless. Sp: gr. 1.77 – It is highly inflammable, on exposure to the atmosphere slow combustion takes place from its combination with oxygen. It fuses at 108°.

Compounds of phosphorus & oxygen
Phosphorous & phosphoric acids

Phosphorous acid may be conveniently prepared by subliming phosphorus through powdered corrosive sublimate (chloride of mercury) contained in a glass tube: proto-chloride of phosphorus is formed, by adding water to which a mutual decomposition takes place: the hydrogen of the water unites with the chlorine forming muriatic acid, while the oxygen combines with the phosphorus, forming phosphorous acid. When phosphorus is heated in highly rarefied air

a white volatile powder is formed supposed to be the anhydrous acid; when brought into contact with oxygen phosphoric acid is formed. It dissolves readily in water & unites to alkalies forms phosphites. It is composed of 1 eq: phosphorus 16 & 1½ of ox: 12 = 28.

Phosphoric Acid, ^{36} and pyro ^{36} phosphoric acid, these compounds afford an instance of two substances consisting of the same ingredients in the same proportions, yet differing essentially in chemical properties. Berzelius has termed these isomeric compounds. These acids may either be obtained by the oxidation of phosphorus, or by the action of sulphuric acid on calcined bones when phosphorus is burned in a dry vessel of air or oxygen gas a copious white smoke appears which falls to the bottom of the vessel like flakes of snow; this is anhydrous pyro-phosphoric acid, on exposure to the air for a day or two it rapidly absorbs moisture & becomes phosphoric acid. It may be procured also by dropping bits of phosph: into strong nitric acid; the water is decomposed, its oxygen unites with the phosph: & its hydrogen with the nitrogen of the acid. The composition of these 2 acids is dissimilar. They are formed by 1 eq: phosph: 16 & 2½ ox 20 = 36.

Phos: acid yields a yellow salt with oxide of silver & does not disturb the transparency of albumen, while pyro-phos^{c}. yields a white salt & albumen is precipitated by it.

IV. IODINE, (*a*) Preparation. (*b*) Properties.

1. *Compounds of Iodine.* (*a*) Iodic acid. (*b*) Chloriodic acid.

V. BROMINE. (*a*) Preparation. (*b*) Properties.

1. *Compounds of Bromine.* (*a*) Bromic acid. (*b*) Chloro-bromic acid, &c.

2. ELECTRO-POSITIVE NON-METALLIC ELEMENTS, AND THEIR BINARY COMPOUNDS WITH THE ELECTRO-NEGATIVE.

VI. HYDROGEN. (*a*) Preparation. (*b*) Properties.

1. *Compounds of Hydrogen with Oxygen.* (*a*) Water. (*b*) Deutoxide of Hydrogen.
2. *Hydro-Acids.* (*a*) Muriatic acid. (*b*) Hydriodic acid. (*c*) Hydro-bromic acid. (*d*) Hydro-fluoric acid.

VII. NITROGEN. (*a*) Preparation. (*b*) Properties.

1. *Compounds of Nitrogen with Oxygen.* (*a*) Atmospheric air. (*b*) Protoxide of nitrogen. (*c*) Deutoxide of nitrogen. (*d*) Nitrous acid. (*e*) Nitric acid. (*f*) Hypo-nitrous acid.
2. *Other Compounds of Nitrogen.* (*a*) Chloride of nitrogen, &c.

VIII. CARBON. (*a*) Preparation. (*b*) Properties. (*c*) Varieties.

1. *Compounds of Carbon and Oxygen.* (*a*) Carbonic oxide. (*b*) Carbonic acid. (*c*) Oxalic acid.
2. *Other Compounds of Carbon.* (*a*) Perchloride of carbon. (*b*) Proto-chloride of carbon. (*c*) Sub-chloride of carbon, &c.

IX. BORON. (*a*) Preparation. (*b*) Properties.

1. *Compounds of Boron.* (*a*) Boracic acid. (*b*) Fluo-boracic acid, &c.

X. SILICON. (*a*) Preparation. (*b*) Properties.

1. *Compounds of Silicon.* (*a*) Silica. (*b.*) Fluo-silicic acid, &c.

XI. PHOSPHORUS. (*a*) Preparation. (*b*) Properties.

1. *Compounds of Phosphorus and Oxygen.* (*a*) Oxide of phosphorus. (*b*) Phosphoric acid. (*c*) Phosphorous acid. (*d*) Hypo-phosphorous acid.
2. *Other Compounds of Phosphorus.* (*a*) Perchloride of phosphorus. (*b*) Proto-chloride of phosphorus, &c.

XII. SULPHUR. (*a*) Preparation. (*b*) Properties.

1. *Compounds of Sulphur and Oxygen.* (*a*) Sulphurous acid. (*b*) Sulphuric acid. (*c*) Hypo-sulphurous acid. (*d*) Hypo-sulphuric acid.
2. *Other Compounds of Sulphur.*

XIII. SELENIUM. (*a*) Preparation. (*b*) Properties.

1 *Compounds of Selenium and Oxygen.* (*a*) Oxide of Selenium. (*b*) Selenious acid. (*c*) Selenic acid.
2 *Other Compounds of Selenium.*

3. Binary Compounds of Electro-Positive Elements with each other.

I. HYDROGEN.

1. *Hydrogen with Nitrogen.* (*a*) Ammonia.
2. *Hydrogen with Sulphur.* (*a*) Sulphuretted hydrogen. (*b*) Bi-sulphuretted hydrogen.
3. *Hydrogen with Selenium.* (*a*) Seleniuretted hydrogen.
4. *Hydrogen with Phosphorus.* (*a*) Per-phosphuretted hydrogen. (*b*) Proto-phosphuretted hydrogen.
5. *Hydrogen with Carbon.* (*a*) Sub-carburetted hydrogen. (*b*) Olefiant gas. (*c*) Fire damp. (*d*) Coal gas. (*e*) Other forms of hydrocarbon.

II. CARBON WITH NITROGEN. (*a*) Cyanogen.

1 *Cyanogen with hydrogen.* (*a*) Hydro-cyanic acid.

2. *Cyanogen with Oxygen.* (*a*) Cyanous acid. (*b*) Cyanic acid. (*c*) Fulminic acid.
3. *With other Electro-Negative Elements.* (*a*) Chloro-cyanic acid. (*b*) Iodide of cyanogen.
4. *With Electro Positive Elements.* (*a*) Sulpho-cyanic acid. (*b*) Ferro-cyanic acid.

III. SULPHUR WITH CARBON. (*a*) Bi-sulphuret of carbon. (*b*) Xanthogen.

1. *Compounds of Xanthogen.* (*a*) Xanthic acid.

4 Metallic Elements.

I. GENERAL PROPERTIES OF METALS. (*a*) Oxides. (*b*) Chlorides. (*c*) Sulphurets.

1. *Noble Metals.* (*a*) Mercury. (*b*) Silver. (*c*) Gold. (*d*) Platinum. (*e*) Palladium. (*f*) Rhodium. (*g*) Iridium. (*h*) Osmium. (*i*) Nickel.
2. *Metals which retain Oxygen at high Temperatures.* (*a*) Lead. (*b*) Tellurium. (*c*) Copper (*d*) Bismuth. (*e*) Titanium. (*f*) Cobalt. (*g*) Cerium. (*h*) Uranium.
3. *Acidifiable Metals.* (*a*) Antimony. (*b*) Columbium. (*c*) Tungsten. (*d*) Chromium. (*e*) Vanadium. (*f*) Molybdenum. (*g*) Arsenic.
4. *Metals which decompose Water at a Red*

Heat. (*a*) Tin. (*b*) Iron. (*c*) Zinc. (*d*) Cadmium. (*e*) Manganese.

5. *Alkalifiable Metals.* (*a*) Potassium. (*b*) Sodium. (*c*) Lithium. (*d*) Calcium. (*e*) Barium. (*f*) Strontium.

6. *Earthy Metals.* (*a*) Magnesium. (*b*) Yttrium. (*c*) Aluminum. (*d*) Glucinum. (*e*) Zirconium. (*f*) Thorinum.

1. Noble Metals.

II. MERCURY. (*a*) Properties and uses. (*b*) Ores. (*c*) Extraction.

1. *Compounds with Oxygen.* (*a*) Protoxide. (*b*) Peroxide.
2. *Compounds with Chlorine.* (*a*) Calomel. (*b*) Corrosive Sublimate.
3. *Compounds with Sulphur.* (*a*) Proto-sulphuret. (*b*) Cinnabar.
4. *Other Binary Compounds.* (*a*) Iodides. (*b*) Amalgams, &c.

III. SILVER. (*a*) Properties and uses. (*b*) Ores. (*c*) Extraction. (*d*) Assaying.

1. *Compounds with Oxygen.* (*a*) Oxide of Silver.
2. *Compounds with Chlorine.* (*a*) Chloride of Silver.
3. *Compounds with Sulphur.* (*a*) Sulphuret of Silver.
4. *Other Binary Compounds.* (*a*) Alloys, &c.

IV. GOLD. (*a*) Properties and uses. (*b*) Ores. (*c*) Extraction. (*d*) Parting.

1. *Compounds with Oxygen.* (*a*) Oxide of Gold.
2. *Compounds with Chlorine.* (*a*) Chlorides of gold.
3. *Compounds with Sulphur.* (*a*) Per-sulphuret of gold.
4. *Other Binary Compounds.* (*a*) Alloys, &c.

V. PLATINUM. (*a*) Properties and uses. (*b*) Ores. (*c*) Extraction.

1. *Binary Compounds.* (*a*) Alloys, &c.

VI. PALLADIUM. (*a*) Properties and uses. (*b*) Ores. (*c*) Extraction.

1. *Binary Compounds.*

VII. RHODIUM. (*a*) Properties and uses. (*b*) Ores. (*c*) Extraction.

1. *Binary Compounds.*

VIII. IRIDIUM. (*a*) Properties. (*b*) Ores. (*c*) Extraction.

1. *Binary Compounds.*

IX. OSMIUM. (*a*) Properties. (*b*) Ores. (*c*) Extraction.

1. *Binary Compounds.*

X. NICKEL. (*a*) Properties and uses. (*b*) Ores. (*c*) Extraction.

1. *Binary Compounds.* (*a*) Alloys, &c.

2. METALS WHICH RETAIN OXYGEN AT HIGH TEMPERATURES.

XI. LEAD. (*a*) Properties and uses. (*b*) Ores. (*c*) Extraction.

1. *Combinations with Oxygen.* (*a*) Protoxide. (*b*) Deutoxide. (*c*) Peroxide.
2. *Combinations with Chlorine.* (*a*) Chloride of lead. (*b*) Patent Yellow.
3. *Compounds with Sulphur.* (*a*) Galena.
4. *Other Binary Compounds.* (*a*) Alloys, &c.

XII. TELLURIUM. (*a*) Properties. (*b*) Ores. (*c*) Extraction.

1. *Binary Compounds.*

XIII. COPPER. (*a*) Properties and uses. (*b*) Ores. (*c*) Extraction.

1. *Compounds with Oxygen.* (*a*) Protoxide. (*b*) Peroxide.
2. *Compounds with Chlorine.* (*a*) Proto-chloride. (*b*) Per-chloride.

3. *Compounds with Sulphur.* (*a*) Proto-sulphuret. (*b*) Bi-sulphuret.
4. *Other Binary Compounds.* (*a*) Alloys, &c.

XIV. BISMUTH. (*a*) Properties and uses. (*b*) Ores. (*c*) Extraction.

1. *Binary Compounds.* (*a*) Alloys, &c.

XV. TITANIUM. (*a*) Properties. (*b*) Ores. (*c*) Extraction.

1. *Binary Compounds.*

XVI. COBALT. (*a*) Properties and uses. (*b*) Ores. (*c*) Extraction.

1. *Binary Compounds.*

XVII. CERIUM. (*a*) Properties. (*b*) Ores. (*c*) Extraction.

1. *Binary Compounds.*

XVIII. URANIUM. (*a*) Properties. (*b*) Ores. (*c*) Extraction.

1. *Binary Compounds.*

3. Acidifiable Metals.

XIX. ANTIMONY. (*a*) Properties and uses. (*b*) Ores. (*c*) Extraction.

1. *Compounds with Oxygen.* (*a*) Protoxide. (*b*) Deutoxide. (*c*) Antimonic acid.

2. *Compounds with Chlorine.* (*a*) Proto-chloride. (*b*) Per-chloride.
3. *Compounds with Sulphur.* (*a*) Proto-sulphuret. (*b*) Golden sulphuret.
4. *Other Binary Compounds.*

XX. COLUMBIUM. (*a*) Properties. (*b*) Ores. (*c*) Extraction.

1. *Binary Compounds.*

XXI. TUNGSTEN. (*a*) Properties. (*b*) Ores. (*c*) Extraction.

1. *Binary Compounds.*

XXII. CHROMIUM. (*a*) Properties. (*b*) Ores. (*c*) Extraction.

1. *Combinations with Oxygen.* (*a*) Protoxide. (*b*) Deutoxide. (*c*) Chromic acid.
2. *Combinations with Chlorine.* (*a*) Chlorochromic acid. (*b*) Per-chloride.
3. *Other Binary Compounds.*

XXIII. VANADIUM. (*a*) Properties. (*b*) Ores. (*c*) Extraction.

1. *Binary Compounds.*

XXIV. MOLYBDENUM. (*a*) Properties. (*b*) Ores. (*c*) Extraction.

1. *Binary Compounds.*

XXV. ARSENIC. (*a*) Properties and uses. (*b*) Ores. (*c*) Attraction.

1. *Combinations with Oxygen.* (*a*) Protoxide of arsenic. (*b*) Arsenious acid. (*c*) Arsenic acid.
2. *Other Binary Compounds.*

A. *Poisoning by Arsenic.* (*a*) Tests, &c.

4. METALS WHICH DECOMPOSE WATER AT A RED HEAT.

XXVI. TIN. (*a*) Properties and uses. (*b*) Ores. (*c*) Extraction.

1. *Combinations with Oxygen.* (*a*) Protoxide. (*b*) Peroxide.
2 *Combinations with Chlorine.* (*a*) Proto-chloride. (*b*) Per-chloride.
3. *Other Binary Compounds.* (*a*) Alloys.

XXVII. IRON. (*a*) Properties and uses. (*b*) Ores. (*c*) Extraction.

1. *Combinations with Oxygen.* (*a*) Protoxide. (*b*) Peroxide.
2. *Combinations with Chlorine.* (*a*) Proto-chloride. (*b*) Per-chloride.
3. *Combinations with Sulphur.* (*a*) Proto-sulphuret. (*b*) Bi-sulphuret.
4. *Other Binary Compounds.* (*a*) Steel. (*b*) Alloys, &c.

XXVIII. ZINC. (*a*) Properties and uses. (*b*) Ores. (*c*) Extraction.

1. *Binary Compounds.* (*a*) Alloys.

XXIX. CADMIUM. (*a*) Properties and uses. (*b*) Ores. (*c*) Extraction.

1. *Binary Compounds.*

XXX. MANGANESE. (*a*) Properties. (*b*) Ores. (*c*) Extraction.

1 *Binary Compounds.*

5. Alkalifiable Metals.

XXXI. POTASSIUM. (*a*) Properties and uses. (*b*) Processes for obtaining.

1. *Binary Compounds.* (*a*) Potassa, &c

XXXII. SODIUM. (*a*) Properties and uses. (*b*) Processes for obtaining.

1. *Binary Compounds.* (*a*) Soda. (*b*) Salt, &c.

XXXIII. LITHIUM. (*a*) Properties. (*b*) Process for obtaining.

1. *Binary Compounds,* (*a*) Lithia, &c.

XXXIV. CALCIUM. (*a*) Properties. (*b*) Process for obtaining.

1. *Binary Compounds.* (*a*) Lime, &c.

XXXV. BARIUM. (*a*) Properties. (*b*) Process for obtaining.

1. *Binary Compounds.* (*a*) Baryta, &c.

XXXVI. STRONTIUM. (*a*) Properties. (*b*) Process for obtaining.

1. *Binary Compounds.* (*a*) Strontia, &c.

6. Earthy Metals.

XXXVII. MAGNESIUM. (*a*) Properties. (*b*) Process for obtaining.

1. *Binary Compounds.* (*a*) Magnesia, &c.

XXXVIII. YTTRIUM. (*a*) Properties. (*b*) Process for obtaining.

1. *Binary Compounds.* (*a*) Yttria, &c.

XXXIX. ALUMINUM. (*a*) Properties. (*b*) Process for obtaining.

1. *Binary Compounds.* (*a*) Alumina, &c.

XL. GLUCINUM. (*a*) Properties. (*b*) Process for obtaining.

1. *Binary Compounds.* (*a*) Glucina, &c.

XLI. ZIRCONIUM. (*a*) Properties. (*b*) Process for obtaining.

1. *Binary Compounds.* (*a*) Zirconia, &c.

XLII. THORINUM. (*a*) Properties. (*b*) Process for obtaining.

1. *Binary Compounds.* (*a*) Thorina, &c.

Combinations of Proximate Principles.

Salts.

I. GENERAL REMARKS ON COMBINATION. (*a*) Atomic Hypothesis. (*b*) Electrical Hypothesis. (*c*) Secondary combinations. (*d*) Nomenclature of salts.

1. *Water of Crystallization.* (*a*) Decrepitation. (*b*) Efflorescence. (*c*) Deliquescence. (*d*) Igneous fusion. (*e*) Aqueous fusion.

2. *Decomposition.* (*a*) Influence of Cohesion. (*b*) Elasticity. (*c*) Solubility.

3. *Crystallization.* (*a*) Isomorphism. (*b*) Isomerism.

4. *Salts of the Hydracids.* (*a*) Muriates. (*b*) Hydriodates. (*c*) Sulpho-salts.

5. *Classification.* (*a*) In the order of the acids. (*b*) In the order of the bases.

§ Salts in the Order of the Acids.

II. NITROGEN RADICLE.

1. *Nitrates.* (*a*) Nitrate of potassa, (Pulvis

fulminans, Gunpowder.) (*b*) Nitrate of soda. (*c*) Nitrate of ammonia. (*d*) Nitrates of baryta, strontia, lime, &c. (*e*) Nitrates of copper, lead, mercury, silver, &c. (*f*.) Tests.

2. *Hypo-nitrites.* (*a*) Hypo-nitrite of potassa, &c. (*b*) Hypo-nitrites of lead, copper, &c. (*c*) Tests.

III. CHLORINE RADICLE,

1. *Chlorates.* (*a*) Chlorates of potassa, soda, &c. (*b*) Chlorates of baryta, &c. (*c*) Tests.

2. *Per-chlorates.* (*a*) Per-chlorates of potassa, &c. (*b*) Tests.

3. *Chlorides of Oxides.* (*a*) Chloride of lime, (bleaching processes). (*b*) Chlorides of soda, &c. (disinfecting processes.)

4. *Muriates.* (*a*) Muriate of ammonia. (*b*) Muriate of magnesia, &c. (*c*) Muriate of Chromium, &c. (*d*) Tests.

A. Double Salts. (*a*) Double chlorides. (*b*) Double oxi-salts.

IV. BROMINE RADICLE.

1. *Bromates.* (*a*) Bromate of Potassa, &c.

2. *Hydro-Bromates.* (*a*) Hydro-bromates of Potassa, &c. (*b*) Tests.

V. IODINE RADICLE.

1. *Iodates.* (*a*) Iodate of potassa, &c.
2. *Hydriodates.* (*a*) Hydriodate of Potassa, &c. (*b*) Tests.

VI. SULPHUR RADICLE.

1. *Sulphates.* (*a*) Sulphates of silver, mercury, copper, iron, &c. (*b*) Sulphates of ammonia, potassa, soda, &c. (*c*) Sulphates of lime, alumina, &c. (*d*) Alums. (*e*) Tests.
2. *Sulphites.* (*a*) Sulphite of lime, &c. (*b*) Tests.
3. *Hypo-Sulphites.* (*a*) Hypo-sulphite of ammonia, &c. (*b*) Hypo-sulphite of silver, &c. (*c*) Tests.
4. *Hypo-Sulphates.* (*a*) Hypo-sulphate of manganese, &c. (*b*) Hypo-sulphate of baryta, &c. (*c*) Tests.
5. *Hydro-Sulphurets.* (*a*) Hydro-sulphuret of ammonia, &c. (*b*) Tests.
6. *Sulphuretted Hydro-Sulphurets.*

VII. PHOSPHORUS RADICLE.

1. *Phosphates,* (*a*) Phosphate of soda, &c. (*b*) Phosphate of lime, &c. (*c*) Phosphate of lead, &c. (*d*) Pyro-phosphates. (*e*) Tests.
2. *Phosphites.*
3. *Hypo-Phosphites.*

VIII. CARBON RADICLE.

1. *Carbonates.* (*a*) Carbonates of ammonia, potassa, soda, &c. (*b*) Carbonates of baryta, &c. (*c*) Carbonates of iron, copper, lead, &c. (*d*) Tests.
2. *Oxalates.* (*a*) Tests.

IX. BORON RADICLE.

1. *Borates.* (*a*) Bi-borate of soda, &c. (*b*) Tests.

X. FLUORINE RADICLE.

1. *Hydro-Fluates.* (*a*) Hydro-fluate of ammonia, &c. (*b*) Fluoride of calcium, &c. (*c*) Tests.
2. *Fluo-Silicates.*
3. *Fluo-Borates.*

XI. CYANOGEN RADICLE.

1. *Hydro-Cyanates.* (*a*) Hydro-cyanates of ammonia, &c. (*b*) Cyanide of mercury, &c. (*c*) Tests.
2. *Cyanites.*
3. *Fulminates.*
4. *Cyanates.*
5. *Ferro-Cyanates.* (*a*) Ferro-cyanate of potassa. (*b*) Red ferro-cyanate of potassa. (*c*) Prussian blue, &c. (*d*) Tests.
6. *Sulpho-Cyanates.* (*a*) Sulpho-cyanate of potassa. (*b*) Tests.

XII. METALLIC RADICLES.

1. *Antimoniates.* (*a*) Antimonites. (*b*) Tests.
2. *Chromates.* (*a*) Tests.
3. *Arseniates.* (*a*) Arsenites. (*b*) Tests.

§ Salts in the Order of their Bases.

XIII. SUBDIVISION OF SALTS.

I. *Not precipitated by Hydro-Sulphuret of Ammonia.* (*a*) Not precipitated by carbonate of potassa. (*b*) Precipitated by carbonate of potassa.

2. *Precipitated by Hydro-Sulphuret of Ammonia.* (*a*) Not precipitated by sulphuretted hydrogen. (*b*) Precipitated by sulphuretted hydrogen.

XIV. SALTS NOT PRECIPITATED BY HYDRO-SULPHURET OF AMMONIA, NOR BY CARBONATE OF POTASSA.

1. *Potassa.* (*a*) Tests.
2. *Soda.* (*a*) Tests.
3. *Ammonia.* (*a*) Tests.

XV. SALTS NOT PRECIPITATED BY HYDRO-SULPHURET OF AMMONIA, BUT BY CARBONATE OF POTASSA.

1. *Lithia.* (*a*) Tests.

2. *Baryta.* (*a*) Tests.
3. *Strontia.* (*a*) Tests.
4. *Lime.* (*a*) Tests.
5. *Magnesia.* (*a*) Tests.

XVI. SALTS PRECIPITATED BY SULPHURET OF AMMONIA, BUT NOT BY SULPHURETTED HYDROGEN.

1. *Alumina.* (*a*) Tests.
2. *Manganese.* (*a*) Tests.
3. *Zinc.* (*a*) Tests.
4. *Iron.* (*a*) Tests.
5. *Cobalt.* (*a*) Tests.
6. *Nickel.* (*a*) Tests.

XVII. SALTS PRECIPITATED BY HYDROSULPHURET OF AMMONIA AND BY SULPHURETTED HYDROGEN.

1. *Chromium.* (*a*) Tests.
2. *Tin.* (*a*) Tests.
3. *Cadmium.* (*a*) Tests.
4. *Antimony.* (*a*) Tests.
5. *Bismuth.* (*a*) Tests.
6. *Lead.* (*a*) Tests.
7. *Copper.* (*a*) Tests.
8. *Mercury.* (*a*) Tests.
9. *Silver.* (*a*) Tests.
10. *Platinum.* (*a*) Tests.
11. *Gold.* (*a*) Tests.

XVIII. SILICATES. (*a*) Glass. (*b*) Porcelain.

A. *Analysis of Minerals.*

Part II.

THE PRINCIPLES, PROCESSES, AND PRODUCTS OF ORGANIC CHEMISTRY.

I. INTRODUCTORY REMARKS. (*a*) Processes of life. (*b*) Organization. (*c*) Products. (*d*) Death. (*e*) Definite compounds. (*f*) Mixtures.

II. ANALYSIS. (*a*) Destructive distillation. (*b*) Method of Gay Lussac and Thenard. (*c*) Method of Dr. Prout. (*d*) Ultimate and proximate analyses.

III. DIVISION OF THE SUBJECT.

1. *Vegetable Chemistry.*
2. *Animal Chemistry.*

§ *VEGETABLE CHEMISTRY.*

I. PROXIMATE PRINCIPLES.

1. *Acids.*
2. *Bases.*
3. *Inflammable Substances.*
4. *Neutral Substances.*
5. *Indefinite Substances.*

II. ASHES.

1. Vegetable Acids.

III. ACETIC ACIDS. (*a*) Vinegar. (*b*) Pyroligneous acid. (*c*) Crystallizable acid. (*d*) Analysis. (*e*) Lampic acid. (*f*) Lactic acid.

1. *Acetates.* (*a*) Acetate of ammonia, &c. (*b*) Acetate of baryta, &c. (*c*) Acetate of copper, &c. (*d*) Tests.

IV. OXALIC ACID. (*a*) Preparation. (*b*) Properties. (*c*) Analysis.

1. *Oxalates.* (*a*) Oxalate of ammonia, &c. (*b*) Oxalate of lime, &c. (*c*) Tests.
2. *Oxalamide.*

V. TARTARIC ACID. (*a*) Preparation. (*b*) Properties. (*c*) Analysis. (*d*) Pyro-tartaric acid.

1. *Tartrates.* (*a*) Tartrate of Potassa, &c. (*b*) Double tartrates. (*c*) Tests.

VI. CITRIC ACID. (*a*) Preparation. (*b*) Properties. (*c*) Analysis. (*d*) Pyro-citric acid.

1. *Citrates.* (*a*) Tests.

VII. MALIC ACID. (*a*) Preparation. (*b*) Properties. (*c*) Analysis.

1. *Malates.* (*a*) Tests.

VIII. *Gallic Acid.* (*a*) Preparation. (*b*) Properties. (*c*) Analysis.

1. *Gallates.* (*a*) Ink. (*b*) Tests.

IX. TANNIN. (*a*) Preparation. (*b*) Properties. (*c*) Tests.

1. *Process of Tanning.*

X. PECTIC ACID. (*a*) Preparation. (*b*) Properties.

1. *Pectates.* (*a*) Tests.

XI. SUCCINIC ACID. (*a*) Preparation. (*b*) Properties.

1. *Succinates.* (*a*) Tests.

XII. BENZOIC ACID. (*a*) Preparation. (*b*) Properties.

1. *Benzoates.* (*a*) Tests.

XIII. ULMIC ACID. (*a*) Preparation. (*b*) Properties.

1. *Ulmates.* (*a*) Tests.

XIV. SUBERIC ACID. (*a*) Preparation. (*b*) Properties.

2. Vegetable Bases.

XV. MORPHIA. (*a*) Preparation. (*b*) Properties. (*c*) Analysis.

1. *Narcotine.*
2. *Meconic Acid.*
3. *Salts of Morphia.* (*a*) Tests.

XVI. STRYCHNIA. (*a*) Preparation. (*b*) Properties. (*c*) Analysis.

1. *Salts of Strychnia.*

XVII. VERATRIA. (*a*) Preparation. (*b*) Properties. (*c*) Analysis.

1. *Salts of Veratria.*

XVIII. BRUCIA. (*a*) Preparation. (*b*) Properties. (*c*) Analysis.

1. *Salts of Brucia.*

XIX. CINCHONIA. (*a*) Preparation. (*b*) Properties. (*c*) Analysis.

1. *Salts of Cinchonia.*

XX. QUINIA. (*a*) Preparation. (*b*) Properties. (*c*) Analysis.

1. *Salts of Quinia.*
2. *Kinic Acid.*

XXI. SALICINA. (*a*) Preparation. (*b*) Properties. (*c*) Analysis.

XXII. PICROTOXIA. (*a*) Preparation. (*b*) Properties. (*c*) Analysis.

XXIII. EMETINA. (*a*) Preparation. (*b*) Properties, &c.

XXIV. PIPERINA. (*a*) Preparation. (*b*) Properties, &c.

XXV. DELPHINIA. (*a*) Preparation. (*b*) Properties, &c.

XXVI. CAFEA. (*a*) Preparation. (*b*) Properties, &c.

3. Inflammable Principles.

XXVII. FIXED OILS. (*a*) Stearine. (*b*) Oleine. (*c*) Drying oils. (*d*) Analysis.

XXVIII. WAX. (*a*) Bees' wax. (*b*) Vegetable wax. (*c*) Analysis.

XXIX. CAOUTCHOUC. (*a*) Preparation. (*b*) Properties. (*c*) Analysis.

A. *Saponification.* (*a*) Margaric acid. (*b*) Oleic acid. (*c*) Stearic acid. (*d*) Glycerine.

1. *Salts of the Fatty Acids.* (*a*) Soaps.

XXX. VOLATILE OILS.

1. *Vegetable.* (*a*) Spirits of turpentine, &c. (*b*) Camphor.
2. *Mineral.* (*a*) Naphtha. (*b*) Petroleum, &c.

XXXI. RESINS. (*a*) Rosin, &c. (*b*) Guaiacum.

2. *Balsams.* (*a*) Tolu, &c.

3. *Gum Resins.* (*a*) Gamboge. (*b*) Aloes. (*c*) Assafœtida, &c.

XXXII. ALCOHOL. (*a*) Preparation. (*b*) Properties. (*c*) Analysis.

1. *Alcohates.*

XXXIII. ETHER. (*a*) Preparation. (*b*) Properties. (*c*) Analysis.

1. *Sulpho-vinic Acid.* (*a*) Oil of wine. (*b*) Sulpho-vinates.

2. *Hydro - acid Ethers.* (*a*) Muriatic ether. Hydriodic ether.

3. *Vegetable Acid Ethers.* (*a*) Nitric ether. (*b*) Acetic ether. (*c*) Oxalic ether.

XXXIV. PYRO-ACETIC SPIRIT. (*a*) Preparation. (*b*) Properties. (*c*) Analysis.

4. Neutral Principles.

XXXV. SUGAR. (*a*) Manufacture. (*b*) Refining. (*c*) Properties. (*d*) Analysis.

1. *Varieties.* (*a*) Beet. (*b*) Grape. (*c*) Honey. (*d*) Manna.

XXXVI. STARCH. (*a*) Preparation. (*b*) Properties. (*c*) Analysis. (*d*) Sugar.

1 *Varieties.* (*a*) Arrow root. (*b*) Sago. (*c*) Tapioca. (*d*) Iceland moss.

XXXVII. GLUTEN. (*a*) Preparation. (*b*) Properties. (*c*) Analysis.

XXXVIII. LIGNIN. (*a*) Preparation. (*b*) Properties. (*c*) Sugar.

1. *Varieties.* (*a*) Hemp. (*b*) Flax. (*c*) Cotton.

XXXIX. MUCILAGE. (*a*) Preparation. (*b*) Properties.

1. *Varieties.* (*a*) Gum Arabic. (*b*) Tragacanth, &c.

5. Indefinite Substances.

XL. COLOURING MATTERS. (*a*) Indigo. (*b*) Archil. (*c*) Cochineal. (*d*) Lac. (*e*) Madder. (*f*) Alarazzine. (*g*) Quercitron, &c.

1. *Dyeing.*
2. *Calico Printing.*

XLI. CHEMICAL CHANGES OF THE FUNCTIONS OF PLANTS. (*a*) Germination. (*b*) Process of malting. (*c*) Atmospheric changes. (*d*) Action of the foliage. (*e*) Maturation of fruits.

XLII. FERMENTATION.

1. *Vinous.* (*a*) Wine. (*b*) Beer. (*c*) Bread.

2. *Acetous.* (*a*) Vinegar.
3. *Putrefactive.*

ANIMAL CHEMISTRY.

I. PROXIMATE PRINCIPLES.

1. *Substances neither Acid nor Oleaginous.*
2. *Animal Acids.*
3. *Animal Fats.*

1. Substances neither Acid nor Oleaginous.

II. GELATINE. (*a*) Preparation. (*b*) Properties. (*c*) Tests. (*d*) Analysis.

III. ALBUMEN. (*a*) Preparation. (*b*) Properties. (*c*) Tests. (*d*) Analysis.

IV. FIBRIN. (*a*) Preparation. (*b*) Properties.
1. *Adipocere.*

V. MUCUS. (*a*) Preparation. (*b*) Properties. (*c*) Tests.

VI. OSMAZOME. (*a*) Preparation. (*b*) Properties.

VII. UREA. (*a*) Preparation. (*b*) Properties. (*c*) Analysis. (*d*) Artificial.

VIII. ANIMAL SUGAR. (*a*) Of Milk. (*b*) Of Diabetes. (*c*) Of glue.

2. Animal Acids.

IX. LITHIC ACID. (*a*) Preparation. (*b*) Properties. (*c*) Analysis. (*d*) Tests.

1. *Lithates.*
2. *Pyro-lithic Acid.*

X. PURPURIC ACID. (*a*) Preparation. (*b*) Properties,

1. *Purpurates.*

XI. SACCHOLACTIC ACID. (*a*) Preparation. (*b*) Properties. (*c*) Analysis.

1. *Saccholactates.*

XII. FORMIC ACID. (*a*) Preparation. (*b*) Properties.

1. *Formiates.*

3. Oleaginous Principles.

XIII. FAT. (*a*) Oils.

XIV. SPERMACETI. (*a*) Preparation. (*b*) Properties.

XV. CHOLESTERINE. (*a*) Preparation. (*b*) Properties.

XVI. CANTHARADINE. (*a*) Preparation. (*b*) Properties.

XVII. COMPLEX PARTS OF ANIMALS.

1. *Solid.*
2. *Fluid.*

1. Solid Parts of Animals.

I. BONES. (*a*) Shells. (*b*) Crusts, &c.

II. HORNS. (*a*) Nails. (*b*) Scales. (*c*) Hair, &c.

III. MUSCLES. (*a*) Tendons. (*b*) Skin, &c.

2. Fluid Parts of Animals.

IV. CHYLE. (*a*) Chyme. (*b*) Gastric juice.

V. BLOOD. (*a*) Serum. (*b*) Crassamentum. (*c*) Colour. (*d*) Analysis.

VI. MILK. (*a*) Cream. (*b*) Whey. (*c*) Curd.

VII. BILE. (*a*) Resin. (*c*) Picromel. (*c*) Gall-stones.

VIII. URINE. (*a*) Analysis. (*b*) Diseased.

1. *Urinary Calculi.* (*a*) Lithic acid series.

(*b*) Oxalate of lime series. (*c*) Cystic oxide and phosphate of lime.

IX. CHEMICAL CHANGES OF THE FUNCTIONS OF ANIMALS. (*a*) Digestion. (*b*) Respiration. (*c*) Secretion.

X. FERMENTATION. (*a*) Putrefaction.

At the close of the session, an examination for prizes and certificates of honour is instituted and conducted by means of written answers to printed questions.

FINIS.

R. CLAY, PRINTER, BREAD-STREET-HILL.