

# **Syllabus of the course of lectures on medical chemistry delivered in the Medical Department of Pennsylvania College / by John J. Reese.**

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Philadelphia : Lindsay & Blakiston, 1857.

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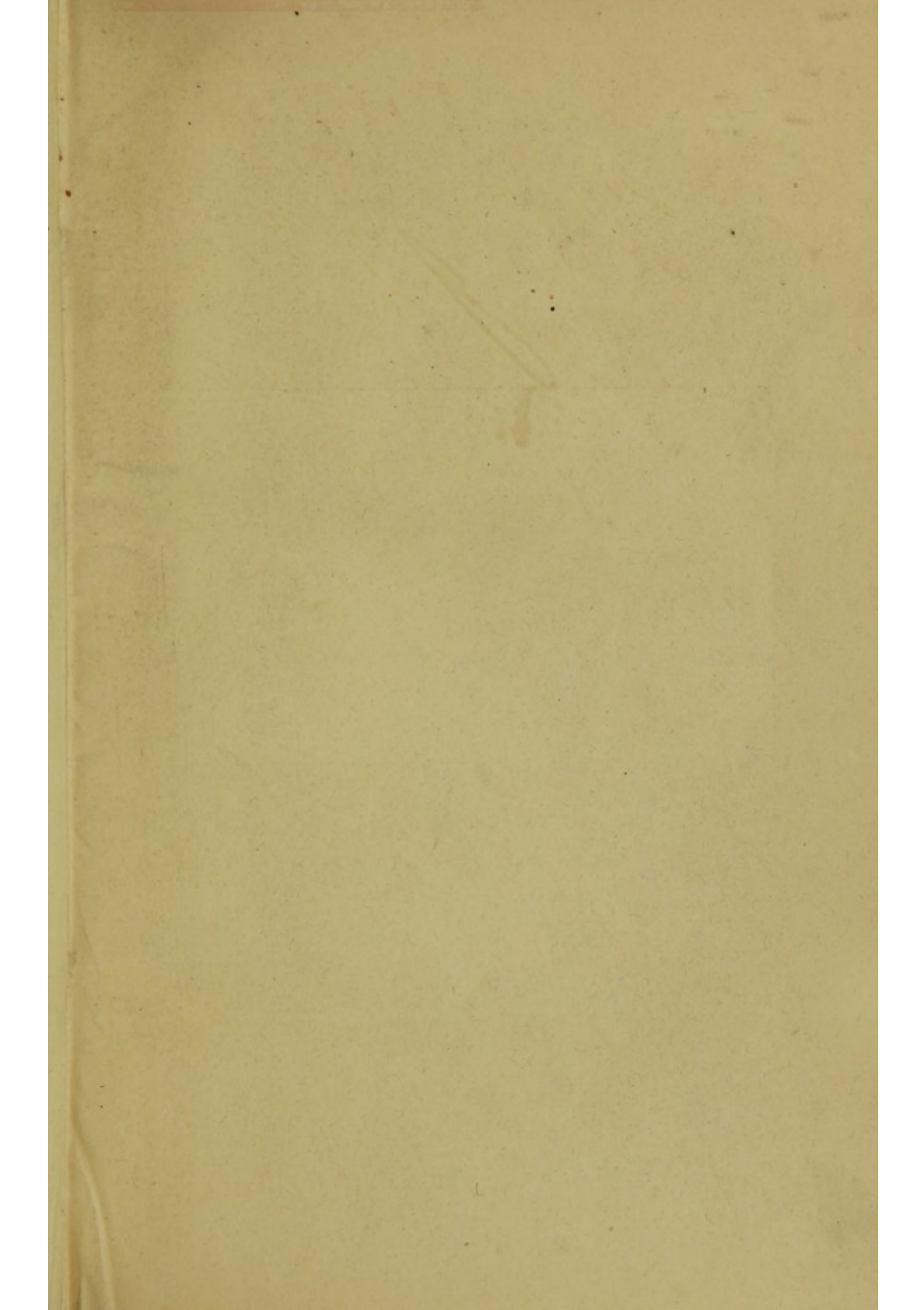
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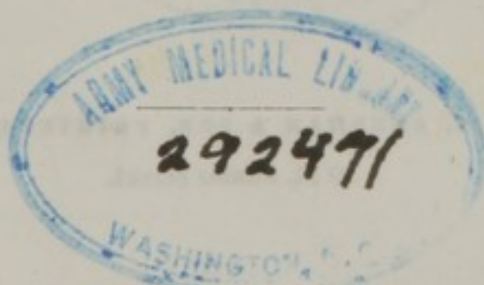
SYLLABUS

THE COURSE OF LECTURES

MEDICAL CHEMISTRY

SYLLABUS  
OF  
THE COURSE OF LECTURES  
ON  
MEDICAL CHEMISTRY,  
DELIVERED IN THE  
MEDICAL DEPARTMENT OF PENNSYLVANIA COLLEGE.

BY  
AMES  
JOHN J. REESE, M.D.,  
PROFESSOR OF MEDICAL CHEMISTRY.



PHILADELPHIA:  
LINDSAY & BLAKISTON.  
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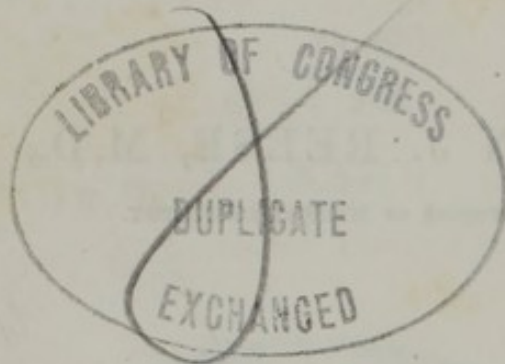
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TO  
THE STUDENTS OF MEDICINE  
OF PENNSYLVANIA COLLEGE,

*This Volume*  
IS RESPECTFULLY DEDICATED,

BY THEIR FRIEND,

THE AUTHOR.



## P R E F A C E.

---

IN preparing the following Syllabus of his Course of Lectures on Chemistry, the author has been actuated by an earnest desire to facilitate the labors of the medical student in acquiring a knowledge of this branch of his Profession.

It were much to be desired that the student of medicine had already become familiar with the general details of Chemistry, before commencing his attendance upon the Lectures. But unfortunately, the case is too often the reverse; and, from the necessity of the matter, the teacher is compelled to occupy time in the discussion of elementary subjects, which otherwise, might be more appropriately employed. The author is fully aware of the difficulty experienced by the student in obtaining clear and systematic ideas of this department of his studies, especially with his mind crowded



with the other branches of medicine at the same time. He has endeavored to present his subject in as analytical a manner as possible, arranging the various topics according to their natural order, and dwelling more particularly on those points which are of greatest practical value.

The work can only be appreciated in connection with the author's Lectures; and therefore it can lay no claim to criticism as an independent treatise. It may probably prove useful to the teacher, in the examination of his pupils; and by the latter, it is hoped, it will be found a valuable aid, both in the class-room, and in the study.

PHILADELPHIA, October, 1857.

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# SYLLABUS OF LECTURES.

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## PART I.

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2. *Light*.—The light between two charcoal points.—Proof

that it is not the effect of combustion.—Applications in the arts.

3. *Chemical Effects.*—*Electrolysis.*—Definite action of the electricity.—Two essential conditions for electrolysis.—Faraday's researches.—Secondary decompositions.—Electrotyping and electroplating.

4. *Magnetic Effects.*—*Electro-Magnetism.*—Modes of estimating current electricity.—(a) By the galvanometer.—(b) By the voltameter.



## ELECTRO-MAGNETISM.

Observed effects of lightning on the compass.—Experiments of Ørsted and Ampère.

Directions of a magnetic needle, under the influence of an electric current.—The galvanometer.

An *electro-magnet* defined.—Helices acting as magnets (De la Rive).

Horseshoe electro-magnet.—Its power.—Mode of making a permanent magnet, by galvanic electricity.—Motion produced.—Application as a motor force to machinery.—The electro-magnetic engine.—Obstacles to its use.

Electro-magnetic machines.

The electro-magnetic telegraph explained.

*Secondary* or *induced* galvanic currents explained and illustrated.—The vibrating machine, or *electrotome*.—Its use in medicine.

Power of magnetism to produce a galvanic current.—*Magneto-electric* machines.—Their superiority over the *electrotome*, in medical practice.

*Thermo-Electricity*. — Effect of heating two dissimilar metals, in contact.—The Thermo-multiplier of Melloni.

Probable cause of the earth's magnetism.

## ANIMAL ELECTRICITY.

Evidence that electricity is generated by living animals, from the fact that every life-action is accompanied by *chemical* changes.

Dynamic electricity exhibited in the highest state of tension in the Electric Ray or Torpedo, and in the Electric Eel or Gymnotus.—Anatomical arrangement of the *electrical apparatus* in these fishes.—Mode of receiving a shock.—Proof that it is common electricity which is thus evolved.

Muscular contractions excited by electricity.—Extreme sensitiveness of a freshly-dissected frog's leg.

Electrical currents naturally existing in the muscles, and other parts of the body.

Effects of electricity upon animals.

Difference between the effects of a *direct* and an *inverse* current upon a muscle.—Deductions for the therapeutical application of electricity.

Influence of the *interrupted* currents.

Theories of the *origin* of muscular electricity (Liebig and Matteucci).

Probable use of the muscular currents.

Question as to the identity of animal electricity and the *nerve-force*.

Therapeutical applications of electricity.—Instruments employed.



## PART II.

### INORGANIC CHEMISTRY.

SUBSTANCES, as usually presented to the chemist, are complex.—An *element* defined.—Number of elementary bodies at present known.—The tendency of these elements to combine together, constitutes chemical affinity.

Illustration of the distinction between the solution of a substance in water, and true chemical combination.—Chemical affinity between bodies always takes place in definite proportions; and these latter are termed their *equivalents*, or *combining proportions*.

Table of chemical equivalents.—Two standards adopted,—one in which hydrogen is taken as 1; the other, in which oxygen is taken as 100.

Dalton's *atomic theory*.

Different cases of affinity:

1. *Simple Combination*:—When two bodies, A and B, combine together, to form a compound AB.—Examples.

2. *Single Elective Affinity*:—Where a single body, A, decomposes a compound body, BC, and unites with either B or C, to form a new compound, AB, or AC.—Examples.

3. *Double Elective Affinity*, or double decomposition:—Where two compound bodies mutually decompose each other,



forming two new compounds; as AB and CD, forming AC, and BD.—Examples.

4. A third body being added to two others already combined, unites itself with both,—as A uniting with CD, to form ACD.—Example.

The laws which regulate chemical combination by weight, are termed the “Laws of Combination.”—They are as follows:

1. The Law of Definite Proportions.—Explanation.
2. The Law of Equivalents.—Explanation.
3. The Law of Multiple Proportions.—Explanation.
4. The Law for Compound Bodies.—Example.

The circumstances influencing Chemical Affinity, and the changes accompanying it, have already been considered under Part I.

## CHEMICAL NOMENCLATURE.

Chemical Nomenclature very unsettled until the time of Lavoisier, who originated the present system, in 1787.

The names of elementary bodies often arbitrary;—but frequently have reference to some property they may possess.—Examples.

The Latin or Greek name given.—Rule, where the substance is composed of two elements, that the most electro-negative shall take precedence.—Example.

Rule, if the electro-negative element be in more than one proportion, that the Greek or Latin numeral shall be prefixed.—Examples.

Rule, where the electro-positive element is more than one. Signification of the word *sesqui*.—Mode of termination, if the compound is *acid*.

Application of the terms *hypo* and *hyper*.

Nomenclature of salts formed from acids terminating in *ous* and *ic*.

Nomenclature of salts containing more than one equivalent of acid.

Failure of this nomenclature in Organic Chemistry.

Advantage and use of Symbols.



## SIMPLE, OR ELEMENTARY BODIES.

Division of elementary bodies into the two classes of *non-metallic* and *metallic*.

*Thirteen* only belong to the former division.

## OXYGEN.

Symbol, O.—Equivalent, 8.

Universal prevalence in nature.—Discovered by Priestley, in 1774, and by Scheele, subsequently.—Name.

Management of gases.—Pneumatic trough.

Mode of procuring:—from oxide of mercury,—from peroxide of manganese,—from chlorate and nitrate of potassa.—Rationale.—To be collected over water.

Properties.—A permanent gas.—Neutral,—colorless,—inodorous.—Specific gravity, 1.1057.—A powerful supporter of combustion and of respiration;—not combustible.—Illustrations.

Its union with other bodies gives rise to the formation of *oxides* or *acids*.

Proof that it is the oxygen of the atmosphere which supports respiration and combustion.

Effects of breathing pure oxygen.

Physiological uses of oxygen in respiration.—Quantity of



oxygen consumed in respiration.—A body undergoing combustion in oxygen always gains weight.

The quantity of *heat* evolved is proportionate to the amount of oxygen consumed;—and is the same, whether from rapid or slow combustion.

Term *Combustible*.—Products of ordinary combustion.—Nature of the air remaining after combustion.—Evolution of heat explained.

Heat evolved by the germination and flowering of plants.—Animal heat.

Therapeutical use of oxygen.—Ozone.

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## HYDROGEN.

Symbol, H.—Equivalent, 1.—Discovered by Cavendish, in 1766.—Name.—Exists in nature.—Obtained by the decomposition of water by several processes.—Rationale.—Cause of the impurity, as usually procured.—Self-regulating reservoir of Dr. Hare.

*Properties*.—*Physical*.—Color, taste, and smell.—Specific gravity, 0.692.—Its levity shown.—Its employment for balloons now superseded by coal gas.—Its great diffusibility.

*Chemical*.—Neutral.—A non-supporter of combustion, but combustible.—Has a strong affinity for oxygen.—A powerful deoxidizer.—Forms an explosive mixture, with oxygen, in certain proportions.—Color of the flame.—Result of combustion in air or oxygen shown.

Philosophical candle.—Musical sounds.

Effect of spongy platinum on a mixture of hydrogen and oxygen.—Dobereiner's lamp.—Explanation.

Great heat of the hydrogen flame.—Oxy-hydrogen blow-pipe.

—Effect of this jet on lime or magnesia.—Application to the Drummond light, and the microscope.—Effect of breathing pure hydrogen.—Strong analogy between the chemical habitudes of hydrogen and the metals.—Influence as to its nature.

#### COMPOUNDS OF HYDROGEN AND OXYGEN.

*Protoxide of Hydrogen.*—*Water.*—Symbol, HO.—Equivalent,  $1+8=9$ .—Its composition demonstrated both by analysis and synthesis.

*Properties.*—*Physical.*—Color, taste, and odor, when pure.—Specific gravity, 1.—Highly refractive of light.—A good conductor of electricity.—Freezing and boiling points.—Greatest density at about  $40^{\circ}$  F.—Never exists pure in nature.—Usual impurities.—Composition of the air existing in water.—Obtained pure only by distillation.—Source of the salines found in springs.—Filtration.—Soft and hard waters.—Remedy for hard waters.

*Chemical.*—Neutral.—A powerful solvent.—Solvent power over salts is usually increased by heat.—Exceptions.—Effect of a temperature above  $212^{\circ}$  upon its solvent properties.—Water acts as a feeble acid, forming *hydrates*.—Examples.—As a base.—Examples.—Necessity for water in the strongest acids.—As water of crystallization.—As water of constitution.—Examples.

Classification of saline springs.

Tests for the impurities of common water :—For the carbonic acid ;—Chloride of sodium ;—Sulphate of lime ;—Carbonate of lime.

Importance of a due supply of water to health.—Impurities in water often a source of disease.—Effects of a deficiency of water in the animal economy.—Effects of an excess.



*Deutoxide, or Binoxide of Hydrogen.*—Symbol,  $\text{HO}_2$ .—Equivalent,  $1+16=17$ .—Obtained.—Properties.—A liquid.—Sinks in water.—Specific gravity, 1.4.—Bleaches.—Facility of decomposition.

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## NITROGEN.

Symbol, N.—Equivalent, 14.—Name.—Name *azote* given by Lavoisier.—Discovered by Rutherford.—Exists in nature.—Proportion in the atmosphere.—Necessity of it in the food of animals.—Also in the alkaloids.

Modes of obtaining: (1.) By burning out the oxygen from a limited portion of atmospheric air, by means of phosphorus;—impurities.—(2.) By passing atmospheric air over copper heated to redness.—(3.) By passing chlorine through a solution of ammonia;—danger.—(4.) By action of dilute nitric acid on muscular flesh.

*Properties.*—Neutral.—Irrespirable, though not poisonous.—Indifferent to nearly all bodies in its free state.—Not so in its nascent condition.—Specific gravity, .972.—Not absorbed by water.—Probable use of it in the atmosphere.—Not employed in medicine.—Gradual combination of the nitrogen and oxygen of the air, under the influence of electricity.

Nitrogen forms with oxygen five compounds, and one mixture.

### *The Atmosphere.*

A mixture of nitrogen and oxygen, and not a chemical compound.—Composition by weight and volume.

*Physical Properties* already discussed.

*Chemical Properties.*—Color, taste, and smell, when pure.—Other matters usually contained in the atmosphere.—Pro-

portion of *carbonic acid*.—Sources.—Proof of its existence.—Variation in its quantity.—Use of it in the vegetable world.—*Watery vapor* of the atmosphere.—Variable quantity.—Humidity and dryness of the atmosphere.—*Ammonia* in the atmosphere.—Use of it.—Other impurities of the atmosphere.—Great importance of the law of “diffusibility of gases” to the integrity of the atmosphere.

Analysis of the air.—(1.) Eudiometry.—Eudiometers:—Hope’s.—Ure’s, &c.—Dr. Hare’s Volumscope.—Principle involved in analyzing the atmosphere by hydrogen.—(2.) By passing the air over copper heated to redness, in a porcelain tube.—(3.) By the slow oxidation of phosphorus in a known quantity of atmospheric air.

Chemical influence of the atmosphere on surrounding bodies.—Seen in oxidation, fermentation, and decomposition.—Difference in the composition of the atmosphere at the present time, and at the earlier epoch of the earth’s history.

Influence of atmospheric variations on health.

#### COMPOUNDS OF NITROGEN AND OXYGEN.

*Protoxide of Nitrogen*.—*Nitrous Oxide*.—*Laughing Gas*.—Symbol, NO.—Equivalent,  $14 + 8 = 22$ .—Obtained by decomposing nitrate of ammonia by heat.—Rationale.

*Properties*.—Color, odor, and taste.—Liquefied by a pressure of fifty atmospheres.—Absorbed by water.—How collected.—Nearly as good a supporter of combustion as oxygen.—Specific gravity, 1.52.—Products when exploded with hydrogen.—Effects of inhaling it into the lungs.—Physiological explanation.—Therapeutical uses.

*Deutoxide, or Binoxide of Nitrogen*.—*Nitric Oxide*.—Symbol, NO<sub>2</sub>.—Equivalent,  $14 + 16 = 30$ .—Procured by action of nitric acid on metallic copper.—Rationale.



**Properties.**—Colorless.—Irrespirable.—A non-supporter of combustion generally, although containing twice as much oxygen as the protoxide.—**Explanation.**—Specific gravity, 1.039.—Great affinity for oxygen shown.—Its employment for analyzing the atmosphere.—Effect on a solution of protosulphate of iron.—Effect of burning it with an equal measure of hydrogen.—Effect of certain of the more oxidizable metals on it.

*Nitrous Acid.*—(*Hyponitrous Acid.*)—Symbol,  $\text{NO}_3$ .—Equivalent,  $14 + 24 = 38$ .—Specific gravity.—Direct mode of forming it, by combining together four measures of the deut-oxide of nitrogen with one of oxygen, and condensing it by means of cold.

**Properties.**—Effect of water upon the liquid.—Cannot be made to unite directly with bases.—Nitrate of lead and nitrate of soda, how made.—It combines with several of the strong acids, to form compounds.

*Peroxide of Nitrogen.*—(*Nitrous, or Hyponitric Acid.*)—Symbol,  $\text{NO}_4$ .—Equivalent,  $14 + 32 = 46$ .—Reason for name.—Want of all acid properties.—Obtained by uniting together two measures of deutoxide of nitrogen, and one of dry oxygen, and condensing by means of cold,—or by the distillation of nitrate of lead.—Rationale.

**Properties of the liquid.**—Specific gravity, 1.45.—Great volatility.—Corrosive.—Effect of water.—Its vapor absorbed by strong nitric acid.—Decomposed by the oxidizable metals.

*Nitric Acid*—(*Azotic Acid.*)—Symbol,  $\text{NO}_5$ .—Equivalent,  $14 + 40 = 54$ .—Commercial name.—Its composition first determined by Cavendish.—A trace of it discoverable in the atmosphere, after a thunder-storm.—Occurs in nature only in combination with bases.—Origin.

Mode of preparation, by action of oil of vitriol on nitrate of



potassa, or nitrate of soda.—Rationale.—Importance of using two equivalents of sulphuric acid.

Properties, when pure.—Colorless.—Specific gravity, 1.52.—Contains one equivalent of water.—The anhydrous acid is destitute of acid properties.—Boils at 184° F., and freezes at 40°;—fumes in the air;—becomes yellowish by exposure.—Its action on tin and iron.

Another definite hydrate exists, containing four equivalents of water.—Specific gravity, 1.42;—boils at 250°F.—Effect of boiling nitric acid of different strengths, is to reduce them to one uniform standard of 1.42,—the strength of the ordinary acid of the shops.—Yellow color due to the peroxide in solution.—Effect of water.—Fuming nitric acid.

Impurities of the common acid,—detected.—Corrosive properties.—Effect on the skin.—A powerful oxidizer.—Effect on red-hot charcoal,—on oil of turpentine;—sulphur and iodine;—on metals; on vegetable substances.—Action of the strong acid on paper and cotton.—How decomposed.—Uses.

Character of the *nitrates*.—Their uses.

Poisonous effects of nitric acid.—Antidotes.

*Tests*.—For the strong acid:—Copper,—Morphia.—For the diluted acid:—Sulphate of indigo;—Protosulphate of iron;—Copper filings.—Mode of proceeding to detect it in a nitrate.—Its most important salts.

#### COMPOUNDS OF NITROGEN AND HYDROGEN.

*Ammonia*.—Symbol,  $\text{NH}_3$ .—Equivalent,  $14+3=17$ .—Name.—Exists naturally in small quantities in the air; also in the soil, as the product of organic decomposition.

Prepared by heating together sal ammoniac and quicklime.—Rationale.—Must be collected over mercury, or by displacement.

*Properties*.—A colorless gas,—very pungent,—has a power-



ful alkaline reaction.—Forms salts with acids.—Specific gravity .589.—Absorbed by water.—Extinguishes flame.—Liquefied by a pressure of 6.5 atmospheres, at 60°.

*Solution of Ammonia.*—*Liquor Ammoniac*, or *Aqua Ammoniac*.—Prepared by passing gaseous ammonia into water.—Of different strengths.—Properties.—Impurities detected.—Strength of solution estimated.

Analysis of ammonia by electricity.

Tests for ammonia.

Uses of ammonia by plants.

*Salts of Ammonia.*—Deferred.

*Ammonium.*—Symbol,  $\text{NH}_4$ .—A hypothetical metal.—Its consideration postponed.

*Amidogen.*—Symbol,  $\text{NH}_2$ .—A hypothetical radical,—has never been isolated;—only in combination as an *amide*.

## SULPHUR.

Symbol, S.—Equivalent, 16.

Occurs in nature free, and combined with certain metals, as sulphurets;—and also in certain organic bodies.—Mode of extraction.—Commercial varieties.—Brimstone and flowers of sulphur.—*Sulphur lotum*, or washed sulphur.—*Sulphur præcipitatum*.

*Properties.*—Color.—Odor.—Solubility.—Specific gravity, 1.98.—Fusing-point.—Effect of an increase of heat.—Boiling-point.—Density of vapor.—Best mode of procuring crystals.—Dimorphism of Sulphur.—Inflammability.—Result of combustion in the air, or oxygen.—Resembles oxygen in its habitudes.—Its vapor a supporter of combustion.

Uses in the arts and in medicine.

## COMPOUNDS OF SULPHUR AND OXYGEN.

*Hyposulphurous Acid*.—Symbol,  $S_2O_2$ .—Equivalent,  $32 + 16 = 48$ .

Mode of forming a hyposulphite.—The acid cannot be isolated from a base.

Useful property of the alkaline hyposulphites to dissolve the haloid salts of silver; hence their employment in photography.

*Sulphurous Acid*.—Symbol,  $SO_2$ .—Equivalent,  $16 + 16 = 32$ .—The product of the combustion of sulphur in dry air or oxygen.

Prepared by boiling sulphuric acid, or copper, or mercury.—Rationale.

*Properties*.—A colorless, suffocating gas, a non-supporter of combustion.—Specific gravity, 2.21.—Liquefied at  $0^\circ$ .—Very soluble in water.—Action of the air upon its solution.—Effect on colors.

The *sulphites* of no practical importance.—Effect of nitric acid upon them.

Therapeutical uses.

*Sulphuric Acid*.—*Oil of Vitriol*.—Symbol,  $SO_3$ .—Equivalent.— $16 + 24 = 40$ .

Discovered by Basil Valentin.—Great importance to the chemist and in the arts.—Old method of preparation.—Fuming acid of Nordhausen.—Rationale.

Present mode of preparation.—Rationale.—Mode of concentration.—Impurities.—Properties of Nordhausen acid ( $2SO_3 + HO$ ).—Dark color.—Fumes in the air.—Specific gravity, 1.9.—Effect of distilling.

*Anhydrous Sulphuric Acid*.—Properties.

*Properties of Oil of Vitriol*.—( $SO_3 + HO$ ).—A dense, oily, colorless liquid.—Specific gravity, 1.85.—Very corrosive,—



The most powerful of the acids.—Effect on organic bodies.—Boils at  $620^{\circ}$ ; freezes at  $-15^{\circ}$ .—Strong affinity for water.—Changes of temperature produced by combining together sulphuric acid and water, in different proportions.

*Hydrates of Sulphuric Acid.*— $2\text{SO}_3 + \text{HO}$  (*Nordhausen*);  $\text{SO}_3 + \text{HO}$  (oil of vitriol);  $\text{SO}_3 + 2\text{HO}$ ;  $\text{SO}_3 + 3\text{HO}$ .

Mode of ascertaining the quantity of real acid in any given specimen.

Diverse action of oil of vitriol on the metals.—Sometimes contains arsenic as an impurity.

*Test*, for the undiluted and the diluted acids.

Its vapor, how decomposed.—The most important *sulphates*.

*Chloro-sulphuric, Nitro-sulphuric, and Azoto-sulphuric Acid.*

*Hyposulphuric Acid.*—Symbol,  $\text{S}_2\text{O}_5$ .—Equivalent,  $32 + 40 = 72$ .

Mode of preparing it in solution.—Properties.—The *hyposulphates*.

*Trithionic*, or Sulphuretted Hyposulphuric Acid,  $\text{S}_3\text{O}_5$ , or  $\text{S}_2\text{O}_5 + \text{S}$ .

*Tetrathionic*, or Bisulphuretted Hyposulphuric Acid,  $\text{S}_4\text{O}_5$ , or  $\text{S}_2\text{O}_5 + \text{S}_2$ .

*Pentathionic*, or Trisulphuretted Hyposulphuric Acid,  $\text{S}_5\text{O}_5$ , or  $\text{S}_2\text{O}_5 + \text{S}_3$ .

#### COMPOUNDS OF SULPHUR AND HYDROGEN.

*Sulphydric Acid—Sulphuretted Hydrogen*,—or *Hydrosulphuric Acid*.—Symbol,  $\text{SH}$ .—Equivalent,  $16 + 1 = 17$ .

Sulphur and hydrogen will only combine directly in the nascent condition.

Exists naturally in sulphurous waters;—also as a product of organic decomposition.

Modes of preparation.—Rationale.

*Properties.*—Colorless.—Fetid odor and taste;—poisonous if inhaled;—reddens litmus;—absorbed by water.—Natural sulphur springs.—A non-supporter of combustion, but combustible.—Products of combustion.—Is decomposed by chlorine. Specific gravity, 1.19.—Liquefied by pressure of seventeen atmospheres at 50°.—It detonates when mixed with oxygen in certain proportions.—Effects of strong nitric acid.

Its great value to the chemist as a test.—Used either in solution, or better in the gaseous form.—Action on metallic solutions.—Tests.—Therapeutical use of sulphur waters.

Relation to miasmata.

*Bisulphuretted Hydrogen*,  $\text{HS}_2$ .—Mode of preparing.—Properties.—Resembles the Binoxide of Hydrogen.

*Compound of Sulphur and Nitrogen.*—*Sulphide of Nitrogen*,  $\text{NS}_3$ .

## SELENIUM.

Symbol, Se.—Equivalent, 39.—Discovered by Berzelius, in 1817, in a specimen of Swedish sulphur.—Name.—Usually found associated with sulphur, in minute quantities.

*Properties.*—A brittle, grayish-colored, solid, non-metallic, though having a metallic lustre.—Specific gravity, 4.3.—Without odor or taste.—Softens by heat, fuses at 482°.—Peculiar odor of its vapor, by which it may be recognized.—Resembles sulphur in its habitudes.

### COMPOUNDS OF SELENIUM AND OXYGEN.

The *Oxide* is doubtful.

*Selenious Acid*,  $\text{SeO}_2$ .—Analogous to sulphurous acid.—



Mode of preparing.—Properties.—A very strong acid, displacing nitric and chlorohydric acids, but not sulphuric.—Forms *selenites*.

*Selenic Acid*,  $\text{SeO}_3$ .—Analogous to sulphuric acid.—How obtained.—Properties.—Forms *selenates*.

#### SELENIUM AND HYDROGEN.

*Selenhydric Acid—Hydroselenic Acid—or Seleniuretted Hydrogen*,  $\text{HSe}$ .—Analogous to sulphuretted hydrogen.—Mode of procuring.—Properties.

#### PHOSPHORUS.

Symbol, P.—Equivalent 32.

Exists in the organic and inorganic kingdoms.—Its importance in the animal economy,—being an essential ingredient of bones and of nerve-substance.—Proportion in the brain.

Discovered by Brandt, of Hamburg, in 1660, in urine.—Name.

Mode of preparation.—Purified.

Properties.—A translucent, solid, waxy lustre.—Specific gravity, 1.77.—Melts at  $108^\circ \text{F}$ .—boils at  $550^\circ \text{F}$ .—Should be kept under water.—Danger of handling.—Proper solvents.—Effect of light.—Nature of *red phosphorus*.—Crystals.—Inflammability.

Effect of exposure to the air.—Nature of the vapors evolved.—Effect of inflammable gases on the slow oxidation of phosphorus.—Result of burning in the air, or in oxygen.—Use of phosphorus for manufacture of lucifer matches.—Poisonous properties.

## COMPOUNDS OF PHOSPHORUS AND OXYGEN.

*Oxide*,  $P_2O$ .—Mode of obtaining.—Properties.

*Hypophosphorous acid*,  $PO$ .—Formed indirectly by the mutual reaction of phosphorus, water, and an alkali.—Properties.—A powerful deoxidizer.—Forms salts.

*Phosphorous Acid*.—Symbol,  $PO_3$ .—Equivalent, 56.—Produced by the slow oxidation of phosphorus in the air.—Obtained anhydrous.—Properties.—Properties of the solution.—Strong affinity for oxygen.—Forms *phosphites*.

*Phosphoric Acid*.—Symbol,  $PO_5$ .—Equivalent, 72.—Obtained anhydrous.—Properties.

Modes of procuring the hydrated acid.—*Glacial phosphoric acid*.—Properties.

The *polybasic* nature of phosphoric acid.

Three hydrates :

$3HO, PO_5$ , or tribasic phosphoric acid.

$2HO, PO_5$ , or bibasic phosphoric acid.

$HO, PO_5$ , or monobasic phosphoric acid.

The first of these, or *common phosphoric acid*—how obtained.—Characters.—Test.—Salts.

The second, also named *pyrophosphoric acid*.—How procured.—Character.—Salts.

The third, also named *metaphosphoric acid*.—How obtained.—Character.—Salts.

The phosphates found in the animal solids and fluids,—also in urinary deposits and calculi.

The phosphates existing in plants—how derived.—Phosphatic manures.

## COMPOUNDS OF PHOSPHORUS AND HYDROGEN.

Three allotropic conditions.—Difference of their properties.



*Gaseous Phosphuretted Hydrogen*,  $\text{PH}_3$ .—Obtained.—Rationale.—How collected.—Properties.—Colorless.—A non-supporter of combustion.—Inflammable.—Phenomenon accompanying its escape into the air, or oxygen gas.—Cause of its combustibility.—Effect on metallic solutions.

*Solid Hydride of Phosphorus*,  $\text{P}_2\text{H}$ .—Formed.—Properties.

*Liquid Hydride of Phosphorus*,  $\text{PH}_2$ .—Formed.—Properties.

*Phosphorus and Nitrogen*,  $\text{PN}_2$ .—A solid, easily decomposed by heat.

*Phosphorus and Sulphur* unite in several proportions, often with explosive violence.—Properties.

## CARBON.

Symbol, C.—Equivalent, 6.

Exists abundantly in the organic and inorganic kingdoms.—The chief constituent of animals and vegetables.—Dimorphous states.

Physical characters :

- Varieties.—1. The *diamond* the purest.—Localities.—Color.—Shape.—Specific gravity, 3.5.—Origin.—Infusibility out of the air.—Proof of its nature.—Hardness.
2. *Graphite* or *Plumbago*.—Localities.—Shape of crystals.—Composition.—Artificial formation.—Specific gravity, 1.9 to 2.3.
3. *Anthracite*.—Amorphous.—Very nearly pure carbon, but differs in its purity.
4. *Charcoal from Wood*.—Mode of preparing on a large scale.—Impurities.—Obtained for chemical purposes.

5. *Lamp-black*.—Mode of preparation.—The purest variety from alcohol, or oil of turpentine.
6. *Coke*.—The residue from the distillation of bituminous coal.—Impurities.—Use.
7. *Animal Charcoal*—(Ivory or Bone Black).—Mode of preparation.—Properties.—Impurities.—Remarkable attraction for organic coloring matters.—Its value to the chemical manufacturer.—Effect on the vegetable alkalies.—Use as an antidote.

Appearance of common charcoal.—Difference in its density.—Property of absorbing gases.—Effect on noisome gases;—on tainted meat;—on foul water.

*Uses of Charcoal*: as a fuel;—in the laboratory as a powerful deoxidizer;—in metallurgy, for the reduction of various oxides;—in the arts, for the manufacture of steel, printing-ink,—and as a pigment.

#### COMPOUNDS OF CARBON AND OXYGEN.

*Carbonic Oxide*.—Symbol, CO.—Equivalent,  $6+8=14$ .—Modes of obtaining it: (1.) By passing carbonic acid over red-hot charcoal. (2.) By action of sulphuric acid on oxalic acid, by aid of heat.—(3.) By action of sulphuric acid on ferrocyanide of potassium.—Rationales.

*Properties*.—A colorless gas,—combustible.—Specific gravity, .972.—Very poisonous.—Products of its combustion.—Unites with chlorine to form *phosgene* gas.

*Carbonic Acid*.—Symbol, CO<sub>2</sub>.—Equivalent,  $6+16=22$ .—Discovered by Dr. Black, and named *fixed air*.—Sources of it in nature.—Preparation.—Rationale.—Collected over water, or by displacement.—Dried.

Properties.—Color, odor, and taste.—Specific gravity, 1.52.



—A non-supporter of combustion and respiration.—Incombustible.—Solubility in water,—increased by pressure.—*Artificial mineral water*, or *carbonic acid water* formed.—Liquefied by a pressure of twenty-eight atmospheres, at 32°F.—Solidified.—Intense cold produced by its evaporation.

A feeble acid.—Effect on litmus,—on lime-water.—Exists naturally in certain waters, and in fermented liquors.—Effervescence.—Fatal effects of breathing it.—Importance of ventilation.—Accumulation in wells.—Mode of purifying.

Proof of its existence in expired air.—The quantity varies at different periods of the day, averaging from 3 to 4 per cent. (Prout.)—It is also produced in the germinating and flowering of plants, but is consumed in their healthy growth.

Amount existing in the atmosphere.—Its accumulation prevented.

Test.—The *carbonates*,—test for.—Therapeutical uses of carbonic acid.

Mode of treating its poisonous effects.

*Oxalic Acid*, and the other compounds of carbon and oxygen, are deferred to Organic Chemistry.

#### COMPOUNDS OF CARBON AND HYDROGEN.

The *Hydrocarbons* are very numerous, and properly belong to the department of Organic Chemistry, since they are the result exclusively of organic decomposition. Two of them, only, will be alluded to under the present division.

*Light Carburetted Hydrogen*.—Synonymes.—*Marsh Gas*.—*Gas of the Acetates*.—*Dicarburet of hydrogen*.—Symbol,  $\text{CH}_4$ .—Equivalent, 8.

Exists in nature,—at the bottom of stagnant marshes, in combination with carbonic acid;—also in certain coal-mines, constituting the explosive *fire-damp*.—A constituent of coal gas.—Obtained by agitating the bottoms of marshes, and col-

lecting the gas in a receiver.—The carbonic acid separated by means of lime-water.

Prepared by heating together dry acetate of soda, and hydrates of potassa and lime; the gas results from the decomposition of the acetic acid.

*Properties.*—Without color, taste, or smell.—Specific gravity, .554.—Partially respirable.—Very combustible, with a bright flame.—A non-supporter of combustion.—Products of combustion.—Detonates with air or oxygen.—A very high temperature requisite to ignite it.—Davy's *safety lamp*.—Analysis by oxygen.—Effect of chlorine.

*Bicarburetted Hydrogen.*—Named also *Heavy Carburetted Hydrogen*, and *Olefiant Gas*.—Symbol,  $C_2H_2$ .—Equivalent, 14.

Prepared by the action of sulphuric acid on alcohol, by the aid of heat.—Rationale.—Substances generated at the same time.—Purified.

*Properties.*—Colorless, tasteless, nearly inodorous.—Specific gravity, .985.—Not absorbed by water.—A non-supporter of combustion, but very combustible.—Products of combustion.—Luminous character of flame.—A constituent of coal gas.—Analysis by oxygen.—Detonates with air or oxygen.—Forms with chlorine *Dutch liquid*.—Results of ignition with chlorine.

### *Coal and Oil Gases.*

Variety of coal employed in the manufacture of coal gas.—Nature of apparatus used in the distillation.—Three sorts of products resulting: (1.) Permanent gases.—(2.) The ammoniacal liquor.—(3.) The coal-tar.—Circumstances affecting the relative proportion of these several products.—Mode of purifying the gas.—Mode of collecting it.—Composition of the *purified* gas.—The matters separated.



The *illuminating* property of the gas depends upon the light and heavy carburetted hydrogen present; and these vary considerably, according to the period of the process of distillation.

Illuminating gas of excellent quality, is also manufactured from oil and rosin.

#### COMBUSTION, AND THE STRUCTURE OF FLAME.

Terms, *red-hot*, *white-hot*, and *incandescence*.—Difference between these and *combustion*.—Definition of combustion.—Ordinary combustion.—Origin of the heat and light.

Modes of increasing the heat and light: (1.) By increasing the supply of air (oxygen), by means of a bellows.—(2.) By effecting the same end by lengthening the chimney or draft.—The smith's forge.—The blast furnace.—The reverberatory furnace.

Definition of "flame."—The temperature of flame is necessarily greater than the white heat of solid bodies.—The light emitted by pure flame is very feeble, as in a jet of pure hydrogen.—The *light* of flame dependent upon the elevated temperature.

Three different portions in every flame.—The oxidizing and deoxidizing points.—Effect of introducing a tube into the dark or inner cone of the flame of a lamp.—Effect of a piece of fine wire gauze upon the surface of a flame.—Proof that the combustible gas rises through the meshes of the gauze.—Cooling effect of the wire-gauze upon the flame.—Principle of the *safety lamp* explained.

The *argand burner*.—Effect of mingling atmospheric air (oxygen) with coal gas, before burning.—The *gas furnace* of the chemist.—Necessity of a full supply of oxygen to give brilliancy to the flame.

## COMPOUND OF CARBON AND NITROGEN.

*Cyanogen.*—*Bicarburet of Nitrogen.*—Symbol,  $\text{NC}_2$ , or Cy.—Equivalent,  $14 + 12 = 26$ .

Cannot be formed directly from its elements; but is generated by the decomposition of nitrogenized bodies, in the presence of an alkali,—a cyanide of the metal being formed.—These cyanides are usually made by heating nitrogenized bodies in the air with carbonate of potassa.

Cyanogen is best procured in a separate state by decomposing the cyanide of mercury by heat.

*Properties.*—A colorless gas.—Odor of peach-kernels.—Absorbed by water, and still more by alcohol.—Liquefied by a pressure of three and a half atmospheres, at the temperature of  $45^\circ$ .—A non-supporter of combustion, but burns with a roseate flame.—Products of combustion.—Specific gravity, 1.80.—Analysis by oxygen.

Cyanogen, though a compound body, resembles in its habits the halogen bodies Chlorine, Bromine, &c.—Classed among the “compound radicals.”

*Paracyanogen.*—Isomeric with cyanogen.—The most important cyanides.

## COMPOUNDS OF CYANOGEN AND OXYGEN.

Three isomeric bodies—cyanic acid, cyanuric acid, and fulminic acid. They are all, properly speaking, organic bodies.

*Cyanic acid.*—( $\text{Cy O}$ ,  $\text{HO}$ , or  $\text{C}_2\text{NO}$ ,  $\text{HO}$ .)—When cyanide of potassium is heated in the air, cyanate of potassa is formed; but the acid cannot, practically, be separated from its base, the presence of water converting it into bicarbonate of ammonia. ( $\text{C}_2\text{NO}$ ,  $3\text{HO} = \text{C}_2\text{O}_4$ ,  $\text{NH}_3$ .)



*Cyanuric acid.*— $\text{Cy}_3\text{O}_3, 3\text{HO}$ .—Obtained by decomposing urea by heat; the ammonia escapes, and the cyanuric acid remains, combining chemically with three atoms of water.

When cyanuric acid is deprived of its water of crystallization, and is heated to redness, it is converted into hydrous cyanic acid.—Characters of cyanic acid.

*Fulminic Acid.*— $\text{Cy}_2\text{O}_2$ .—Never isolated.—Is developed by the action of nitrous acid on alcohol in the presence of a salt of silver, or of mercury.—Rationale.—Character of the *fulminates*.—Use of the fulminate of mercury.

#### COMPOUND OF CYANOGEN AND HYDROGEN.

*Cyanhydric or Hydrocyanic Acid.*—*Prussic Acid.*—Symbol,  $\text{HCy}$ .—Equivalent, 27.

Discovered in 1782 by Scheele.—Exists widely in the vegetable world.

Obtained, anhydrous, by passing dry sulphydric acid gas over cyanide of mercury, and condensing dry products.—Properties.—A colorless liquid, having a powerful odor and taste of bitter almonds.—Sp. grav. .7058.—Very volatile.—Boils at  $79^\circ \text{F}$ .—A very feeble acid.—Very easily decomposed.—A violent poison.—Symptoms.—Antidotes.

Tests: 1. The silver test; 2. The iron test; 3. The copper test; 4. The sulphur test.—Mode of proceeding.

Solution of cyanhydric acid made: 1. By action of chlorohydric acid on cyanide of mercury and water; 2. By boiling dilute sulphuric acid on ferrocyanide of potassium (U. S. Phar.); 3. By tartaric acid on cyanide of potassium in solution; 4. Chlorohydric acid on cyanide of silver in water.

Properties of the dilute acid.—Strength.—Scheele's acid.—Effect of exposure to the light.—Strength of different specimens estimated.

## COMPOUND OF CARBON AND SULPHUR.

*Bisulphide of Carbon*.—Symbol,  $\text{CS}_2$ .—Equivalent, 38.—Mode of preparing.—Properties.—Great volatility.—High refractive power.—Sp. grav. 1.27.—Odor.—Inflammability.—Solvent power.—Explosiveness of vapor.

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## THE HALOGEN GROUP.

Name, *halogen*, given by Berzelius to a group of elementary bodies, comprising chlorine, bromine, iodine, and fluorine, together with one compound body—Cyanogen.—Reason for the name.—General characteristics of the group.

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## CHLORINE.

Symbol, Cl.—Equivalent, 35.5.

Exists in nature always in combination—generally as chloride of sodium. Modes of obtaining : 1. By action of chlorohydric acid on peroxide of manganese.—Rationale.—Products. 2. By action of sulphuric acid, chloride of sodium, and peroxide of manganese.—Rationale.—Products. 3. By action of nitric and chlorohydric acids.

Supposed by Scheele to be a compound body, and named *oxymuriatic acid*.—Its true nature first ascertained by Davy.—Name.—Must be collected either over water at  $90^\circ \text{F.}$ , or by displacement.



Properties.—Greenish-yellow color.—Excites violent irritation when breathed into the lungs.—Sp. grav. 2.47.—Condensed into a liquid by a pressure of four atmospheres.—Absorbed by water at common temperatures.

Effect of exposure on the solution.

Action on water at 30°.

Its affinities for hydrogen much stronger than for oxygen.—A mixture of chlorine and hydrogen, how exploded.

Chlorine a supporter of combustion in certain cases.—Its powerful bleaching qualities.—Moisture always necessary.—Bleaching by chlorine—how effected.—Used in medicine for fumigations.—The most important chlorides.

Test for chlorine.—For a soluble chloride.

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### BROMINE.

Exists where in nature.—Discovered in 1826 by Ballard, of Montpellier.—Mode of extracting it from the bittern of seawater.

Properties.—A liquid.—Odor.—Taste.—Color.—Sp. grav. 2.96.—Volatility.—Boils at 116° F.—Fuses a little below 0°.—Slightly soluble in water; much more so in alcohol and ether.—Color of vapor.—Bleaching properties.—Effect on the skin.—Its vapor supports combustion.

Most important bromides.

Test for bromine.—For a bromide.

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### IODINE.

Symbol, I.—Equivalent, 126.

Accidental discovery in 1812.—Extracts naturally in small quantities—in sea-water and sea-plants; also in springs.

How procured from *kelp*.—Nature of *kelp*.

Properties.—A solid.—Sp. grav. 4.94.—Color, taste, and smell.—Fusing-point.—Bleaching properties.—Color of the vapor best shown.—Sp. grav. of vapor 8.71.—Very slightly soluble in water; more so in alcohol and ether; also in a solution of an iodide.—Lugol's solution.

The affinities of iodine, though resembling those of chlorine and bromine, are less strong.

Test.—Color of its vapor.—Starch.—Test for an iodide.

Uses in the arts and medicine.—The most important *iodides*.—Antidote for its poisonous effects.

#### COMPOUNDS OF CHLORINE, BROMINE, AND IODINE, WITH HYDROGEN.

*Chlorohydric Acid*.—Hydrochloric acid.

*Muriatic Acid*.—Symbol, HCl.—Equivalent, 36.5. Formerly named *spirit of salt* and *marine acid*.—First procured as a gas by Priestley, in 1772.

Obtained by distilling together chloride of sodium and oil of vitriol.—Rationale.—Very rapidly absorbed by water.—Collected over mercury.

Properties.—Condensed into a liquid by great pressure and cold.—Sp. grav. 1.27.—A non-supporter of combustion and not combustible.—Effect on gaseous ammonia shown.—Absorption by water shown.—Effect of heat, or of sulphuric acid on the solution.

*Solution of Chlorohydric Acid; or Liquid Muriatic Acid*.—How prepared.

Properties.—Colorless, when pure—fumes in the air.—Yellow color due to.—Sp. grav. of the strongest is 1.21, and con-



tains 42 per cent. of real acid. The acid cannot exist without some water in combination.

Commercial acid—how purified.

Test.—Behavior with a metal.—With an oxide.

*Nitro-muriatic Acid*; or, *Aqua regia*.—Proportion of ingredients.—Rationale.—Properties.

*Bromohydric* or *Hydrobromic Acid*.—HBr.—Obtained by action of water on bromine and phosphorus.—Rationale.—Properties.

*Iodohydric*, or *Hydriodic Acid*.—HI.—Prepared as a gas, like bromohydric acid.—As a liquid, by passing sulphydric acid through water, holding iodine in suspension.—Rationale.—Properties of the solution.—Properties of the gas.

#### COMPOUNDS OF CHLORINE, BROMINE, AND IODINE, WITH OXYGEN.

*Hypochlorous Acid*.—ClO.

Procured by passing chlorine over red oxide of mercury suspended in water.—Rationale.

Properties.—An orange-colored liquid.—Boils at  $68^{\circ}$ .—Sp. grav. 2.9.—Explodes violently at  $212^{\circ}$ , being resolved into its elements.—Has powerful bleaching properties.—Forms *hypochlorites*.

Nature of commercial *bleaching salts*.—How made.—Rationale.

The *Euchlorine* of Davy, is a mixture of chlorine and chlorochloric acid.—Properties.

*Chlorous Acid*.—Hypochlorous acid.—ClO<sub>2</sub>.—Properties.—A gaseous body; very easily decomposed; of a greenish-yellow color; much absorbed by water.

Procured by deoxidizing chloric acid, as by the action of nitric acid on a mixture of chlorate of potash and arsenious acid.—Rationale.—Forms *chlorites*.

*Peroxide of Chlorine.*— $\text{ClO}_4$ .—(Graham.)—The *chlorous acid* of most writers.—Reason for the name.

Mode of preparation, by distillation of sulphuric acid and chlorate of potassa.—Rationale.—Danger of preparing it.

Properties.—A deep yellow-colored gas.—Extremely explosive.—Does not redden litmus.—Soluble in water.—The solution bleaches.—Resembles the peroxide of nitrogen ( $\text{NO}_2$ ) in many of its habitudes.—Its violent action on combustibles shown.

*Chloric Acid.*— $\text{ClO}_3$ .—The analogue of nitric acid.—Effect of passing chlorine gas through a strong solution of an alkali.—The acid obtained, in solution, by decomposing chlorate of baryta by sulphuric acid.

Properties.—Character of the *chlorates*.

*Hyperchloric Acid.*—*Perchloric Acid.*—*Oxychloric Acid.*— $\text{ClO}_7$ .—The residue after making the peroxide of chlorine.—Prepared, also, by the action of hot nitric acid on chlorate of potassa.—Rationale.

Properties.—A concentrated acid solution.—Much more permanent than the other compounds of chlorine and oxygen.—Has a strong affinity for moisture.—No bleaching properties.

*Bromic Acid.*— $\text{BrO}_3$ .—The only known oxide of bromine.—Action of bromine on a solution of a caustic alkali resembles that of chlorine, with the same results.—The bromate of baryta decomposed by sulphuric acid.

Properties.—Similar to those of chloric acid.

*Iodic Acid.*— $\text{IO}_3$ .—Obtained by oxidizing iodine by means of nitric acid, with the aid of heat.

Properties.—Crystalline.—Soluble in water.—Forms *iodates* which resemble the chlorates.

*Periodic Acid.*— $\text{IO}_7$ .—Mode of preparation.—Properties.

The halogen bodies form compounds with each other, thus :

*Chloride of Bromine.*— $\text{BrCl}_3$ .—A liquid.



*Chloride of Iodine.*— $\text{ICl}$ .—A liquid.

*Terchloride of Iodine.*— $\text{ICl}_3$ .—A solid.

There are two *Bromides of Iodine*.

*Chloride of Nitrogen.*— $\text{NCl}_4$ .—Prepared by inverting a bottle of chlorine gas over a solution of sal ammoniac.—Great danger in its preparation.—Properties.

*Iodide of Nitrogen.*— $\text{I}_2\text{HN}$ .

Prepared by the action of liquor ammoniæ on iodine.—Properties.

*Chlorides of Sulphur.*— $\text{S}_2\text{Cl}$  and  $\text{SCl}$ .—Mode of preparing them.—Properties.

*Chlorides of Phosphorus.*— $\text{PCl}_3$  and  $\text{PCl}_5$ .

The first procured by passing chlorine over melted phosphorus; the second, by the spontaneous inflammation of phosphorus in chlorine.—Properties.

Bromine and Iodine form compounds with phosphorus, similar to the above.

Bromine and Iodine both form compounds with *Sulphur*.

## FLUORINE.

Symbol, Fl.—Equivalent, 18.

Only lately isolated.—Exists in nature chiefly in combination with calcium, as *fluor spar*.—Found also in animals.—Its great tendency to form combinations.

No compound with oxygen yet discovered.

*Fluohydric* or *Hydrofluoric Acid*.— $\text{HFl}$ .

Mode of preparing similar to that for chlorohydric acid.—(Oil of vitriol on fluoride of calcium.)—Necessity for employing a leaden retort.—Properties.—Effect on glass.—Use in the arts.—Effect of acid solution on the skin.

## SILICIUM, OR SILICON.

Symbol, Si.—Equivalent, 28.

Exists in nature only in combination.

Its nature.—Mode of obtaining it.—Properties.—Effect of heating in the air.

*Silica* or *Silex*,—*Silicic Acid*.— $\text{SiO}_2$ .—The only known oxide.—Exists nearly pure in nature.—Modes of preparing it.—Reaction of fluoride of silicon on water.

Properties.—Color.—Taste.—Smell.—Solubility.—Sp. grav. 2.66.—Infusibility.—Its acid properties demonstrated.—Its action in the manufacture of glass.—Soluble glass.

*Fluoride of Silicon*—*Fluosilicic Acid*.— $\text{SiF}_4$ .—Always made when fluohydric acid comes in contact with glass.—Rationale.

Properties.—A gaseous body.—Colorless.—Forms white fumes in the air.—Sp. grav. 3.57.—Must be collected over mercury.

## BORON.

Symbol, B.—Equivalent, 10.9.

Closely allied to Silicon in properties.—Exists in nature as boracic acid and borax.—Prepared as Silicon.—Properties.

*Boracic Acid*.— $\text{BO}_3$ .—The only oxide.—Occurs in nature in the hot lagoons of Tuscany.—Prepared from borax by action of sulphuric acid.

Properties.—How vitrified.—Used in blowpipe operations.

*Borax* (Biborate of Soda).—Uses.

*Fluoride of Boron*.—*Fluoboric Acid*.— $\text{BF}_3$ .—Resembles gaseous fluoride of silicon.—Preparation.—Decomposition by water.—Results.



## THE METALS.

The metals comprise by far the largest number of elementary bodies.—Seven only were known to the ancients.—The greater proportion are of rare occurrence, and of very little practical value in medicine; others, on the contrary, are of the utmost value.—Many are of comparatively recent discovery.—With few exceptions, they are found, in nature, combined with other elementary substances.

*Physical Properties.*—They are all good conductors of heat and electricity;—possess a lustre, termed metallic;—are opaque.—(Apparent exception in the case of gold-leaf.)—Their prevailing color.—Great variation in their specific gravities;—the extremes.

Certain properties possessed by some metals, and not by others:—

1. *Malleability.*—The most malleable metals.
2. *Ductility.*—Usually accompanies malleability.—The most ductile metals.
3. *Tenacity.*—Mode of estimating it.—Iron the most tenacious metal.
4. *The welding property.*—Examples.
5. *Hardness.*—Great difference, in this respect, among metals.
6. *Elasticity and Sonorousness.*—These are closely allied to hardness.
7. *Crystallization.*—The crystalline metals.
8. *Volatility.*—The volatile metals.

The *fusibility* of metals varies as much as their density.—The extremes.

The metals are electro-positive, with respect to other simple bodies.

Believed to be elementary, or simple bodies;—having hitherto resisted all attempts at decomposition.

They have never yet been transmuted into each other.

*Chemical Relations.*—The metals possess an extensive range of affinities;—hence, are rarely found in a separate state.—They are most disposed to combine with simple bodies, as oxygen, sulphur, &c.—Effect of this combination.—Alloys.

#### I. COMBINATION WITH OXYGEN.

All are capable of uniting with oxygen, but differ greatly in their affinity for it;—this affords a ground of classification.

##### *Modes of oxidizing metals:*

1. Some spontaneously decompose water,—from their powerful affinity for oxygen.—Examples.
2. Some combine it rapidly at a high temperature.
3. By deflagration with nitrate of potassa.
4. By nitric acid.
5. By nitro-muriatic acid.

##### *Modes of reducing metallic oxides:*

1. By heat alone,—when the affinity is weak.
2. By heat and a combustible body, as hydrogen, carbon, or black flux.
3. By deoxidizing agents, as carbonic oxide, phosphorous acid, &c.
4. By the action of other metals.—Precipitation.

Metals form, with oxygen, either *acids* or *bases*;—the latter the most numerous.—The lowest oxides are the most powerful



bases;—the highest are often destitute of basic properties, and are, on the contrary, acid.—Illustrations.

The metallic oxides, generally, are insoluble in water.—Exceptions.

## II. COMBINATION WITH SULPHUR.

General rule that the sulphides correspond, in number and composition, with the oxides.—Exceptions.—Characters of the sulphides.

*Combination with sulphur effected :*

1. By heating them together.
2. By bringing the metal in contact with the vapor of sulphur.
3. By igniting together a metallic oxide and sulphur.
4. By acting on a sulphate by heat and a combustible.
5. By sulphydric acid, or sulphide of ammonium.

*The sulphides are reduced :*

1. By exposure to the action of the air.—(Into sulphates.)
2. By the combined action of heat and the air.—Results.
3. A few by hydrogen, at a red heat.

Sulphur not disposed to unite with an oxide.—Action, when boiled with an alkali.

## III. COMBINATION WITH THE HALOGEN GROUP.

With *chlorine*.—The affinity very strong.

The chlorides cannot be decomposed by heat alone, but by heat and hydrogen, or by oil of vitriol.—Characters of the chlorides.

The same remarks apply to the combinations of the metals, with *iodine*, *bromine*, and *fluorine*. The *cyanides* are more easily decomposed.

## IV. COMBINATION WITH PHOSPHORUS AND CARBON.

Effect of phosphorus and carbon on the character of metals.

Tendency of metallic compounds to combine *within their own series*—as oxides with oxides, sulphides with sulphides, &c.—Results of combining an oxide and chloride, as chlorohydric acid and oxide of iron; or a sulphide and an oxide,—as the sulphide of arsenic and potassa.



## SALTS.

Former definition of the terms "acid" and "alkali."—Numerous exceptions.—Present restricted definition.—Definition of a *salt*.

Two distinct classes of salts :

## I. AMPHIGEN SALTS.

Term "amphigen," how used by Berzelius.—They comprise four divisions.—(1) Oxy-salts.—(2) Sulphur-salts.—(3) Selenium-salts.—(4) Tellurium-salts. For illustration, the oxy-salts, being by far the most common, may be taken as the types of the whole class.

A *neutral* salt.—Constancy between the number of equivalents of its acid, and the equivalents of oxygen in the base.

A *sub*, or *basic* salt.

A *super*, or *acid* salt.

## II. THE HALOID, OR HALOGEN SALTS.

Definition.—Distinction between the two classes.

The *binary theory*,—an attempt to reconcile them.—Illustrations.

*Double Salts*.—Examples.

Salts, nearly all solid, and crystalline at ordinary temperatures.—Of variable color.—Generally inodorous.—Sapid, if soluble.—They differ much in their affinity for water.—Deliquescence.—Water of crystallization.—Efflorescence.—Water of constitution.—Water mechanically confined.—Decrepitation.

## CRYSTALLIZATION.

Crystallization—a property of nearly all bodies capable of assuming the solid form.—A *crystal* defined.

Cause of crystallization.—The most perfect crystals when formed.

Modes of forming crystals artificially :

1. Solution in water—hot or cold, and evaporation.
2. Fusion, and slow cooling.—Examples.
3. Condensation of a vapor in cold surfaces.—Examples.

Facts proving that crystals are formed according to a certain regular internal structure :—1. Their growth, if placed in a saturated solution ; 2. Their cleavage ; 3. Their mode of expansion by heat.

Every substance has its own distinct crystalline form ; but some forms are common to numerous bodies.—Illustrations.—Dimorphism.

Measurement of crystals.—The goniometer.—*Faces* of a crystal.—*Edges*.—*Angles*.

Arrangement of crystals into six classes :

1. The regular octohedral, or monometric system.
2. The dimetric, or square prismatic system.
3. The trimetric, or right prismatic system.
4. The oblique prismatic system.
5. The double oblique prismatic system.
6. The rhombohedral system.



Passage of one crystalline form into another of the same natural group.—Examples.

*Isomorphism*.—Definition.—The term not confined to crystalline bodies, but extended to their elements.—Illustrations.—Isomorphous groups.

Use of isomorphism in determining the chemical composition of a body.

Physiological and therapeutical applications.

## CLASSIFICATION OF METALS.

Division of metals into two classes :

CLASS I. THOSE WHICH ARE SO READILY OXIDIZABLE AS TO BE UNFIT FOR USE IN THE METALLIC STATE.

CLASS II. THOSE WHICH ARE NOT SO.

The first class comprises three orders :

1. The alkaline metals.
2. The alkaline-earthly metals.
3. The earthy metals.

## CLASS I.

## ORDER I.

## THE ALKALINE METALS.

## POTASSIUM.

Symbol K (Kalium).—Equivalent, 39.

Extensively diffused over the earth, in combination. Discovered by Davy, in 1807, by the agency of galvanism.—Present method of obtaining it, by the action of charcoal on carbonate of potash, by the aid of heat.—Rationale.—Mode of preserving it.

Properties.—A brilliant white metal; soon tarnishing on exposure to the air.—Soft at common temperatures.—Hard at 32°.—Melts at 150°, and volatilizes.—Sp. grav. .865.

Effect when thrown on water.—Color of the flame.—Explanation.—Slower oxidation in the air.—Result in both cases.

## COMPOUNDS OF POTASSIUM AND OXYGEN.

*Protoxide of Potassium*.—*Potassa*, or *Potash*.—Symbol, KO.—Equivalent, 47.

Anhydrous—how made.—Properties.

The hydrate—KO,HO. — Obtained by boiling together carbonate of potassa, lime and water, and rapidly concentrating.—Rationale.

Properties.—When pure, grayish-white.—Solid.—Has a strong alkaline taste and reaction.—Powerfully caustic.—



Great affinity for water.—Very deliquescent.—Soluble in water, also in alcohol.—Used in surgery as a caustic (common caustic—*lapis infernalis*), in the form of sticks—made by fusing the hydrate, and running into moulds.—Exposed to the air, it rapidly absorbs moisture and carbonic acid.

Its solution—*liquor potassæ*—a valuable reagent to the chemist.

*Peroxide of Potassium*.— $\text{KO}_3$ .—Made by burning potassium in an excess of dry oxygen.—Properties.

#### SALTS OF POTASSA.

*Carbonate of Potassa*.— $\text{KO}, \text{CO}_2$ .—Is found in the ashes of inland plants.

Origin of the alkali in plants, and its mode of combination in the living plant.—Effect of incineration.—Variable quantity in plants.

*Pot and Pearlashes*.—Impurities.—Mode of purifying.—Salt of tartar.

Properties.—Very deliquescent.—Very soluble in water.—Insoluble in alcohol.—Has a strong alkaline taste and reaction.—Fuses at a red heat.—Much used in medicine; and as a chemical reagent.

*Bicarbonate of Potassa*.— $\text{KO}, 2\text{CO}_2 + \text{HO}$ ; or  $\text{KO}, \text{CO}_2 + \text{HO}, \text{CO}_2$ .—Mode of preparation.

Properties.—A white salt, crystallizing in eight-sided prisms, less soluble than the carbonate; nearly neutral to test-paper. By heat it is converted into the carbonate, by losing carbonic acid.—Used in medicine.

The *sesquicarbonate* is doubtful.

*Sulphate of Potassa*.— $\text{KO}, \text{SO}_3$ .—Mode of preparation.—Properties.—Anhydrous.—Crystallizes in six-sided prisms.—

Very hard.—Soluble in ten parts of water.—Decrepitates in the fire.—Used in medicine.

*Bisulphate of Potassa.*— $\text{KO}, \text{SO}_3 + \text{HO}, \text{SO}_3$ .—The residue in the retort after the preparation of nitric acid from the nitrate.

Properties.—Crystalline.—Solubility.—Has a sour taste and acid reaction.

*Anhydrous Bisulphate.*— $\text{KO}, 2\text{SO}_3$ .

*Sesquisulphate.*— $\text{HO}, \text{SO}_3 + 2 (\text{KO}, \text{SO}_3)$ .

*Nitrate of Potassa (Saltpetre or Nitre).*— $\text{KO}, \text{NO}_5$ .—Natural origin in the earth.—Mode of its formation.—Artificial nitre-beds.—Made directly by the action of nitric acid on carbonate of potassa.

Properties.—A white salt,—in six-sided prisms,—striated.—Fuses by heat.—Soluble in water.—Decomposes at a high temperature.—Antiseptic.—Deflagrates in the fire.—A strong supporter of combustion.

Uses in the arts, and in chemistry.

Composition of *gunpowder*.—Mode of manufacture.—Rationale of its explosion, and its propelling power.

Poisonous effects of nitre.

*Chlorate of Potassa.*— $\text{KO}, \text{ClO}_5$ .—Procured by passing chlorine through a solution of potassa.—Rationale.

Properties.—Occurs in white tabular crystals.—Soluble in water.—A powerfully deflagrating agent,—yielding up all its oxygen, and leaving a residue of chloride of potassium.—It cannot be substituted for the nitrate in gunpowder.

*Perchlorate.*— $\text{KO}, \text{ClO}_7$ .—How obtained.—Properties.—A crystalline salt, sparingly soluble in water.—Less deflagrating than the chlorate.

*Iodate,*  $\text{KO}, \text{IO}_5$ .—Resembles the chlorate.

*Silicate,*  $\text{KO}, \text{SiO}_3$ .—Natural source of it in the soil.—Uses of it by plants.—Artificially made.



Glass.—Its composition and varieties.

Properties.—Mode of coloring.—Annealing process.

*Chloride of Potassium*,  $\text{KCl}$ .—Obtained in the preparation of the *chlorate*.—Exists also in the ashes of sea-weed, and in kelp.

Properties.—Very soluble.—Strongly resembles the chloride of sodium.

Used for making alum.

*Iodide of Potassium*,  $\text{KI}$ .—Procured—(1.) By action of iodine in a strong solution of the carbonate.—(2.) By decomposing iodide of iron by means of carbonate of potassa.

Properties.—A white crystalline salt.—Very soluble in water.—Much used in medicine.—Its solution has the property of dissolving iodine.

*Bromide of Potassium*,  $\text{KBr}$ .—Obtained as the iodide.—Properties—Similar to those of the iodide.

*Cyanide of Potassium*,  $\text{KCy}$ .—Prepared by heating the ferrocyanide.

Properties.—Occurs in cubical crystals.—Deliquescent.—Very soluble.—Odor of the solution due to.—Danger of using it in medicine.

The *Ferrocyanide* and *Ferricyanide of Potassium* (yellow and red prussiate), will be treated of under the head of Iron.

*Sulphides of Potassium*.— $\text{KS}$ ;  $\text{KS}_2$ ; and  $\text{KS}_5$ .

The protosulphide,  $\text{KS}$ , is made by heating the constituents together;—or by heating the sulphate with charcoal.

Properties.—A red crystalline mass.—Very soluble in water, and caustic in its action.

The other sulphides are formed by fusing the protosulphide with different portions of sulphur.

*Hepar-Sulphuris* (*Liver of Sulphur*).—Procured by fusing together different proportions of the carbonate and sulphur.

Properties.—A very variable mixture of the two higher sulphides, and the hyposulphite and sulphate of potassa.—Formula.

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## SODIUM.

Symbol, Na (Natrium).—Equivalent, 23.

Discovered by Davy, at the same time as potassium.—Mode of preparation similar to that of potassium.

Exists, naturally, in combination, in sea-water, saline springs, rock-salt, and in the ashes of marine plants;—also in animals.

*Properties.*—Very similar to potassium.—Specific gravity, 0.970.—Fuses at  $194^{\circ}$ .—If exposed to the air, it tarnishes, and is speedily converted into the protoxide (soda).

Action of water upon it.—Color of the flame.

## COMPOUNDS OF SODIUM AND OXYGEN.

*Protoxide of Sodium.*—*Soda.*

Symbol, NaO.—Equivalent, 31.

Anhydrous—how made.—Properties.

The *hydrate*, NaO,HO,—prepared as the hydrate of potassa; and its properties similar.

*Peroxide of Sodium.*— $\text{NaO}_2$ .—As peroxide of potassium.

## SALTS OF SODA.

*Carbonate of Soda*,  $\text{NaO}, \text{CO}_2 + 10\text{HO}$ .

Naturally exists in the ashes of marine plants, from which it was formerly obtained.—Kelp and barylla.

Manufactured, at present, from common salt, by first con-



verting it into a sulphate, and then decomposing, by means of charcoal and carbonate of lime.—Rationale.

Properties.—Crystallizes in large transparent rhombs, when first made;—very efflorescent.—Very soluble in water;—has a strong alkaline reaction and taste.—Loses some of its water by heat.—Fuses.

Much of the commercial carbonate is not crystalline;—it is named *Soda ash*.

Used in medicine, and as a reagent.

*Bicarbonate of Soda*,  $\text{NaO}, \text{CO}_2 + \text{HO}, \text{CO}_2$ .

Named also *supercarbonate*.—Mode of preparation.

Properties.—A white powder;—less soluble than the carbonate,—much less alkaline.—Used in medicine.

*Sesquicarbonate of Soda*. —  $2\text{NaO}, 3\text{CO}_2 + 4\text{HO}$ . — The native *natron*.—Sal-æratuſ.

Process involved in *alkalimetry*:—to ascertain the real quantity of alkali in the specimen, by finding how much of the latter is required to neutralize a known quantity of an acid of a standard strength.

*Sulphate of Soda*.—*Glauber's Salt*.— $\text{NaO}, \text{SO}_3 + 10\text{HO}$ . —Occurs in nature crystallized; also in springs.—A constituent of sea-water.

Mode of preparation.—The residue in making muriatic acid.

Properties.—A crystalline salt, in four-sided prisms.—Efflorescent.—More soluble in water at  $90^\circ$  than at  $212^\circ$ .—Fuses in its water of crystallization.

*Bisulphate of Soda*.— $\text{NaO}, \text{SO}_3 + \text{HO}, \text{SO}_3$ .

Made by action of sulphuric acid on the sulphate.—Very soluble.—Has an acid reaction.

*Hyposulphite of Soda*.— $\text{NaO}, \text{S}_2\text{O}_2$ .

Preparation.—Used in photography.

*Nitrate of Soda.*— $\text{NaO}, \text{NO}_5$ .—*Cubical Nitre.*—Found native in Peru.—Made by action of nitric acid on the carbonate.

It crystallizes in rhombs.—Very soluble.—Deliquescent.—Used as a substitute for saltpetre in making nitric acid; but cannot be employed in the manufacture of gunpowder, on account of its absorbing moisture from the air.

*Chlorate of Soda.*— $\text{K}\text{aO}, \text{ClO}_5$ .—Resembles the chlorate of potassa.

*Hypochlorite of Soda.*—(*Chlorinated Soda.*)— $\text{NaO}, \text{ClO}$ .—Mode of preparation.—Nature.—Uses.

*Phosphates of Soda.*—Three classes of them :

I. *Tribasic :*

1. Neutral tribasic phosphate.— $2\text{NaO} + \text{HO}, \text{PO}_5 + 24\text{HO}$ .—(*Common phosphate.*) Made by neutralizing superphosphate of lime by carbonate of soda.

Properties.—Crystalline, in oblique rhombic prisms.—Efflorescent.—Solubility.—Taste.—Heat converts it into the bibasic phosphate.

2. Subphosphate, or alkaline tribasic phosphate.— $3\text{NaO}, \text{PO}_5 + 24\text{HO}$ . Made by adding an excess of caustic soda to the preceding.

Occurs in slender six-sided prisms.—Less soluble than the former.—Alkaline in its reaction.

3. Acid tribasic phosphate.—Biphosphate.— $\text{NaO} + 2\text{HO}, \text{PO}_5 + 2\text{HO}$ .

Obtained by addition of phosphoric acid to the neutral phosphate.—Crystalline.—Effect of a high heat.

*Test.*—They all give a yellow precipitate with nitrate of silver.

II. *Bibasic Phosphates :*



1. Pyrophosphate.— $2\text{NaO}, \text{PO}_5 + 10\text{HO}$ .—Obtained by heating *common phosphate*.

2. Bipyrophosphate.— $\text{HO}, \text{NaO}, \text{PO}_5$ .

*Test*.—Both afford a *white* precipitate with nitrate of silver.

III. *Monobasic Phosphate*.—*Metaphosphate*.— $\text{NaO}, \text{PO}_5$ .—Obtained by heating the *biphosphate*.—A transparent glassy substance.

*Test*.—It yields a *white* precipitate with nitrate of silver.

*Tribasic Phosphate of Soda and Ammonia*.—*Microcosmic Salt*.— $\text{NaO} + \text{NH}_4\text{O} + \text{HO}, \text{PO}_5 + 8\text{HO}$ .

Obtained by heating together common phosphate of soda, sal ammoniac and water.—*Rationale*.

Much used in blowpipe operations.—Occurs sometimes in the urine.

*Biborate of Soda*.—*Borax*.— $\text{NaO}, 2\text{BO}_3 + 10\text{HO}$ .

Found native in India.—*Tincal*.—Manufactured from boric acid and carbonate of soda.

Properties.—Crystalline, in six-sided prisms.—Sparingly soluble.—Efflorescent.

Used medicinally, and in blowpipe experiments.

*Neutral Borate*.— $\text{NaO}, \text{BO}_3 + \text{HO}$ .

*Chloride of Sodium*.—*Common Salt*.— $\text{NaCl}$ .

Native in sea-water and saline springs; also as *crystalline rock-salt*.—Proportion in the ocean.

Properties.—Taste.—Solubility.—Impurity.

The *Iodide*, *Bromide*, and *Sulphides*, closely resemble the corresponding salts of potassium.

## LITHIUM.

Symbol, L.—Equivalent, 6.5.

Obtained by the voltaic decomposition of lithia.

Properties.—Resembles sodium.—Very easily oxidizes.

*Protoxide.*—*Lithia.*—LO.—Exists in certain rare minerals.

Properties.—White.—Less soluble than the other two alkalis.—Forms salts.

## SALTS OF AMMONIA.

These are most conveniently studied in the present connection.

*Ammonium.*— $\text{NH}_4$ .—A hypothetical metal.—Never isolated.

Modes of making the *ammoniacal amalgam*.

Properties.—Its spontaneous decomposition.

*Oxide of Ammonium.*—*Ammonia.*— $\text{NH}_4\text{O}$ , or  $\text{NH}_3\text{HO}$ .—Already treated of.—A powerful alkali.

*Carbonate of Ammonia.*— $\text{NH}_4\text{O}, \text{CO}_2$ .—Anhydrous.—Mode of preparing.—Properties.

*Sesquicarbonate.*—The *carbonate* of pharmacy.— $2\text{NH}_4\text{O}, 3\text{CO}_2$ .—Preparation.—Rationale.—Properties.—Effect of exposure.—Use.

*Sulphate of Ammonia.*— $\text{NH}_4\text{O}, \text{SO}_3 + \text{HO}$ .

Mode of obtaining.—Preparation on a large scale.—Properties.

*Nitrate of Ammonia.*— $\text{NH}_4\text{O}, \text{NO}_5$ .



Preparation.—Appearance.—Properties.—Use in the laboratory.

*Phosphate of Ammonia.*— $2\text{NH}_4\text{O}, \text{HO}, \text{PO}_5 + \text{HO}$ .—Made by decomposing superphosphate of lime by carbonate of ammonia.—Used in medicine.

*Chloride of Ammonium.*—*Sal Ammoniac.*— $\text{NH}_4\text{Cl}$ .—Formerly obtained from Egypt.—Mode of manufacture. Properties.—Effect of heat.

*Sulphides of Ammonium.*—Several of them.—The bisulphide— $\text{NH}_4\text{S}_2$ —is made by passing sulphuretted hydrogen through solution of ammonia.—Properties.—Uses in chemistry.

*Tests for salts of ammonia.*

## ORDER II.

## METALS OF THE ALKALINE EARTHS.

These are Barium, Strontium, Calcium, and Magnesium.

## BARIUM.

Symbol, Ba.—Equivalent, 68.5.

Obtained by Davy, by voltaic decomposition of carbonate of baryta.—Properties.—Name.

*Protoxide.*—*Baryta.*—BaO.

Obtained by calcining the nitrate.

Properties. — A grayish powder.—Sp. grav. 4. — Strong affinity for water.—Solubility. Use of the solution in the laboratory.

*Peroxide of Barium.*—BaO<sub>2</sub>.—Mode of preparing.—Use.

## SALTS OF BARYTA.

*Carbonate.*—BaO,CO<sub>2</sub>.—Native, as Witherite.—Artificially made.—Properties.

*Sulphate.*—BaO,SO<sub>3</sub>.—Native, as *heavy spar.*—Sp. grav. 4.5.—Preparation.—Use.



*Nitrate.*— $\text{BaO}, \text{NO}_5$ .—Preparation.—Solubility.—Used as a reagent.

*Chloride of Barium.*— $\text{BaCl}$ .—Preparation.—Solubility.—Used as a reagent.

*Iodide.*— $\text{BaI}$ .—Made as the chloride, and its properties similar.

*Sulphide.*— $\text{BaS}$ .—Prepared by heating the sulphate with charcoal.

*Tests for the salts of baryta.*

## STRONTIUM.

Symbol,  $\text{Sr}$ .—Equivalent, 43.8.

Name.—Mode of preparation.—Properties.

*Protoxide.*—*Strontia.*— $\text{SrO}$ .—Preparation.

Properties.—Similar to those of baryta.

*Peroxide,*  $\text{SrO}_2$ .—Resembles peroxide of barium.

## SALTS OF STRONTIA.

*Carbonate.*— $\text{SrO}, \text{CO}_2$  (*Strontianite*).—Native.—Properties.

*Sulphate.*— $\text{SrO}, \text{SO}_3$  (*Celestine*).—Native.—Solubility.

*Nitrate.*— $\text{SrO}, \text{NO}_5$ .—Preparation.—Properties.—Used in pyrotechny.—Red fire.

*Chloride of Strontium.*— $\text{SrCl}$ .—Preparation.—Solubility.

*Tests for salts of strontium.*

## CALCIUM.

Symbol, Ca.—Equivalent, 20.

Obtained as Barium and Strontium.—Properties.

*Protoxide.*—*Lime.*— $\text{CaO}$  (Quicklime).

Obtained by calcining the carbonate.—Preparation of pure lime.—Impurities in common lime.

Properties.—Density.—Color.—Phosphorescence.—Effect of water;—*hydrate of lime* or *slacked lime*.—Cause of the heat evolved in slacking.—Solubility in water.—*Lime-water*.—Properties of lime-water;—effect of exposure to the air.—*Milk of lime*.

Use of lime in the arts.—Composition of *mortars*.—*Hydraulic mortars*.—Use of lime in agriculture.

*Peroxide of Calcium.*— $\text{CaO}_2$ .—Preparation.—Uses.

## SALTS OF CALCIUM.

*Carbonate of Lime.*— $\text{CaO}, \text{CO}_2$ .

Natural varieties:—Limestone, Marble, Iceland Spar, and Arragonite.

Properties.—Solubility in water.—Hard waters.—Mode of remedying.

Stalactites.—Petrifying wells.

*Sulphate.*— $\text{CaO}, \text{SO}_3$ .—Native,—as Gypsum and Selenite;—also anhydrous, as Anhydrite.

Artificially made.—Solubility in water.—Use of native gypsum as a manure, and for taking casts.

The sulphate of lime a common impurity of hard waters.

*Phosphates.*—They correspond, in number and in composi-



tion, to the phosphates of soda.—Mode of preparation.—Insolubility in pure water.—Solubility in dilute acids.

State of combination in the blood and urine.

*Nitrate*.— $\text{CaO}, \text{NO}_5 + 6\text{HO}$ .—Preparation.—Deliquescence.—Solubility.

*Chloride of Calcium*.— $\text{CaCl}$ .—Preparation.

Properties.—Uses of the anhydrous salt.

*Fluoride of Calcium*.—*Fluor Spar*.—*Derbyshire Spar*.— $\text{CaFl}$ .—Native.—Uses.

The *Iodides* and *Bromide* resemble the corresponding salts of Barium and Strontium.

*Chlorinated Lime*.—*Bleaching Salt*.—Mode of preparing.—Improperly called *Chloride of Lime*.—Composition.—Variable strength.—Properties.

Effect of the atmosphere.—Mode of using it for bleaching, and as a disinfectant.

*Sulphide of Calcium*.— $\text{CaS}$ .—Obtained by heating the sulphate with charcoal.

The higher sulphides are made by boiling lime with sulphur.

*Phosphide of Calcium*.—Preparation.—Action of water.—Use.

*Test for lime*.

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## MAGNESIUM.

Symbol,  $\text{Mg}$ .—Equivalent, 12.2.

Obtained by decomposing the chloride, by sodium and heat.

Properties.—A grayish-colored metal,—fusible at a red heat,—burns in the air, being converted into magnesia.

*Protoxide.*—*Magnesia.*— $\text{MgO}$ .—The only oxide.

Obtained by calcining the carbonate.—Called *magnesia usta*.—Procured, also, by precipitation.

Properties.—Forms a hydrate with water;—almost insoluble in water.—Though apparently a feeble alkali, it nevertheless will neutralize a large quantity of acid.

Effect of ammonia on a soluble salt of magnesia.

How estimated in analysis.

#### SALTS OF MAGNESIUM.

*Carbonate of Magnesia*— $\text{MgO}, \text{CO}_2$ —The neutral carbonate.—Occurs native;—anhydrous, as magnesite, or in crystals.

Artificially as a hydrate,—by dissolving magnesia alba in carbonic acid water, and evaporating.

*Magnesia Alba.*—A hydro-carbonate.

Formula,  $3 (\text{MgO}, \text{CO}_2, \text{HO}) + \text{MgO}, \text{HO}$ .—Properties.

Native *dolomite*.

*Sulphate of Magnesia.*—*Epsom Salt.*— $\text{MgO}, \text{SO}_3 + 7\text{HO}$ .

Natural sources.—Mode of obtaining from sea-water;—from magnesian limestone.—From soapstone.

Properties.—Shape of crystals;—taste;—solubility.—Effect of heat.

*Phosphate of Magnesia.*— $2\text{MgO}, \text{HO} + \text{PO}_5$ .

Made by decomposing the carbonate, by a solution of common phosphate of soda.

Shape of crystals.—Solubility.

*Phosphate of Magnesia and Ammonia*, or *Ammonio-magnesian Phosphate.*— $2\text{MgO}, \text{NH}_4\text{O} + \text{PO}_5 + 12\text{HO}$ .



Preparation.—Its production a test of the presence of magnesia.

A constituent of urinary calculi;—also of guano.

*Silicates*.—Varieties:—*Soapstone*, *Steatite*, *Hornblende*, *Serpentine*, &c.

*Chloride of Magnesium*.— $MgCl$ .—Preparation.—Properties.

Tests for magnesia.

## ORDER III.

## METALS OF THE EARTHS PROPER.

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ALUMINIUM, OR ALUMINUM.

Symbol, Al.—Equivalent, 13·7.

Obtained by heating together the chloride and potassium or sodium.

Properties.—A whitish metal, resembling silver.—Decomposes water at 212°.—Burns in the open air.—Requires a high temperature to fuse.

Sesquioxide—alumina.— $\text{Al}_2\text{O}_3$ .—The only oxide known.—Its composition inferred from its isomorphism with sesquioxide of iron.—Preparation.—Abundance in nature.—Feldspar.—Clay.

Uses of clay—to the soil, and for pottery.

Native forms of alumina.

Properties.—A feeble base, forming salts of an acid reaction.—Affinity for water, forming a hydrate.—Attraction for organic coloring matters.—Use as a mordant.

## SALTS OF ALUMINUM.

*Sulphate of Alumina.*— $\text{Al}_2\text{O}_3, 3\text{SO}_3 + 18\text{HO}$ .

Obtained from alum.—Properties.

Tendency to unite with other sulphates.



*Sulphate of Alumina and Potassa—Alum.*— $\text{Al}_2\text{O}_3, 3\text{SO}_3 + \text{KO}, \text{SO}_3 + 24\text{HO}$ . — Native variety.—Several modes of manufacture.—Impurity.

Properties.—Color.—Shape of crystals.—Taste.—Solubility.—Effect of heat.—*Dried Alum*.

Homberg's pyrophorus.—Composition.

Soda and ammonia alums.—Iron, manganese, and chrome alums.

*Silicates of Alumina.*—Varieties of *clay*.—Origin from feldspar.—*Marls*.

*Earthenware and Porcelain.*—Essentially, silicates of alumina.—Difference between true porcelain, and earthen or stone ware.

Sort of clay used for porcelain.—Glazing.—Biscuit ware.—Stone ware.—Hessian crucibles.

*Chloride of Aluminum.*— $\text{Al}_2\text{Cl}_3$ .—Obtained.

There exist also a *sulphide* and a *fluoride*.

*Tests* for alumina salts.

## GLUCINUM, OR BERYLLIUM.

Name.—Symbol, G, or Be.—Equivalent, 6.9.

*Glucina* or *Berylla*.— $\text{G}_2\text{O}_3$ .—Where found.

The other metals of the earths are *Yttrium*, *Erbium*, *Terbium*, *Zirconium*, *Cerium*, *Lanthanum*, *Didymium*, and *Thorium*,—each of which forms an oxide.

## CLASS II.

METALS WHICH ARE NOT TOO OXIDIZABLE TO  
BE USED IN THE METALLIC STATE.

## ORDER I.

METALS WHOSE OXIDES ARE POWERFUL BASES.

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MANGANESE.

Symbol, Mn.—Equivalent, 27·7.

Diffused throughout nature.—Often associated with iron.—  
Preparation.

Properties.—A hard, grayish metal, resembling cast iron.—  
Sp. grav. 8.—Has a strong affinity for oxygen.—Difficult to  
fuse.—Forms *seven* compounds with oxygen.

*Protoxide*.— $\text{MnO}$ .—The most basic.

Mode of obtaining.—Color.—Affinity for oxygen.

Obtained as a hydrate by precipitation.—Effect of exposure.

*Sesquioxide*.— $\text{Mn}_2\text{O}_3$ .—Occurs native in the Hartz Moun-  
tains.—The residue, in heating the binoxide.—Color, black or  
brown.—A feeble base.—Isomorphous with alumina.

*Binoxide*—*Peroxide*.— $\text{MnO}_2$ .—The most common of the



manganese ores.—Occurs usually massive, combined with iron, silix, and lime;—sometimes crystalline.

Obtained, by calcining the nitrate of the protoxide, or by the action of chlorinated lime on a protosalt.

Properties.—Black.—Neutral.—Insoluble in water.—Much used in the laboratory, and in the arts.

*Red Oxide.*— $\text{Mn}_3\text{O}_4$ , or rather  $\text{MnO} + \text{Mn}_2\text{O}_3$ .

Found native.—Artificially made.—Uses.—Action of a strong acid upon it.—Very permanent.

*Varvacite.*— $\text{Mn}_4\text{O}_7$ .—A natural product of Warwickshire, England.—Crystalline.

*Manganic Acid.*— $\text{MnO}_3$ .—Obtained as *manganate of potassa*.—Cannot be isolated.

*Mineral Chameleon.*—Effect of exposure.—Action of water.

*Permanganic Acid.*— $\text{Mn}_2\text{O}_7$ .—Obtained as *permanganate of potassa*.—Not isolable.—Properties.

#### SALTS OF MANGANESE.

*Carbonate.*— $\text{MnO}, \text{CO}_2$ .—Procured by precipitation, by an alkaline carbonate on the protochloride.—Properties.

*Sulphate.*— $\text{MnO}, \text{SO}_3$ .—Preparation.—Properties.—Use in dyeing.—Isomorphous with sulphate of magnesia.

*Protochloride.*— $\text{MnCl}$ .—The residue in the preparation of chlorine from the binoxide.—Properties.

*Sesquichloride.*— $\text{Mn}_2\text{Cl}_3$ .—Made by the action of chlorohydric acid on the sesquioxide.

*Tests for manganese salts:* Alkalies;—Sulphide of Ammonium;—Ferrocyanide of potassium;—The production of the mineral chameleon.—Action of the blowpipe.

## IRON.

Symbol, Fe. (Ferrum.)—Equivalent, 28.

Great importance in the arts.—Known to the ancients.—Found pure in nature ; though generally mineralized.—Usual combinations.—Most important iron ores.—Metallurgy of iron.—Construction and operation of the *blast furnace*.—Cast iron.—Varieties.—Impurities.—The *puddling furnace*.—Malleable iron.—Varieties.

Properties of malleable iron.—Texture.—Tenacity.—Welding.—Brittleness by constant motion.—Example.

Properties of pure iron.—Color.—Sp. grav. 7.8.—Does not oxidize in dry air, nor in pure water.—Tendency to rust in moist air.—Composition of iron-rust.—Action on water, at a red heat.—Action of dilute acids on iron.

Obtained chemically pure by action of hydrogen on the oxide.—Properties.

Iron forms *four* compounds with oxygen.

*Protoxide*.— $\text{FeO}$ .—A strong base, isomorphous with magnesia, &c. Impossibility of isolating it. Preparation as a hydrate.—Effect of exposure to the air.—Color of its salts.

*Sesquioxide*—*Peroxide*.— $\text{Fe}_2\text{O}_3$ .—Abundance in nature.—as specular iron ore (crystalline), and red and brown hematite.—Artificially made.

Properties.—A feeble base, isomorphous with alumina.—Color.—Solubility.—Color of its salts.—Use of the hydrated oxide in medicine.

*Black Oxide*.— $\text{Fe}_3\text{O}_4$ , or  $\text{FeO} + \text{Fe}_2\text{O}_3$ .—Occurs native, as *loadstone*.—A valuable ore.—Artificially made.—Does not form salts.



*Ferric Acid.*— $\text{FeO}_3$ .—Isomorphous with manganic acid.—Cannot be isolated, but obtained as a ferrate of potash.—Properties.

#### SALTS OF IRON.

*Carbonate.*— $\text{FeO}, \text{CO}_2 + \text{HO}$ .—Native varieties:—*Spathic iron-ore* (crystalline).—Composition and *argillaceous iron-ore*.

Artificially made.—Color.—Changes on exposure.—Mode of preventing.—*Vallet's Preparations*.

Insolubility in pure water.—Chalybeate waters.—Effect of boiling, or of exposure of such waters.

*Sulphate.*— $\text{FeO}, \text{SO}_3 + 7\text{HO}$ .—Isomorphous with Epsom salt, &c.

Mode of obtaining pure.—Common mode of manufacturing.—Commercial name.

Solubility.—Change of solution on exposure.

*Sesquisulphate.*—*Persulphate.*— $\text{Fe}_2\text{O}_3, 3\text{SO}_3$ .—Mode of preparation.—Appearance when dried.—Effect of an alkali, or of an alkaline carbonate.—Forms an *alum* with sulphate of potash.

*Protonitrate.*— $\text{FeO}, \text{NO}_5$ .—Mode of preparation.—Forms green crystals;—not permanent.

*Sesquinitrate.*—*Pernitrate.*— $\text{Fe}_2\text{O}_3, 3\text{NO}_5$ .—Mode of preparation.—Properties.—Use in medicine.

*Phosphate.*—*Citrate.*—*Acetate*, &c.

*Protochloride.*— $\text{FeCl}$ .—Modes of procuring.—Properties.—Liability to change on exposure.

*Sesquichloride.*—*Perchloride.*— $\text{Fe}_2\text{Cl}_3$ .—Preparation.—Appearance.

*Tincture of the chloride* used in medicine.

*Protiodide*.— $\text{FeI}$ .—Mode of preparation.—Appearance.—Properties.—Effect of iron wire on the permanency of the solution.—Used in medicine.

*Sesquiodide*—*Periodide*.— $\text{Fe}_2\text{I}_3$ .—More permanent than the former.

*Protosulphide*— $\text{FeS}$ .—Mode of procuring.—Use in the laboratory.—Properties.

Action of sulphydric acid on a salt of iron.—Action of sulphide of ammonium.

*Sesquisulphide*.— $\text{Fe}_2\text{S}_3$ .

*Bisulphide*.— $\text{FeS}_2$ .—A native ore.—Known as *Fool's gold*. There is likewise a native *magnetic pyrites*.

*Carburets of Iron*.—Cast iron and steel.—Proportion of carbon.—Modes of manufacturing steel.—Varieties.—Modes of hardening.

*Phosphide of Iron*.—Effect of the phosphorus.

*Cyanide of Iron*.— $\text{FeCy}$ .—Preparation.

*Ferrocyanogen*.— $\text{FeCy}_3$ , or  $\text{Cfy}$ .—A compound radical, not isolable.—Bibasic.

*Ferrocyanide of Potassium*.—*Yellow Prussiate of Potash*.— $2\text{K}, \text{FeCy}_3$ , or  $2\text{KCfy}$ .—Mode of preparing the salt.—A more simple view of its composition, as being a double salt ( $\text{FeCy} + 2\text{KCy}$ )—cyanide of iron and potassium,—not the correct one.—Proof that the cyanogen and the iron are combined together in a peculiar mode.

*Ferrocyanide of Iron*—*Prussian Blue*.— $\text{Fe}_4, 3(\text{FeCy}_3)$ , or  $\text{Fe}_4, 3\text{Cfy}$ .—Prepared by adding ferrocyanide of potassium to a persalt of iron.—Properties.—Uses.

*Ferricyanogen*.— $\text{Fe}_2\text{Cy}_6$ , or  $\text{Cfdy}$ .—A compound radical, not isolable.—Resembling ferrocyanogen.—Tribasic.



*Ferricyanide of Potassium.*—*Red Prussiate of Potash.*— $3K, Fe_2Cy_6$ , or  $3K, Cfdy$ .—Mode of preparation.—Properties.  
Mode of viewing it as a double salt.—( $Fe_2Cy_3 + 3KCy$ .)

*Ferricyanide of Iron.*—*Turnbull's Blue.*— $3Fe, Cfdy$ , or  $3Fe, Fe_2Cy_6$ .—Prepared by adding the ferricyanide of potassium to a protosalt of iron.—Appearance.

*Tests for Protosalts of Iron.*—(1.) Color.—(2.) Alkalies.—(3.) Alkaline carbonates.—(4.) Ferricyanide of potassium.—(5.) Sulphide of ammonium.

*Tests for Persalts.*—(1.) Color.—(2.) Alkalies.—(3.) Alkaline carbonates.—(4.) Tannic acid.—(5.) Ferrocyanide of potassium.—(6.) Sulphide of ammonium.

## COPPER.

Symbol, Cu (Cuprum).—Equivalent, 31.7.

Name.—Known to the ancients.—General diffusion throughout nature.—Occasionally found pure in crystals.—Localities.

Most common ores—*yellow* and *gray copper* ores.—Most important localities of these ores.

Mode of reducing copper pyrites.—How chemically pure.

Properties.—Color.—Film on sheet copper.—Specific gravity, 8.9.—Malleability and ductility.—A good conductor of heat and electricity.—Not affected in dry air.—Influence of moist air.—Result of heating to redness in the air, or oxygen.—Effect of acids, dilute and strong.

It forms *three* compounds with oxygen.

*Suboxide—Dioxide—Red Oxide.*— $Cu_2O$ .

Occurs native in octohedral crystals.—Artificially made.—Action of grape sugar on a protosalt of copper.—Properties.

It forms colorless unstable salts.—Use in the manufacture of glass.

Effect of copper on a solution of ammonia, in the air.

*Protoxide*.—*Black Oxide*.— $\text{CuO}$ .

Obtained by heating copper in the air, or better by calcining the nitrate.

Properties.—Strongly basic.—Facility of reduction in contact with organic bodies.—Use in organic analysis.

Obtained as a *hydrate*.—Effect of boiling.—Action of ammonia.

The *Binoxide*— $\text{CuO}_2$ —is said to exist.

#### SALTS OF COPPER.

*Sulphate*.— $\text{CuO}, \text{SO}_3 + 5\text{HO}$ . (Blue vitriol.)

Manufactured on a large scale.—Mode of obtaining chemically pure.—Rationale.

Properties.—Color.—Isomorphous with.—Forms double salts.—Effect of heat.—Action of ammonia.

There is also a *subsulphate*.

*Nitrate*.— $\text{CuO}, \text{NO}_5 + 3\text{HO}$ .

Action of nitric acid on copper.

Properties.—Color.—Deliquescence.—Acid, corrosive action.—Action on tin foil.

*Carbonates*.—The *subcarbonate*,  $2\text{CuO}, \text{CO}_2 + \text{HO}$ , forms on copper when exposed to moist air.

The *hydrocarbonate*,  $\text{CuO}, \text{CO}_2 + \text{CuO}, \text{HO}$ , is formed by the action of carbonate of soda on sulphate of copper.

Composition of native *malachite*.

*Verditer* obtained.—Use.



*Acetate* (neutral).—Mode of obtaining.—Properties.

*Subacetate*—*Diacetate*—*Verdigris*.—Mode of manufacture.—Properties.—Uses.

*Arsenite* (Scheele's green).—Properties.—Uses.

*Subchloride*,—*Dichloride*.— $\text{Cu}_2\text{Cl}$ .—Modes of forming.—Properties.

*Protochloride*.— $\text{CuCl}$ .—Preparation.—Color.—Solubility.

*Subsulphide*.— $\text{Cu}_2\text{S}$ .—Native, as *copper glance*.—Artificially made.

*Protosulphide*.— $\text{CuS}$ .—Preparation.—Color.

*Ammoniated Copper*.—Mode of preparing.—Composition.—Uses.

*Alloys of Copper*.—*Brass*, *bronze*, and *gun-metal*; *bell-metal*; *speculum metal*.—Bronze of the ancients.—Common bronze.

*Tests for protosalts*: (1) Alkalies.—(2) Ammonia.—(3) Ferrocyanide of potassium.—(4) Sulphydric acid.—(5) Alkaline carbonates.—(6) Albumen.—(7) Precipitation on iron.

Poisonous effects of copper and its salts.—Antidotes.

## ZINC.

Symbol,  $\text{Zn}$ .—Equivalent, 33.

Always found mineralized.—Most common ores.—*Calamine*, how reduced.—*Distillation by descent*.

Properties.—Color.—Brittleness.—Malleability above  $212^\circ$ .

—Crystals.—Effect of exposure.—Sp. grav. 6·8 to 7·2.—Fusing-point, 773°.—Combustion in the air.—Product.

Effect of dilute acids.

Impurities of commercial zinc or spelter.

It forms only *one* compound with oxygen.

*Protoxide*.— $\text{ZnO}$ .—Procured by burning metallic zinc in the air; also by heating the carbonate.

Properties.—Appearance.—Solubility in acids.

Its salts isomorphous with those of magnesia, &c.

Effect of an alkali on a salt of zinc.

Use of the oxide as a pigment.

#### SALTS OF ZINC.

*Sulphate* (white vitriol).— $\text{ZnO}, \text{SO}_4 + 6\text{HO}$ .—Isomorphous with sulphate of magnesia, &c.

Mode of preparation on a large scale.—Properties.—Uses.

*Carbonate*.— $\text{ZnO}, \text{CO}_2 + \text{HO}$ .—Found native as *calamine*.—Neutral.—When obtained by precipitation by an alkaline carbonate, it is a hydrocarbonate, as in the case of magnesia.

Properties.—Use in medicine.

*Chloride*.— $\text{ZnCl}$ .—(Butter of zinc.)

Modes of preparation.—Properties.—Uses.

*Sulphide*.— $\text{ZnS}$ .—(Zinc Blende.)—A native product.—Artificially made.—Properties.

*Iodide*.— $\text{ZnI}$ .—Preparation.—Properties.—Use.

*Tests*: (1) Alkalies.—(2) Ferrocyanide of potassium.—(3) Sulphydric acid.



## CADMIUM.

Symbol, Cd.—Equivalent, 55.8.

Usually found associated with zinc.—Mode of reducing the ore.—Separated from zinc by making an acid solution, and using sulphydric acid.

Properties.—White, like tin; malleable and ductile.—Sp. grav. 8.7.—Volatile.—Fuses below  $500^{\circ}$ .—Burns in the air.—Best solvent.

*Protoxide*.—CdO.—The only oxide.—Made by burning the metal in the air.—Color.

## SALTS OF CADMIUM.

*Sulphate*.— $\text{CdO}, \text{SO}_3 + 4\text{HO}$ . — Preparation. — Resembles sulphate of zinc.—Used in medicine.

*Chloride*.—CdCl.—Preparation.

*Sulphide*. — CdS. — Preparation. — Color. — How distinguished from sulphide of arsenic.

*Tests*: (1) Caustic alkalies.—(2) Sulphydric acid, or sulphide of ammonium.

## LEAD.

Symbol, Pb (Plumbum).—Equivalent, 103.7.

Known to the ancients.—Found in nature mineralized.—The sulphide (*galena*), the most abundant ore.—How reduced.

Properties.—Color.—Malleability and ductility.—Tenacity.—Sp. grav. 11.45.—Fusing-point.—Crystals obtained.

Effects of exposure to moist air.—Result of melting in the air.

Action of pure soft water.—Effects of salts in the water.—Action of the acids.

Forms *four* compounds with oxygen.

*Suboxide*.—*Dioxide*.— $\text{Pb}_2\text{O}$ .—Constitutes the film on the surface of lead on exposure.—Procured also from the oxalate.—Does not form salts.

*Protoxide*.— $\text{PbO}$ .—A strong base.—Mode of preparing.—*Massicot* and *Litharge*.

Properties.—Uses in the arts.

It forms numerous salts.

Mode of obtaining as a *hydrate*.

*Binoxide*.—*Peroxide* (brown or puce oxide).— $\text{PbO}_2$ .—Obtained by the action of nitric acid on red lead.—Rationale.

Properties.—Action of heat;—of chlorohydric acid;—of sulphurous acid;—of ammonia.

*Minium, or Red Lead*.— $2\text{PbO} + \text{PbO}_2$ .

Mode of preparation.—Variable composition.

Properties.—Uses.—Effect of heating.

#### SALTS OF LEAD.

*Carbonate*.— $\text{PbO}, \text{CO}_2$ .—(White lead,—Cereuse.)

Occurs native, in crystals.—Made by precipitation.

Mode of manufacture.—Rationale.

Properties.—Color.—Weight.—Solubility in water and acids.—Use as a pigment.

*Sulphate*.— $\text{PbO}, \text{SO}_3$ .—How formed.—Insolubility.



*Nitrate*.— $\text{PbO}, \text{NO}_3$ .—Action of nitric acid on lead.—Solubility.

The *subnitrate*—how procured.

*Acetate* (neutral).—Sugar of lead.— $\text{PbO}, \text{C}_4\text{H}_3\text{O}_3 + 3\text{HO}$ .—Preparation.

Properties.—Color.—Shape of crystals.—Odor and taste.—Action of the air.—Solubility.—Color of the solution.—Use in medicine.—Poisonous properties.

*Subacetate*.—Great tendency of lead to form sub or basic salts.

*Goulard's Extract*, probably a trisacetate.— $3\text{PbO}, \text{C}_4\text{H}_3\text{O}_3 + \text{HO}$ .—Mode of preparing.—Solubility.—Effect of common water.

*Lead-water*.—Use in medicine.

*Chromate*.— $\text{PbO}, \text{CrO}_3$ —*Chrome yellow*.—Use.

*Chloride*.— $\text{PbCl}$ .—Modes of forming.

Properties.—When fused, constitutes *plumbum corneum*.—Distinguished from chloride of silver.

*Subchlorides* of Lead.

*Iodide*.— $\text{PbI}$ .—Preparation.—Properties.

*Bromide*.— $\text{PbBr}$ .—As the Iodide.

*Protosulphide*.—Native *galena*.— $\text{PbS}$ .

Mode of preparation.—Properties.

*Persulphide*.— $\text{PbS}_2$ .—Preparation.

*Tests*: (1) Caustic potash and soda.—(2) Alkaline carbonates.—(3) Chlorohydric acid, or a soluble chloride.—(4) Iodide of potassium.—(5) Sulphuric acid.—(6) Chromate of potash.—(7) Sulphydric acid.

*Alloys of Lead*.—Fine and coarse solder.—Composition.—Fusibility.

## BISMUTH.

Symbol, Bi.—Equivalent, 71.

Occurs mostly in the metallic state.

Obtained pure from the nitrate.

Properties.—Color.—Structure.—Specific gravity, 9.9.

Melting-point,  $500^{\circ}$ .—Burns in the air.—Proper solvent.

Its alloys remarkable for their fusibility.—*Rose's fusible metal*.—Other alloys.

It forms two compounds with oxygen.

*Suboxide*.— $\text{Bi}_2\text{O}_3$ .—Formed by the action of chloride of tin on the subnitrate.

*Protoxide*.— $\text{BiO}$ .—Made by burning bismuth in the air, or by heating the subnitrate.

Properties.

## SALTS OF BISMUTH.

*Nitrate*.— $\text{BiO}, \text{NO}_5 + 3\text{HO}$ .—Preparation.

Appearance of crystals.—Effect of water.

*Subnitrate*.— $3\text{BiO}, \text{NO}_5 + \text{HO}$ .—Made by throwing the nitrate into water.—Rationale.

Properties.—Uses.

*Chloride*.— $\text{BiCl}_3$ .—Obtained by throwing powdered bismuth into chlorine.

Properties.—Effect of water.

*Tests*.—(1.) Water on the protosalts.—(2.) Sulphydric acid.



## COBALT.

Symbol, Co.—Equivalent, 29·5.

Occurs in nature, associated with nickel and arsenic.—A constituent of meteoric iron.—Name.

Procured by heating the oxalate with charcoal.

Properties.—Color.—Brittleness.—Specific gravity, 8·5.—Magnetic.

It forms *two* compounds with oxygen.

*Protoxide*.—CoO.—Obtained, by calcining the carbonate.—As a hydrate.—Properties.

Its salts, isomorphous with those of magnesia.

*Sesquioxide*.—Co<sub>2</sub>O<sub>3</sub>.—Mode of preparation.—Does not form salts.

## SALTS OF COBALT.

*Sulphate*.—CoO,SO<sub>3</sub>+7HO.—Isomorphous with sulphate of magnesia.—Preparation.

Properties.

*Carbonate*.—CoO,CO<sub>2</sub>+CoO,HO.—Preparation.

*Chloride*.—CoCl.—Prepared by the action of chlorohydric acid on the oxide.—Change of color of the crystals, in passing from the moist to the dry state.—*Sympathetic ink*.

Effect of the oxide of cobalt on glass.—*Smalt*,—*Speiss*,—*Zaffre*,—*Cobalt Blue*.

*Tests*:—(1.) Solution of potassa.—(2.) Change in color of the chloride.—(3.) The blowpipe.

## NICKEL.

Symbol, Ni.—Equivalent, 29.6.

Occurs in nature, as cobalt.—Name.

Mode of preparation, like cobalt.

Properties.—White, hard, magnetic, malleable, and ductile.

—Specific gravity, 8.8.

It forms two compounds with oxygen.

*Protoxide*.—NiO.—Obtained by heating the nitrate;—or, as a hydrate, by precipitation.—Color.—The basis of the salts.

*Sesquioxide*.—Ni<sub>2</sub>O<sub>3</sub>.—Mode of preparation.

Properties.—Black color;—insoluble.—Does not form salts.

## SALTS OF NICKEL.

*Sulphate*.—NiO,SO<sub>3</sub>+7HO.—Isomorphous with sulphate of magnesia.—Preparation.

Properties.—Color of crystals.

*Carbonate*.—NiO,CO<sub>2</sub>+NiO,HO.—Obtained by precipitation.—Properties.

*Chloride*.—NiCl.—Prepared as the chloride of cobalt.—Color.

*German Silver*.—Composition.

*Tests*:—(1.) Green color of the salts.—(2.) Solution of potassa.—(3.) Ammonia.—(4.) Sulphide of ammonium.



## URANIUM.

Symbol, U.—Equivalent, 60.

Exists in *pitchblende* and *uranite*.

Properties.—Specific gravity, 9.

Forms *three* oxides.

*Protoxide*.— $\text{UO}$ .

*Black Oxide*.— $2\text{UO} + \text{U}_2\text{O}_3$ .

*Sesquioxide*.— $\text{U}_2\text{O}_3$ .—The most important.—A yellow powder, used in enamel painting, and for glass-staining.—Forms salts.

## ORDER II.

METALS, WHOSE OXIDES ARE WEAK BASES, OR ACIDS.

## TIN.

Symbol, Sn (Stannum).—Equivalent, 58.9.

Known to the ancients.—Most important localities.—Is found associated with oxygen, sulphur, and other bodies.

Composition of *mine tin* and *stream tin*.

Mode of reduction.—*Grain* and *block tin*.

Properties. —Color. —Softness.—Malleability.—Ductility. —Sound when bent.—Specific gravity, 7.2.—Fusing-point, 442°.—Burns when heated to whiteness.

Crystals procured.

Action of strong acids.—Action of weak nitric acid.

Uses of tin for coating other metals.

Process for tinning sheet-iron.

Mode of tinning pins.—Pewter.

Tin forms *three* compounds with oxygen.

*Protoxide*.— $\text{SnO}$ .—Process of obtaining it from the chloride.—Properties.—Action of heat.

*Sesquioxide*.— $\text{Sn}_2\text{O}_3$ .—Obtained by the action of the chloride on the sesquioxide of iron.—Color, grayish.



*Binoxide.*—*Stannic Acid.*— $\text{SnO}_2$ .

Exists under two isomeric conditions:—(1.) The hydrated binoxide,—from the action of nitric acid on the metal.—(2.) By precipitation from the bichloride, as a white bulky hydrate.

Properties.—*Jewellers' putty.*

*Protochloride.*— $\text{SnCl}$ .—Prepared as a hydrate.—Obtained in the anhydrous form.—Effect of much water.

Properties.—A powerful deoxidizer.—Effect on the persalts of metals.—Tendency to form double chlorides.

*Bichloride*—*Perchloride*—*Fuming Liquor of Libavius.*— $\text{SnCl}_2$ .

Prepared by heating metallic tin in chlorine; or by distillation of tin and corrosive sublimate together.

Properties.—Use in dyeing.

*Protosulphide.*— $\text{SnS}$ .—Obtained by fusing tin and sulphur together.

*Bisulphide.*— $\text{SnS}_2$ .—Obtained from the persalts by sulphydric acid.—Mode of preparing *Mosaic gold.*—Rationale.

The sulphides of tin act as *sulphur-acids*.

*Tests:* (1) The protosalts form the *purple of Cassius* with the chloride of gold.—(2) They deoxidize.—(3) They yield a black precipitate with sulphydric acid.—(4) The persalts give a yellow precipitate with sulphydric acid and sulphide of ammonia, soluble in an excess of the latter.

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## CHROMIUM.

Symbol, Cr.—Equivalent, 28.

Found in nature chiefly in combination with iron (*chrome iron*), and lead.—Localities.

Mode of separation.

Properties.—Grayish-white, — resembles steel.—Sp. grav. 5.9.—Difficulty of fusion.—Brittle.—Isomorphous with manganese and iron.

It forms *three* compounds with oxygen.

*Protoxide*.— $\text{CrO}$ .—Obtained as a hydrate.—It resembles the protoxide of iron in its tendency to absorb oxygen.—Color.

*Sesquioxide*.— $\text{Cr}_2\text{O}_3$ .—Isomorphous with  $\text{Fe}_2\text{O}_3$ .

Procured from chromate of mercury by heat; also by de-oxidizing the chromic acid of the bichromate of potash.

Properties.—A feeble base.—Green color.—Forms an alum with sulphate of potash— $\text{Cr}_2\text{O}_3, 3\text{SO}_3 + \text{KO}, \text{SO}_3 + 24\text{HO}$ .—Its solution yields the sesquioxide, by precipitation.

*Chromic Acid*.— $\text{CrO}_3$ .—Obtained nearly pure by the action of sulphuric acid on the bichromate of potash.—Properties.—Strong oxidizing property.—Effect on alcohol.

*Chromate of Potash*.— $\text{KO}, \text{CrO}_3$ .—Mode of obtaining from native chrome iron.

Properties.—Uses.

*Bichromate of Potash* (Red Chromate).— $\text{KO}, 2\text{CrO}_3$ .—Obtained by the action of sulphuric acid on the chromate.

Properties.—Uses in dyeing.

*Chromate of Lead*.— $\text{PbO}, \text{CrO}_3$ .—(Chrome yellow.)

Preparation.—Properties.—Use.

*Protochloride*.— $\text{CrCl}$ .—Mode of preparing.

Properties.—A powerful deoxidizer.

*Sesquichloride*.— $\text{Cr}_2\text{Cl}_3$ .—Preparation.



*Tests:* The different colors given to metallic solutions, as of lead, silver, mercury, zinc, and baryta.

Other metals belonging to this Order are :

VANADIUM, TUNGSTEN or WOLFRAM, MOLYBDENUM, COLUMBIUM or TANTALUM, TELLURIUM, TITANIUM, NIOBIUM, and PELOPIUM.

## ORDER III.

## METALS ISOMORPHOUS WITH PHOSPHORUS.

## ANTIMONY.

Symbol, Sb (Stibium).—Equivalent, 129.

The *tersulphide*, called crude antimony, the most common ore.—Localities.—Mode of reduction.—*Regulus of Antimony*.

Properties.—A white crystalline metal.—Sp. grav. 6.8.—Brittle.—Melts at  $842^{\circ}$ .—Takes fire at a white heat, giving off vapors of the oxide.—*Argentine flowers of Antimony*.

Action of hot chlorohydric and nitric acids.

Use of antimony in the arts.—Composition and characters of type-metal.

Antimony forms *four* compounds with oxygen.

*Teroxide*.— $\text{SbO}_3$ .—Formed by burning antimony in the air.—As an oxychloride, by throwing the terchloride into water.

Properties.—The basis of tartar emetic.

*Antimonious Acid*.— $\text{SbO}_3$ .—Preparation.

Properties.—Acid reaction.

*Antimonic Acid*.— $\text{SbO}_5$ .—Modes of forming it.

Properties.—*Antimoniate of Potash*.



## SALTS OF ANTIMONY.

*Terchloride*.— $\text{SbCl}_3$ .—Modes of preparation.

Properties.—Name, *butter of antimony*.

Effect of water.

*Pentachloride*.— $\text{SbCl}_5$ .—Corresponding to  $\text{SbO}_5$ .—Preparation.—Properties.

A chloride— $\text{SbCl}_4$ .—corresponding to  $\text{SbO}_4$ , is said to exist.

*Tersulphide*.— $\text{SbS}_3$ .—The *crude antimony* of commerce.—A native product.

Artificial formation.—Properties.

Effect of roasting the tersulphide.—*Glass, crocus, and liver* of antimony.

Effect of an alkali on an antimonial solution, through which sulphydric acid is passed.

Preparation and composition of *Kermes' mineral, precipitated sulphuret, and golden sulphur of antimony*.—Rationale.

*Sulphantimonious Acid*.— $\text{SbS}_4$ .—Preparation.

*Sulphantimonic Acid—Pentasulphide* —  $\text{SbS}_5$ . — Preparation.—Properties.

*Tartar Emetic* (tartrate of antimony and potash).— $\text{KO}$ ,  $\text{SbO}_3$ ,  $\text{C}_8\text{H}_4\text{O}_{10} + 2\text{HO}$ .—A bibasic salt.

Mode of preparation.—Rationale.

Properties.—Incompatibles.

Effects as a poison.—Treatment.—Antidote.

*Tests*: (1) Sulphydric acid through an acid solution: from this procure the metal.—(2) Action of water on the terchloride.

## ARSENIC.

Symbol, As.—Equivalent, 75.

Occasionally found native, but more usually in combination with other metals.

Mode of reduction—first, to sublime it as arsenious acid, and then to decompose this by heat and charcoal.

Properties.—Of an iron-gray color.—Brittle.—Sp. grav. 5·8.—Sublimes before fusing.—Odor of the vapor.—Condenses in close vessels in crystals.—Effect of the presence of air.—Mode of exhibiting the vapor.

Arsenic combines with metals like phosphorus.

It forms *two* compounds with oxygen; both of them acid.

*Teroxide*.—*Arsenious Acid*.— $\text{AsO}_3$  (white oxide).—Obtained in roasting the native ore.

Two varieties—the *vitreous* and *opaque*.

Points of difference between them.

Taste.—Solubility.—Crystalline form.—Sp. grav. 3·7.—Sublimes at  $380^\circ$ .—Density of vapor.—Solubility in acid and alkaline solutions.

Forms *arsenites*.—Isomorphous with phosphorous acid.

Taste.—Poisonous effects.—Treatment.—Antidotes.

*Arsenic Acid*.— $\text{AsO}_5$ .—Isomorphous with phosphoric acid.

Formed by action of nitric acid on  $\text{AsO}_3$ .

Properties.—Solubility.—Color.—Deliquescence.—Forms *arsenates* (tribasic).

*Suboxide* (Fly stone).—The dark-colored film which collects on the metal, on exposure.



*Terchloride*.— $\text{AsCl}_3$ .—Three methods of preparing it.

A volatile colorless liquid, decomposed by water into chlorhydric acid and arsenious acid.

*Teriodide*.— $\text{AsI}_3$ .—Preparation.

*Terbromide*.— $\text{AsBr}_3$ .

*Bisulphide*.— $\text{AsS}_2$ .—Native *Realgar*.—Artificially made.—Properties.—Use.

*Tersulphide*.— $\text{AsS}_3$ .—Native *orpiment*.—Artificial formation.—Properties.—Color.—Solubility in an alkaline solution.—Use as a test.

Both of these sulphides are sulphur-acids.

*Pentasulphide*.— $\text{AsS}_5$ .—(Sulpharsenic acid.)—Mode of preparation.—Properties.

*Arseniuretted Hydrogen*.— $\text{AsH}_3$ .—How formed.

Properties.—Colorless.—Alliaceous odor.—Specific gravity, 2.6.—Deleterious nature.—Color of its flame.—Products of combustion.—Modes of decomposing.

### *Tests.*

- I. The *solid* tests.—Mode of distinguishing arsenious acid from other white powder: (a) By heating in a test-tube, and noticing the crystalline sublimate. (b) Its sparing solubility in water. (c) The action of solution of potash. (d) The odor of the vapor when thrown on red-hot charcoal. (e) Obtaining the metallic ring by reduction.
- II. The *Liquid Tests*: (a) Ammonio-sulphate of copper.—Mode of making it. (b) Ammonio-nitrate of silver.—Mode of making it. (c) Sulphydric acid, through an acid solution;—and reduce the sulphide in the form of the metallic ring.

III. The *Gaseous Test*.—Marsh's apparatus.—The *tache*—how distinguished from that produced by antimony.

Flandin's modification of Marsh's apparatus.—Precautions to be observed.

IV. Reinsch's process,—by precipitation of the metal on copper.—Precautions.

Modes of proceeding in case of suspected poisoning.

Method of ascertaining the existence of the poison in the *solids* of the body.

Antidotes.



## ORDER IV.

METALS WHOSE OXIDES ARE REDUCED BY HEAT ALONE.

## MERCURY.

Symbol, Hg (Hydrargyrum).—Equivalent, 100 or 200.—Reason for assuming the former number.

Occasionally found in nature in the form of metallic globules.—Most common ore is the sulphide (cinnabar).—Localities.

Mode of reduction.

Properties.—Fluidity.—Color.—Specific gravity, 13.5.—Solidifies at the temperature of  $-39^{\circ}$  Faht.—Properties of the solid.—Boils at  $662^{\circ}$ .—Gives off vapor at common temperatures.

Impurities of commercial mercury.—Modes of purification.—Test of its purity.

Effect of exposure to the air.—Effect of boiling it in the air.

Action of the strong acids.

The alloys of mercury named *amalgams*.

The amalgam of *tin* employed for coating looking-glasses.—Method adopted.

It forms *two* compounds with oxygen.

Reasons for the nomenclature here adopted.

*Black Oxide.*—*Suboxide.*— $\text{Hg}_2\text{O}$ .—Obtained by the action of potassa on the subnitrate.—Rationale.—*Black wash*.

Properties.—Effect of exposure to light.

Chemical nature of *blue mass* and *mercurial ointment*.

Microscopic appearance.

*Red Oxide.*—*Protoxide.*— $\text{HgO}$  (red precipitate.)—The most powerful base.

Modes of preparation:—1. By heating the metal, in contact with the air. 2. By heating the nitrate. 3. By precipitation.

Differences in the resulting compounds.

Properties.—Color.—Solubility.—Action of heat.

Poisonous properties.—*Yellow wash*.

Use in medicine.

#### SALTS OF MERCURY.

Each oxide forms both a neutral and a basic salt.

*Nitrate of the Black Oxide.*— $\text{Hg}_2\text{O}, \text{NO}_5 + 2\text{HO}$ .—Made by an excess of cold dilute nitric acid on mercury.—Occurs in large colorless crystals;—decomposed by a large quantity of water.

*Basic Nitrate of the Black Oxide.*— $3\text{Hg}_2\text{O}, 2\text{NO}_5 + 3\text{HO}$ .—Made by cold dilute nitric acid on an excess of mercury.—Appearance.

Mode of distinguishing these two nitrates.

*Nitrate of the Red Oxide.*— $\text{HgO}, \text{NO}_5$ .

Made by boiling nitric acid in excess on mercury.—The *neutral* condition preserved only while in solution.—Change on drying.



Medical use.

*Basic Nitrate of the Red Oxide.*— $3\text{HgO}, \text{NO}_5 + \text{HO}$ .

Action of water on the former oxide.

*Sulphate of the Black Oxide.*— $\text{Hg}_2\text{O}, \text{SO}_3$ .

Modes of preparing.—Properties.

*Sulphate of the Red Oxide.*— $\text{HgO}, \text{SO}_3$ .—Obtained by boiling mercury and sulphuric acid together.—Rationale.

Effect of water.—Basic sulphate (turpeth mineral)— $3\text{HgO}, \text{SO}_3$ .—Use in medicine.

The *Carbonates*—how made.

*Subchloride—Calomel*— $\text{Hg}_2\text{Cl}$ .

Modes of preparation:—1. By the action of chlorine on mercury. 2. By solution of chloride of sodium on the sub-nitrate. 3. By subliming together common salt, the sulphate of the red oxide, and metallic mercury. 4. By subliming together common salt and corrosive sublimate.

Rationale in the above cases.

Properties.—Crystals (found native).—Color.—Solubility.—Specific gravity, 6.5.—Effect of exposure to light.—Effect of alkalis.

Test of its purity.—Use in medicine.—Howard's Calomel.

*Protochloride—Corrosive Sublimate*— $\text{HgCl}$ .

Prepared by subliming together common salt, and the sulphate of the red oxide.—Rationale.

Properties.—Colorless crystals.—Solubility in water, alcohol, and ether.—Specific gravity, 6.5.

Use in medicine.—Incompatibles.

Poisonous effects.—Antidote.

Use in the arts, and in the laboratory.

Tendency to form double salts.—*Sal alembroth*.

*White Precipitate.*—(Ammoniated mercury.)— $\text{HgCl} +$

$\text{HgNH}_2$ .—An *ammonio-chloride of mercury*.—Mode of preparation.—Rationale.—Properties.—Use.

Subiodide— $\text{Hg}_2\text{I}$ .—Modes of preparation.—Color.—Use in medicine.

*Protiodide—Red iodide*— $\text{HgI}$ .

Modes of obtaining.—Color.

Change of its molecular condition by heat.

Use in medicine.

The two *bromides* are analogous to the iodides.

*Cyanide*.— $\text{HgCy}$ .—The only one.—Reason for not considering it a *bicyanide*.

Obtained by the action of cyanhydric acid on the red oxide.

Usually manufactured by boiling together the red oxide and Prussian blue.—Rationale.

Use in the laboratory.

*Black Sulphide—Subsulphide*— $\text{Hg}_2\text{S}$ .—Obtained by the action of sulphydric acid on a subsalt.—Properties.

*Red Sulphide—Protosulphide*— $\text{HgS}$ .—(Native Cinnabar.)—Artificially made by fusing mercury and sulphur together.

Properties.—*Vermilion*.

*Ethiops Mineral*.—Made by triturating mercury and sulphur together.—Composition.

*Tests*: 1. Action of the alkalies on the subsalts.—2. Their action on the protosalts.—3. Action of protochloride of tin on a subsalt.—4. Action of iodide of potassium on both classes of salts.—5. Action of sulphydric acid on both.—6. Precipitation of metallic mercury on gold and copper.



## SILVER.

Symbol, Ag (Argentum).—Equivalent, 108.

Occasionally found native, in grains or threads.—More frequently as a sulphide, or chloride.—Antiquity.—Localities.

Two methods of reduction,—*amalgamation* and *cupellation*.

Processes described.

Mode of obtaining it *chemically pure*, from silver coin.

Properties.—Color.—The best conductor of heat and electricity.—Very malleable and ductile.—Sp. grav. 10.5.—Not acted on by the air or moisture.—Its tarnishing owing to the presence of sulphydric acid.

Effect of exposure to oxygen, when melted.

Effect of alloying it with copper.

Action of acids.—Proper solvent.

It forms *three* oxides.

*Suboxide*.— $\text{Ag}_2\text{O}$ .—Made by heating the citrate with hydrogen gas, and precipitating by potash.—Properties.

*Protoxide*.— $\text{AgO}$ .—Obtained by action of potash on the nitrate.

Properties.—Black color.—Nearly insoluble in water.—Soluble in ammonia.—The basis of all the salts.

*Peroxide*.— $\text{AgO}_2$ .—Obtained by galvanic agency on a weak solution of the nitrate.—Properties.

## SALTS OF SILVER.

*Nitrate*.— $\text{AgO}, \text{NO}_5$ .—Mode of preparation.

Properties.—Shape and color of crystals.—Solubility.—

Effect of the presence of organic matter, when exposed to light.

*Lunar Caustic*.—Preparation.—Impurities.

Uses in the arts, and in medicine.

Mode of removing its dark stains.

*Sulphate*.— $\text{AgO}, \text{SO}_3$ .—Made by boiling silver in sulphuric acid; or by the action of an alkaline sulphate on the nitrate.

Properties.—Difficult solubility in water.—Soluble in ammonia, forming a double salt.

*Carbonate*.— $\text{AgO}, \text{CO}_2$ .—Formed by double decomposition of the nitrate and carbonate of potash or soda.

Properties.—A white powder, becoming black on exposure.

*Hyposulphite and Hyposulphate*.

*Chloride*.— $\text{AgCl}$ .—(Horn Silver.)

Occurs native.—Made by decomposing the nitrate by a soluble chloride.

Properties.—A white bulky substance, insoluble in nitric acid, but soluble in ammonia.

The *Iodide*— $\text{AgI}$ , *Bromide*— $\text{AgBr}$ , and *Cyanide*— $\text{AgCy}$ , may be obtained, as the chloride, by double decomposition.

*Sulphide*— $\text{AgS}$ .—Occurs native.

Made by the action of sulphydric acid on a soluble salt of silver.—Properties.

*Ammoniuret*.—Obtained by dissolving the freshly precipitated oxide in ammonia.

Properties.—Violently explosive.—Rationale.

Modes of precipitating metallic silver from its solution.—*Arbor Dianæ*.

*Test*: Chlorohydric acid, or a soluble chloride.

*Alloys of Silver*.—Composition of *silver coin*.



## GOLD.

Symbol, Au (Aurum).—Equivalent, 99.5.

Found mostly in the metallic state, either pure, or alloyed with silver; and frequently in grains, or diffused through quartz.—Localities.

How separated.

Mode of separating from silver, by the process of *quartation*.

Mode of obtaining chemically pure.

Properties.—Color.—Malleability and ductility.—Conducting power.—Sp. grav. 19.5.—Not affected by air, moisture, or any pure acid.—Proper solvent.

It forms *two* compounds with oxygen.

*Suboxide*.— $\text{Au}_2\text{O}$ .—Made by the action of potassa on the subchloride.

Properties.—Not basic;—A green powder; soon decomposing into metallic gold and the sesquioxide.

*Sesquioxide*.—*Auric Acid*.— $\text{Au}_2\text{O}_3$ .

Mode of preparation.

Properties.—A reddish powder.—Acts as an acid.—Deoxidized by organic bodies, setting free metallic gold.—Digested with ammonia, it forms *fulminating gold*.

*Subchloride*.— $\text{Au}_2\text{Cl}$ .—Obtained by heating the sesquichloride.—Properties.

*Sesquichloride*.— $\text{Au}_2\text{Cl}_3$ .—The most important of all the salts.

Obtained by dissolving gold in aqua regia.—It forms double chlorides.

The solution used for gilding.

Etherial solution of gold.

*Test*: The formation of the Purple of Cassius.—Its composition.

*Alloys of Gold*.—Composition of gold coins.

Processes of gilding.—Assay of gold by the *touchstone*.

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PLATINUM.

Symbol, Pt.—Equivalent, 98·7.

Occurs in the metallic condition, in combination with palladium, rhodium, osmium, iridium, and ruthenium.—Localities.

Mode of extraction.—Rationale.

Properties.—Color.—Hardness.—Malleability and ductility.—Sp. grav. 21·5.—Not affected by exposure to the air or moisture, or any simple acid.—Proper solvent.—Mode of fusion.—Welding.

Careful use of platinum crucibles.

*Spongy platinum*, and *platinum black*.—Preparation.—Properties.

It forms *two* oxides, and *two* chlorides.

*Protoxide*.—PtO.—Made by the action of potassa on the chloride.—Rationale.—Properties.

*Binoxide*.—PtO<sub>2</sub>.—Obtained by the action of potassa on the bichloride, heating, and the addition of acetic acid.

Properties.—Soluble in acids and alkalies.—Forms salts.

*Protochloride*.—Obtained by heating the bichloride.

Properties.—A greenish powder—insoluble in water.

*Bichloride*.—PtCl<sub>2</sub>.—Obtained by dissolving the metal in aqua regia.



Properties.—Color.—Solubility. It forms double chlorides.  
—Use in the laboratory.

*Test*: The yellowish double chloride, formed with a salt of potash.

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### PALLADIUM.

Symbol, Pd.—Equivalent, 53.

Obtained from the chloride by iodide of potassium,—and heating the resulting iodide.

Properties.—Resemble those of platinum.—More readily fused.—Malleable.—Welding.—Sp. grav. 11·8.

The compounds of Palladium resemble those of platinum.

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### RHODIUM.

Symbol, R.—Equivalent, 52.

Obtained from the chloride, as palladium.

Properties.—Color.—Infusibility.—Sp. grav. 11.

Is not acted upon by any acids, nor by aqua regia, if in the pure state.

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### IRIDIUM.

Symbol, Ir.—Equivalent, 98·6.

Mode of extraction.

Properties.—Hardness.—Infusibility.—Sp. grav. 21·8 (the heaviest body known).

Use in the arts.

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## OSMIUM.

Symbol, Os.—Equivalent, 99·5.

Mode of extraction.—Properties.

It forms *four* compounds with oxygen.

*Osmic Acid*.— $\text{OsO}_4$ .

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## RUTHENIUM.

The last discovered of the associates of platinum.—Mode of extraction.

Properties.—Gray color.—Infusibility.—Sp. grav. 8·6.—Not easily acted on by aqua regia.—Forms compounds.



## PART III.

### ORGANIC CHEMISTRY.

DEFINITION.—Distinction between an *organic* and an *organized* body.—Organic bodies the products of organized bodies.—Examples.

*Primary and secondary organic bodies.*

Impossibility of making artificially any primary organic body.—Transformation into each other.

The *living vegetable-cell*, the true parent of organic matter.—Illustrations.

*Chemical composition of Organic Bodies.*—Their four *essential* elements,—carbon, hydrogen, oxygen, and nitrogen.

Their *accidental* elements,—sulphur, phosphorus, chlorine, fluorine, silicon, potassium, sodium, magnesium, calcium, iron, and manganese.—(Only *fifteen* in all.)

Necessity of these *accidental* elements.—Illustrations.

A chief difference between inorganic and organic bodies is the manner in which their elements are grouped together.

*Binary combination in inorganic bodies.*

More complex method in organic bodies.

Doctrine of *Compound Radicals*.—Examples.

*Behavior of these Compound Radicals:*

Some are *electro-positive*, and some *electro-negative*.

Liebig's definition of "Organic Chemistry."

Many of the Compound Radicals have been isolated.

Some act as the combustibles—sulphur, carbon, and phosphorus.—Examples.

Some act as the metals.—Examples.

Some partake of the nature of both.—Examples.

Highly probable that all organic compounds consist of one or more compound radicals.

The chief points of distinction between organic and inorganic bodies are :

1st. Their origin,—the former being always produced by a *living organism*, either directly or indirectly.

2d. The preponderance of carbon in organic bodies, united with oxygen, hydrogen, and nitrogen.

Results of heating organic bodies in open vessels.

Results of heating them in close vessels.

Heat is, consequently, a *test* for organic bodies.

Definition of "Organic Bodies," founded upon the above results.—(Turner.)

Proneness to spontaneous decomposition of organic substances, dependent on their complex composition.

Animal bodies more readily decomposed than vegetables.

The *least* tendency to decompose is found in those bodies whose elements are in the proportion to saturate each other.—Illustrations.

Products of the decomposition.

Controlling influence of the *vital force* in living animals and vegetables.

*Isomerism* very frequent among organic bodies.—Explanation.—Examples.



## ANALYSIS OF ORGANIC BODIES.

Various methods employed.—Liebig's considered the best.

Principles involved in determining the ultimate composition of a *ternary* organic body: "to ascertain the amount of hydrogen and carbon, by converting them, respectively, into water and carbonic acid; and the amount of oxygen by subtracting."

The oxygen obtained from the black oxide of copper.—Mode of preparation.—Accuracy in drying.—Quantity of the substance proper to be analyzed.—Mode of weighing.—The *combustion-tube*.—Method of filling it.—Mode of heating.—Chloride of calcium tube.—Liebig's potash bulbs.—Method of proceeding.

Mode of calculating the results.

Mode of determining the *nitrogen* and *sulphur*, in more complex organic bodies.

## PROXIMATE ORGANIC PRINCIPLES.

Definition of the term *Proximate Principles*.—Sometimes named *immediate principles*.—Their composition always complex.—Distinguished from *ultimate principles*.—Examples from the vegetable and animal kingdom.

The proximate principles are separated by *proximate analysis*.

Proximate analysis effected by different methods :

1. By solution.—The solvents employed.
2. By washing out mechanically.—Example.
3. By moderate heat.—Examples.
4. By compression.—Examples.
5. By chemical reagents, acting by virtue of their affinities.—Examples.

Importance of the proximate principles.—Their chemical composition very similar.—Isomerism very frequent.—Effect of a high heat.



## SECTION I.

SUBSTANCES COMPOSED OF CARBON, HYDROGEN, AND OXYGEN;—THE TWO LATTER BEING IN THE PROPORTION TO FORM WATER—(*Hydrates of Carbon*).

## GUM.

Technical definition of *Gum*.—Guerin's classification of gums.

Characters of *Arabin*.—Composition,  $C_{12}H_{11}O_{11}$ ;—isomeric with cane-sugar.

Strict definition of *mucilage*.—Chemical difference between mucilage, and a solution of gum.

Action of dilute sulphuric and nitric acids.

Characteristics of *Bassorin*.—Found in what gums.—Isomeric with arabin.

Characters of *Cerasin*.—Found in what varieties of gum.—Action of boiling water.—Isomeric with arabin.

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STARCH, OR FECULA.

Composition,  $C_{12}H_{10}O_{10}$ .—Wide diffusion throughout the vegetable kingdom.—Parts of plants yielding it.—Mode of separating it.

Appearance to the naked eye.—Physical conformation.—Appearance under the microscope.—Unequal size of the granules.

Action of water, alcohol, and ether.—Action of boiling water.—Effects of dry heat.—Appearance when dried, after being dissolved.—Action of iodine, and of other reagents.—Effect of strong acids.—Action of dilute acids and heat.—Action of malt.

Natural conversion of starch into sugar.

Varieties of starch.—Uses in medicine, and the arts.

*Dextrin*.—Name.—Mode of procuring it from starch.—Use in the arts.—Composition,  $C_{12}H_{10}O_{10}$ .

Properties. — Natural production in germinating grains under the influence of *diastase*.—Easy conversion into grape sugar.

*Pectin*.—Found in vegetable jellies.

Mode of extraction.—Action of chemical reagents.

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## SUGAR.

The term generically applied.—True and false sugar.

Four varieties of true sugar:—Cane Sugar, Grape Sugar, Sugar of Milk, and Uncrystallizable Sugar, or Molasses.

### I. CANE SUGAR.

Composition,  $C_{12}H_{22}O_{11}$ .—Sources.

Mode of extracting from the sugar-cane.—Mode of *refining*.

Properties. — Appearance. — Solubility. — Taste. — Crystals procured.—*Caramel*.—*Syrup*.



Action of subacetate of lead.—Action of strong and dilute sulphuric acid.—Action of strong and dilute nitric acid.—Action of alkalies and alkaline earths.

Influence of cane sugar on polarized light.

## II. GRAPE SUGAR—GLUCOSE.

Composition,  $C_{12}H_{22}O_{14}$ .

Occurs in numerous fruits,—in candied preserves,—in honey,—and in diabetic urine.

Artificial formation from most of the amylaceous bodies.

Points of difference between grape and cane sugar.—Action on polarized light.

Action of acids and alkalies.

Trommer's test.—Rationale.

Physiological importance of glucose.

## III. SUGAR OF MILK—LACTIN.

Composition,  $C_{12}H_{22}O_{12}$ .—Name.

Obtained by evaporating whey.—Appearance.

Properties.—Action of acids.

The *False Sugars*.—Their properties.

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## CELLULOSE AND LIGNIN.

Distinction between these two principles.—Composition,  $C_{12}H_{10}O_{10}$ .

Examples of true lignin.—Action of strong sulphuric acid is to convert them into grape sugar.—Action of nitric acid.

*Pyroxylin* or *Pyroxyl*—(*Gun Cotton*).—Composition,  $C_{24}H_{17}O_{17}5NO_5$ .

Mode of making.—Properties of gun cotton.

*Collodion*.—Preparation.—Uses.

*Xyloidin*.— $C_6H_4O_4NO_5$ .—Analogous to pyroxylin.—Made by the action of nitric acid on paper.



## SECTION II.

PRINCIPLES RESULTING FROM THE ACTION OF NITRIC ACID ON SOME OF THE FOREGOING SUBSTANCES.

## MUCIC ACID.

Composition,  $C_6H_4O_7, HO$ .

Made by the action of nitric acid on gum, or sugar of milk.

—Preparation.—Properties.

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## OXALIC ACID.

Composition,  $C_2O_3, HO + 2HO$ , or  $CO + CO_2, HO + 2HO$ .

Made by the action of strong nitric acid on any of the amylaceous bodies, except gum and lactin.

Usual mode of preparation.—Rationale.

Properties.—Crystals.—Taste.—Solubility.—Poisonous effects.—Antidotes.

Use in the laboratory.

## SALTS OF OXALIC ACID.

The *Oxalate* and *Binoxalate* of Potassa.

*Oxalate of Ammonia*.—*Oxalate of Lime*.—Properties.

*Oxamide*.— $C_2O_2 + NH_2$ , or  $C_2H_2NO_2$ .—Preparation.

*Suberic Acid*.— $C_8H_6O_3 + HO$ .—Obtained by the action of nitric acid on cork.



## SECTION III.

## FERMENTATION.

The term *Fermentation* used formerly in a restricted sense.  
—Now more extended.—Distinguished from catalysis.

A *ferment* defined.—Composition.

Circumstances influencing fermentation :

1. *Temperature*.—It cannot occur below 40°.—The *result* of the fermentation dependent on the degree of heat.—Illustrations.

2. The *degree of decomposition of the ferment*.—Illustrations.

Small quantity of ferment requisite to affect a large amount of material.—Example.

During fermentation, the ferment itself is destroyed, unless there be present some albuminous substance, out of which fresh ferment is generated.—Example in the case of *yeast*.

Application to the pathology of the different *viruses*.

Speculations as to the *modus operandi* of ferments.—Microscopic appearance of yeast.

The *results* of fermentation are widely different, being dependent upon the temperature, but chiefly on the degree of decomposition of the ferment.—Examples.

*Antiseptics*.

Six species of Fermentation :

I. *Organic Fermentation*.—The lowest form.—Circumstances favorable to it.—Mould and mildew.—The product is cellulose.

II. *Germinative Fermentation*.—Circumstances requisite.—The most favorable temperature.—Results.

III. *Vinous Fermentation*.—Circumstances necessary.—Proper temperature.

Natural occurrence in the juices of fruits when exposed to the air.

Phenomena attending its occurrence in grape-juice.—Deposit of *argol*.

Examples of *fermented liquors*.

Chemical changes occurring in Vinous Fermentation.

Effect of distilling the fermented liquors.

## ALCOHOL.

Composition— $C_4H_6O_2$ , or  $C_4H_5O,HO$ .—Always produced as the result of the vinous fermentation.—Small quantity at first produced.—The liquors concentrated by distillation.

Process of distillation.

*Ardent spirits*, or *distilled liquors*—The result of the first distillation.—Examples.

*Spirits of wine*, or *officinal alcohol*—The result of a second distillation.

Quantity of real alcohol contained in distilled liquors.—Quantity in spirits of wine.

Properties of common alcohol (spirits of wine).—Limpid;—Colorless;—Peculiar odor;—Inflammable.—Color of flame.



—Results of combustion.—Solvent properties.—Sp. grav. .835.

—Contains 15 per cent. of water.

*Absolute Alcohol*.—Obtained from the common, by distilling with quick-lime, and by other processes.

Properties.—Sp. grav. .793.—Boils at 177°.—Blue color of flame.—Has never been frozen.—Is miscible with water in all proportions.

Extensive use in the laboratory, and in the arts.

*Alcoates*.

IV. *Lactic Acid Fermentation*.—When produced.—Examples.—Chemical change involved.

*Lactic Acid*.—Best mode of preparation.

Properties.—A colorless syrupy liquid.—Sp. grav. 1.215.—Very acid.—Soluble in water.

Cause of thickening of milk.—Effect of rennet.

Physiological importance of lactic acid.

The most important *lactates*.

V. *Butyric Acid Fermentation*.—Discovered by Pelouze.

It succeeds the lactic acid fermentation.

Mode of producing it.—Rationale.

Properties of *Butyric Acid*.—An oily liquid, of an unpleasant odor.—Sp. grav. .963.—Soluble in water, alcohol, and ether.—Forms salts.

It is also a product of the decomposition of fibrin.

*Butter* is a *butyrate of the oxide of lipyle*.

VI. *Viscous Fermentation*.—Circumstances favorable to its production.

Chemical changes involved.—Nature of the results.

## SECTION IV.

PRODUCTS OF THE ACTION OF ACIDS ON ALCOHOL—  
ETHERIFICATION.

## THE ETHYLE COMPOUNDS.

Ethyle,  $C_4H_5$ , or Ae.

Oxide (ether),  $C_4H_5O$ , or AeO.

Hydrated oxide (alcohol),  $C_4H_5O, HO$ , or AeO, HO.

Chloride (muriatic ether),  $C_4H_5Cl$ , or AeCl.

Bromide (hydrobromic ether),  $C_4H_5Br$ , or AeBr.

Cyanide (hydrocyanic ether),  $C_4H_5Cy$ , or AeCy.

Nitrate of oxide (nitric ether),  $C_4H_5O, NO_5$ , or AeO,  $NO_5$ .

Hyponitrite of oxide (nitrous ether),  $C_4H_5O, NO_3$ , or AeO,  $NO_3$ .

Sulphate of oxide (sulphuric ether),  $C_4H_5O, SO_3$ , or AeO,  $SO_3$ .

Bisulphate of oxide (sulphovinic acid),  $C_4H_5O, 2SO_3, HO$ .

Carbonate of oxide (carbonic ether),  $C_4H_5O, CO_2$ , or AeO,  $CO_2$ .

Oxalate of oxide (oxalic ether),  $C_4H_5O, C_2O_3$ , or AeO,  $C_2O_3$ .

The radical *Ethyle* has lately been isolated.—Mode of separating it.

Properties.—A colorless, inodorous gas, burning with a brilliant flame.—Condenses into a thin mobile liquid.—Sp. grav. 2.0.



## ETHER.

Composition. —  $C_4H_5O$ . — Improperly named *Sulphuric Ether*.—Made by depriving alcohol of its one equivalent of water.

Mode of preparation.—Rationale.—How purified.

Properties.—A thin, mobile, colorless liquid.—Odor and taste.—Sp. grav. .720.—Boils at  $96^\circ$ .—Volatility.—Inflammability.—Products of combustion.—Cold produced by its evaporation.—Density of vapor, 2.586.—Attracts oxygen from the air, and is converted into acetic acid.—Solubility in water and alcohol.—Its solvent powers.

*Pure or washed ether prepared.*

Use as an anæsthetic.—Rationale.

## COMPOUND ETHERS.

These ethers are true *salts*,—consisting either of an acid combined with the oxide of ethyle, or of a halogen body combined with the radical ethyle.

General method of forming them.

*Chloride of Ethyle.*—*Chlorohydric or Muriatic Ether.*— $C_4H_5Cl$ .

Mode of preparation.—Properties. — Odor.—Volatility.—Sp. grav. .872.—Boils at  $52^\circ$ .

The *bromide* and *iodide* are prepared in the same general way.

Sp. grav. of the iodide, 1.9.—Boils at  $160^\circ$ .

*Nitrate.*—*Nitric Ether.*— $C_4H_5O, NO_5$ .—Mode of preparation.—Use of the urea.

Properties.—Sp. grav. 1.112.—Insoluble.

*Hyponitrite.*—*Nitrous or Hyponitrous Ether.*— $C_4H_5O, NO_3$ .

Modes of obtaining it pure.—How, containing aldehyde.

Composition of *Sweet Spirit of Nitre*.

*Sulphate.*—*Sulphuric Ether* (true).— $C_4H_5O, SO_3$ .—Only lately isolated.—Mode of preparation.—Properties.

*Acid Sulphate.*—*Sulphovinic Acid.*— $C_4H_5O, 2SO_3, HO$ .

Mode of formation.—Rationale.—Properties.—Forms salts.

*Heavy Oil of Wine.*— $C_4H_4, SO_3 + C_4H_5O, SO_3$ .

Mode of procuring.—Properties.

*Phosphovinic Acid.*— $C_4H_5O, 2PO_5$ .

Similar in preparation and properties, to sulphovinic acid.

*Olefiant Gas.*— $C_2H_2$ .—Already treated of.

Mode of making.—Action of chlorine.

#### ACTION OF CHLORINE ON ALCOHOL AND ETHER.

*Chloral.*— $C_4Cl_3O, HO$ .—Made by passing chlorine through alcohol.

Analogous in composition to aldehyde.

Principle of *substitution*.

Properties.—A thin, oily, colorless liquid, of a penetrating odor.—Specific gravity, 1.5.—Solubility.

*Action of Chlorine on Ether.*—Series of compounds formed on the principle of substitution.—Examples.



## SECTION V.

## ACTION OF OXYGEN ON ALCOHOL.

## THE ACETYLE COMPOUNDS.

Products of the combustion of alcohol and ether, in the air.  
—Possibility of so slowly oxidizing them, as only to deprive them of a portion of their *hydrogen*.

As a result, a series of compounds is formed, inferred to have one common base—*Acetylene*.

The radical *acetylene* is formed from ethylene, by depriving the latter of two equivalents of oxygen.

Point of difference between ethylene and acetylene.

*Eremacausis* defined and explained.

Differs essentially from fermentation.

Prerequisites.—Examples.

Importance in the animal economy.—Physiological deductions.

Acetylene, Ac, or  $C_2H_2$  (unknown).

Oxide,  $C_2H_2O$  (unknown).

Hydrated Oxide,—aldehyde.— $C_2H_2O, HO$ .

Acetylous Acid (aldehydic acid).— $C_2H_2O_2, HO$ .

Acetylic Acid (acetic acid).— $C_2H_2O_3, HO$ .

*Aldehyde*.— $C_4H_3O, HO$ .

Name.—Principle involved in its formation.

Modes of preparation.—Rationale of action of chromic acid on alcohol.

Properties.—A limpid, colorless liquid, having an odor of apples.—Specific gravity, .790.—Boils at  $72^\circ$ .—Solubility.—Action on the oxide of silver.—Action of the atmosphere.

*Aldehydic Acid*—(*Lampic Acid*).— $C_4H_3O_2, HO$ .

*Acetic Acid*.— $C_4H_3O_3, HO$ .

Action of alcohol vapor on platinum.—Effect of exposing dilute alcohol to the air.

True nature of the so-called *acetous* fermentation.

Nature of *Vinegar*.—Sources of it.—German manner of making it.

Chemical change accompanying the conversion of alcohol into acetic acid.

*Pyroligneous Acid*.—Name.—Preparation.—Obtained pure from dry acetate of soda.

*Properties*.—Colorless.—Odor and taste.—Boiling-point,  $248^\circ$ ,—freezes at  $50^\circ$ .

*Glacial Acetic Acid*.—Preparation.—Strong affinity for water.—Properties.

Use of acetic acid in the arts, and medicine.

Forms salts, named *acetates*.

The acetates most used in medicine.

*Acetal*.— $C_8H_9O_3$ .—Mode of obtaining.—Impurities.—Properties.—Odor.

*Chloroacetic Acid*.— $C_4Cl_3O_3, HO$ .

Mode of procuring.

*Acetone*—*Pyroacetic Spirit*.— $C_4H_4O$ .

Procured by distilling acetate of lead.

Properties.



## SECTION VI.

## THE KAKODYLE COMPOUNDS.

*Kakodyle*.— $C_4H_6As$ , or Kd.

Lately isolated.—Procured from the chloride.

Properties.—A thin liquid, of an offensive odor.

*Oxide—Cadet's Fuming Liquid*.— $C_4H_6AsO$ .—Named also *Alkarsin*.

Danger of inhaling it.—Properties.

The other Kakodyle compounds are the *Chloride, Iodide, Bromide, Cyanide, Sulphide, Kakodylic Acid, &c.*

## SECTION VII.

## THE METHYLE COMPOUNDS.

Methyle (not isolated).— $C_2H_3$ , or Me.

Oxide (wood ether).— $C_2H_3O$ , or MeO.

Hydrated Oxide (wood alcohol).— $C_2H_3O, HO$ , or MeO, HO.

Chloride (wood muriatic ether).— $C_2H_3Cl$ , or MeCl.

Sulphate (wood sulphuric ether).— $C_2H_3O, SO_3$ , or MeO,  $SO_3$ , &c. &c.

## METHYLIC ALCOHOL.

*Wood Spirit*—*Wood Naphtha*—*Pyroxylic Spirit*.— $C_2H_3O, HO$ .

A product of the destructive distillation of wood, along with pyroligneous acid.—Proportion.—Mode of purifying.

Properties.—A true alcohol.—Nearly colorless.—Volatile.—Inflammable.—Peculiar odor.—Specific gravity, .798.—Boils at  $152^\circ$ .—Solubility.—Solvent powers.—Antiseptic.

## METHYLIC ETHER.

*Wood Ether*.— $C_2H_3O$ .

Mode of preparation, similar to that of common ether, only substituting methylic alcohol.



Properties.—A permanent gas, sparingly soluble in water, —more so in alcohol.—Inflammable.—Of an ethereal odor.

*Sulphate*.— $C_2H_3O,SO_3$ .—Made by a large excess of sulphuric acid on wood spirit.

Properties.—A heavy oily liquid, of an alliaceous odor.—Neutral to test paper.—Insoluble in water.

*Acid Sulphate*—*Sulphomethylic Acid*.— $C_2H_3O,2SO_3+HO$ .—Prepared as sulphovinic acid.

The other compounds of Methylene are obtained in a manner analogous to the corresponding Ethylene compounds;—and their properties closely correspond to those of the latter.

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#### OXIDATION OF METHYLIC ALCOHOL.—THE FORMYLE COMPOUNDS.

Products of the combustion of wood spirit in the open air.

The *eremacausis*, or slow oxidation of wood-spirit, effected like that of common alcohol;—the result is a new acid, named *Formic Acid*.

The Formyle Compounds are as follows:

Formyle (not isolable),  $C_2H$ .

Hydrated teroxide (formic acid),  $C_2HO_3,HO$ .

Terchloride (chloroform),  $C_2HCl_3$ .

Teriodide (iodoform),  $C_2HI_3$ .

Terbromide (bromoform),  $C_2HBr_3$ .

*Formic Acid*.— $C_2HO_3, HO$ .—Named from.—Mode of obtaining from ants.

Procured, as an aldehyde, by the action of sulphuric acid and bichromate of potash on wood spirit;—also by dilute sulphuric acid on sugar, or starch, and peroxide of manganese.

Properties.—A clear, colorless, pungent liquid.—Powerfully acid.—Having the odor of ants.—Corrosive.—Forms *formiates*.

Distinguished, how, from acetic acid.

*Chloroform*.— $C_2HCl_3$ .—Is formed by the action of chlorine on the chloride of methyle, in the sun's light;—two equivalents of hydrogen are substituted by two of chlorine.

Mode of manufacture.—Purification.

Properties.—A colorless limpid liquid, of a peculiar aromatic odor;—pungent, sweetish taste.—Sp. grav. 1.49.—Not inflammable.—Insoluble in water.—Soluble in alcohol and ether.

Use, in medicine, as an anæsthetic.—Differs from ether.

*Bromoform* and *Iodoform* are compounds similar to chloroform; and their mode of preparation analogous to that of the latter.

Substitution—action of chlorine on the Methylene series, analogous to that upon the Ethylene series.—Examples.

*Other products arising from the destructive distillation of wood*.—These are found in the *wood-tar*.—Difference between it and coal-tar.

*Creasote* the most important product.—Its mode of separation complex.

Properties.—Colorless when pure.—Sp. grav. 1.03.—Odor and taste, pungent and peculiar.—Highly refractive.—Boils



at  $397^{\circ}$ .—Inflames with difficulty.—Slightly soluble in water, alcohol, and acetic acid.—A powerful antiseptic.—Strong affinity for albumen.—Uses.

Influence of wood-smoke in preserving meats.

Other principles found in wood-tar are *paraffin*, *eupione*, *picamar*, and *kapnomor*.

## SECTION VIII.

## THE AMYLE COMPOUNDS.

Amyle (not isolable),  $C_{10}H_{11}$ , or Ayl.

Oxide (amylic ether),  $C_{10}H_{11}O$ .

Hydrated oxide (amylic alcohol),  $C_{10}H_{11}O, HO$ .

Chloride,  $C_{10}H_{11}Cl$ .

Iodide,  $C_{10}H_{11}I$ .

Acetate,  $C_{10}H_{11}O, AcO$ .

*Amylic Alcohol*.— $C_{10}H_{11}O, HO$ .

The *fusel oil*, found in the whiskey obtained from potatoes, is the impure amylic alcohol.—It is found also towards the close of the process for making common alcohol.

Appearance of *fusel oil*.—Mode of purification.

Properties.—A thin, colorless, mobile liquid, of a pungent odor and burning taste.—Sp. grav. .818.—Burns with difficulty.—Boils at  $262^{\circ} F$ .—It has all the essential properties of a true alcohol.

*Amylic Ether*.— $C_{10}H_{11}O$ .—Made in a manner analogous to the other two ethers.

Properties.—A colorless liquid, of a pleasant odor; boiling at  $233^{\circ} F$ .

The *acetate*, *chloride*, *iodide*, &c., are formed like the corresponding methyle compounds.



The *acid sulphate* of amyle, or *sulphamylic acid*— $C_{10}H_{11}O$ ,  $2SO_3,HO$ —is very analogous to sulphovinic and sulphomethylic acids.—Obtained in a similar manner.

By *eremacausis*, or slow oxidation, amylic alcohol is converted into a new acid—the *valerianic*—in a manner precisely analogous to acetic and formic acids. This acid is the *hydrated teroxide* of a new radical,  $C_{10}H_9$ —named *Valyle*.

*Valerianic Acid*.— $C_{10}H_9O_3,2HO$ .—A natural product of the valerian root.—Best mode of forming it artificially.

Properties.—Identity with the natural acid.—Uses.

*Valerianic Aldehyde*.— $C_{10}H_9O,HO$ .—How made.—Properties.—Uses.

## SECTION IX.

## THE BENZOILE COMPOUNDS.

The compound radical *Benzoile*— $C_{14}H_5O_2$ , or Bz—has never been isolated.

*Hydruret (Oil of Bitter Almonds)*.— $C_{14}H_5O_2 + H$ , or BzH. —Obtained by distillation from the bitter almond, peach kernels, &c.

It does not pre-exist in these substances, in the free state.—Explanation of its mode of formation.—The *amygdalic fermentation*.—Nature of the *ferment*.

*Amygdaline*.— $C_{40}H_{27}O_{23}N$ .—How obtained.—Properties.

The oil of bitter almonds of commerce contains hydrocyanic acid.—Poisonous properties.

Properties of the pure oil.

*Oxide of Benzoile (Benzoic Acid)*.— $C_{14}H_5O_2 + O$ , or BzO. —Natural sources.

Modes of preparation.—Properties.

*Benzoates*.—Uses in medicine.

Its conversion into hippuric acid, in passing through the animal system.



## SECTION X.

## THE CINNAMYLE COMPOUNDS.

The compound radical, *Cinnamyle*— $C_{18}H_7O_2$ , or  $Ci$ ,—has not yet been obtained in a separate state.

*Hydruret (Oil of Cinnamon)*.— $C_{18}H_7O_2 + H$ , or  $CiH$ .—  
Natural source, from the cinnamon bark by distillation.—  
Properties.

*Oxide (Cinnamic Acid)*.— $C_{18}H_7O_2 + O$ , or  $CiO$ .

Obtained by the oxidation of oil of cinnamon.

An ingredient in the true *balsams*.

## SECTION XI.

## THE SALICYLE COMPOUNDS.

The compound radical *Salicyle*— $C_{14}H_5O_4$ , or  $Sl$ —has never been separated.

*Salicine*.— $C_{21}H_{14}O_{11}$ .—A neutral proximate principle, found in the bark of the willow, poplar, and other trees.

Properties.—Use in medicine.

*Hydruret of Salicyle*.— $C_{14}H_5O_4 + H$ , or  $SlH$ .—(*Artificial Oil of Meadow Sweet*).—Obtained by distillation of salicine with bichromate of potassa and sulphuric acid.—Properties.

Analogy with the natural oil.

*Salicylic Acid*—(*Hydrated Oxide of Salicyle*).— $SlO,HO$ .—Preparation.—Properties.

*Salicylate of the Oxide of Methylene* (*Oil of Gaultheria procumbens*).— $MeO + SlO,HO$ .

Natural source.—Artificially made, by distilling salicine with methylic alcohol.—Properties.



## SECTION XII.

## ORGANIC OR VEGETABLE ACIDS.

Their frequent occurrence in the vegetable kingdom.—Parts of plants in which they are most generally found.—Their origin is ascribed to the oxidizement of the amylaceous compounds; and, as they are generally found associated with the volatile oils, both are believed to be formed simultaneously from the same source,—the one by receiving the oxygen, which is relinquished by the other.

Many of them used in medicine.

Two classes of vegetable acids:—the one, found ready formed in plants;—the other, the result of the action of heat on the former.

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ACETIC ACID.

Composition,  $C_4H_3O_3, HO$ .—Already noticed as the result of the oxidizement of alcohol.—Its frequent occurrence in vegetables,—usually in combination with potassa. When the plants are burned, the organic acid is converted into carbonic acid; and, accordingly, the *carbonate of potassa* is found in the ash.

Its properties have already been noticed.

## CITRIC ACID.

Composition.— $C_{12}H_5O_{11}, 3HO$ .—A tribasic acid.

Exists naturally in the lemon, lime, sour orange, &c.—Obtained from lemon-juice, by adding chalk, which forms citrate of lime;—then decompose by sulphuric acid, and crystallize the residue by evaporation.

Properties.—Large size of the crystals.—Colorless.—Freely soluble in water.—Taste.

Mode of distinguishing it from *Tartaric Acid*.

Uses in medicine.—Citrates.

Effect of heating citric acid is to convert it into three equivalents of *aconitic acid*— $C_4HO_3 + HO$ , and two equivalents of water.

## TARTARIC ACID.

Composition,  $C_8H_4O_{10} + 2HO$ .—Bibasic.

Exists naturally in certain fruits,—as the grape, tamarind, gooseberry, &c.

Obtained from the acid tartrate of potash (cream of tartar) by the action of chalk, which throws down the tartrate of lime;—then decompose this by means of sulphuric acid, and crystallize by evaporation.

Properties.—Large colorless crystals.—Soluble in water.—Very sour.—Tendency to form bibasic salts.

*Test*.—Its action upon potassa.

*Acid Tartrate of Potassa* (Cream of Tartar).— $KO, HO, C_8H_4O_{10}$ .—A bibasic salt, improperly called *Bitartrate*.

Obtained by purifying *argol*.—Nature, and mode of formation of *argol*.



Properties.—Sour taste.—Sparing solubility in water.—  
Effect of a strong heat.

*Neutral Tartrate of Potassa*— $2\text{KO}, \text{C}_8\text{H}_4\text{O}_{10}$ .

Obtained from cream of tartar by boiling it with carbonate of potassa.

Properties.—Very soluble in water, and hence named *Soluble Tartar*.—Used in medicine.

*Tartrate of Potassa and Soda*—(Rochelle Salt).— $\text{KO}, \text{NaO}, \text{C}_8\text{H}_4\text{O}_{10} + 10\text{HO}$ .

Made, by boiling cream of tartar with carbonate of soda.

Properties.—Large colorless crystals.—Soluble in water.—  
An ingredient in the Seidlitz powders.

*Tartrate of Antimony and Potassa* (Tartar Emetic).—A bibasic salt.—Composition— $\text{KO}, \text{SbO}_3, \text{C}_8\text{H}_4\text{O}_{10} + 2\text{HO}$ .

Mode of manufacture and properties, already discussed under the head of Antimony.

Effect of heat on tartaric acid is to convert it into *pyrotartaric* or *pyrumic acid* ( $\text{C}_6\text{H}_3\text{O}_5$ ), and carbonic acid.

#### RACEMIC ACID.

Isomeric with tartaric acid.—Called also *paratartaric acid*.

Origin.—Differs, how, from tartaric acid.

#### MALIC ACID.

Composition.— $\text{C}_8\text{H}_4\text{O}_8 + 3\text{HO}$ .—Tribasic.

Found in the apple, rhubarb stalk, &c.—Mode of procuring.  
Properties.—Crystalline, soluble in water.—Liability to decompose.

Action of heat,—to convert it into *malleic* and *fumaric* acids.

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## TANNIC ACID.

Composition.— $C_{18}H_5O_9 + 3HO$ .—Tribasic.

A natural product in galls, oak bark, and many other vegetables.—Usually associated with gallic acid.

Pelouze's method of procuring it from powdered galls, by means of ether.

Properties.—Color.—Taste.—Solubility.—Two varieties of tannic acid.—*Tannates*.

*Test*.—Gelatin, and salts of the peroxide of iron.

Uses in the arts, and in medicine.

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## GALLIC ACID.

Composition— $C_7HO_3 + 2HO$ .—Bibasic.

Not so abundant in nature as tannic acid.

Formed naturally, by the oxidizement of tannic acid.—Rationale.

Mode of forming artificially.

Properties.—Astringent taste; but does not precipitate gelatin.



## SECTION XIII.

## ORGANIC SALT BASES—VEGETABLE ALKALIES.

Their importance in the vegetable kingdom.—Always occur associated with an acid, which itself is often quite peculiar.

Found in the different parts of plants,—as the bark, leaves, seeds, root, and fruit.

Their composition complex.—They generally contain nitrogen.—They are all more or less poisonous; though at the same time most valuable as medicines. They combine with acids, like the inorganic bases. They possess none of the other usual alkaline properties.

General method of separating them in the free state.

General properties.—Usually crystalline.—Insolubility in water.—Solubility in alcohol.—Taste.—Solubility of their salts.

The salts preferred for medical use.

*Morphia*.— $C_{35}H_{20}NO_6$ .—The most important principle in opium.—Exists naturally in combination with *meconic acid*.

Mode of extracting.—Mode of separating from *Narcotina*.

Salts most used,—the sulphate, acetate, and muriate.

*Tests*.—Nitric acid; and a persalt of iron.

*Narcotina*.— $C_{48}H_{24}NO_{15}$ .

Mode of procuring.—Appearance.

Supposed physiological properties.—Uses.

*Codeia*.— $C_{35}H_{20}NO_5$ .—A principle of opium.—How separated.—Properties.

*Meconic Acid*.—The peculiar *acid* principle found in opium.—It contains no nitrogen.

Test.—The blood-red color given to a persalt of iron.—In testing for opium, in case of suspected poisoning, it is proper to search for the *meconic acid*, by the above test.

*Quinia*— $C_{20}H_{12}NO_2$ . }  
*Cinchonia*— $C_{20}H_{12}NO$ . }

The active principles of Peruvian bark.—Method of extracting them.

Mode of separating them from each other.

Properties.—Comparative solubility.

*Sulphate of Quinia*.—How made.—Chemically, a *disulphate*.

Properties.—Mode of increasing its solubility.—Incompatibles.

Test.—A fresh solution of chlorine and liquor ammoniæ yield a fine green color.—Also, acetic acid and tincture of iodine yield with it a green spangled appearance.

*Quinoidine*.— $C_{18}H_{11}NO$ .—Another principle more recently discovered in Peruvian bark.

*Aricina*.— $C_{20}H_{12}NO_3$ .—An alkaloid, found in certain varieties of *Cinchona* barks.

*Strychnia*.— $C_{44}H_{23}N_2O_8$ .—The active principle of *Nux Vomica*, *St. Ignatius bean*, &c., usually associated with *brucia*, and in combination with *Igasuric acid*.

Mode of extraction.

Properties.—Color.—Taste.—Solubility.—Poisonous effects.—Antidotes.



*Test.*—The purple color produced by the action of the puce-oxide of lead, and a drop of sulphuric acid. Nitric acid does *not* afford a red color, if brucia is absent.

*Brucia.*— $C_{44}H_{25}N_2O_7$ .—Found in certain vegetables associated with strychnia, as an *igasurate*.—Mode of separation.

*Test.*—It affords a deep-red color, when touched with nitric acid.

*Veratria.*— $C_{34}H_{22}NO_6$ .—Where found in nature.—Properties.—Uses.

*Concia.*— $C_{16}H_{16}N$ .—The active alkaloid of *Conium maculatum*.

Properties.—An oily liquid, having the reaction of the alkaloids generally.

*Nicotia.*— $C_{10}H_8N$ .—The active principle of tobacco.

Properties.—An oily substance, exceedingly poisonous.

Among the other alkaloid principles may be enumerated *Emetia*, *Aconitia*, *Hyoscyamia*, *Atropia*, *Daturia*, *Solania*, &c.

Besides the vegetable alkaloids, there are certain neutral principles, many of which constitute most important remedial agents.

*Thein* and *Caffein*.—The active principles of tea and coffee.—Composition— $C_8H_5N_2O_2$ .

Mode of procuring.—Properties.

*Piperin*, *Asparagin*, *Picrotoxin*, *Gentianin*, *Elaterin*, *Beberin*, &c.

## SECTION XIV.

## OILS AND FATS.

Division into *vegetable* and *animal* oils.

The vegetable fixed oils are procured chiefly by expression, from the seeds of plants; and are hence named *expressed* oils.

Examples:—Castor oil, linseed oil, poppy-seed oil.—Olive oil, from the fruit.

They are generally liquid at ordinary temperatures.

Exceptions.—*Palm oil* and *oil of mace*, which are solid.

Animal oils are usually solid, and are named *fats*.

Properties.—When perfectly pure, they are colorless, tasteless, and inodorous.—Their usual odor and taste depend on a volatile substance.—They leave a permanent, greasy stain on paper.—Boil at a temperature above  $212^{\circ}$ .—Decompose at  $600^{\circ}$ .—Take fire at a higher temperature, generating water and carbonic acid.—By decomposition, they yield several hydrocarbons,—as in the manufacturing of oil gas.

Insoluble in water,—but may be suspended in it, as in the case of *emulsions*.—Slightly soluble in alcohol.—Very soluble in ether, and in the volatile oils.—They have more or less attraction for oxygen.—Drying, and non-drying oils.

Oils not strictly proximate principles, but composed of several,—two of which, *stearine* and *margarine*, are solid, and



one, *oleine*, is liquid at ordinary temperatures.—These principles may be easily separated.

*Stearine*.— $C_{71}H_{70}O_{80}$ .—The solid portion of suet, and of animal fats generally,—except human fat.

Obtained, by action of ether upon suet :—it is dissolved, and deposited in crystals.

Properties.—Of a pearly aspect ;—fuses at  $130^{\circ}$ .—Used in the manufacture of candles.

*Margarine*.— $C_{76}H_{75}O_{12}$ .—The solid principle of human fat, and of vegetable fixed oils.—Exists also in animal fats.

Procured, by action of boiling ether upon mutton-suet, which deposits the stearine.

Properties.—Much resembles stearine.—Fuses at  $116^{\circ}$ .

*Oleine*, or *Elaine*.— $C_{94}H_{87}O_{15}$ .—The fluid principle of all fats and oils.—May be partially separated by a low temperature, which congeals the other two constituents,—or by hot alcohol.

Properties.—Colorless if pure.—Resembles common oil.—Freezes at  $20^{\circ}$  F.

The true proximate composition of each of the above three principles, is an acid, named according to the substance—*oleic*, *margaric*, and *stearic*,—and a common base, *glycerine*.—Inference, that oils are true *salts*.—Effects of an alkali on oils.

*Stearic Acid*.— $C_{68}H_{66}O_5 + 2HO$ .

Obtained by saponifying suet with lime.—A stearate of lime is formed, which is decomposed by sulphuric acid.

Properties.—A white, silky, flaky substance, insoluble in water.—Unites with bases.

*Margaric Acid*.— $C_{68}H_{66}O_6 + 2HO$ .

Obtained, by decomposing the margarate of lime by sulphuric acid.

Properties.—Very much resembles those of stearic acid.

*Oleic Acid*.— $C_{36}H_{33}O_3 + HO$ .

Obtained from the oleate of lead, by the action of ether.

Properties.—A colorless liquid, solidifying below  $54^\circ$ ; insoluble in water, but soluble in alcohol, ether, and the essential oils.

Chemical characters of *Suet*, *Lard*, *Butter*, *Olive Oil*, and *Cod-liver Oil*.

Action of nitrous acid on olive oil,—is to convert it into *elaidin*, a principle which is saponifiable, and yields *elaidic acid* and glycerine.

*Glycerine*.— $C_6H_7O_5 + HO$ .—The *hydrated oxide of lipyle*.—Best mode of procuring it.

Properties.—Colorless;—oily consistence;—sweetish taste.  
—Medical uses.—*Aerolein*.

The formula for the radical *lipyle* is  $C_3H_2$ .

### *Origin of Oils and Fats.*

In vegetables, they are produced by the deoxidizement of the amylaceous bodies.—Examples:—the disappearance of fecula in the sun-flower seed, flaxseed, castor oil bean, &c., to be replaced by oil.

In animals, a portion is derived from the food directly, and a portion *manufactured* by the animal.—Action of the *liver* in producing fat.

### *Saponification.*

Its chemical nature.—Chemical composition of soap.—The soaps formed by the alkalies are soluble;—those formed by the earths and metallic oxides are insoluble.—The latter are termed *plasters*.



The *consistence* of the alkaline soaps varies.—The potash soaps are soft ;—the soda soaps are hard.—Mode of converting a soft soap into a hard soap.

*Castile Soap*—An *oleo-margarate of soda*.—Two varieties—the white and the mottled.

*Palm Soap*—A *palmitate of soda*.

*Common Soap*.—An *oleo-stearate of soda*.—Made from tallow and carbonate of soda.

*General Properties of Soaps*.—Solubility in water and alcohol.—Action of acids, earths, and metallic salts.—Action of *hard* water.—Mode of *softening* the water.

Use of the tincture of soap as a *test*.

*Wax*.—An animal secretion, and also a vegetable product.—Physical properties.

*Proximate Composition*.—Contains two principles,—*cerin*, which is saponifiable, and yields margaric and oleic acids, and *myrocin*, which is not saponifiable.

Use of wax in Pharmacy.

*Spermaceti*.—A secretion in the head of a species of whale ;—Physical properties.

Chemical composition.—A neutral fatty body, of the nature of a compound ether—the *cetylate of the oxide of cetyl*.—By a difficult saponification, it is converted into *cetylic alcohol* (a crystalline fat), and *cetylic* or *ethalic acid*.

The formula for the radical *cetyl* or *ethal* is,  $C_{32}H_{33}O,HO$ .

Pharmaceutical use of spermaceti.

## VOLATILE OILS.

Naturally exists in different parts of certain plants.—Usually procured by distillation with water.—Sometimes by expression.

They contain two proximate principles analogous to olein and stearine, and named *elaoptine* and *stearoptine*.

They differ essentially from fixed oils:—in not being saponifiable;—in not leaving a permanent greasy stain on paper;—in being slightly soluble in water,—and in being volatilized at a temperature a little above  $212^{\circ}$ .

A high heat decomposes them, as it does the fixed oils.

Three classes of volatile oils:

1. Those composed of carbon and hydrogen.—Examples:—  
*Oil of Turpentine* and *Oil of Lemons*.
2. Those composed of carbon, hydrogen, and oxygen.—Examples:—*Oils of Anise, Mint, &c.*
3. Those containing carbon, hydrogen, oxygen, and sulphur.—Examples.—*Oils of Horseradish, Mustard, and Garlic.*



## SECTION XV.

## RESINS, AND ALLIED BODIES.

General properties :—Solid ;—brittle. — Fracture, smooth and shining.—Semitranslucent.—Insoluble in water.—Soluble in alcohol, ether, the fixed and volatile oils.—Without odor or taste, if perfectly pure.—Softened by heat, and ultimately take fire, depositing carbon in the form of *lampblack*.—Unite with alkalies, forming soaps.—Distilled in close vessels, they yield hydrocarbons, forming a brilliant gas for burning.

Their origin in plants is to be traced to the oxidation of the volatile oils.

Remarks on *Common Rosin, Lac, Mastich, Sandarach, Dragon's blood, Elemi, Damar, and Copal*.

Composition of a *turpentine*.

Composition of a *balsam*.

Composition of a *gum-resin*.—Examples.

*Caoutchouc or Gum Elastic*.—The concrete juice of the *Syphilla elastica*.

Mode of obtaining.—Properties.—Effects of heat.—Best solvents.

Effect of combining it with sulphur, or *vulcanizing*.

Applications in the arts.

*Gutta Percha*.—The concrete juice of the *Isonandra Gutta*.  
—Analogous to caoutchouc in some particulars,—but differs  
in others.

Effect of heat.—Best solvents.

Uses in the arts, and medicine.



## SECTION XVI.

## ORGANIC COLORING MATTERS.

Their great importance in the art of dyeing.—With the single exception of cochineal, they are all of vegetable origin.

Distinction between *substantive* and *adjective* colors.—Nature and use of *mordants*.—*Lakes*.—Calico printing.

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## BLUE COLORING PRINCIPLES.

*Indigo*.—The product of several species of the genus *Indigofera*, growing in tropical countries.—Mode of procuring it.—Composition— $C_{26}H_5NO_2$ .

Properties.—Solid;—of an intensely deep-blue color.—Insoluble in water, alcohol, dilute acids, or alkalies.—Soluble in strong sulphuric acid.—Volatile by heat.—Sp. grav. 1.350.

Action of deoxidizing agents—to convert it into *indigogene*.—Nature of this substance.—Theory of dyeing with indigo.

Numerous compounds resulting from the reaction of different agents upon indigo.

*Litmus*, *Archil*, and *Cudbear*.—Similar substances, differ-

ing only in the details of their preparation.—Procured from various lichens, chiefly the *Rocella tinctoria*.—Their *natural* color is red; but they become blue from the presence of an alkali, in their manufacture.

Use of litmus to the chemist, as a test.—Mode of preparing *test-papers*.—Action of acids.

Substances derived from litmus.

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### RED COLORING PRINCIPLES.

*Cochineal*.—Dried insects—the *Coccus cacti*—found in tropical countries.

Properties.—Soluble in water and alcohol.—Form *lakes* with alumina, and oxide of tin.—*Carmine*.

Its coloring principle, called *carminic acid*, has been separated.

*Madder*.—The root of the *Rubia tinctorium*.—Grown in the south of France, and the Levant.

Its most valuable coloring principles are *alizarin* and *purpurin*.

Madder is employed for giving the *Turkey-red* color to cotton cloths.

*Brazil Wood*.—*Cæsalpinia Sappan*.—It contains an orange, crystalline solid, called *Brazilein*,  $C_{36}H_{14}O_{14}$ .

*Logwood*.—*Hæmatoxylon Campechianum*.

This affords a deep reddish-purple dye.—Its coloring principle—*hæmatoxylin*, is composed of  $C_{40}H_{17}O_{15} + 8HO$ ;—a solid crystalline body.—Acids brighten the color; and alkalies render it darker.



*Safflower*.—The dried petals of the *Carthamus tinctoria*.—It derives its color from *catharmin*,  $C_{14}H_8O_7$ —a dark-red substance, insoluble in water, but soluble in alkalies.

*Alkanet*.—The root of the *Anchusa tinctoria*.—It contains *anchusic acid*—a dark-red solid, insoluble in water.

*Lac*.—The coloring matter of the resin lac;—prepared in India, from stick lac.

*Annotta*.—Obtained from the seeds of the *Bixa orellana*.—An orange powder, insoluble in water.

Its coloring principle—*orellein*, is red.—Used, chiefly, to give color to butter and cheese.

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#### YELLOW COLORING PRINCIPLES.

*Quercitron*.—The bark of the *Quercus tinctoria*, or Black Oak.—It contains a yellow coloring principle—*Quercitrine*.

*Fustic*.—The wood of the *Morus tinctoria*.—Contains a yellow crystalline principle.—*Morine*.

*Turmeric*.—The root of *Curcuma longa*.—It contains a yellow coloring principle—*Curcumine*.

Use to the chemist as a test.—Action of alkalies;—of muriatic and boracic acids.—Mode of preparing *turmeric papers*.

*Saffron*.—The dried stigmas of the flowers of the *Crocus sativus*.—Contains a brilliant yellow coloring matter, named *Polychroite*.

*Sumach*.—The young branches of *Rhus coriaria*.—It contains a bitter yellow principle named *Fustine*.

*Barberry*.—The root and wood of the *Berberis vulgaris* and *tinctoria*.—It contains a peculiar yellow coloring matter—*Berberine*.

## PART IV.

### CHEMISTRY OF THE ANIMAL BODY.

COMPLEX nature of the animal body.—Great variety of its component parts.—All may, however, be comprised under the two divisions of the *organic* and the *inorganic* constituents.

I. The animal organic constituents include those which are peculiar to animals, and likewise some which are found in vegetables. They comprise the following :

1. *The Proteine Bodies* :—Albumen, fibrine, caseine, &c.
2. *The Gelatinous Tissues* :—Skin, membranes, bones, cartilages, ligaments, &c.
3. *Fats* (stearine, margarine, oleine), and *oleophosphoric acid*.
4. *Neurine*, or nerve-substance.
5. Peculiar principles found in muscular flesh, as *creatin*, *creatinin*, &c.
6. The peculiar principles found in the urine, as *urea*, *uric acid*, &c.
7. The peculiar principles found in bile.

II. The animal *inorganic* constituents are not peculiar.—They comprise chiefly the *sulphates*, *phosphates*, and *chlorides of potassium* and *sodium*,—the *phosphates of lime* and *magnesia*, the *carbonate of lime*, *silica*, *fluoride of calcium*, *iron*, &c.

The first division will now be examined in detail.



## SECTION I.

## THE PROTEINE GROUP.

This group includes *Albumen*, *Fibrine*, *Caseine*, the two *Oxides* (binoxide and tritoxide) of *Proteine*, *Pepsine*, *Ptyaline*, or *Salivary Diastase*, *Crystalline*, *Globuline*, and *Pyine*.

Some of these principles exist both in vegetables and animals.

Their origin in plants.

Great importance of the Proteine group.

Theories in relation to the existence of *Proteine* in a separate state.

The Proteine of Mulder,—how obtained.

Properties.—Composition.—Chemical relations.—Characters of the *binoxide* and *tritoxide* of Proteine.

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ALBUMEN.

Exists in two forms—solid and liquid.—Found in what parts of animals and vegetables.

Best types of liquid and solid Albumen.

Two varieties :—*ov-albumen* and *ser-albumen*.

*Characters of Albumen.*—Color.—Consistence.—Effect of heat.—Action of acids and alkalies.—Substances which coagulate it.—Therapeutical deductions.

*Tests for albumen:*—Heat, and nitric acid.

Relations of albumen to animals.—Abnormal elimination of it, in disease.

### FIBRINE.

Exists in two forms—solid and fluid.

Found chiefly in the blood, and muscles of animals;—and in the juices, and other parts of plants, as *gluten*.

Its spontaneous coagulation, its characteristic property.—Insolubility.

Mode of procuring it from blood, and muscle.—Appearance.

Proportion in healthy blood.—Increase of it in disease.—Simon's doctrine as to its *origin*, in the animal economy.

Mode of procuring vegetable fibrine or *gluten*.—Its appearance.—Consistence.—Use in flour.—Nutritious qualities.

*Test for fibrine.*

### CASEINE.

The nitrogenized principle of milk,—constituting the *curd*.

Found also in vegetables, as *legumine*.

Obtained, by spontaneous, or artificial coagulation of milk.

—Effect of *rennet* upon milk.

Properties.—Color.—Solubility.—Chemical habitudes.



*Pepsine* or *Gasterase*.—Found in the mucous membrane of the stomach.—Its action in the process of Digestion.—Nature of the *gastric* juice.

Chemical reactions.—Mode of procuring.

*Ptyaline*, or *Salivary Diastase*.—Name.

Mode of obtaining it in the separate state.

Properties.—Its function in Digestion.

*Globuline*.—A constituent of the red corpuscles of the blood, associated with *hæmatin*.—Supposed origin.

*Crystalline*.—Believed to be a mere modification of albumen.—Found in the crystalline lens of the eye.

*Pyine*.—The peculiar principle found in pus.—Characters to distinguish pus from mucus.

## SECTION II.

## THE GELATINE GROUP.

There are two varieties of gelatine, according to Mulder,—named *Gelatine*, or *Glutin*, and *Chondrine*.

The former, procured from skins, membranes, bones, tendons, and fibro-cartilages.

The latter (chondrine), from permanent cartilages, foetal bones, and fungous bones.

Composition of gelatine.— $C_{13}H_{10}N_2O_5$ .

Composition of chondrine.— $C_{16}H_{13}N_4O_7$ .

Gelatine obtained by long boiling of the tissues which yield it.

Varieties of commercial gelatine:—*glue*, *size*, *isinglass*, and the *prepared gelatine* of the shops.

Gelatine not found in the animal fluids.

Origin of it in the animal economy.

Properties of gelatine.—Hard; semi-translucent.—Soluble in boiling water.—Solidifies on cooling.

Action of tannic acid.

Chemical distinctions between gelatine and chondrine.

*Glycocoll*, or *Gelatine Sugar*.— $C_4H_5NO_4$ .

Made, by boiling gelatine with a solution of potash; or by treating it with sulphuric acid.

Also obtained by the action of sulphuric acid on hippuric



acid, which is thereby converted into benzoic acid and glycocoll.

Properties.—A white, crystalline, sweet substance,—soluble in water and alcohol;—does not undergo fermentation.

Probable disposition of Glycocoll in the animal economy.

## SECTION III.

## THE ANIMAL SOLIDS.

The solids which form the various organs of the body, constitute the apparatus in which are performed all the phenomena of life.—They comprise *bones, teeth, cartilages, ligaments, tendons, corneous tissue, skin, membranes, muscular flesh, fats, and cerebral substance.*

*Bones.*—These constitute the framework, or skeleton.—They are composed of two distinct portions : (1.) The *organic*, consisting of gelatine ;—(2.) The *inorganic*, consisting chiefly of carbonate and phosphate of lime.

Relative proportion of these two.—Mode of removing the earthy matter.—Mode of removing the animal matter.

Product of the carbonization of bones.

The composition of bones varies according to the age.

Analysis of bones.

*Teeth.*—These do not differ in composition, essentially, from bones.—They consist of three parts : (1.) Dentine or ivory ;—(2.) Enamel ;—(3.) Cementum.

Analysis of *dentine*.—Contains much more *mineral* ingredients than bone.

Composition of *enamel*.—Its great hardness and density.



*Cartilages.*—Where found in the animal body.—Their function.

Chemical composition.—Chiefly consist of gelatine, or chondrine.

*Corneous Tissue.*—This comprises horns, nails, claws and hoofs, human hair, nails, and feathers. These all, nearly identical in composition,—and consist essentially of gelatine.

Comparison of the analyses of the horns of the cow, and human nails.

*Skin and Membranes.*—These are composed essentially of gelatine, associated with fat, bloodvessels, &c.

Effect of drying;—of boiling.

Explanation of the process of *tanning*.

*Muscular Flesh.*—A very complex tissue, consisting of fibrine, albumen, fat, bloodvessels and nerves, creatine, creatinine, and inosinic acid.

Effect of desiccation, on flesh.

Nature of the salts contained in it.

Result of exhausting muscular flesh in cold water.—Effect of boiling.

*Creatine.*— $C_8H_9N_3O_4 + 2HO$ .

Mode of procuring it from fresh meat.

Properties.—Crystalline.—Soluble in hot water; slightly so in cold water.—Neutral in its reaction.—Action of strong acids.—Action of strong alkalies.

*Creatinine.*— $C_8H_7N_3O_2$ .—Obtained from Creatine by the action of strong acids.

Properties.—Strongly alkaline,—like ammonia.

*Sarcosine.*— $C_6H_7NO_4$ .—Production.

*Inosinic Acid*.— $C_{10}H_6N_2O_{10} + HO$ .

Mode of procuring it.—Crystalline.

Views of Liebig and others, in relation to the production, and physiological functions performed by these bodies.

*The Fats*.—These have already been treated of (p. 159).

*Cerebral Substance (Neurine)*.—Two kinds—the *white* and the *gray*.

Different positions with respect to each other.—Different offices.

Fremy's analysis.

*Cerebric Acid*.—Properties.—White.—Crystalline.—Soluble in boiling alcohol.

Differs from common fats, in containing phosphorus and nitrogen.—A very feeble acid.

*Oleo-phosphoric Acid*.—Obtained by the action of cold ether.

Properties.—An oily fluid, of a yellow color;—insoluble in cold water.—Saponifiable.

Effect of boiling in water.—Proneness to decomposition.

Quantity of phosphorus in the human brain.

Deficiency of phosphorus in the brains of idiots.



## SECTION IV.

## THE ANIMAL FLUIDS.

These comprise the *blood, chyle, lymph, salivary and pancreatic fluids, milk, bile, and urine.*

Most of them are discussed at length in the department of PHYSIOLOGY. A few only will be noticed here.

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## THE URINE.

Its secretion described.—Composed of two distinct portions—the *liquid*, which is water, and the various *solids* held in solution by the liquid.

Physiology of the secretion of these two portions.

Properties of healthy urine :—Color.—Average sp. grav. 1015 to 1020 (Prout).—The sp. gravity varies at different periods of the day.—Usually *acid* when first voided—becoming alkaline on standing.

Whole quantity voided in twenty-four hours.—Quantity of solid matter passed in twenty-four hours.

Sources of the urine : 1. The water taken in by drinking ; —2. The non-assimilated food ; —3. The disintegration of nitrogenized tissues.

Dr. Golding Bird's analysis of urine.

Deposits from the urine on standing.

*Urea*.— $C_2H_4N_2O_2$ .

The most important of the solid constituents of the urine.

Properties.—Colorless.—Four-sided prisms.—Very soluble in water,—less so in alcohol.—Taste, saline and cooling.—Neutral to test paper, but unites with acids.

Proportion in healthy urine, 12 to 30 parts in 1000 (average, 15).

Its presence in urine is shown by evaporating it to one-third its bulk, and then adding nitric acid, which converts it into a bulky *nitrate of urea*.

Obtained pure, from urine, by first evaporating it, and then adding oxalic acid; and decomposing the oxalate by chalk.

Made artificially (as the *cyanate of ammonia*), by decomposing cyanate of potassa by sulphate of ammonia; evaporating to dryness, and adding strong alcohol, which dissolves out the urea.

The whole quantity secreted in twenty-four hours estimated at 270 to 430 grains.

This variation of quantity due to several causes,—as age, sex, diet, and exercise.—Results of Prof. Lehman's experiments.

Detected in the blood.—Physiological origin.

Effects of accumulation in the blood.

May be suspected to be in excess in the urine, if its sp. gravity exceeds 1030.

Spontaneous change of urea into carbonate of ammonia— $C_2H_4N_2O_2 + 2HO = 2(NH_3 + CO_2)$ .—This conversion sometimes occurs (in disease) before the urine has been voided from the bladder.

Properties, and microscopic appearance of the *nitrate of urea*.



*Uric Acid.*—*Lithic Acid.*— $C_{10}H_4N_4O_6$ .

Very small quantity naturally found in healthy urine,—from 0.3 to 1 part, only, in 1000. In birds and serpents, it constitutes nearly the whole of the solid portion of the urine.

Generally combined with ammonia, in healthy urine.

Properties.—Fine, sandy, crystalline grains.—Very insoluble in water.—Soluble in alkaline solutions.—Microscopic appearance.

Its presence shown, if in excess, by adding nitric acid, and evaporating by a gentle heat;—a red spot is formed, which becomes purple by adding liquor ammoniæ.—(G. Bird.)

The whole quantity of uric acid voided in twenty-four hours, is estimated at 8 to 10 grains,—but liable to variations, as in the case of urea,—and from similar causes.

It increases in certain diseases.

Physiological relation between uric acid and urea.—Formulæ.

*Hippuric Acid.*— $C_{18}H_8NO_5 + HO$ .

Name.—Exists in large quantities in the urine of the horse, and other herbivorous animals.

A normal constituent of human urine.

Its presence,—how best shown.

Properties.—Friable, tufted crystals.—Sparingly soluble in cold water; more so in hot water; and very soluble in alcohol and ether.—Heat converts it into *benzoic acid* and *benzoate of ammonia*, together with an oily matter.

Conversion of benzoic acid into hippuric acid, in passing through the animal system.

Dr. Prout's error, concerning the use of benzoic acid in lithiasis.

Great amount of carbon in hippuric acid (64 parts in 100).  
—Its probable function.

*Lactic Acid*.—Supposed by some to be a normal constituent of the urine,—but very doubtful.

*Butyric Acid*, also, said to be sometimes found.—Probable origin.

*Vesical Mucus* and *Epithelium Scales* faintly appear in healthy urine.

Origin.—Microscopic appearance.

*Extractive Matters*.—Include all the uncrystallizable organic matters found in the residue of evaporated urine.

They comprise *Creatine*, *Creatinine*, and *Yellow Coloring-matter*.

Normal quantity,—7 to 12 parts in 1000.

Physiological relations of *Creatine* and *Creatinine*.

Nature of the coloring matter.—Simon's views.

Large amount of carbon contained.

Mode of showing the coloring matter.

*Sulphur-Extractive*.—Sources.—Amount of unoxidized sulphur voided in 24 hours—from 3 to 5 grains.

*Fixed Salts*.—Obtained by incinerating the evaporated residue of urine.

They are composed of a mixture of alkaline and earthy salts,—together amounting to about 138 grains in 24 hours.

Separated by boiling water, which dissolves out the alkaline salts.

The *Alkaline Salts*.—Their composition.

Normal quantity,—13 to 14 parts in 1000.—Microscopic appearance.

Tests: (a) For the *chlorine* and *phosphoric acid*. (b) For the *sulphuric acid*. (c) For *potash*. (d) For *soda*.

The *Earthy Salts*.—Their composition.

Normal quantity,—1 part in 1000.—How kept in solution.



Effect of adding ammonia to healthy urine.—Nature of the precipitate.

Microscopic characters of the *triple phosphate*.

*Test* for the earthy phosphates, when in the urine in excess.

—How distinguished from albumen.

Origin of the fixed salts in the urine.—Probable use of the chloride of sodium.

## SECTION V.

## THE URINE IN DISEASE.

Value of the urine as a means of diagnosis.

Two kinds of morbid changes:—(1.) When there is merely an excess, or diminution of some natural ingredient.—(2.) When there is one or more abnormal ingredient.

Mode of proceeding.—Test-paper.—Specific gravity.—Decantation of clear liquid.

I. *Examination of the deposits :*

The deposits are most likely to consist of earthy phosphates, —uric acid,—urate of ammonia,—and oxalate of lime.

Tests:—for *urate of ammonia*;—for *phosphates*;—for *uric acid*;—for *oxalate of lime*;—for *pus*;—for *mucus*;—for *blood*;—for *cystine*;—for *urate of soda*;—for *fatty matter*;—for *chyle*;—for *spermatozoa*.

II. *Examination of the clear liquor :*

Test for acidity.—Take specific gravity.—Inference, if it exceed 1025.

*Urea* in excess, tested for.

*Sugar*.—Tests for.—Quantity estimated.

*Albumen* tested for.

*Earthy phosphates* recognized.

*Uric and hippuric acids* tested for.

*Bile*.—Pettenkoffer's test.



## SECTION VI.

## URINARY CALCULI.

Their general composition.—Mode of formation.—Nuclei.  
—Seldom composed of a single ingredient.

Mode of analysis.

I. *Uric or Lithic Acid Calculus*.—One of the most common forms of stone.

Characters.—Smooth, or slightly warty,—hard,—concentric,—yellowish-brown.

Tests :—Burns before the blowpipe, exhaling an ammoniacal odor.—The *murexed test*.—Soluble in a solution of potash, from which it is precipitated by an acid.—The microscope.

The *lateritious deposits* of fever, rheumatism, gout, &c.—usually composed of uric acid and urate of ammonia.

II. *Urate of Ammonia*.—Seldom occurs alone;—generally alternating with uric acid, or the earthy phosphates.

Characters. — Small, smooth, or slightly tuberculated.—Color,—pale slate, or brown.

Tests :—Soluble in hot water.—Decomposed by dilute acids.—Decrepitates before blowpipe.—Soluble in a hot solution of potash, with evolution of ammonia.

A frequent ingredient of the *lateritious deposits*.

III. *Phosphate of lime.*

Characters.—Smooth, or even polished, on the surface.—Composed of concentric laminæ, very easily separated.—Color, fawn, or stone.

Tests.—Chars before blowpipe.—Is nearly infusible.—Soluble in dilute acids.—Phosphoric acid tested by nitrate of silver.—Lime tested by oxalate of ammonia.

IV. *Ammonio-Magnesian Phosphate* (triple phosphate).—Very common as one of the ingredients of a calculus.

Characters.—Nearly colorless.—Surface rough, or covered with small shining crystals.

Tests: Charred by blowpipe, exhaling an ammoniacal odor.—Soluble in dilute acids.—Heated in a solution of potash, it gives off ammonia, and precipitates magnesia.

V. *Fusible Calculus*.—A mixture of the two last described.—The most common ingredient, next to uric acid.

Characters.—Often of a large size.—Soft.—White.—Chalky and friable.

Tests: Fuses before blowpipe into a bead.—Soluble in dilute acids.—The presence of lime shown.

VI. *Mulberry Calculus* (oxalate of lime).—Sometimes entire; again, with a nucleus of uric acid.

Characters.—Very dark color, brown or dirty purple.—Irregular, jagged surface.—Appearance when sawn.

Tests: Insoluble in acetic acid.—Soluble in dilute nitric and chlorohydric acids.—Blowpipe at first blackens, and then converts it into carbonate of lime, which is easily recognized.

The *Cystic Oxide* and *Xanthic Oxide*,—are very rare forms of calculi.

The *Urate of Lime* is occasionally met with.



## BILIARY CALCULI—GALL-STONES.

Found in the gall-bladder.—Often very numerous.

Characters.—Brownish or yellow color.—Soft and soapy to the touch.—Easily crushed.—Of a crystalline texture.—Form very irregular.

Composition.

*Cholesterine*.— $C_{26}H_{52}O$ .—Mode of obtaining it from gall-stones.—Properties.—Not saponifiable.

## SECTION VII.

## MILK, BILE, AND BLOOD.

MILK.—“An emulsion of fat in water, holding caseine, sugar, and salts in solution.”

Homogeneous appearance to the naked eye.—Microscopic appearance.

Oil globules of Donné.—*Cream*.

Alkalinity due to.—Its effect on the caseine.—Effect of *churning*.

Composition of the oily matter.

Composition of the salts.—Similar to those of the blood.

Spontaneous coagulation of milk due to.

Composition of *whey*.

Comparison between the milk of the cow, goat, and human female.

The amount of oily matter and of caseine, much influenced by exercise.

Microscopic appearance of diseased milk.—*Colostrum*.

Other morbid ingredients found in milk.

Use of the *lactometer*.

Adulteration of milk.



BILE.—Appearance in the ordinary state.

Obtained pure, by first evaporating to dryness at  $212^{\circ}$ , then dissolving in alcohol, which leaves behind the mucus. The solution contains coloring matter and cholesterine. Animal charcoal removes the former, and ether the latter.

Characters of pure bile.—A yellowish, solid, brittle mass, —soluble in water and alcohol.

Strecker's analysis shows it to be composed essentially of a mixture of two peculiar acids (the *cholic* or *glyco-cholalic*, and the *choleic* or *tauro-cholalic*), united with soda.

Composition of *glyco-cholalic acid*— $C_{52}H_{42}NO_{11},HO$ .

Composition of *tauro-cholalic acid*— $C_{52}H_{44}NS_2O_{13},HO$ .

Tests for bile.

The consideration of the Blood is referred to PHYSIOLOGY.

## SECTION VIII.

## CHEMISTRY OF VEGETABLE LIFE.

*Food of Plants.*

1. The soil.—Its composition ;—A mixture of silica, alumina, lime, magnesia, organic matters, oxide of iron, with small quantities of phosphates, sulphates, carbonates, nitrates, and chlorides.—Its mechanical structure varies very much, and materially influences its nature.

2. The air.—The ingredients used by plants are, carbonic acid, ammonia, and moisture.—Importance of the carbonic acid.

*Growth of Plants.*

Germination.—Development of the seed, when placed under favorable circumstances.

Conditions necessary to germination,—temperature, moisture, and oxygen.

Chemical changes produced.

Appearance of *diastase*.—Its importance.

Change of starch into *dextrine* and *glucose*.

*Further development of the Plant*.—Importance of *light*.—

Action of the green cells upon the carbonic acid of the air.—

Production of the nitrogenized principles—*vegetable albumen*, *glutin*, and *legumin*.



Production, and deposition of the oils and resins.

Isomerism of most of the proximate materials of plants.

Elimination of oxygen during the growth of plants.

Changes involved at the period of forming and ripening of the seed.

Changes occurring at the death of the plant.—Its *cremation*, or slow oxidation.—Products.

Exhaustion of soils by successive growth of the same crops.—Importance of a rotation of crops.—Composition and use of *manures*.

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## CHEMISTRY OF ANIMAL LIFE.

### *Composition of Animals.*

1. *Solids*.—Comprising *Bone*, composed of phosphate and carbonate of lime, with gelatine and oily matter.—*Cartilage*, consisting of gelatine, with a little phosphate of lime.—*Muscle*, chiefly of fibrine.—*Skin* and *membranes*, essentially composed of gelatine.—*Nerve-substance*, chiefly of albumen and oily matter (fat acids).—*Ligaments* and *tendons*, chiefly gelatine.—*Fats*, consisting of oleine, margarine, and stearine.

2. *Liquids*.—Comprising *blood*, composed of water, albumen, fibrine, various salines, globulin, and hæmatin.—*Chyle*, consisting of water, albumen, fibrine, and salines.—*Lymph*, very similar, in composition, to chyle.

### *Animal Secretions.*

*Milk*,—containing water, oily matter, caseine, sugar, and saline matters.

*Saliva*—composed of water, salts, traces of mucus, and organic matters.

*Bile*—composed of water, cholate and choleate of soda, resin, mucus, and salines.

*Urine*—consisting of water, urea, uric acid, hippuric acid, and various salts of potash, soda, magnesia, and lime, together with some organic principles.

Other lesser secretions.

### *Chemical Processes of Life.*

*Respiration*.—Its object to introduce oxygen into the blood, and to eliminate carbonic acid, by the action of the lungs.

*Digestion*.—A species of fermentation.—Influence of *ptyalin* and *pepsin*.—Action of the *gastric juice*; of the *bile*.—Progress of the chyle.

*Calorification*.—Union of the oxygen inspired, with the hydrogen, carbon, and other combustibles of the food and the tissues.

*Secretion*.—This is often merely the separation of matters already formed, from the blood; but sometimes it is a true chemical process, performed by the seccerning gland.



The body is composed of various parts, each of which has its own function. The bones, for example, are the framework of the body, and the muscles are the organs of motion. The blood is the life-giving fluid, and the nerves are the channels of sensation. The organs of the senses are the eyes, ears, nose, tongue, and skin. The organs of the digestive system are the mouth, stomach, and intestines. The organs of the respiratory system are the lungs. The organs of the excretory system are the kidneys and bladder. The organs of the reproductive system are the testes and ovaries.

THE CONSTITUTION OF THE HUMAN BODY

The human body is a complex machine, and its constitution is the result of many factors. The most important of these are the heredity, the environment, and the habits of life. Heredity is the inheritance of physical characteristics from the parents. The environment is the external world, which influences the body in many ways. The habits of life are the actions and behaviors of the individual, which can either strengthen or weaken the body. The constitution of the body is also influenced by the state of the mind. A healthy mind is a healthy body, and a diseased mind is a diseased body. The constitution of the body is also influenced by the state of the soul. A pure soul is a healthy body, and an impure soul is a diseased body.

The constitution of the body is also influenced by the state of the atmosphere. A pure atmosphere is a healthy body, and an impure atmosphere is a diseased body. The constitution of the body is also influenced by the state of the water. Pure water is a healthy body, and impure water is a diseased body. The constitution of the body is also influenced by the state of the food. Pure food is a healthy body, and impure food is a diseased body. The constitution of the body is also influenced by the state of the air. Pure air is a healthy body, and impure air is a diseased body. The constitution of the body is also influenced by the state of the earth. Pure earth is a healthy body, and impure earth is a diseased body.

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