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A RAPID REVISION COURSE.

IN

CHEMISTRY

FOR

G. C. E. (Ordinary level) STUDENTS

MODEL QUESTIONS
AND
ANSWERS

BY

Mrs. Meenambikai Thavaratnam B. Sc.

(STAFF, HINDU COLLEGE, URUMPIRAI)

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Preface

My purpose in writing this book in a question and answer form is to help the students of Chemistry to tackle general questions without much difficulty. Different types of questions - both textual and general - have been dealt with. Any suggestions to improve the answers are welcome.

I hope the students will defenitley benefit by studying this book and the effort of publishing this book would not have been in vain if this hope is realised at least in a small measure.

(MRS.) M. THAVARATNAM

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MODEL QUESTIONS AND ANSWERS IN CHEMISTRY

FOR

G. C. E. (ORDINARY LEVEL) STUDENTS

1. Name a gas that bleaches by oxidation. Explain the bleaching action of the gas with suitable equations.

or

Explain with equations that chlorine bleaches by oxidation and it bleaches substances in the presence of moisture.

The chlorine gas bleaches vegetable colouring matter such as flowers, green leaves, indigo and litmus *in the presence of moisture.* Its bleaching property can be illustrated by the following equations.

$Cl_2 + H_2O \rightarrow HCl + HClO$ (acids)
$HClO$ (**unstable**) $\rightarrow HCl + [O]$ **nascent state.**
$[O]$ + colouring matter $\rightarrow$ **colourless.**

It must be noted that dry materials cannot be bleached by chlorine. Only in the presence of moisture, Hypochlorous acid will be formed which will give out the atomic oxygen for bleaching. Since the bleaching property of chlorine is due to the *Atomic Oxygen* that has been released from Hypochlorous acid which has been formed by the action of chlorine on water it is said that chlorine bleaches by oxidation in the presence of moisture.

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2. Name a gas that bleaches by Reduction. Explain the chemical reactions involved in the process.

Just like chlorine, sulphur-di-oxide bleaches vegetable colouring matter such as petals of flowers, indigo, green leaves etc. *in the presence of moisture.* But Cl_2 bleaches by oxidation SO_2 bleaches by reduction. The bleaching property of SO_2 can be well illustrated by the following equations.

$H_2O + SO_2 \rightarrow H_2SO_3$ (sulphurous acids)
$H_2SO_3 + H_2O \rightarrow H_2SO_4 + 2[H]$ (nascent state)
$2H +$ colouring matter $\rightarrow$ colourless matter.

It must be noted that SO_2 cannot bleach substances in the absence of moisture. It needs H_2O to form sulphurous acid which being unstable gets converted to sulphuric acid and liberates nascent hydrogen. This nascent hydrogen is responsible for the bleaching action of SO_2. That is why it is said that SO_2 bleaches by reduction. (Bleaching effected in the presence of moisture).

3. Give reasons for the following:—

(1) Dilute H_2SO_4 cannot be used in the preparation of CO_2 from marble chips.

(2) H_2 from the Kipps apparatus will not decolourize acidified $KMnO_4$. (How can the decolourization be done).

(3) NaOH should not be kept exposed to air.

(4) Ordinary glass is coloured green.

(5) Sodium is kept in kerosene in the lab. instead of water.

(1) Dil. H_2SO_4 cannot be used in the preparation of CO_2 from marble chips because dil. H_2SO_4 reacts with $CaCO_3$ (marble chips) to form $CaSO_4$.

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$$CaCO_3 + \text{dil } H_2SO_4 \rightarrow CaSO_4 + H_2O + CO_2 \uparrow$$

The $CaSO_4$ formed will form a coating around $CaCO_3$ preventing further action of the acid on marble chips. Hence the liberation of CO_2 will be stopped. That is why dil. H_2SO_4 is not used in the preparation of CO_2. Instead dil. HCl is used to get CO_2 from $CaCO_3$.

(2) Hydrogen from the Kipps Apparatus when passed into a test tube containing acidified potassium permanganate will not decolourise it because it is in the "Molecular state". Molecular Hydrogen is not a powerful reducing agent as "Nascent Hydrogen". The term "Nascent" means "New born" or 'Active' state, Hence in order to decolourise acidified $KMnO_4$ the hydrogen is prepared in the same tube itself by adding to $KMnO_4$, Zinc and dilute Sulphuric acid. The reaction involved can be represented by the following equations.

$$Zn + H_2SO_4 \rightarrow ZnSO_4 + 2H \text{ (nascent)}$$

$$2KMnO_4 + 3H_2SO_4 + 10H \rightarrow K_2SO_4 + 2MnSO_4 + 8H_2O$$

(3) Sodium hydroxide should not be kept exposed to air because it is a *deliquescent* substance which can absorb moisture from the atmosphere and completly dissolve in it to form a solution. ~~The deliquesence is due to the presence of $CaCl_2$ and $MgCl_2$~~.

(4) Ordinary glass is coloured green because glass is an amorphous transparent or translucent homogenous mixture of a number of metallic silicates very often that of sodium, calcium and lead with traces of cuprous cupric, chromium cobalt salts. The Ferrous salts give a green colour.

(5) Sodium is stored up in Kerosene and not in water in the lab. Because sodium is a very active metal which reacts with water very vigorously to form Sodium hydroxide and Hydrogen.

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$$2Na+2H_2O \rightarrow 2NaOH+H_2\uparrow$$

This hydrogen is produced with a 'hissing' noise and the reaction is an exothermic one producing considerable amount of heat. Sodium floats in water. Hence it is stored up in kerosene which is a paraffin—an inert substance which cannot chemically react with sodium.

4. Explain the statement that 'Oxidation and Reduction takes place simultaneously'. Illustate your answer with a suitable example.

The term 'Oxidation' may be defined as a chemical reaction that involves the

1. Addition of Oxygen or any other Electro - negative element or radical to a substance.

For example

$2Mg+O_2 \rightarrow 2MgO$ (addition of O_2)

$2FeCl_2+Cl_2 \rightarrow 2FeCl_3$ (addition of Electro Negative element)

or 2. removal of Hydrogen or any other Electro positive element or radical.

For example

i. $MnO_2+4HCl \rightarrow MnCl_2+Cl_2+2H_2O$ (removal of H_2 from HCl)

ii. $2KI+H_2O_2 \rightarrow 2KOH+I_2$ (removal of an electro positive element K)

Reduction is the reverse process of oxidation. It is a chemical reaction which involves

1. The addition of Hydrogen or any other electro positive element or radical.

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For Example

i. $H_2+Cl_2 \rightarrow 2HCl$ (**addition of H_2 to Cl_2**)
ii. $2Fe+3Cl_2 \rightarrow 2FeCl_3$ (**addition of electro positive Fe to Cl_2**).

or **2. removal of Oxygen or any other electro-negative element or radical.**

For Example

i. $CuO+H_2 \rightarrow Cu+H_2O$ (**O_2 is removed from CuO.**)
ii. $2FeCl_3+H_2S \rightarrow 2FeCl_2+2HCl+S$ (**removal of electro negative element Cl_2 from $FeCl_3$**)

Both oxidation and reduction take place simultaneously.

For Example

$CuO+H_2 \rightarrow Cu+H_2O$.

Now in this particular reaction hydrogen has *reduced* copper-oxide to metallic copper by removing the oxygen atom from the compound copper oxide. At the same time copper oxide has *oxidized* hydrogen to water by adding to it an atom of oxygen. Hydrogen while reducing copper oxide to metallic copper has got itself oxidized to water, while copper oxide in oxidising hydrogen to water has got itself reduced to copper. Thus oxidation and reduction take place simultaneously.

5. **Explain the following chemical terms:—**

(1) **Catalysis** (2) **Occlusion** (3) **Deliquescence**
(4) **Hygroscopic** (5) **Water of Crystallisation**
(6) **Efflorescence.**

(1) Catalysis :—

It is a phenomenan in which the velocity (speed) of a chemical reaction is influenced—(either accelereted or retarded) —by the addition of a substance which does not chemically react with the reactants or the products and which remains unchanged both in composition and weight at the end of the reaction. The substance thus used is called a catalyst. The catalyst that accelerates the speed of a chemical reaction is called a positive catalyst.

For example

Manganese dioxide is used as a catalyst in the preparation of oxygen from potassium chlorate, The decomposition of potassium chlorate by heat is very very slow. But if manganese dioxide is added, potassium chlorate decomposes at a very low temperature liberating oxygen very quickly. Hence manganese dioxide accelerates the decomposition of potassium chlorate and so it is a positive catalyst.

The catalysts which retards the speed of a chemical reaction is called a negative catalyst. For example the decomposition of hydrogen peroxide under normal conditions can be prevented by the addition of a trace of glycerine or dilute Sulphuric acid.

(NOTE :—the decomposition can be accelerated by the addition of silver and platinum.)

(2) Occlusion :—

Certain metals can absorb gases at ordinary temperature. This phenomenon is called occlusion.

For example

Platinum and palladium can absorb hydrogen at ordinary temperature. The gas will however be liberated on heating the metals to dull red heat.

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(3) Deliquescence :—

Certain substances such as sodium hydroxide, calcium chloride, magnesium chloride possess the property of absorbing water or moisture from the atmosphere and completely dissolve in that to form a solution. This phenomonen is called deliquescence and the substances which have this property are called deliquescent substances. These substances must always be kept in air tight bottle lest they will absorb moisture and get dissolved in it to form solutions.

(4) Hygroscopic :—

Certain substances have an affinity or attraction for water and hence they absorb it. But unlike in the case of deliquescent substances they don't get dissolved in that to form solutions.

For Example

i. Concentrated sulphuric acid.
ii. Cupric oxide.

(5) Water of Crystallisation ;

Certain chemical substances owe their crystalline shapes to molecules of water. Each molecule of substance is found to be in combination with a definite number of molecules of water. These molecules of water are called water of crystallisation. The crystalline shapes of the substances are lost once these molecules of water are seperated from them.

For example

Crystalline copper sulphate is $CuSO_4 \cdot 5H_2O$.

It is also called Blue vitriol ~~virtok~~, whereas Anhydrous copper sulphate is $CuSO_4$ which is **White and powdery.**

Other examples are

$FeSO_4 \cdot 7H_2O$ (green vitriol)
$ZnSO_4 \cdot 7H_2O$ (white vitriol)

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$MgSO_4 \cdot 7H_2O$ (Epsom salt)
$Na_2CO_3 \cdot 10H_2O$ (washing soda)

The number of molecules of water represent the water of crystallisation of the respective substances.

(6) **Efflorescence:—**

This is a phenomenon in which certain hydrated crystalline salts loose part or all their molecules of water of crystallisation and crumble to a powder **when left exposed to air at ordinary temperature.** A very common example is washing soda which we very often find in the shops. Crystaline washing soda is $Na_2CO_3 \cdot 10H_2O$. But when it is kept exposed to air it loses 9 molseules of water and crumbles into an opaque powder of the composition $Na_2CO_3 \cdot H_2O$.

Other examples are

$$CuSO_4 \cdot 5H_2O \rightarrow CuSO_4 \cdot 3H_2O$$

6. What is Galvanized Iron? Give reasons for using this in making articles?

Galvanized Iron is iron that is coated with zinc. This is done by cleaning the Iron sheets scruplously by a blast of sand or with dilute hydrochloric acid and then dipping the cleaned sheets in molten zinc.

Iron sheets thus coated with zinc are more resistant to the action of air. It is well known that moist air attacks commercial iron which becomes coated with a scaly, brittle reddish brown deposit known as Rust. This 'Rust' is nothing but a mixture of hydrated ferric oxide $2Fe_2O_3 \cdot 3H_2O$ with a small quantity of Ferrous carbonate $FeCO_3$, which are formed in the presence of moisture, oxygen and Carbon-di-oxide.

Thus articles made of Galvanized Iron will not rust and they will last long.

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7. Explain the Chemical reactions involved in the rusting of Iron· How can it be prevented?

Rusting is otherwise called "*Corrosion of Iron*".

On exposure to moist air, Iron is coated with a loose, reddish brown deposit called Rust.

It is chiefly a hydrated Ferric Oxide $Fe_2O_3 \cdot 3H_2O$.

The Composition however varies with the time of exposure.

The theory and mechanism involved in the process can be explained as follows.

1. Rusting takes place *in the presence of Air* (O_2) Moisture and Carbon di-oxide. Ferrous Carbonate being formed as an intermediate Compound.

$Fe(OH)_3$ is the final product. The reactions involved can be represented thus:—

$$Fe + H_2O + CO_2 = FeCO_3 + H_2 \uparrow$$

$$4FeCO_3 + 6H_2O + O_2 = 4Fe(OH)_3 + 4CO_2 \uparrow$$

Another theory suggested by leading Scientist is that H_2O_2 is formed as an intermediate product according to the equation

$$Fe + O_2 + H_2O = FeO + H_2O_2.$$

$$2FeO + H_2O_2 = Fe_2O_3 + H_2O.$$

A third view is that rusting of Iron takes place as a result of Electrolytic action being set up between Iron and impurities present in contact with Moisture. The reaction involved is as follows:—

$$H_2O \rightarrow H^{+} + OH^{-}$$

$$Fe + 2H^{++} \rightarrow Fe^{++} + H_2$$

$$Fe^{++} + 2(OH) \rightarrow Fe(OH)_2$$

$$4Fe(OH)_2 + O_2 + 2H_2O \rightarrow 4Fe(OH)_3 \text{ or } 2[Fe_2O_3 \cdot 3H_2O].$$

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Rusting of Iron is therefore favoured by moisture, Air, Carbon-di-oxide and the impurities present in Iron.

Rusting can be prevented:

i) by coating the surface with paints, pitch, coal tar, Lacquer, or black Japan.

ii) by galvanizing or tinplating

iii) by electroplating with Chromium, Nickel, Copper and

iv) by heating the surface and passing a current of steam over it. A coating of magnetic Oxide Fe_3O_4 is formed.

8. Given a powder which you are told is a pure oxide of Lead, describe one physical and two chemical tests that you would choose to identify which oxide of Lead it is?

Lead forms a series of oxides the most important of which are:

1. PbO Lead monoxide. Litharge.
2. Pb_3O_4 (Red Lead) Triplumbic tetroxide
3. PbO_2 Lead di oxide

One physical test by which they can be distinguished from each other is from their colour.

1. Lead mon oxide is a yellow Crystalline powder.
2. Pb_3O_4 Red Lead is a brilliant red powder
3. Pbo_2 Lead dioxide is a dark brown powder or chocolate coloured powder.

Chemically they can be distinguished from each other from their action with dilute hydro chloric acid. When these different oxides are heated with dilute hydrochloric acid in separate test tubes chlorine is produced by both PbO_2 and Pb_3O_4 where as PbO does not liberate chlorine as can be seen from the following equations.

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$$2\,PbO + 4\,HCl = 2\,PbCl_2 + 2\,H_2O$$
$$PbO_2 + 4\,HCl = PbCl_2 + 2\,H_2O + Cl_2$$
$$Pb_3O_4 + 8\,HCl = 3\,PbCl_2 + 4\,H_2O + Cl_2$$

To distinguish between PbO_2 and Pb_3O_4 they are again heated with dilute nitric acid in separate test tubes. Insoluble Lead dioxide is formed in the test tube containing Red Lead

$$Pb_3O_4 + 4\,HNO_3 \rightarrow 2\,Pb(NO_3)_2 + PbO_2 \downarrow + 2\,H_2O$$

Thus the different oxides of lead can be distinguished from each other from the above reactions.

9. A black Crystalline solid A when added to concentrated hydro chloric acid gave a gas which turned a red litmus paper white. The coloured solution of a became colourless when treated with Hydrogen per oxide and Sulphur-di-oxide. Identify A and explain the reactions involved.

The black crystalline solid A is Potassium Permanganate. Solid $KMnO_4$ being a good oxidising agent when treated with concentrated Hydro chloric acid oxidises it liberating chlorine according to the equation.

$$2\,KMnO_4 + 16\,HCl = 2\,KCl + 2MnCl_2 + 8H_2O + 5Cl_2$$

Chlorine acts as a good bleaching agent in the presence of water. So it bleaches Red Litmus paper white. The bleaching action takes place as follows:.

$$Cl_2 + H_2O \rightarrow HCl + HClO$$
$$HClO \rightarrow HCl + [O] \text{ nascent}$$
$$[O] + \text{Red Litmus} \rightarrow \text{white}$$

$KMNO_4$ when dissolved in water gives a pink or purple solution which is decolourized by hydrogen per-oxide and sulphur di oxide. The reactions can be explained as follows.

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$$2\,KMnO_4+4H_2SO_4+5H_2O_2 \rightarrow 2KHSo_4+ \\ 2\,MnSO_4 \pm 8\,H_2O+5O_2$$

In this reaction Hydrogen-per-oxide reduces acidified Potassium permanganate to Potassium-bi-Sulphate Manganese Sulphate, water and oxygen. This is a reaction which is being employed to estimate solutions of Hydrogen per-oxide.

Sulphur dioxide also reduces Potassium Permanganate and render the solution colourless with the formation of Manganese sulphate and Potassium-bi-sulphate.

$$2KMnO_4+2H_2O+5SO_2 \rightarrow 2MnSO_4+2KHSO_4+ \\ H_2SO_4$$

In this reaction sulphur di oxide while reducing Potassium Permanganate gets itself oxidised to sulphuric acid.

10. Why is

(1) Sodium Carbonate efflorescent?

(2) Sodium Chloride deliquescent?

(3) Sulphuric acid hygroscopic?

(4) Air a mixture?

(1) The actual composition of crystalline sodium carbonate is $Na_2\,CO_3\,10\,H_2\,O$. This crystalline substance lose a part or all the water of crystallisation and crumbles to a powder when left exposed to air at ordinary temperature.

$$Na_2CO_3.\ 10H_2O \rightarrow Na_2CO_3.\ H_2O + 9H_2O.$$

Monohydrate of Sodium Carbonate·

This phenomenon is called efflorescence and the substance that exhibits such a property is called efflorescent substance.

(2) Sodium chloride is a deliquescent substance because it absorbs water or moistore from the atmosphere and dissolves in that to form a solution. This property is called deliquescence and the substance that exhibits such a character or property

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is called a deliquescent substance. Pure Sodium chloride is not deliquescent. But common salt or impure Sodium Chloride is deliquescent because it contains Magnesium Chloride and Calcium-chloride as impurities.

(3) Sulphuric acid is a hygroscopic substance because it absorbs water from substances. That is why it is used as a drying agent in the laboratory.

(4) Air is a mixture because it contains oxygen, nitrogen carbon-di-oxide, rare gases and water vapour in varying proportions. These gases can be easily separated from one another by physical methods without much difficulty. Its composition is not absolutely constant and it varies in different places. Besides it retains the properties of its components like oxygen, nitrogen and carbon di-oxide. Above all the gases are held in loose combination with one another and are not held together by any chemical force.

11. Explain how these substances are prepared;

(1) Hydraulic cement (2) Portland cement
(3) Plaster of Paris (4) Bleaching powder
(5) Mortar (6) concrete

(1) Hydraulic Cement

This is prepared by heating a mixture of clay and chalk or lime-stone in rotatory kilns. The resulting cement clinker is cooled and finely ground. It is mixed with water and allowed to set to a hard stone-like mass even under water, and it is called hydraulic cement.

(2) Portland cement

This is prepared by mixing Tri calcium silicate Ca_3SiO_5, Calcium Ortho silicate Ca_2SiO_4 Tri Calcuim Aluminate $Ca_3Al_2O_6$, Penta Calcium Tri Aluminate $Ca_5Al_6O_{14}$, free lime and ferric oxide.

The setting of cement not only involves the hydration of the calcium aluminates and silicates which form crystals. But colloidal substances are formed which slowly become dehydrated and lead to hardening of the mass.

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(3) Plaster of Paris, $2CaSo_4H_2O$

It is formed when Gypsum ($CaSO_4$) is heated to 120—130°C, heating is usually done in steel pots or in Rotatory kiln. It is then mixed with water when Plaster of Paris sets to a solid mass in a few minutes with the production of much heat (exothermic) and expanding slightly at the same time. The setting is due to the reformation of the dihydrate which forms inter lacing bundles of fine crystals. Owing to the expansion it can he used for obtaining sharp plaster casts Bandages soaked in wet Plaster of paris are used to immobilise, limbs, after broken bones have been set. The limb becomes fixed when the plaster sets.

(4) Bleaching powder or chloride of lime $Ca(OCl_2)$

It is prepared by passing chlorine over slaked lime ($Ca(OH)_2$.) It reacts to from bleaching powder or chloride of lime $Ca(OCL)_2$ and water.

$$Ca(OH)_2 + Cl_2 = Ca(OCL)_2 + H_2O.$$

It is regarded as a mixture of Calcium hypochlorite and basic calcium chloride with some free moisture. The actual formula of bleaching powder is $3Ca(OCL)Cl.\ Ca(OH)_5.\ 5H_2O$ It is a white solid smelling of chlorine and soluble in water. It is used as a bleaching agent and disinfectant.

5 Mortar.

This is prepared by mixing slaked lime with about three times its weight of sand and water. The hard paste thus obtained is used for setting bricks in a few days they become hard. The hardening of mortar takes place in the following way.

Partly due to the drying out of excess of water it forms a lock of hydrated lime and sand and by slow conversion becomes converted into $Ca(CO_3)$ by the action of carbon di-oxide in the atmosphere. (This is also called the setting of Mortar.)

6. Concrete

This is prepared by mixing gravel sand and cement in the roportion of 1: 2: 4. This sets into a hard solid mass.

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12. Explain the following terms:—

(1) Lime stone (2) Quick lime (3) Slaked lime (4) Milk of lime 5) Soda lime (6) Lime water — with special reference to their mode of preparation, properties and uses.

1. Lime Stone:

It is impure Calcium Carbonate ($CaCO_3$.) It is one of the sources from which calcium and its other chief compounds are prepared. To prepare pure Calcium Carbonate from lime stone it is first dissolved in dilute Hydro Chloric acid, precipitating iron and other metallic impurities with ammonia, and then adding Ammonium Carbonate

$$CaCO_3\text{ (Impure)} + \text{dil } 2HCl \rightarrow CaCl_2 + H_2O + CO_2\uparrow$$

$$CaCl_2 + (NH_4)_2CO_3 \rightarrow CaCO_3 + 2NH_4Cl$$

Calcium Carbonate or lime stone when heated produces Calcium Oxide which is called quick lime.

$$CaCO_3 \rightleftharpoons CaO + CO_2\uparrow$$

2. Quick Lime:

Quick lime is Calcium oxide which is formed when Calcium, Calcium hydroxide, Calcium nitrate or Calcium carbonate are heated. It is prepared commercially by heating lime stone ($CaCO_3$) in a lime kiln with a little coal. The Calcium Oxide thus obtained is contaminated with impurities like coal. In order to get a pure sample of Calcium Oxide, Calcium Carbonate is heated by producer gas prepared from coke. The temperature required to effect the decomposition is between 800—1000°C and this is better done in a muffle furnace.

It can also be obtained by heating Iceland spar in a platinum vessel to 1000°

It is a white amorphous, infusible solid. It reacts energetically with water forming clouds of steam (Exothermic reaction since

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much heat is produced during mixing) and leaving a crumbly white powder known as slaked lime [$Ca(OH)_2$]

$$CaO + H_2O \rightarrow Ca(OH_2)$$

Calcium hydroxide is slightly soluble in water to form an alkaline liquid called *lime water*. Calcium oxide has a great affinity or attraction for water and hence it is used for drying gases like ammonia. When a paste of lime and water is shaken with more water a suspension called milk of lime is got which is used for white washing purposes. When heated CaO reacts with acid gases and most non metals. It is used in the purification of coal gas, manufacture of caustic soda, (NH_3) ammonia, bleaching powder in tanning glass making, sugar refining, agriculture and in the preparation of mortar and plaster.

(3) **Slaked Lime; Ca (OH)$_2$.**

It is prepared by adding the requisite amount of water to lime (CaO) or by the addition of a soluble hydroxide to a solution of a calcium salt. It is only sparingly soluble in water and when heated decomposes to CaO and H_2O.

$$Ca(OH)_2 \overset{heated}{\rightleftharpoons} CaO + H_2O$$ (the reaction being reversible).

In solution it behaves as an alkali.

When Calcium hydroxide is slaked with **NaOH** (caustic Soda) the product is called *Soda lime*. This has all the properties of Caustic soda but not easily affected by the heat and its action on glass apparatus is therefore less marked. It is used as an acidic gas absorbant.

(4) **Milk of Lime :—**

When a paste of CaO and water is shaken up with more water a suspension of CaO in water is got. This is called Milk of Lime which is generally used for white washings After white washing the Calcium hydroxide gradually gets oxidised to Calcium carbonate by the atmospheric carbon - di_ oxide. Calcium hydroxide is sparingly soluble where as calcium carbonate is insoluble. That is why white washing is not affected by rain *once it sets* (i.e. after it gets converted to Calcium Carbonate).

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(5) **Soda Lime:—**

This is got by slaking (NaOH) caustic soda with ($Ca(OH)_2$) lime. This has all the properties of caustic soda, but does not melt so readily and its action on glass apparatus is therefore less marked. It is used to absorb acid gases.

(6) **Lime water:—**

Quick lime (CaO) when slaked with water forms a crumbly white paste. This paste is slightly soluble in water to form an alkaline liquid known as lime water. Chemically it is represented as $Ca(OH)_2$. This is generally a clear solution and it is used to test the presence of Carbon-di-oxide. It first turns milky due to the formation of Calcium Carbonate. However if excess of Carbon-di-oxide is passed into the solution Calcium bi-carbonate is got and the milkyness disappears. The reactions involved can be well represented by the following equations.

$$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$$

($CaCO_3$ insoluble)

$$CaCO_3 + H_2O + CO_2 \rightarrow Ca(HCO_3)_2 \text{ (soluble)}.$$

13. Explain (1) the action of heat on carbonates and bi-carbonates.

(2) Action of carbon-di-oxide on lime water.

(3) Action of heat on nitrates.

(1) Action of heat on carbonates and bi-carbonates.

All carbonates except carbonates of Sodium and Potassium are decomposed by heat into their respective oxides with the evolution of carbon-di-oxide.

$$\left.\begin{array}{l} CaCO_3 \rightleftharpoons CaO + CO_2 \uparrow \\ ZnCO_3 \rightleftharpoons ZnO + CO_2 \uparrow \\ MgCO_3 \rightleftharpoons MgO + CO_2 \uparrow \end{array}\right\} \text{Reversible reactions}$$

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This [is] one of the methods by which **Carbon - di - oxide is prepared.**

Bicarbonates of Sodium and Potassium when heated undergo decomposition into the normal carbonate liberating carbon-di-oxide. But they undergo no further decomposition. The reactions involved can be represented thus.

$$2Na(HCO_3)_2 \rightarrow Na_2CO_3 + 2H_2O + CO_2 \uparrow$$
$$2K(HCO_3)_2 \rightarrow K_2CO_3 + 2H_2O + CO_2 \uparrow$$

But the bicarbonates of other metals like Zinc, Calcium, Magnesium etc. not only undergo decomposition into the normal carbonates, but also further decompose into their respective metallic oxides.

1. $Mg(HCO_3)_2 \rightarrow MgCO_3 + H_2O + CO_2 \uparrow$
   $MgCO_3 \rightarrow MgO + CO_2 \uparrow$
2. $Ca(HCO_3)_2 \rightarrow CaCO_3 + H_2O + CO_2 \uparrow$
   $CaCO_3 \rightarrow CaO + CO_2 \uparrow$
3. $Zn(HCO_3)_2 \rightarrow ZnCO_3 + H_2O + CO_2 \uparrow$
   $ZnCO_3 \rightarrow ZnO + CO_2 \uparrow$

NOTE. The carbonates of *Sodium and Potassium are soluble* whereas the other metallic carbonates are insoluble in water.

(2) Action of Carbon - di - oxide on lime water.

Carbon - di - oxide when passed into lime water turns it milky. The milkyness is due to the precipitation of insoluble white Calcium carbonate. The reaction can be represented thus

$$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 \downarrow + H_2O$$

If excess of carbon - di - oxide is passed into the above solution calcium bi - carbonate will be formed which is soluble in water. As a result the milkyness disappears and the solution becomes clear.

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$$CaCO_3 + H_2O + CO_2 \rightarrow Ca\,(HCO_3)_2 \text{ (Soluble in } H_2O\text{)}$$

However if the above solution is heated we get back the normal carbonate, and the carbon-di-oxide which has dissolved in it in excess, will be expelled off.

$$Ca\,(HCO_3)_2 \rightarrow CaCO_3 \downarrow + H_2O + CO_2 \uparrow$$

This reaction is used to test the presence of Carbon-di-oxide.

(3) Action of heat on Nitrates.

The nitrates of alkali metals such as Lithium, Sodium and Potassium decompose on heating into their respective nitrites and oxygen. The nitrites do not undergo any further decomposition

$$\left.\begin{array}{l} 2\,KNO_3 \rightarrow 2\,KNO_2 + O_2 \\ 2\,NaNO_3 \rightarrow 2\,NaNO_2 + O_2 \end{array}\right\} \text{Nitrite and Oxygen}$$

The nitrates of Calcium, Magnesium, Zinc, Iron, lead and Copper etc are decomposed on heating into their respective oxides with the evolution of nitrogen peroxide and oxygen.

$$\left.\begin{array}{l} 2Cu\,(NO_3)_2 \rightarrow 2CuO + 4NO_2 + O_2 \uparrow \\ 2Pb\,(NO_3)_2 \rightarrow 2PbO + 4NO_2 \uparrow + O_2 \\ 2Ca\,(NO_3)_2 \rightarrow 2CaO + 4NO_2 + O_2 \uparrow \\ 2Zn\,(NO_3)_2 \rightarrow 2ZnO + 4NO_2 + O_2 \uparrow \\ 2Mg\,(NO_3)_2 \rightarrow 2MgO + 4NO_2 + O_2 \uparrow \end{array}\right\} \begin{array}{c} \text{Respective} \\ \text{oxide} \\ O_2 \text{ and } NO_2 \end{array}$$

Nitrates of mercury and silver decompose on heating into the metal, oxygen and nitrogen per oxide.

$$\left.\begin{array}{ll} \text{I.} & Hg(NO_3)_2 \rightarrow Hg + 2\,NO_2 \uparrow + O_2 \uparrow \\ \text{II.} & AgNO_3 \rightarrow AgO + NO_2 \\ & 2\,AgO \rightarrow 2\,Ag + O_2 \end{array}\right\} \begin{array}{c} \text{Metal, oxygen} \\ \text{and } NO_2 \end{array}$$

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Ammonium nitrate decomposes on heating to nitrous oxide and steam.

$$NH_4NO_3 \rightarrow N_2O \text{ (nitrous oxide)} + H_2O \text{ (steam)}$$

14. Write equations and explain the chemical changes that take place.

(1) When sea shells are burnt (2) Burnt sea shells are converted into Milk of lime
(3) White wash sets

When sea shells which is mainly composed of Calcium Carbonate are burnt they get converted to calcium oxide, with the evolution of CO_2.

$$CaCO_3 \rightarrow CaO + CO_2 \uparrow$$

The oxide is called quick lime. It is then slaked with water. It reacts with water energetically producing clouds of steam and forms a white paste. The reaction is exothermic as much heat is evolved during the process. The paste of Calcium oxide with water is called "Slaked Lime'.

$$CaO + H_2O \rightarrow Ca(OH)_2$$

When a paste of lime (CaO) is shaken up with more water a suspension of lime in water called Milk of Lime is formed. This is used for white washing purposes. Walls which are white washed with milk of lime have a coating of $Ca(OH)_2$ *at first* which is sparingly soluble in water. Gradually this gets oxidised to Calcium Carbonate on exposure to atmospheric Co_2 and it sets hard on to the wall.

$$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$$

The Calcium Carbonate is insoluble and hence it is not affected by rain during the rainy season. White washing is said to have set only after the formation of Calcium Carbonate. This is of great advantage as otherwise the $Ca(OH)_2$ will be washed off by rain water. The setting takes place automatically as soon as the white washing is done. The whole process involved can be epresented by the following equations:-

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$$CaCO_3 \rightleftharpoons CaO + CO_2 \uparrow$$
$$CaO + H_2O \rightarrow Ca(OH)_2$$
$$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$$

15. Write equations and explain the reactions that takes place when sulphuric acid reacts with the following substances.

(1) ammonia (2) Ethyl alcohol
(3) Sulphur trioxide (4) Sodium nitrate.
Mention the uses of the reactions.

(1) Ammonia gas is an anhydride of NH_4OH. When it is bubbled through moderately dilute sulphuric acid frist it reacts with the water in the acid to from the base Ammonium hydroxide.

$$NH_3 + H_2O \rightarrow NH_4OH$$

The Ammonium hydroxide thus formed acts as a base and it reacts with the acid to from a salt and water according to the equation.

$$2\,NH_4OH + H_2SO_4 \rightarrow (NH_4)_2SO_4 + 2\,H_2O$$

Use:—

This method is used to prepare Ammonium sulphate which on heating gives back Ammonia gas at 100°C

$$(NH_4)_2SO_4 \xrightarrow[\text{heat}]{100^\circ C} NH_4HSO_4 + NH \uparrow$$

(2) Ethyl alcohol reacts with sulphuric acid under three conditions. Ethyl alcohol when heated with concentrated sulphuric acid forms Ethyl hydrogen sulphate and water according to the equation.

$$C_2H_5 - \boxed{OH + H} + H_2SO_4 \rightarrow C_2H_5 \cdot HSO_4 + H_2O$$

Ethyl hydrogen sulphate

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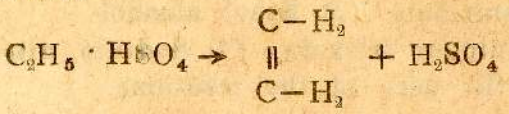
If we use excess of alcohol then at 140°C the Ethyl hydrogen sulphate formed will react with the excess of alcohol and forms Di Ethyl ether.

$$C_2H_5\,\boxed{HSO_4+H}\,O-C_2H_5 \rightarrow C_2H_5-O-C_2H_5+H_2SO_4$$

Di Ethyl ether.

On the other hand if the acid is in excess, at 160°C ethylene gas is evolved.



$$C_2H_5\cdot HSO_4 \rightarrow \begin{matrix} C-H_2 \\ \| \\ C-H_2 \end{matrix} + H_2SO_4$$

Uses:—

This method is used to prepare Ethylene gas and Ether.

(3) When sulphur trioxide is passed into a tower, down which 98% sulphuric acid trickles down (sprayed) the acid absorbs the gas and forms a highly concentrated acid called Oleum otherwise called fuming sulphuric acid.

$$H_2SO_4 + SO_3 \rightarrow H_2S_2O_7$$

This method is used in the manufacture of Sulphuric acid by contact process. By this method sulphur trioxide can be better absorbed than in water and an acid of desired strength can be got later by diluting the fuming sulphuric acid.

This acid renders iron passive and can be transported in iron containers

(4) When sodium nitrate is distilled with concentrated sulphuric acid (98%) brown vapours of nitric acid are evolved and the vapours are condensed in well cooled receivers.

$$3\,NaNO_3+2H_2SO_4 \rightleftharpoons NaHSO_4+3\,HNO_3+Na_2SO_4$$

This method is employed in the manufacture of nitric acid from chile salt petre.

16. Explain the reactions that take place between the following substances and what inferences do you draw from them.

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(1) Hydrogen per-oxide + lead sulphide.
(2) Ferric chloride + Hydrogen sulphide.
(3) Potassium permanganate + sulphuric acid + Hydrogen per-oxide.
(4) Silican-di-oxide + sodium hydroxide.
(5) Formic acid + sulphuric acid.

(1) If Hydrogen per-oxide is added to an aqueous suspension of black Lead sulphide it is oxidised to white Lead sulphate.

$$PbS + 4\,H_2O_2 \rightarrow PbSO_4 + 4\,H_2O$$

From this reaction we infer that Hydrogen per-oxide is a good oxidiser or oxidising agent. This reaction is used to restore colour to old oil paintings. Lead forms a number of compounds which are used in making paints. The white paint is basic lead carbonate. When these are exposed to air, they turn black owing to the action of Hydrogen sulphide present in the air. Thus black lead sulphide is produced which blackens the paint. If this is treated with Hydrogen per-oxide, the black sulphide is converted into white Lead sulphate and the colour of the painting is restored.

(2) Hydrogen sulphide is a powerful reducing agent. If it is passed into an orange coloured Ferric chloride solution it is reduced almost to a colourless solution of Ferrous chloride with the precipitation of Sulphur. The reaction involved can be represented by the following equation.

$$2\,FeCl_3 + H_2S = 2\,FeCl_2 + S\downarrow + 2\,HCl$$

This reaction is a very good example to show that Hydrogen sulphide is a powerful reducing agent.

(3) Hydrogen peroxide reacts with a pink solution of acidified Potassium per manganate rendering it colourless and *reducing* it with the liberation of oxygen, with the formation of Potassium sulphate and Manganese sulphate.

$$2\,KMnO_4 + 3\,H_2SO_4 + 5\,H_2O_2 \rightarrow K_2SO_4 + 2\,MnSO_4 + 8H_2O + 5\,O_2$$

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This reaction proves the fact that Hydrogen per-oxide is not only a good oxidising agent, but also a good reducing agent. Potassium permanganate is a well known oxidiser and it has been reduced by Hydrogen per-oxide in this reaction.

(4) Silica or Silican di-oxide behaves as an *acidic oxide*. On account of its acidic properties it reacts with alkalis or bases to produce salt and water. The reaction takes place thus

$$2\,NaOH + SiO_2 \rightarrow Na_2SiO_3 + H_2O$$

This reaction reveals the *acidic character* of Silican di-oxide, and justifies its classification as an acidic oxide.

5. Formic acid and concentrated sulphuric acid are two acids and yet they react with each other liberating $Co\uparrow$. It is a well known fact that concentrated Sulphuric acid is a good hygroscopic substance which has a great affinity for water molecules and it removes water moleclues from substances. That is why it is used as a drying agent in the laboratory.

Here in this particular reaction it removes molecules of water from formic acid and liberates carbon mon-oxide. This is one of the methods employed in the preparation of carbonmon oxide.

$$\boxed{H}-CO\boxed{OH} + H_2SO_4 \rightarrow H_2SO_4 \cdot H_2O + CO\uparrow$$

17. State Dulong and Petits Law;

The chloride of a metal contains 54·4% of chlorine. The specific heat of the metal is 0·056. Find

1. The equivalent weight of the metal.
2. The atomic weight of the metal.
3. Give the formula of the chloride of the metal.

Dulong and Petits law states that the product of the atomic weight of an element and its specific heat in the *Solid state*

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is a constant. The numerical value of this constant is 6·4. This number is called the *atomic heat of an element* which is same for all solid elements. In other words "atoms of different elements have the same capacity for heat".

(1) Weight of Chlorine present in 100 grams of the chloride = 54·4 grams.

∴ Weight of metal present in 100 grams of chloride = 100 – 54·4 = 45·6 grams

54·4 grams of chlorine combines with 45·6 grams of the metal

∴ 35·5 grams of chlorine combines with $\frac{45 \cdot 6 \times 35 \cdot 5}{54 \cdot 4}$

= 29·76 grams.

∴ The equivalent wight of the metal is 29·76 grams

(2) atomic wight × specific heat = 6·4 (according to Dulong & Petits law)

Specific heat of the metal = ·056

∴ approximate atomic weight = $\frac{6 \cdot 4}{\cdot 056}$ = 114·2 grams

∴ Valency of the metal is $= \frac{\text{at} \cdot \text{wt}}{\text{eq} \cdot \text{wt}} = \frac{114 \cdot 2}{29 \cdot 76} = 4$

(to the nearest whole number)

∴ accurate atomic weight = 4×29·76 = 119·04

∴ The formula of the chloride = MCL_4

(*b*) 0·3 grams of a bivalent metal M dissolved in Hydro chloric acid evolved 286 c c of dry Hydrogen at 13° c and 770 m m pressure. Calculate the (1) Equivalent weight (2) The atomic weight of the metal.

Write down the formula of the Chloride, sulphate and nitrate of M. (1 litre of H_2 at N. T. P. weighs ·09 gram)

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(3) Volume of Hydrogen evolved = 286 c.c.
Pressure at which hydrogen is evolved = 770 m m.
Temperature „ „ „ „ = 13° c = 273 + 13
= 286° Ab. temp.

Applying gas equation

$$\frac{Po\,Vo}{To} = \frac{P_1\,V_1}{T_1} \qquad \left(\begin{array}{l} P_0 = 760 \text{ m. m.} \\ T_0 = 273° \text{ A} \end{array}\right)$$

$$Vo = \frac{P_1\,V_1 \times T_0}{P_0 \times T_1} = \frac{770 \times 286 \times 273}{760 \times 286} = 276 \cdot 6 \text{ c.c.}$$

$$= 277 \text{ c.c. of } H_2$$

The volume of hydrogen liberated at N. T. P. = 277 c c.
·09 grams of hydrogen occupies 1000 c.c.

$$\therefore 1 \text{ ,, ,, ,, ,,} \quad \frac{1000}{\cdot 09} = 11111 \text{ c.c.}$$

277 c.c. of hydrogen is liberated by 0 · 3 grams of metal.

$$\therefore 11111 \text{ ,, ,, ,, ,, ,,} \quad \frac{0 \cdot 3 \times 11111}{277}$$

$$= 120 \cdot 33 \text{ grams}$$

∴ The eq. weight of the metal is 120 · 33 „
Atomic weight = Eq. wt. × Valency.
Valency = 2
∴ Atomic weight = 2 × 120 · 33 = 240·66 grams
Formula of the chloride of the metal is MCL_2
„ „ „ sulphate „ „ „ „ MSO_4
„ „ „ nitrate „ „ „ „ $M(NO_3)_2$

18. What is the equivalent weight of the Potassium Permanganate in

(1) Acid medium. (2) Alkaline medium.

Potassium Permanganate is a well known oxidising agent and its equivalent weight is calculated from the amount of oxygen

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it yields for oxidation in the different media namely acid and alkaline. In the acid medium Potassium Per manganate yields 5 atoms of oxygen for oxidation and the reaction can be represented thus

$$2KMnO_4 \underset{\text{acid medium}}{\underline{+3H_2SO_4}} \rightarrow K_2SO_4 + 2MnSO_4 +$$
$$3H_2O + 5[O]\text{atomic state}$$
$$5H_2C_2O_4 + 5[O] \rightarrow 10CO_2 \uparrow + 5H_2O$$
$$10\,FeSO_4 + 5H_2SO_4 + 5[O] \rightarrow 5Fe_2(SO_4)_3 + 5H_2O$$
$$5H_2O_2 + 5[O] \rightarrow 5H_2O + 5O_2$$
$$5HNO_2 + 5[O] = 5HNO_3$$
$$5H_2SO_3 + 5[O] = 5H_2SO_4$$
$$10\,HI + 5[O] = 5H_2O + 5I_2$$

In all these reactions [in acid medium] Potassium Per manganate liberates 5 atoms of oxygen for oxidation. Hence its equivalent weight is that weight of it which can librate 8 parts by weight of oxygen for oxidation ie.

$$2KMnO_4 + 3H_2SO_4 \longrightarrow K_2SO_4 + 2MnSo_4 + 3H_2O + 5[O]$$
$$2\times158 \xrightarrow{\hspace{6em}} 5\times16$$

$$\therefore \text{Equivalent wt.of } KMnO_4 = \frac{2\times158\times8}{5\times16_2} = \frac{158}{5}$$

$$\frac{\text{Its molecular wt.}}{5} = \underline{\underline{31{\cdot}6}}$$

In the alkaline medium $KMnO_4$ yields (lower quantity of oxygen) less amount of oxygen for oxidation The reaction involved can be represented thus

$$2\,KMnO_4 + 2\,KOH \longrightarrow 2\,K_2MnO_4 + H_2O + [O]$$
$$2\,K_2MNO_4 + 2\,H_2O \longrightarrow 2\,MnO_2 + 4\,KOH + 2[O]$$
$$\text{adding } 2KMNO_4 + H_2O \longrightarrow 2MnO_2 + 2KOH + 3[O]$$
$$2\,KMnO_4 + H_2O \longrightarrow 2MnO_2 + \ KOH + 3[O]$$

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Hence in alkaline medium it yields 3 atoms of oxygen for oxidation. Therefore its equivalent weight is that weight (in alkaline medium) of it which can liberate 8 parts by weight of oxygen for oxidation.

$$2KMnO_4 + H_2O \rightarrow 2MnO_2 + 2KOH + 3[O]$$

$$2\times 158 \longrightarrow (3\times 16)$$

$$\therefore \text{Eq. wt of } KMnO_4 \text{ in alkaline medium} = \frac{2\times 168\times \cancel{8}}{3\times \underset{2}{\cancel{16}}}$$

$$= \frac{158}{3} = 52\,667$$

$$= \frac{\text{Its molecular weight}}{3}$$

19. If the labels of the bottles containing Hydrochloric acid, Nitric acid and Sulphuric acid in your laboratory have been washed off How will youi dentify the acids to re-label them.

In order to identify the acids the following tests are done.

1. The acids are taken in three separate test tubes and Ammonium hydroxide is brought close to each of them. In the case of Hydro chloric acid we get dense white fumes of Ammonium chloride. In the other two cases no such fumes are produced

$$NH_4OH + HCL \rightarrow NH_4CL + H_2O$$

2. Added Barium chloride ($BaCl_2$) to all the acids. Only in the case of Sulphuric acid we get a white precipitate of Barium sulphate In the other two cases no precipitate is got.

$$BaCl_2 + H_2SO_4 \rightarrow BaSO_4 \downarrow + 2HCL$$

3. Added Silver nitrate to all the acids. Only in the case of Hydrochloric acid we get a *drity* white or curdy white precipitate of Silver chloride. In the other two cases no precipitate is got.

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$$AgNO_3 + HCl \longrightarrow \underbrace{AgCl}_{\text{curdy white}} + HnO_3$$

4. Copper turnings are added to the acids. In the case of Nitric acid reddish brown fumes of Nitrogen per oxide is produced with the formation of a blue solutian of copper nitrate $(Cu(No_3)_2)$

$$\overset{\text{Reddish brown fumes.}}{}$$

$$Cu + \underline{Con}\ 4HNO_3 \quad > Cu(NO_3)_2 + 2NO_2 \uparrow + 2H_2O$$

$$3Cu + \underline{dil}\ 8HNO_3 - > Cu(NO_3)_2 + 2NO \uparrow + 4H_2O$$

In the case of dilute Sulphuric acid no reaction takes place with copper in the cold.

But hot concentrated Sulphuric acid reacts with Copper turnings to produce a blue solution of Copper sulphate, Sulphur di oxide and water.

$$Cu + 2H_2SO_4 \dashrightarrow CuSO_4 + SO_2 \uparrow + 2H_2O$$

In this reaction Sulphuric acid not only behaves as an acid but also as an oxidiser and while oxidising Copper to Copper sulphate it gets itself reduced to sulphur di oxide and water. Sulphur di oxide turns acidified dichromate paper green.

$$K_2Cr\ O_7 + H_2SO_4 + 3SO_2 \longrightarrow K_2SO_4 + Cr_2(SO_4)_3\ \text{green} + H_2O$$

In the case of Hydro chloric acid Cupric chloride is formed with the evolution of Hydrogen which can be tested by introducing a burning splinter that will produce a pop sound with Hydrogen

$$Cu + 2HCl \longrightarrow CuCl_2 + H_2 \uparrow$$

Suppose Lead nitrate is added to Hydro chloric acid a white precipitate of Lead chloride is got which is soluble in hot water and insoluble in cold water.

$$2Pb(NO_3)_2 + 2HCL \longrightarrow PbCl_2 + 2HNo_3$$

5. Heat is evolved when Sulphuric acid is mixed with water and it charrs sugar.

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20. **How does Hydrogen sulphide react with the following substances:—**

1. Potassium Permanganate 2. Potassium dichromate 3. Ferric sulphate 4. Sodium hydroxide.

1. Hydrogen sulphide is a powerful reducing agent. When the gas is passed into an acidified pink solution of Potassium Permanganate, it will be decolourized. The reaction involved can be represented thus.

$$2KMnO_4 + 3H_2SO_4 \text{—>} K_2SO_4 + 2MnSO_4 + 3H_2O + 5[O] \text{ nascent}$$

$$5[O] + 5H_2S \text{—>} 5H_2O + 5S$$

Adding we get

$$2KMNO_4 + 3H_2SO_4 + 5H_2S \text{—>} K_2SO_4 + 2MnSO_4 + 8H_2O + 5S$$

The release of nascent oxygen from Potassium Permanganate on the addition of an acid shows that it is a powerful oxidising agent. This is reduced by Hydrogen sulphide and rendered colourless While reducing Potassium Permanganate, Hydrogen sulphide gets itself oxidised to sulphur. This reaction explains that a reducing agent while reducing another substance gets itself oxidised and an oxidising agent while oxidising another substance gets itself reduced. Hence the saying "Oxidation and reduction takes place simultaneously"

2. Just like Patassium Permanganate, orange Potassium dichromate is also reduced to green Chromic salt by Hydrogen sulphide.

When Hydrogen sulphide is passed into an acidified solution of Potassium di chromate ($K_2Cr_2O_7$) Potassium dichromate loses its orange colour and changes into a green solution. The reaction involved can be represented thus.

$$K_2Cr_2O_7 + 4H_2SO_4 \text{—>} K_2SO_4 + Cr_2(SO_4)_3 + 4H_2O + 3[O] \text{ nacent}$$

$$3[O] + 3H_2S \text{—>} 3H_2O + 3S$$

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The release of three atoms of oxygen by Potassium dichromate on the addition of an acid shows that it is a good oxidiser. So it oxidises Hydrogen sulphide to Sulphur. Hydrogen sulphide reduces Potassium di Chromate to green Chromic salt and gets itself oxidised to sulphur.

3. $Fe_2(SO_4)_3 + H_2S \rightarrow 2FeSO_4 + H_2SO_4 + S \downarrow$

Here a brown solution of Ferric sulphate is reduced to Ferrous sulphate which is pale green in colour. Hydrogen sulphide is oxidised to sulphur.

4. Hydrogen sulphide in some cases behaves as an acid and react with metals and metalic hydroxides to form salts. For example when Hydrogen sulphide is passed through a solution of Sodium Hydroxide Sodium sulphide and water are formed.

$$2NaOH + H_2S \rightarrow 2H_2O + Na_2S$$

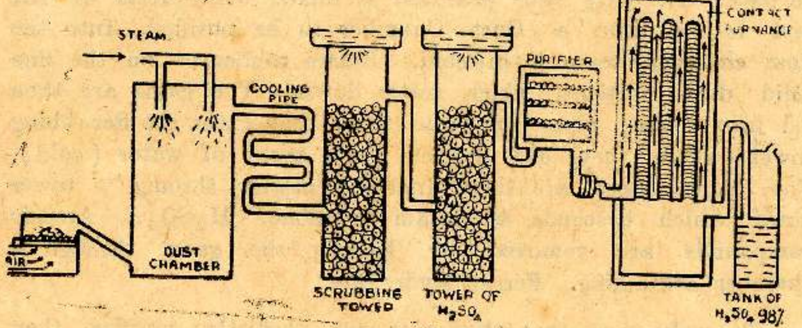
However if excess of Hydrogen sulphide is passed into Sodium Hydroxide then sodium bi-Sulphide or Sodium - Hydrogen - Sulphide is formed.

$$NaOH + H_2S \rightarrow NaHS + H_2O$$

In these reactions Hydrogen Sulphide behaves as a di basic acid.

21. Outline the method by which Sulphuric acid is manufactured by the contact process?

What is platinised Asbestos;—Suggest a substiute for this?



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The process consists in the oxidation of SO_2 into SO_3 in the presence of platinized asbestoes as catalyst and then the SO_3 is absorbed in 98% sulphuric acid. The acid got can be diluted later to the desired strength.

As the reaction $2SO_2 + O_2 \rightleftharpoons 2SO_3 + 45{,}000$ cals is catalylic exothermic, as well as reversible the following conditions must be maintained for the best results.

(1) The gas mixture (SO_2 and Air) must be dry and free from particles of dust, sulphur and *Arsenious Oxids* as otherwise the catalyst would be poisoned and its activity stopped.

(2) The temperature of the catalyst is to be kept at 450°C. A higher temperature decomposes SO_3 into SO_2 and O_2. While a lower temperature slows down the formation of SO_3.

(3) Excess of Oxygen must be supplied for complete Oxidation of SO_2 into SO_3.

The raw - materials required for the process are

i. Platinized Asbestos to serve as Catalyst
ii. Iron pyrites to produce SO_2
iii. Air or Oxygen for oxidation of SO_2 to SO_3
iv. H_2SO_4 (98%) to absorb SO_3.

To begin with Iron pyrites are roasted in a reverberatory furnace. The SO_2 thus produced is mixed with *excess* of Air and is led into a Dust Chamber to be purified. Into the dust chamber steam is injected. Steam condenses on the fine solid dust particles which settle down. The gases are then led into cooling pipes and from there they enter the Scrubbing lower where they are washed by a spray of water (cold). The moist gases are then dried by passing through a tower down which descends a stream of Conc. H_2SO_4. Arsenic compounds are removed by leading the gases through a chamber containing. Ferric Hydroxide.

To make sure that the gases are perfectly purified they are periodically tested in the Optic Box. A strong beam of

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light is passed across the box and when viewed vertically dust particles if present would be clearly visible due to scattering of light. Otherwise the box would appear entirely dark.

The purified gases are led into the Contact chamber heated to a temperature of 450 - 500°C by a set of burners Once the reaction starts between SO_2 and O_2 the burners can be removed as the heat produced during the reaction will be sufficient to continue the reaction

$$(2\,SO_2 + O_2 \rightarrow 2\,SO_3 + K \text{ cals}) \quad (\textbf{Exothermic})$$

Care is taken to see that the temperature of the contact mass is maintained at 450°c — 500°c. SO_2 is oxidised to SO_3 and the latter is best absorbed in 98% H_2SO_4. If water is used instead of 98% H_2SO_4 to absorb SO_3, the absorption is not complete and the particles of SO_3 and H_2SO_4 will spread out. Hence 98% H_2SO_4 is used for absorption. The acid produced after absorption is *highly* concentrated. It is called Fuming Sulphuric Acid or Pyro Sulphuric Acid or Oleum.

$$H_2So_4 + SO_3 \rightarrow H_2S_2O_7$$

The Oleum can then be diluted to the desired strength to get H_2SO_4.

Platinized Asbestos

It is prepared by soaking Asbestos in Platinum chloride solution and then igniting it. A very small amount of costly platinum is left in Asbestos in an extreamly finely divided state, presenting a very large surface of contact to the gas mixture which is advantageous for a Catalytic reaction.

Nowadays Vanadium pentoxide is used as a substitute for platinized asbestos.

22. Give reactions to show that concentrated Sulphuric acid behaves

(1) as an Oxidising Agent

(2) as a dehydrating Agent

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(3) It's action with Water

(4) It's action with Bromides and Iodides.

(1) Concentrated Sulphuric acid behaves as an oxidising agent. Its oxidising property can be illustrated by the following reactions.

Concentrated Sulphuric acid when heated with metals such as Copper, Zinc, Mercury, Silver, Aluminium, Tin etc. oxidises them to their respective sulphates with the liberation of Sulphur - di - oxide.

$$Hg + 2H_2SO_4 \rightarrow HgSO_4 + 2H_2O + SO_2 \uparrow$$
$$2Al + 6H_2SO_4 \rightarrow Al_2(SO_4)_3 + 6H_2O + 3SO_2 \uparrow$$
$$Cu + 2H_2SO_4 \rightarrow CuSO_4 + 2H_2O + SO_2 \uparrow$$

When Zinc is heated with concentrated Sulphuric acid it oxidises Zinc to Zinc sulphate, getting itself reduced to Sulphur-di-oxide Sulphur and even to Hydrogen Sulphide.

$$Zn + 2H_2SO_4 \rightarrow ZnSO_4 + 2H_2O + SO_2 \uparrow$$
$$3Zn + 4H_2SO_4 \rightarrow 3ZnSO_4 + 4H_2O + S \downarrow$$
$$4Zn + 5H_2SO_4 \rightarrow 4ZnSO_4 + 4H_2O + H_2S \uparrow$$

It oxidises non - metals like Carbon, Sulphur and Phosphorus

(Conc) $2H_2SO_4 + C = 2H_2O + 2SO_2 + CO_2$
(„) $2H_2SO_4 + S = 2H_2O + 3SO_2$
(„) $P + 5H_2SO_4 = 2H_2O + 5SO_2 + 2H_3PO_4$
(phosphoric acid)

If Hydrogen sulphide is bubbled through concentrated Sulphuric acid, Hydrogen sulphide gets oxidised to Sulphur.

$$H_2S + H_2SO_4 \rightarrow 2H_2O + S + SO_2 \uparrow$$

(2) Concentrated Sulphuric acid behaves as a dehydrating agent. That is the reason why it is used in the Labs in

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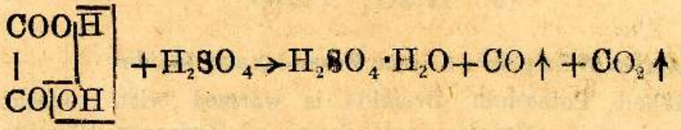
dessiccators and also to dry gases that do not react with it chemically. The concentrated acid has a *great affinity* for water. The affinity is so powerful and great that it can extract the elements of water from very stable compounds such as Sugar, Oxalic acid, Fomic acid and Ethyl alcohol.

1. when Sugar is treated with Conc H_2SO_4 it is charred

$$\underset{\text{Cane sugar}}{C_{12}H_{22}O_{11}} + H_2SO_4 \rightarrow H_2SO_4 \cdot 11H_2O + 12C$$

In the same way the acid charrs wood or tissues of the body

2. When Sulphuric acid is warmed with crystals of Oxalic acid the elements of water are removed form it with the liberation of Carbon - di - oxide and Carbon - mon - oxide.



$$\begin{array}{l} COO\boxed{H} \\ \;| \\ CO\boxed{OH} \end{array} + H_2SO_4 \rightarrow H_2SO_4 \cdot H_2O + CO\uparrow + CO_2\uparrow$$

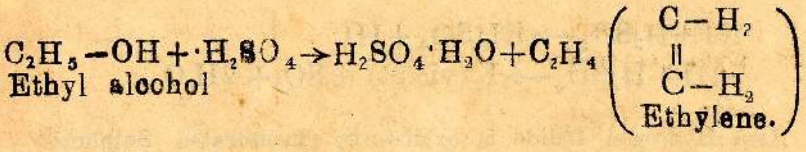
Oxalic acid

With Formic acid it yields Carbon - mon - oxide

$$\boxed{H - CO\,|\,OH} + H_2SO_4 \rightarrow H_2SO_4 \cdot H_2O + CO\uparrow.$$

The above two reactions are used to prepare Carbon-mon-oxide

When Ethyl alcohol is warmed with concentrated Sulphuric acid the elements of water are reomved from the alcohol and an unsaturated compound called Ethylene gas is formed.



$$\underset{\text{Ethyl alcohol}}{C_2H_5-OH} + H_2SO_4 \rightarrow H_2SO_4 \cdot H_2O + C_2H_4 \left(\begin{array}{c} C-H_2 \\ \| \\ C-H_2 \\ \text{Ethylene.} \end{array} \right)$$

Thus the above reactions show that con. H_2SO_4 is a powerful dehydrating agent.

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(3) Action of concentrated Sulphuric acid with water:

Very often we have seen that in diluting concentrated Sulphuric acid, the acid is added to water and not water to the acid. The reason is that when water is added to the acid considerable amount of heat is produced which is sometimes sufficient to boil the acid solution which might result in explosion and accidents. To aviod such mishaps usually the acid is added to water. This is also an exothermic reaction where much heat is produced but this is not so great as, when water is added to the acid. The acid must be added "little by little" to the water along the sides of the vessel. Sulphuric acid has a great affinity for water. So it formes a mumber of hydrates of the following compositions.

(1) $H_2SO_4 \cdot H_2O$
(2) $H_2SO_4 \cdot 2H_2O$
(3) $H_2SO_4 \cdot 4H_2O$.

(4) Action of Sulphuric acid on Bromides and Iodides

When Potassium Bromide is warmed with concentrated Sulphuric acid colourless acid fumes of Hydrogen Bromide and Potassium-bi-sulphate are formed Then almost immediately the gas takes a brown colour due to the liberation of Bromine from HBr by concentrated Sulphuric acid. The reactions involved can be represented by the following equations.

$$KBr + H_2SO_4 \longrightarrow KHSO_4 + HBr$$
$$2HBr + H_2SO_4 \longrightarrow Br_2\uparrow + 2H_2O + SO_2\uparrow \text{ (Oxidation)}$$

The same type of reactions takes place between Potassium Iodide and Sulphuric acid. The reactions involved can be represented by the following equations.

$$KI + H_2SO_4 \longrightarrow KHSO_4 + HI$$
$$2HI + H_2SO_4 \longrightarrow I_2 \text{ (violet) } + SO_2 + 2H_2O$$

Here Hydrogen Iodide is oxidised by concentrated Sulphuric acid to I which produces a violet colour and Sulphuric acid gets itself reduced to Sulphur-di-oxide and water.

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23. (1) What two tests would you perform to identify bottles containing a Chloride, Bromide and an Iodide.

(2) What chemical tests would you do to show conclusively that a given salt is Lead nitrate.

1. (a) The Chloride, Bromide and Iodides are taken separately in 3 test tubes and Conc. Sulphuric acid and a pinch of MnO_2 are added to each of them and gently warmed. A greenish yellow gas will be produced from the tube containing the Chloride. The gas has an irritating pungent smell and it bleaches moist petals. The reactions involved can be represented thus.

$$MnO_2 + 2\,NaCl + 3\,H_2SO_4 \longrightarrow 2\,NaHSO_4 + MnSO_4 + 2\,H_2O + Cl_2$$

$$Cl_2 + H_2O \longrightarrow HCl + HClO$$

$$HClO \longrightarrow HCl + [O] \text{ nascent state}$$

Nascent. $[O]$ + colouring matter = colourless matter.

The Bromide will produce brown fumes.

$$MnO_2 + 2NaBr + 3H_2SO_4 = 2\,NaHSO_4 + MnSO_4 + Br_2 + 2H_2O$$

The Iodide will produce Violet Vapours

$$MnO_2 + 2KI + 3H_2SO_4 = 2KHSO_4 + MnSO_4 + 2H_2O + I_2$$

This method is employed to release the halogens from their respective compounds.

(b) **Silver – Nitrate Test**

The Bromide Chloride and Iodide are taken in 3 separate test tubes and a few drops of dilute Nitric acid and then Silver Nitate are added. In the tube containing the Chloride we get a *curdy white* or *dirty white* precipitate insoluble in Acids and soluble in Ammonia.

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$$NaCl + AgNO_3 \rightarrow AgCl\downarrow + NaNO_3$$

In the tube containing the Bromide we get a *pale yellow precipitate* of Silver Bromide which is insoluble in Con. Nitric Acid but only sparingly soluble in Ammonia.

$$NaBr + AgNO_3 \rightarrow NaNO_3 + AgBr\downarrow$$

In the case of the Iodide we get a *dark* yellow precipitate insoluble in both concentrated Acids and Ammonia.

$$KI + AgNO_3 \rightarrow KNO_3 + AgI$$

Thus by applying the above two tests we can identify the bottles containing a Chloride, Bromide and an Iodide.

(2) Lead salts are generally insoluble in dilute acids. So to an aqueous solution of the Lead Salt dilute Hydro Chloric Acid is added in excess. A white precipitate is got which is insoluble in cold Ammonium Hydroxide. The white precipitate of Lead Chloride is soluble in hot water and reprecipitates on cooling. To confirm that it is Lead, to an aqueous solution of the substance Potassium Iodide is added. A yellow precipitate is got. If this solution is boiled the yellow precipitate dissolves giving a colourless solution. But on cooling *shining golden sprangles* will be got

$$2KI + Pb(NO_3)_2 = 2KNO_3 + PbI_2$$

(Golden yellow Sprangles or precipitate)

To confirm the presence of Nitrate the Brown ring test is done.

To an aqueous solution of the Nitrate add excess of freshly prepared Ferrous Sulphate solution and then concentrated Sulphuric acid along the sides of the test tube held in a slanting position. Care is taken to see that the test tube is not shaken or tilted. A brown ring is formed at the junction where the two liquids mix. The reactions involed can be represented thus,

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$$Pb(NO_3)_2 + H_2SO_4 \rightarrow PbSO_4 + 2HNO_3$$

The Nitric acid is then reduced by some of the Ferrous Sulphate to Nitric Oxide.

$$6FeSO_4 + 2HNO_3 + 3H_2SO_4 = 3Fe_2(SO_4)_3 + 4H_2O + 2NO$$

The Nitric Oxide thus formed combines with the excess of Ferrous Sulphate soulution to give a compound of the composition $FeSO_4 \cdot NO$. This addition compound is brown in colour and appears as a brown ring.

$$FeSO_4 + NO \rightarrow FeSO_4 . NO$$

24. What are Alloys. Mention the names of some common alloys and in each case mention the different metals that go into their composition and also their uses.

An Alloy may be defined as an intimate association of two or more metals produced by solidifying the moltern mixture when metals are fused together.

(a) They dissolve in any proportion,
(b) They dissolve only partially,
(c) They remain un-dissolved,
or (d) They combine chemically.

Amalgam is an alloy containing mercury as one of its components. A well known example is the Sodium Amalgam which we come across in the manufacture of Chlorine from Sodium Chloride by electrolysis using a Castner kellner cell.

Alloys can be prepared by

(1) Fusing together the constituents in a crucible.
(2) Mixing the components in the fused state and thoroughly stirring with small pieces of charcoal to prevent oxidation at the surface.
(3) Compressing the finely divided components under great pressure.
(4) By electrolytic method using a cathode of a different metal from the Salt Solution used in the bath or by using a bath of mixed Salt Solution.

* **The aim or the purpose of alloying is to modify the properties of metals by reducing the cost and some undesirable properties and increasing other suitable properties.**

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Alloys may be homogenous or heterogenous solids having similar or different lustres from the components. They are harder but less malleable, bad conductors of heat and electricity. They have a lower melting point than the constituents. The tensile strength is highly increased in alloys.

Alloys	Constituent Metals	Uses
1 Brass	Copper and Zinc	Utensils tubes, Cartridges
2 Bronze	Copper and Tin	Vessels machines
3 Phospher Bronze	Copper, Tin and Phosphous	Parts of Mechines
4 Germal Silver	Copper, Zinc and Nickel	Plates Vessels ornaments
5 Muntz Metal	Copper and Zinc	Sheath for Ships
6 Monel Metal	Copper, Nickel, Iron and Manganese	Pumps for acids Sheet Metal Works
7 Gun - Metal	Copper, Tin and Zinc.	Guns and Mechinary
8 Manganin	Manganese, Copper and Nickel	Electrical Instruments
9 Nickel chrome	Chromium nickel and Iron	Resistance wires
10 Stainless Steel	Steel containing 12-15% Chromium	Cutlery
11 Solder	Lead, Tin	Joints
12 Type Metal	Lead, Tin, Copper and Antimony	
13 Magnalium	Aluminium and Magnesium	Aeroplanes balance Beams, Motor parts
14 Elektron	Magnesium zinc and Copper	,,
15 Duralumin	Magnesium manganese Aluminium and Copper	,,
16 Bell Metal	Tin and Copper	Used for making Gongs
17 Britannia Metal	Tin, Copper and Lead	Fancy articles
18 Coinage Bronze	Tin and Copper	Coin making
19 Invar	Iron and Nickel	Pendulum rods Scales, Balances wheels of watches
20 Dentist alloy	Silver and Platinum	

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25. (a) **Starting from** Blue **Vitriol** ($CuSO_4 \cdot 5H_2O$) **how will you prepare** metallic **Copper.**

(b) **How will you separate the components of Gun-powder.**

I (a) Blue vitriol is blue crystalline Copper-Sulphate of the composition $CuSO_4 \cdot 5H_2O$ On heating this crystalline solid to 100 °C it decomposes into a pale blue monohydrate according to the following equation

$$CuSO_4 \cdot 5H_2O \xrightarrow[100°c]{heat} CuSO_4 \cdot H_2O + 4H_2O$$

The monohydrate when further heated to 230°C loses all its water of crystallisation and crumbles into a white powdery substance called "Anhydrous Copper Sulphate $CuSO_4$

$$CuSO_4 \cdot H_2O \xrightarrow[230°c]{heat} CuSO_4 \text{ (anhydrous)} + H_2O.$$

Anhydrous copper sulphate when heated to 400°C decomposes to black Cupric Oxide with the evolution of Sulphur-tri-oxide.

$$CuSO_4 \xrightarrow[400°c]{heat} CuO \text{ (Black)} + SO_3 \uparrow$$

The black Copper oxide can be reduced to metallic copper by a powerful reducing agent such as

(1) **Nascent Hydrogen**
(2) **Carbon** or
(3) **Carbon-non** Oxide

$$CuO + 2H \rightarrow Cu + H_2O$$
$$CuO + C \rightarrow CO + Cu$$
$$CuO + CO \rightarrow CO_2 \uparrow + Cu.$$

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Thus by the above method metallic Copper can be got from blue crystalline Copper Sulphate.

The Copper Sulphate can also be converted into the Copper Carbonate by double decomposition with Sodium Carbonate. The Carbonate can be further reduced to the Oxide and then to the Metal.

$$CuSO_4 + Na_2CO_3 \longrightarrow Na_2SO_4 + CuCO_3\downarrow$$
$$CuCO_3 \longrightarrow CuO + CO_2\uparrow$$
$$CuO + C \longrightarrow Cu + CO\uparrow$$

(b) Gun powder is a mixture of Sulphur, Potassium Nitrate and Charcoal. Sulphur is soluble in Carbon-di-Sulphide. Potassium Nitrate is soluble in water and Charcoal is soluble in neither. Using this principle the components of gun powder can be seperated.

To do this parctically, the given specimen of gun powder is taken in a test tube and shaken with Carbon-di-Sulphide. The Sulphur present in the gun-powder dissolves in Carbon-di-Sulphide leaving behind a residue of Potassium Nitrate and Charcoal. The solution is filtered and the filterate is allowed to evaporate *without* heating. Crystals of Sulphur are got.

The residue containting Potassium Nitrate and Charcoal is boiled with water. Potassium Nitrate goes into solution. This can be filtered off and on evaporation (by heating) we get back Crystals of Potassium Nitrate. Charcoal remains as a residue in the filter paper which can be dried in an oven. Thus by the above method the components of Gun powder can be separated

16. How is soap made? What is Soap-Lather? Explain the detergent action of soap? Why does hard water consume much soap? How can you make soap in the laboratory or at home?

Soap is made *either* (1) by boiling animal fats, oils or vegetable oils with Caustic Potash or Caustic Soda solution of a given strength or (2) by thoroughly churning up calculated amount of a strong alkali like Caustic Soda solution with warm or hot oil.

These oils and fats are mixtures of Organic Compounds known as Glycerides formed by the combination of Glycerine with an organic fatty acid. As a result of the action of the alkali, Glycerine is set free and the fatty acid forms the Sodium or Potassium Salt called the soap. Common soaps are thus mixtures of Sodium and Potassium Salts of Organic Acids. Fats has the formula $C_3H_5(C_{15}H_{31}COO)_3$. The formation of the soap can be expressed by the following equations.

$$\begin{array}{l} C_3H_5(C_{15}H_{31}COO)_3 \\ \qquad + 3\,NaOH \rightarrow \underset{\text{Glycerine}}{C_3H_5(OH)_3} + \underset{\substack{\text{Soap} \\ \text{Sodium palmitate}}}{3\,C_{15}H_{31}-COONa} \end{array}$$

Soap obtained by using Caustic Soda are known as hard Soaps and thdse from Caustic Potash are known as soft Soaps. The latter has a softer body and a higher solubility in water. Washing Soaps and many Toilet soaps are hard where as, liquid soaps, disinfecting soaps etc contain a large portion of soft Soap. Metallic soaps such as Zinc Soap, Lead Soap etc are used in Medicine, face creams, and snows.

Soap lather is formed by small particles of air enclosed by a soap solution containing an Acid Soap, emulsion of oil and dirt. When a soap is dissolved in water a part of it hydrolyses.

$$\begin{array}{r|l} C_{15}H_{31}-COO & Na \\ H\cdot & OH \end{array} \rightarrow \underset{\text{Palmitic Acid}}{C_{15}H_{31}COOH} + NaOH.$$

It forms an Acid and basic soap — by the combination of a molecule of the free acid with an unhydrolysed molecule of the soap.

$$\begin{array}{l} C_{15}H_{31}COONa + C_{15}H_{31}-COOH \\ \qquad\qquad = \underset{\text{Acid Soap}}{(C_{15}H_{31}-COO)_2H\cdot Na} \end{array}$$

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This action lowers the surface tension of water and produces an emulsion with oils and greases present to form lather.

The soap solution, as it lowers the surface tension of water makes an emulsion of the oil whereby dirty matter is released and washed off with enough water. This accounts for the detergent action of soap

Hard water consumes more soap because when hard water is treated with soap, the Calcium and Magnesium Salts present in the hard water form Calcium and Magnesium palmitates or stearates which being insoluble float as a scum and produce a harsh feel. Thus all Calcium and Magnesium Salts are to be removed first at the cost of the soap before actual hydrolysis and consequent lather formotion takes place.

$2C_{15}H_{31}COONa$

Soap

Sodium palmitate

$$+MgSO_4 \rightarrow (C_{15}H_{31}COO)_2Mg + Na_2SO_4$$

Magnesium palmitate

Insoluble scum

$2C_{15}H_{31}-COONa$

Soap

$$+CaSO_4 \rightarrow (C_{15}H_{31}-COO)_2Ca + Na_2SO_4$$

Calcium palmitate

How is soap made at home or in the Laboratory?

Any vegetable oil — Coconut oil — is taken in a beaker and warmed. A concentrated solution of Sodium hydroxide is prepared and that is added to the warm oil and stirred well till we get a Semi solid mass. Then it is poured into a pan or box and allowed to set. Thus soap can be made in the Lab. or at home using Sodium Hydroxide and Coconut oil.

27. If the Labels of the bottles containg Baking Soda and Washing Soda are removed at your home how will you identify them applying simple tests.

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Baking soda is Sodium - bi - Carbonate used for baking purposes. Washing soda is crystalline Sodium Carbonate. ($Na_2CO_3.10H_2O$) Washing soda is used for washing purposes. If the labels of the bottles containing these two substances are removed they can be identified by applying simple tests.

1. Samples of the two substances are separately taken in two small bottles and heated, a burding splinter is introduced into them. Sodium Carbonate is not decomposed by heat whereas Sodium - bi - Carbonate decomposes on heating giving off Carbon-di Oxide. This puts off the burning splinter and turns lime water milky.

$$Na_2CO_2 \xrightarrow{\text{heat}} \text{no action}$$

$$2\,NaHCO_3 \rightarrow Na_2CO_3 + H_2O + CO_2 \uparrow$$

$$CO_2 + \text{the burning splinter} \rightarrow \text{The burning splinter is put off}$$

$$CO_2 + Ca(OH)_2 \rightarrow CaCO_3 \downarrow + H_2O$$

Besides Na_2CO_3 when dissolved in water undergoes partial hydrolysis producing Sodium Hydroxide which is soapy to touch and corrosive.

$$Na_2CO_3 + 2\,H_2O \rightarrow 2\,NaOH + H_2O + CO_2 \uparrow$$

$$\begin{array}{l|l} Na_2 & CO_3 \\ OH & H \rightarrow 2\,NaOH + H_2O + CO_2 \\ OH & H \quad \text{Soapy to touch and Corrosive} \end{array}$$

By the above tests Baking Soda and Washing Soda can be distinguished from each other at home.

28. What is the name of the green incrustation formed on Copper Utensils at home. How can the formation of it be prevented?

Verdigris is the name given to the green incrustation formed on Copper Vessels. Originally Verdigris the green pigment was prepared by exposing Copper plates to the action of wine. This is a basic Acetate of Copper of the composition,

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$(CH_3-COO)_2Cu\cdot 3Cu(OH)_2$ Basic Acetate of Copper.

Later similar incrustations formed on Copper when exposed to air also came to be known as Verdigris as the colour of the salts formed is more or less the same. This is a basic carbonate of Copper $CuCO_3\cdot 3Cu(OH)_2$.

In sea shore districts Copper is covered with a basic chloride $CuCl_2\cdot 2Cu(OH)_2$. In Inland towns it is usually an incrustation of a basic Sulphate $CuSO_4\cdot 3Cu(OH)_2$.

Whatever the composition of the incrustation may be as Copper Salts are poisonous and as the metal is attacked even by weak Organic Acids in the presence of air Copper utensils cannot be used for cooking purposes. So they are usually covered with solder containing 7 parts by weight of Lead and 3 parts by weight of tin.

Nowadays Copper vessels are coated with Chromium (Chromium plated.).

29. Give the Chemical Names and the formula of the compounds given below.

1. **Washing soda**	Sodium Carbonate (crystalline) $Na_2CO_3\cdot 10H_2O$.
2. Baking Soda	Sodium Bicarbonate $NaHCO_3$.
3. Blue Vitriol	Copper Sulphate (crystalline) $CuSO_4\cdot 5H_2O$.
4. Green Vitriol	Ferrous Sulphate (crystalline) $FeSO_4\cdot 7H_2O$.
5. Quick Lime	Calcium Oxide CaO.
6. Slaked Lime	Calcium Hydroxide $Ca(OH)_2$.
7. Caustic Potash	Potassium Hydroxide KOH
8. Caustic soda	Sodium Hydroxide $NaOH$.
9. Soda Lime	$Ca(OH)_2+NaOH$ Mixture of Calcium & Sodium Hydroxides.

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10. White Lead	Basic Carbonate of Lead $2\,PbCO_3 \cdot Pb(OH)_2$.
11. Plaster of Paris	Calcium Sulphate $CaSO_4 \cdot \frac{1}{2}H_2O$ *or* $2\,CaSO_4 \cdot H_2O$.
12. Litharge	PbO· Lead mon oxide
13. Epsom Salt	Magnesium Sulphate $Mg_{,}8O \cdot \frac{1}{8}H_2O$
14. Common Salts	Sodium Chloride $NaCl$
15. Calamine	$ZnCo_3$ Zinc Carbonate
16. Lunar Caustic	Silver Nitrate $AgNO_3$
17. Verdigris	Basic Cabcnate of Cupper $CuCO_3 \cdot Cu(OH)_2$
18. Oleum or Pyro-Sulphuric Acid	$H_2S_2O_7$
19. Philosophers wool	Zinc oxide Zno
20. White Vitriol	$ZnSO_4 \cdot 7\,H_2O$ Zinc Sulphate
21. Zinc white	Zinc oxide · ZnO
22. Corrosive Sublimate	Mercuric Chloride · $HgCl_2$
23. Spirits of Salts	Hydro Chloric Acid HCl
24. Magnetic oxide	Ferreso-Fereic oxide Fe_3O_4
25. Condy's Salt	Potassium Permangate $KMnO_4$
26. Sal-Ammonia	Ammonium Chloride NH_4Cl

30. Discuss the use of Hydrogen sulphide in Analytical Chemisty.

The primary object of qualitative analysis is the detection of salts. Any salt is composed of a metallic radical and an acid radical. Hydrogen sulphide is use for the identification of metallic radicals, since many metallic Sulphide are insoluble in water and possess characteristic colours.

A solution of salt to be identified is made and Hydrogen sulphide is passed through it. It is most likely that the metallic

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sulphide is precipitated. If no precipitate is got, little Ammonia may be added. The metallic sulphide may then be precipitated. Instead of passing Hydrogen sulphide and then adding Ammonia, Ammonium sulphide may be added. The colour of the precipitated sulphide is noted. This is helpful in identifying metallic radical.

For example an orange red precipitate with Hydrogen sulphide shows the presence of Antimony.

$$2\,SbCl_3 + 3\,H_2S \rightarrow \underset{\text{Antimony tri sulphide}}{Sb_2S_3 \downarrow} + 6\,HCl$$

A flesh coloured precipitate with Hydrogen sulphide followed by Ammonia (or with Ammonium sulphide) indicates that Manganese is present,

$$MnSO_4 + (NH_4)_2S \rightarrow MnS \downarrow + (NH_4)_2SO_4$$

A white precipitate under the same conditions shows the presence of Zinc.

$$ZnSO_4 + (NH_4)_2S \rightarrow ZnS \downarrow + (NH_4)_2SO_4$$

But many metallic sulphides possess the same colour Copper sulphide, Ferrous sulphide and Mercuric sulphide are black.

Cadmium and Arsenic sulphides are yellow. But fortumately these sulphides behave differently towards reagents like dilute acids, strong acids and Alkalis.

For example Arsenic sulphide unlike Cadmium sulphide is soluble in Alkalis.

Ferrous Sulphide is soluble in cold dilute HCl where as Copper Sulphide is not.

Mercuric Sulphide does not dissolve in Aqua regia while Copper Sulphide dissolves in hot dilute Nitric acid. Hence the treatment of the precipitated sulphide with these reagents will be helpful in identifying them.

Hydrogen Sulphide is useful in identifying metallic radicals even in mixtures of two or more salts. Suppose a mixture

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of Copper Sulphate and Ferrous Sulphate is given for analysis it is dissolved in water and acidified. Hydrogen sulphide is bubbled through the acidified solution. Only black Cupric sulphide is precipitated It is filtered off. On adding Ammonia to the filterate black Ferrous sulphide is precipitated. Special reagents are then used to detect the Iron in Iron sulphide and Copper in Cupric sulphide.

Hydrogen sulphide enables us to divide metals into several groups based on the solubilities of their sulphides. The classification is of great use in the identification of substances.

(1) **Metals whose sulphides are soluble in water and so are not** precipitated **by** Hydrogen-Sulphide.

eg:—Sodium, Potassium, Ammonium

$$NaOH + H_2S \rightarrow NaHS + H_2O$$
$$NaHS + NaOH \rightarrow Na_2S\text{(Soluble)} + H_2O$$

(2) **Metals whose sulphides are hydrolysed by water and are not** consequently **precipitated.**

eg:—Calcium, Barium, **Magnesium.**

$$\left.\begin{array}{l} CaCl_2 + H_2S \rightarrow CaS + 2\,HCl \\ Mg(OH)_2 + 2\,H_2S \rightarrow Mg(SH)_2 + 2H_2O \end{array}\right\} \begin{array}{l}\textbf{undergo} \\ \textbf{Hydrolysis}\end{array}$$

(3) **Metals whose sulphides are soluble** in dilute acids **and** so **are not precipitated in** the presence of acids.

eg:—Iron, Zinc, Manganese.

$$FeSO_4 + H_2S \rightarrow FeS\text{ (soluble in dil acid)} + H_2SO_4$$
$$FeSO_4 + (NH_4)_2S \rightarrow FeS\text{ (insoluble in }(NH_4)_2SO_4) + (NH_4)_2SO_4$$

(4) **Metals** whose sulphides are insoluble in dilute **acids and are** therefore **precipitated even in their presence.**

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eg:- Lead, Copper, Mercury and **Bismuth.**

$$2\,Bi(NO_3)_3 + 3\,H_2S \rightarrow Bi_2S \downarrow + 6HNO_3$$

$$(CH_3-COO)_2Pb + H_2S \rightarrow PbS \downarrow + 2\,CH_3-COOH$$

5. **Metals whose** sulphides **are soluble in alkalis but insoluble** in acids.

eg:- Arsenic Antimony and Tin.

$$2\,ASCl_3 + 3\,H_2S \rightarrow AS_2S_3 \downarrow + 6\,HCl$$

$$2\,SbCl_3 + 3\,H_2S \rightarrow Sb_2S_3 \downarrow + 6HCl$$

The reducing property of Hydrogen sulphide is **also made** use of in its application to qualitative analysis. Dichromates and Permanganates have to be got rid of during analysis This is done by reducing them with **Hydrogen sulphide.**

$$2\,KMnO_4 + 3\,H_2SO_4 + 5\,H_2S \rightarrow K_2SO_4 + 2\,MnSO_4 + 8\,H_2O + 5\,S \downarrow$$

$$K_2Cr_2O_7 + 4\,H_2SO_4 + 3\,H_2S \rightarrow K_2SO_4 + Cr_2(SO_4)_3 + 7\,H_2O + 3\,S \downarrow$$

Hydrogen sulphide is useful in quantitative **analysis also. Suppose** the weight of Antimony - tri - **sulphide in a given solution has** to be estimated, the Antimony - tri - chloride solution is saturated with Hydrogen sulphide under certain **conditions.** The precipitated Antimony tri - Sulphide is filtered off, washed dried and weighed. From the weight of Antimony-tri-sulphide the weight of Antimony - tri - chloride in the given **solution is calculated.**

$$2SbCl_3 + 3\,H_2S \rightarrow Sb_2S_3 + 6\,HCl$$

Thus we find that Hydrogen sulphide **is an important** regent in **Analytical** Chemistry.

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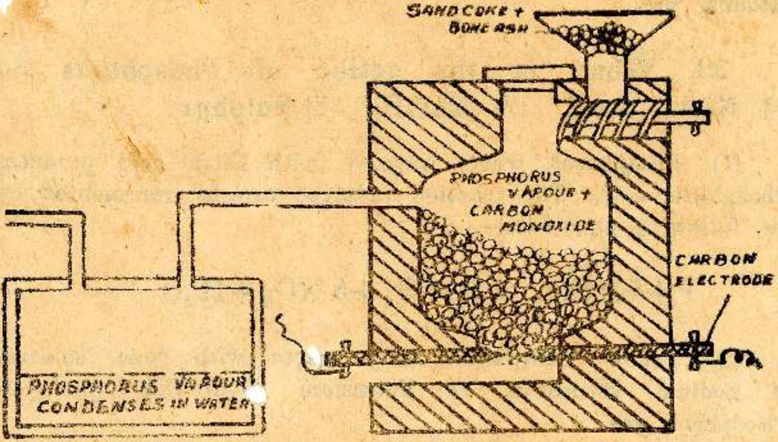
31. How can you prepare Phosphorus from Bone Ash ?



Phosphorus can be manufactured from bone by ash heating a mixture of powdered natural Calcium phosphate, sand and Carbon in an electric furnace, The sand would first react with Calcium Phosphate to from Calcium silicate and Phosphorus-Penta-Oxide P_2O_5. The Carbon (Coke) present in the furnace mixture reduces P_2O_5 to Phosphorus. The reactions involved can be represented by the following equations.

$$Ca_3(PO_4)_2 + 3\,SiO_2 = 3\,CaSiO_3 + P_2O_5$$
$$P_2O_5 + 5\,C = 5\,CO + 2\,P.$$

Details of the Manufacture

Bone ash which is the cheapest source of Phosphorus is mixed with silica (sand) and coke. The mixture is fed into the hopper and conveyed to the electric furnace with the help of a special screw arrangement called "worm conveyor". The furnace is heated by means of striking an electric are between two carbon electrodes. When the mixture is heated to white heat the silica combines with Calcium Phosphate forming a slag of Calcium Silicate and vapours of P_2O_5. The white hot Carbon present there reduces the P_2O_5 to Phosphorus. The vapours of Phosphorus and Carbon-non-Oxide are led nto a vessel containing cold water. Carbon-non-Oxide escapes

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undissolved where as the vapours of Phosphorus condense into small sticks under water. This prevents the Phosphorus from catching fire.

32. What is the action of Phosphorus on (1) Nitric Acid. (2) NaOH. (3) Sulphur?

(1) Phosphorus when warmed with Nitric acid produces Phosphoric acid. The reaction involved can be represented by the following equations:—

$$P + 5HNO_3 \rightarrow H_3PO_4 + 5NO_2 + H_2O$$

(2) Yellow Phosphorus only reacts with cons. solution of Sodium Hydroxide or Potassium Hydroxide to yield Phosphene gas.

$$4P + 3NaOH + 3H_2O = PH_3 + 3NaH_2PO_2$$

Sodium - Hypo - phosphite.

$$4P + 3KOH + 3H_2O = PH_3 + 3KH_2PO_2$$

Potassium - Hypo - Phosphite.

(5) Phosphorus reacts with Sulphur on gentle warming to give sulphides of Phosphorus.

The most important Sulphide of Phosphorus is P_4S_3 which goes into the manufacture of safety matches.

$$4P + 3S \rightarrow P_4S_3$$

33. What is allotropy? Mention the allotropes of Sulphur. Starting from Sulphur how will you prepare a sample of Plastic and Colloidal sulphur. How will you show by an experiment that all the Allotropes of sulphur contain the same element Sulphur?

What are the uses of Sulphur?

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1. (a) **Allotropy** is a property shown by elements especially non-metals like Carbon, Phosphorus and Sulphur By virtue of which the elements exist in two or more forms with different physical properties such as density, colour crystaline form and also to some extent different chemical properties. They are composed of the same element associated with diffrent proportions of available energy.

The physical cause of allotrophy is due to the difference in the arrangement of atoms or number of atoms inside the molecule or a difference of the arrangement of the molecules themselves, sometimes giving rise to a difference in crystalline form. The allotropes of an element are inter-convertable.

(b) The different allotropes of sulphur are

1. Crystalline —
   - Rhombic sulphur
   - Monoclinic ,,
2. Amorphous —
   - Plastic sulphur.
   - Milk of Sulphur
3. Colloidal sulphur

1. Plastic sulphur is prepared by heating powdered roll Sulphur in a test tube till it melts into an amber coloured liquid. It is then poured in a thin stream into a beaker containing cold water. A brown or honey coloured, elastic rubber like mass of Sulphur is got which can be moulded with fingers. It is an amorphous variety of sulphur very unstable, insoluble in water and Carbon-di-sulphide. On keeping it at ordinary temperature it gradually changes into the most stable variety of Sulphur (Rhombic.)

2. **Colloidal sulphur**:-

Colloidal sulphur is prepared by passing Sulphur-di-oxide gas into an aqueous solution of Hydrogen sulphide,

$$2H_2S + SO_2 \rightarrow 2H_2O + 3S\downarrow$$

The particles of sulphur thus precipitated are so small that they can even penerate through the pores of an ordinary filter paper. Such a state is called "Colloidal state" and the

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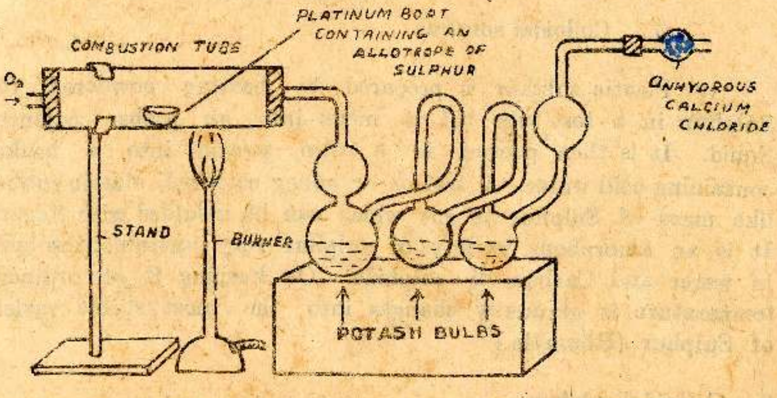
sulphur is called "Colloidal sulphur". It can be separated by a process called "Dialysis". It is a process by which a substance in the Colloidal state is separated from another soluble substance in solution. The aparatus that is used for Dialysis is called a Dialyser. A parchment bag can be used as a dialyser to separate colloidal sulphur from its solution.

On boiling the colloidal solution of sulphur the smaller particles coagulate and they settle down at the bottom of the test tube. It can be experimentally proved that all the allotropes of sulphur contain the same element sulphur.

Equal weights of diffrent allotropes of sulphur are oxidised in a current of Oxygen and in each case, the Sulphur-di-oxide produced is absorbed in weighed potash bulbs. It will be found that equal weights of different forms of Sulphur produce the same weight of Sulphur-di-oxide. Thus it can be experimentally proved that all the allotropes of sulphur contain the same element sulphur.



(Study a similar type of question for Carbon and Phosphorus)

34. Classify the following oxides into their respective groups giving reasons?

(1) Zinc oxide ZnO

(2) Aluminium oxide Al_2O_3

(3) Ferreso-Ferric oxide Fe_3O_4

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(4) **Sulphur - di - oxide** SO_2
(5) **Carbon - di - oxide** CO_2
(6) **Cupric oxide** CuO
(7) **Calcium oxide** CaO

why do you call water a neutral oxide?

Zinc oxide and Aluminium oxide are Amphoteric oxides because they have both acidic and basic properties. When they react with alkalis they behave like acids and when they react with acids they behave like bases. The following reactions will reveal their basic and acidic properties.

(**Acidic**) $ZnO + 2NaOH \rightarrow Na_2ZnO_2 + H_2O$
Sodium Zincate

(**Basic**) $ZnO + H_2SO_4 \rightarrow ZnSO_4 + H_2O$
(Basic) $Al_2O_3 + 6HCl \rightarrow 2AlCl_3 + 3H_2O$
(Acidic) $Al_2O_3 + 2NaOH \rightarrow 2NaAlO_2 + H_2O$
Sodium Aluminate

Ferroso - Ferric oxide is a mixed or compound oxides because it is made up of FeO and Fe_2O_3. Its Compound nature can be revealed by the following reactions.

$$Fe_3O_4 + 8HCl = FeCl_2 + 2FeCl_3 + 4H_2O$$

In this particular reaction, since Ferrous and Ferric chlorides are formed it is proved that Ferreso - ferric - oxide is a compound oxide made up of FeO and Fe_2O_3.

Sulphur - di - oxide and Carbon - di - oxide and acidic oxides. because they dissolve in water to produce their corresponding acids.

$SO_2 + H_2O \rightarrow H_2SO_3$ **Sulphurous acid**
$CO_2 + H_2O \rightarrow H_2CO_3$ **Carbonic acid**

They can be regarded as acidic anhydrides. Besides their acidic character is further revealed by their action on alkalis

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$$SO_2 + 2NaOH \rightarrow Na_2SO_3 + H_2O$$
$$CO_2 + 2NaOH \rightarrow Na_2CO_3 + H_2O$$

CaO and CuO are Basic oxides because **they** react with acids to form salt and water.

$$CuO + H_2SO_4 \rightarrow CuSO_4 + H_2O$$
$$CaO + H_2SO_4 \rightarrow CaSO_4 + H_2O$$

They dissolve in water (if soluble) to produce alkalis which turn red Litmus blue.

$$CaO + H_2O \rightarrow Ca(OH)_2.$$

Water is a neutral oxide (H_2O) because it exihibits *neither* basic *nor* acidic properties. It does not react with acids or alkalis It is neutral to litmus. Other analogues of water are Nitrous and Nitric Oxide. They also do not produce any acid or alkali in contact with water.

35. Define the following terms.

(1) **Equivalent weight of an acid**
(2) „ „ „ „ **Base**
(3) „ „ „ „ **Salt**
(4) **Normal solution**
(5) **Standard solution**

(1) **The Equivalent weight of an acid** is that weight of the acid which contains 1·008 parts by weight of replaceable Hydrogen. For example take the reaction between Sodium and Hydro-chloric acid

$$2Na + 2HCl \rightarrow 2NaCl + H_2$$

According to this equation 2 X 23 parts by weight of Sodium require for complete interaction 2 X 36·5 parts by weight of Hydro-chloric acid. Hence 23 parts by weight of Sodium require for interaction 36·5 parts by weight of Hydro-chloric acid. The equivalent weight of Hydro-chloric acid is therefore 36·5. This represents the weight of the acid containing 1·008 parts by weight of replaceable Hydrogen. It must be remembered that chemical changes take place always between equivalent weights of substances.

(b) The equivalent weight of Sulphuric acid is equal to

$$\frac{\text{Its molecular weight}}{\text{Its basicity}}=\frac{\text{Its molecular weight}}{2}$$

It contains two parts by weight of replaceable Hydrogen atoms as can be shown by the equation

$$2NaOH+H_2SO_4\rightarrow Na_2SO_4+2H_2O$$

(c) The equivalent weight of Nitric acid is its own molecular weight or formula weight because one molecule of the acid contains 1·008 parts by weight of replaceable Hydrogen.

(d) The equivalent weight of Acetic acid (CH_3-COOH) is its molecular weight because even though the acid contains 4 hydrogen atoms in its molecule only one hydrogen atom is replaceable as can be shown by the following chemical reaction

$$CH_3-COO\underline{\boxed{H}+Na\boxed{OH}}\rightarrow \underbrace{CH_3-COONa}_{\text{Sodium acetate}}+H_2O$$

(e) The equivalent weight of Oxalic acid is its molecular weight divided by two

$$\begin{array}{c}COOH\\|\\COOH\end{array}\cdot 2H_2O=\frac{\text{Its formula weight}}{\text{Its basicity (2)}}=\frac{126}{2}$$
$$=63.$$

(2) The equivalent weight of a Base.

The equivalent weight of a base is that weight of it that is required to react *completely* with the molecular weight of a mono basic acid or the equivalent weight of an acid.

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$$= \frac{\text{The formula weight of the Base}}{\text{Its acidity (= the number of (OH) groups in a molecule of it)}}$$

For example

$$Ca(OH)_2 + 2\,HCl \rightarrow CaCl_2 + 2\,H_2O$$

∴ The equivalent weight of $Ca(OH)_2$ is $\frac{\text{its molecular wt}}{2}$

$$= \frac{40+(2\times17)}{2} = 37.$$

It can also be defined as that weight of the base that is required to replace one part by weight of Hydrogen in an acid. For example

$$NaOH + \underline{HCl} \rightarrow NaCl + H_2O$$

Therefore the Equivalent weight of NaOH is equal to its formula weight which is equal to 40. Because 40 grams of Sodium hydroxide can replace 1·008 grams of Hydrogen from a molecule of Hydro-chloric acid.

(3) Equivalent weight of a Salt.

The Equivalent weight of a salt is that weight of the salt that has been formed as a result of the replacement of one hydrogen atom from its corresponding acid. For example NaCl is a salt formed by the interaction of

$$NaOH + HCl \rightarrow NaCl + H_2O$$

Here Sodium Chloride has been formed by replacing one Hydrogen atom from its corresponding acid—HCl. So the equivalent weight of NaCl is its formula weight. Take the case of Sodium Carbonate. This salt has been formed as a result of the replacement of 2 hydrogen atoms from its corresponding acid H_2CO_3 (Carbonic acid).

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Hence the equivalent weight of Sodium

$$\text{Carbonate} = \frac{\text{Its molecular weight}}{2}$$

(4) **Normal solution**—A normal solution is defined as a solution which contains a gram equivalent weight of the substance dissolved in one litre or 1000 cc.

For example a normal solution of Sodium Hydroxide contains 40 grams of the substance dissolved in 1000 cc. Its strength is expressed by the letter N

If $\frac{1}{10}$th of the equivalent weight of NaOH *i.e.* $\frac{40}{10}=4$ grm. is dissolved in 1000cc its strength is expressed as N/10. This is called a *Decino mal solution.*

If $\frac{1}{100}$th of the equivalent weight of Sodium Hydroxide *i.e.* $\frac{40}{100}=0{\cdot}4$ grams of NaOH is dissolved in 1000 cc. it is called a *Centi- - normal - solution* and it's strength is expressed as N/100.

(5) **Standard solution**

If a known weight of a solute is dissolved in a known volume of a solvent it is called a standard solution. The weight of the solute taken *need not* necessarily be the equivalent weight as in the case of normal solutions. Any known weight can be taken and it must be dissolved in a known volume of the solvent. For example 5 grams of NaCl dissolved in 25 cc. of water is a standard solution because we are aware of the amounts of the solute and the solvent taken to prepare the solution.

It must be borne in mind that a normal solution can be a standard solution *but* a standard solution cannot be called a normal solution, unless the weight taken corresponds to its equivalent weight and the volume of the solvent 1000 cc. or fractions of it.

36. How will you prepare a decinormal solution of Sodium Carbonate in your Lab, if provided with anhydrous Sodium Carbonate and a 250 cc standard flask?

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To begin with first the weight to be taken should be calculated.

The equivalent weight of Sodium Carbonate is

$$= \frac{\text{Its molecular weight (106)}}{2 \qquad\qquad (2.)}$$ **as it is the salt of a dibasic acid H_2CO_3 · (Carbonic acid).**

= 53 grams.

To prepare an **N** (normal solution) solution of Sodium Carbonate in 1000 cc. or one litre 53 grams of Sodium Carbonate should be dissolved in 1000 cc. But since we are supplied with only a 250 cc. flask the weight that should be taken to prepare an **N** solution of Sodium Carbonate in

$$250\ \text{cc.} = \tfrac{53}{4} = 13\tfrac{1}{4}\ \text{grams.} = 13 \cdot 25\text{grams.}$$

But if the strength is to be N/10 or decinormal we should disslove $\frac{13 \cdot 25}{10}$grams in 250 cc. to get an N/10 solution of Sodium Carbonate = 1·325grams.

So the weight of Sodium Carbonate that should be taken to prepare an N/10 solution of it in 250 cc. is equal to 1·325 grams.

1·325 grams of Sodium Carbonate are accurately weighed out in a chemical balance and that is dissolved in a few c.c of distilled water in a beaker. Then the solution is transferred carefully into the 250 cc. flask using a glass rod and a funnel. The rod, and the beaker are rinsed several times with distilled water and the washings are also transferred to the 250 cc. standard flask. The solution is then made up to 250 cc. with distilled water. This can be done using a pipette. Care is taken to see that the water level does not exceed the graduation mark in the flask. The flask is then closed with a glass stopper and shaken well till we get a uniform solution of Sodium Carbonate. Thus by the above method an N/10 solution of Sodium Carbonate can be prepared using a 250 cc. standard flask.

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37· Define

(1) The equivalent weight of an Oxidising agent.

(2) " " " " a Reducing agent.

(3) Law of volumetric **analysis?**

The equivalent weight of an Oxidising agent:

The equivalent weight of an Oxidising agent is **estimated** from the amount of Oxygen that it gives off for Oxidation.

For example Potassium-per-manganate is a good oxidising agent. It reacts with Sulphuric acid and gives 5 atoms of oxygen for Oxidation. Hence its equivalent weight is that weight of it which can produce 8 parts by weight of Oxygen (atomic) for oxidation.

$$\underset{2\times158\text{grams}}{2\,KMnO_4} + 3\,H_2SO_4 \rightarrow K_2SO_4 + 2\,MnSO_4 + 3\,H_2O + \underset{5\times16}{5[O]}$$

ie 2X158 parts by weight of $KMnO_4$ furnishes 5X16 parts by weight of Oxygen for oxidation. Hence 8 parts by weight of oxygen are furnished by

$$\frac{158\times2}{5\times16}\times8 = 31\cdot6 \text{ grams of } KMnO_4.$$

Hence the equivalent weight of $KMnO_4$ (in acid medium) is 31·6. (8 is the eq. wt. of oxygen).

The Equivalent weight of a Reducing agent may be defined as that weight of it which can be oxidised by 8 parts by weight of Oxygen as reducing agents can be easily oxidised. **For example:**

$$\underset{2\times152}{2FeSO_4} + H_2SO_4 + \underset{16}{O} \rightarrow Fe_2(SO_4)_3 + H_2O$$

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2 x 152 parts by weight of anhydrous Ferrous sulphate are oxidised by 16 parts by weight of Oxygen. Hence the equivalent weight of anhydrous Ferrous sulphate is 152 (its formula weight).

(3) Law of Volumetric analysis

This Law states that "equal volumes of equi-normal solutions of Acids and Bases neutralise each other completely." In other words "Solution of equal strength always interact in equal volumes." For example :

40 grams of NaOH (its eq. wt.) dissolved in 1000 cc require 36.5 grams of HCl (its eq. wt.) dissolved in 1000 cc for its complete neutralization.

Similarly

1000 cc. of N/10 NaOH require 1000 cc of N/10 HCl for neutralisation. Therefore according to the law if V_1 cc of a solution of strength N_1 are required to neutralise V_2 c c of another solution of strength N_2 then according to the law

$$V_1N_1 = V_2N_2$$

Applying this law, unknown volumes and normalities can be calculated from which weight per litre and equivalent weights are calculated since

Normality × Equivalent weight = Weight per litre.

38. (i) 25 cc. of a solution of a strong base containing 8·4 grams of the solid base in 250 cc. required 19·75 cc. of a solution of H_2SO_4 containing 39·2 grams of the acid per litre. Calculate the equivalent weight of the base?

250 cc of the Base contained 8·4 grams

$$\therefore 1000 \text{ ,, ,, ,, ,, ,, } \frac{8\cdot4}{250} \times 1000$$

$$= 33\cdot6 \text{ grams.}$$

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The weight of Sulphuric acid present in 1000 cc. = 39·2gms
The equivalent weight of Sulphuric acid = 49

$\therefore$ Normality of Sulphuric acid $= \frac{39 \cdot 2}{49} N$

Let X be the equivalent weight of the base

$\therefore$ Normality of the base $= \frac{33 \cdot 6}{X} N$

25 cc of the base was neutralised by 19·75 cc of H_2SO_4
Applying the law of volumetric analysis

$$V_1N_1 = V_2N_2$$

$$25 \times \frac{33 \cdot 6}{X} = 19 \cdot 75 \times \frac{39 \cdot 2}{49} N, \quad \therefore X = \frac{25 \times 33 \cdot 6 \times 49}{19 \cdot 75 \times 39 \cdot 2}$$

$$X = 53 \cdot 2.$$

$\therefore$ The equivalent weight of the base $= 53 \cdot 2$

(ii) 5·16 grams of anhydrous Sodium carbonate (Na_2CO_3) were dissolved in water and the volume of the solution was made up to one litre· 20 cc of this solution required for neutralization 19·3 cc of Sulphuric acid

(a) Find the normality of H_2SO_4

(b) What volume of water must be added to one litre of the acid solution to make it exactly decinormal. (Molecular weight of anhydrous Sodium carbonate is 106).

Molecular weight of Sodium carbonate (anhydrous) = 106 grams

$\therefore$ Its equivalent weight = 53

$\therefore$ The normality of Sodium carbonate $= \frac{5 \cdot 16}{53} N$

Volume of Sodium carbonate solution = 20 cc.

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Volume of Sulphuric acid needed for neutralization $=19\cdot3$ cc.

∴ The normality can be calculated using the law of volumetric analysis *i.e.*

$$V_1N_1=V_2N_2$$
$$20\times\frac{5\cdot16}{53}\ N=19\cdot3\times N_2$$

$$\therefore N_2=\frac{20\times5\cdot16}{53\times19\cdot3}=\cdot1008\ N$$

∴ The Normality of Sulphuric acid solution is ·1008 N
Equivalent weight of sulphuric acid =49
∴ Weight per litre of sulphuric acid $=49\times\cdot1008$
$=4\cdot9392$ gms.

4·9 grams must be dissolved in 1000 cc. to get an N/10 solution·

$$\therefore 4\cdot9392\ ,,\quad ,,\quad ,,\quad ,,\quad ,,\ \frac{4\cdot9\ 92}{4\cdot9}\times1000=1008\text{ cc.}$$

∴ 8 cc. (1008 — 1000) of water must be added to the Sulphuric acid solution to get an exactly N/10 solution of the acid.

3. In a litration 25 cc. of normal sodium Hydroxide solution required for neutralization 15 cc. of hydro-chloric acid solution

Find (a) The normality of the acid solution
(b) The weight per litre of Hydrogen Chloride.

Volume of NaOH required for neutralization = 25 cc.
Normality of Sodium hydroxide solution = N
Volume of Hydro Chloric acid neutralized = 15 cc.

Let X be the normality of HCl solution· Applying the law of Volumetric analysis

$$V_1N_1 = V_2N_2$$

$$25 \times N = 15 \times X$$

$$X = \frac{25 \times N}{15} = \frac{5}{3}N$$

∴ Normality of Hydro-chloric acid $= \frac{5}{3}$N.

Normality × Equivalent weight = weight/litre

Equivalent weight of HCl acid = 36·5.

∴ Weight of HCl acid in one litre = 36·5 × $\frac{5}{3}$N

= 60·81 grams.

39. Write brief notes on

(1) **Silvering or mirroring of glass.**

(2) **Silver plating.**

(3) **Lead - poisoning.**

Mirroring of Glass

Organic compounds reduce Silver Nitrate and form a deposit of metallic Silver. This property is made use of in Silvering glass plates to make mirrors The plates must be prefectly clean and immersed in a silvering solution. The solution is prepared by adding Ammonium-Hydroxide solution to Silver Nitrate solution until the precipitate first formed *nearly* dissolves. This is mixed with Glucose or Rochelle salt solution in a warm bath in which the plate is kept immersed. A brilliant deposit of Silver is obtained in a short time.

Silver plating

It implies the process of coating an article generally made of Iron, Brass or Bronze with metallic Silver to make it more attractive and resistant to the atmospheric action. The plating can be done with the aid of electricity. Double Cyanide of Potassium and Silver K, $Ag(CN)_2$ is dissolved in water and taken in a vessel in which a piece of pure silver serves as

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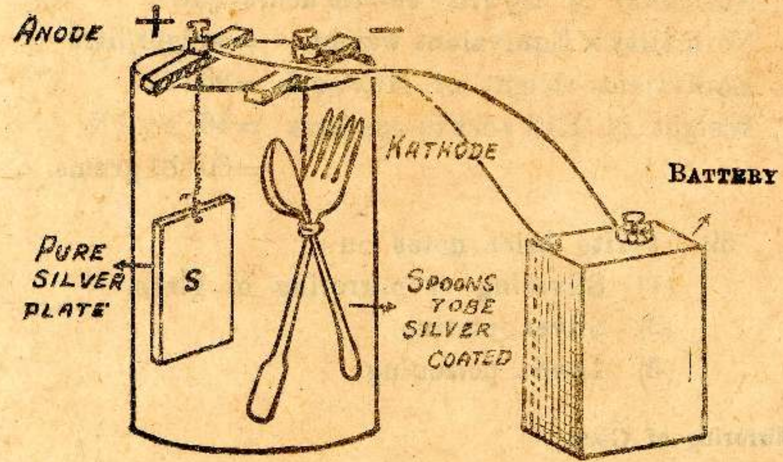
the anode and the thoroughly cleaned article to be coated with Silver is suspended to serve as the cathode. A current is passed through the solution. The article graudally gets coated with Silver. The thickness of the coating can be varied as desired.



Lead poisioning :

The compounds of Lead more specially the soluble ones are strongly poisonous. The workers engaged in manufacture of Lead and Lead compounds, in painting, printing, plumbering manufacture of accumulators etc. are liable to suffer from Lead poisoning. The symptoms are pain in the abdomen constipation, loss of appetite, thirst, nervous prostration known as Lead palsy epileptic fits and total paralysis. One of the signs of chronic lead poisoning is a blue line at the edge of the gums due to the decomposition of Lead sulphide.

This is the reason why water *especially soft water* must not be transported through Lead pipes as. Lead compounds dissolve readily in soft water. Hard water may be safely carried through Lead pipes but softened water must be filtered through or passed over a bed of chalk or animal charcoal in order to minimise the solution of Lead.

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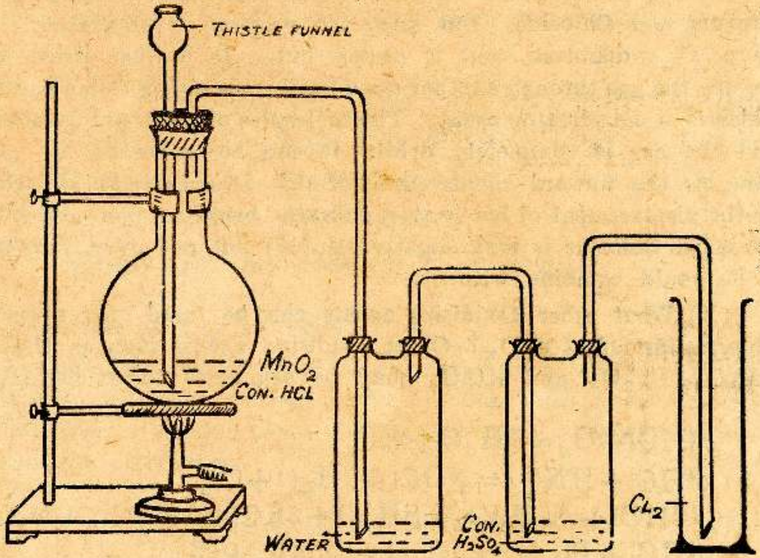
40. How will you prepare Cl_2 in the lab? How can the impurities be removed, the gas dried and collected?



In the laboratory Chlorine can be prepared by the oxidation of Hydro-chloric acid by Manganese-di-oxide.

$$MnO_2 + 4HCl \rightarrow MnCl_2 + 2H_2O + Cl_2$$

Manganese-di-oxide is taken in a round bottomed flask provided with a thistle funnel and a delivery tube. Con. Hydrochloric acid is poured in to the flask through the thistle funnel. In the cold, the solution turns deep brown due to the formation of Manganese-tetra-chloride $MnCl_4$. On gently heating the flask the unstable $MnCl_4$ decomposes to $MnCl_2$ and Cl_2. The reactions involved in the process can be represented thus

$$MnO_2 + 4HCl \rightarrow \underset{\text{unstable}}{MnCl_4} + 2H_2O$$

$$MnCl_4 \xrightarrow[\text{heat}]{} MnCl_2 + Cl_2$$

The impurities present in the gas thus prepared are (1) HCl vapours and (2) H_2O.

The acid vapours can be removed by passing the gas through water in a wash bottle which for sometime absorbs both HCl vapours and Chlorine. But once the solution is saturated, no more Cl_2 dissolves and it passes out. It is then dried by passing the gas through another wash bottle containing Con. H_2SO_4 which is a dehydrating agent. The molecules of water are removed and the gas is completely dried. It can be collected in gas jars by the upward displacement of air. It can also be collected by the displacement of hot water or warm brine or Con. H_2SO_4 (in which Chlorine is very slightly soluble) but not over Mercury as it would combine with it.

(b) **What other Oxidising agents can be used to prepare Chlorine instead of MnO_2?** Other oxidising agents such as HNO_3 $KMnO_4$, Pb_3O_4 and $KClO_3$ may be also used to oxidise HCl.

$$4HCl + O_2 = 2H_2O + 2Cl_2$$
$$3HCl + HNO_3 = NOCl + 2H_2O + Cl_2$$
$$16HCl + 2KMnO_4 = 8H_2O + 2KCl + 2MnCl_2 + 5Cl_2$$
$$8HCl + Pb_3O_4 = 4H_2O + 3PbCl_2 + Cl_2$$

(c) **How can Cl_2 be prepared from NaCl or Common salt or Brine.**

Sodium Chloride is treated with Sulphuric acid and then the resulting acid is oxidized by MnO_2. This is the general method employed to prepare Halogens. The reactions involved can be represented thus

$$2NaCl + H_2SO_4 \rightarrow Na_2SO_4 + 2HCl$$
$$4HCl + MnO_2 \rightarrow MnCl_2 + 2H_2O + Cl_2$$

It can also be prepared from Brine or fused NaCl by electrolysis

$$NaCl \rightarrow Na^{+} + Cl^{-}$$
$$Cl^{-} + Cl^{-} \rightarrow Cl_2$$

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The electrolysis is done in a cell called Castner kellner cell between Carbon anode and Mercury cathode. Cl_2 is got as a bye-product in this method. This electrolysis is mainly employed to manufacture Caustic soda or NaOH from brine (for apparatus refer manufacture of NaOH from brine by electrolysis)

41. Explain with equations the action of Cl_2 on 1. H_2O. 2. Alkalis like KOH & NaOH. 3. Action on Milk of Lime. 4 Slaked lime. 5. NH_3. 6. H_2S 7. SO_2 in water. 8. KBr and KI.

What are the uses of Chlorine.

1. **Action of Cl_2 on water:—**

Chlorine readily dissolves in water forming Chlorine water, which has the greenish yellow colour and smells strongly of Chlorine, Chlorine water decomposes on keeping specially in sunlight as follows.

$$Cl_2 + H_2O \rightarrow HCl + HClO \text{ (Chlorine water)}$$

Unstable $HClO \rightarrow HCl + O$ (nascent)

$$O + O \rightarrow O_2$$

The colder the water, the greater will be the absorption of Chlorine. Ice cold water forms Chlorine hydrate—

$$Cl_2 \cdot 7H_2O, \; Cl_2 \cdot 8H_2O, \; Cl_2 \cdot 10H_2O.$$

Since Chlorine is soluble in water, especially cold water, it is not collected over water.

2. **Action of Chlorine on alkalis:—**

The products formed by the action of Cl_2 on alkalis depends on two facters namely,

1. Concentration of the alkali.
2. Temperature of the alkali.

With cold dilute alkalis, the respective chlorides and hypochlorites are formed. But with hot strong alkalis chlorides and chlorates are formed. The reactions involved can be represented by the following equations.

cold dilute alkalis $\begin{cases} Cl_2 + 2\,KOH = KCl + KClO + H_2O \\ Cl_2 + 2\,NaOH = NaCl + NaClO + H_2O \end{cases}$

Hot Conc alkalis $\begin{cases} 3\,Cl_2 + 6\,KOH = 5\,KCl + KClO_3 + 3\,H_2O \\ 3\,Cl_2 + 6\,NaOH = 5\,NaCl + NaClO_3 + 3\,H_2O \end{cases}$

3. Action of Chlorine on Milk of Lime:—

Milk of lime ($Ca(OH)_2$) absorbs Chlorine forming **Calcium Chloride** and Hypochlorite in the cold but Chloride and Chlorate are formed when the solution is hot and concentrated.

Cold and dil. $2\,Ca(OH)_2 + 2\,Cl_2 = CaCl_2 + Ca(ClO)_2 + 2\,H_2O$

Hot and conc. $6\,Ca(OH)_2 + 6\,Cl_2 = 5\,CaCl_2 + Ca(ClO_3)_2 + 6\,H_2O$

4. Action of Chlorine on Slaked lime (dry)

Cl_2 combines with Slaked Lime to form Bleaching powder.

$$Ca(OH)_2 + Cl_2 \rightarrow Ca(OCl)Cl + H_2O$$

5. Action of Chlorine on Ammonia:—

The products formed by the action of Chlorine on Ammonia depends entirely on the amount of Chlorine and Ammonia present in the reactions.

For example:—

If Ammonia is present in excess, Chlorine when passed into it decomposes NH_3 producing a flame and HCl which reacts with excess of NH_3 forming dense white fumes of NH_4Cl.

$$2\,NH_3 + 3\,Cl_2 \rightarrow N_2 + 6\,HCl$$
$$6\,NH_3 + 6\,HCl \rightarrow 6\,NH_4Cl$$

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But on the other hand if Chlorine is present in excess a yellow oily liquid Nitrogen - tri - Chloride of composition NCl_3 is formed along with HCl.

$$NH_3 + 3\,Cl_2 \rightarrow NCl_3 + 3\,HCl$$

(6) Acion of Chlorine on H_2S :—

(Cl_2 here acts as a powerful oxidiser) When H_2S gas is passed into a jar of Chlorine, it oxidises H_2S producing Sulphur and gets itself redused to HCl.

$$H_2S + Cl_2 \rightarrow 2\,HCl + S\downarrow$$

or when Chlorine is passed into an aqueous solution of H_2S Sulphur is precipitated

(7) Chlorine when passed into moist SO_2 or Sulphurous acid oxidises it to Sulphuric acid. Here the moisture present in it first reacts with Cl_2 forming Hydro Chloric acid and HClO acid. The HClO acid (Hypochlorous acid) being unstable decomposes into HCl and nascent oxygen. The nascent oxygen oxidises SO_2 to SO_3 and then to H_2SO_4 or sulphurous acid to Sulpuric acid. The reactions can be represented by the following equations.

$$H_2O + Cl_2 \rightarrow HCl + HClO$$
$$HClO \rightarrow HCl + [O]$$
$$SO_2 + O \rightarrow SO_3$$
$$SO_3 + H_2O \rightarrow H_2SO_4$$
$$SO_2 + 2\,H_2O + Cl_2 \rightarrow 2\,HCl + H_2SO_4$$
$$H_2SO_3 + O \rightarrow H_2SO_4$$

(8) Action of Chlorine on KBr and KI :—

Chlorine occupies a higher position in the electro chemical series. Hence it can displace its family members Br_2 and I_2 from their respective compounds.

When Cl_2 is passed into KBr, Br_2 will be liberated

$$2\,KBr + Cl_2 \rightarrow 2\,KCl + Br_2$$

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Br_2 is brown in colour.

When Cl_2 is passed into KI, I_2 is set free in the form of violet vapours and KCl is formed.

$$2KI + Cl_2 \rightarrow 2KCl + I_2$$

The reaction is applied as a test for **Chlorine.**

Uses of Chlorine:—

1. It is used as a bleaching agent, for paper and textiles
2. It is used for making Bleaching powder.
3. It is used for making Chloroform and dyes.
4. It is used as a disinfecting agent.
5. It is used for making poison gas and solvents for rubber.

42. Explain the action of I_2 on

1. KOH and NaOH 2. H_2S 3. SO_2
4. Na_2SO_3 5. $KClO_3$ 6. Starch

Iodine reacts with alkalis in the same manner as Cl_2 and Br_2. The products formed depends on the temperature and concentration of the alkalis used.

With cold dilute alkali, the Iodide and Iodite are formed

$$2KOH + I_2 \rightarrow KI + KIO + H_2O$$
$$2NaOH + I_2 \rightarrow NaI + NaIO + H_2O$$

With hot concentrated alkalis he Iodide and Iodates are formed

$$6KOH + 3I_2 \rightarrow 5KI + KIO_3 + 3H_2O$$
$$6NaOH + 3I_2 \rightarrow 5NaI + NaIO_3 + 3H_2O$$

Iodine is a milder oxidising agent and oxidises

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1. $H_2S + I_2 \rightarrow 2HI + S\downarrow$
2. $SO_2 + 2H_2O + I_2 \rightarrow H_2SO_4 + 2HI$
3. $Na_2SO_3 + I_2 + H_2O \rightarrow Na_2SO_4 + 2HI$

Iodine can displace Cl_2 from $KClO_3$ but not from a Chloride.

$$2KClO_3 + I_2 \rightarrow 2KIO_3 + Cl_2$$

Iodine turns starch solution blue. The blue colour disappears on warming but reappears on cooling.

Starch + Iodine —> Iodide of starch (blue)

43. Starting from Brine how will you prepare Sodium Carbonate.

Sodium Carbonate can be manufactured from Brine applying the Ammonia - Soda process. The theory involved in the process is — Ammonical brine (Brine saturated with Ammonia) is subjected to the action of Carbon - di - oxide. The Carbon - di - oxide first reacts with the Ammonia forming Ammonium - bi - carbonate.

$$CO_2 + NH_3 + H_2O = (NH_4)HCO_3$$

The Ammonium - bi - carbonate then reacts with the Sodium-chloride in the Brine solution forming Sodium - bi - carbonate and Ammonium - Chloride by a process of double decomposition.

$$(NH_4)HCO_3 + NaCl \rightleftharpoons NaHCO_3 + NH_4Cl$$

The above reaction is *reversible* and Sodium Chloride is partially converted into Sodium - bi - carbonate which being not much soluble gets precipitated. The optimum temperature for the reaction is 30°C. The bicarbonate on drying and ignition gives the normal carbonate

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The actual process involves 5 important stages.

1. Saturation of Brine with Ammonia.
2. Carbonation
3. Filteration of the Bicarbonate
4. Calcination of the bicarbonate to get normal Carbonate
5. Recovery of Ammonia

A strong solution of Brine is allowed to percolate down an Iron tower provided with perforated shelves, up which Ammonia gas is passed. The Brine thus gets saturated with Ammonia. The reaction evolves much heat and so to make the absorption efficient, the tower is provided with cooling arrangements to keep the temperature somewhere near 30°C. After saturation, the Ammonical Brine is allowed to stand undisturbed so that the hydroxides of Calcium, Iron etc, may get settled. The clear solution is then pumped up to the top of the Carbonating tower. It is also provided with cooling pipes and perforated shelves so as to ensure an intimate contact of the Carbon-di-oxide with the liquor. The CO_2 from lime-kiln at a pressure of 1—2 atmospheres is passed up the tower, and the temperature is kept at 98°C. The whole liquid becomes milky due to the separation of $NaHCO_3$ which settles down and is separated by filteration in rotatory vacum filters. The waste liquor of this process contains the whole of Ammonia as salt and is sent to the Ammonia still for regeneration so that it can be used again.

The Sodium bicarbonate is then calcined in semi Cylinderical troughs provided with suitable stirring arrangements and the gases evolved are carefully collected and utilized again. The bicarbonate gets decomposed into the normal Carbonate

$$2NaHCO_3 = Na_2CO_3 + H_2O + CO_2$$

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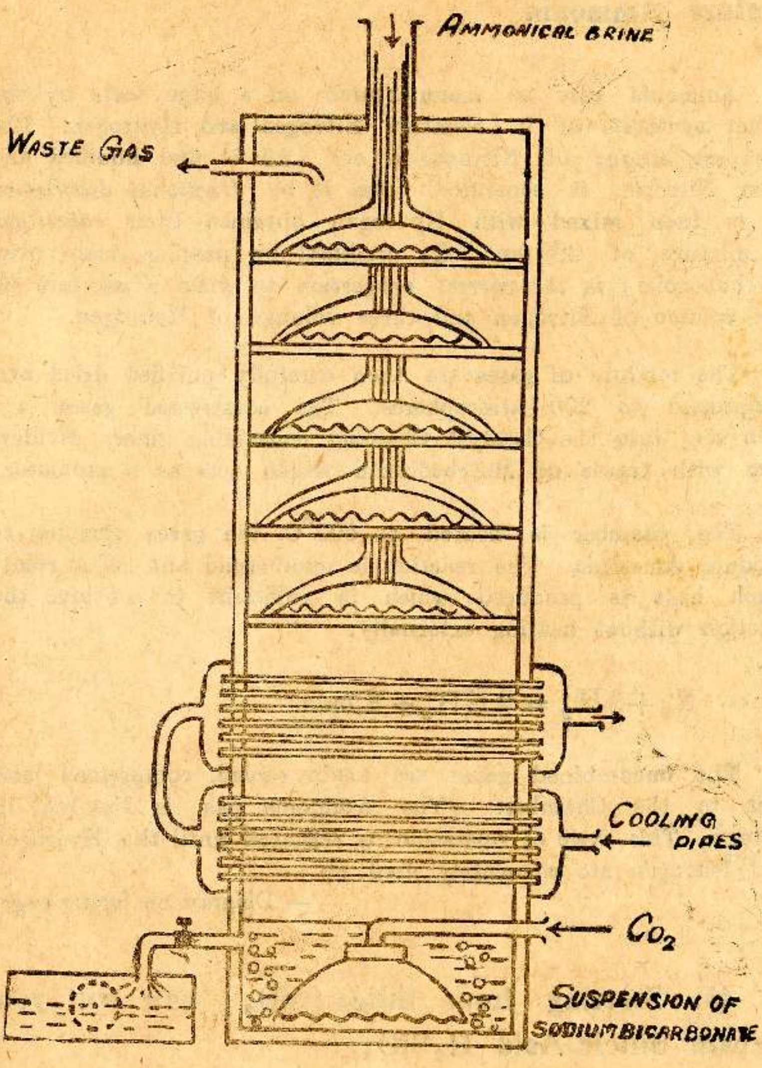
Solvay's Carbonator used to manufacture Sodinm Carbonate



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44. Starting from Nitrogen how will you manufacture Ammonia.

Ammonia can be manufactured on a large scale by the direct synthesis of its elements Nitrogen and Hydrogen. The cheapest source of Nitrogen is air. Air is first liquified and then Nitrogen is separated from it by *fractional distillation* It is then mixed with Hydrogen obtained from water gas (a mixture of CO and H_2 produced by passing steam over red hot coke) *in the correct proportion* to yield a mixture of one volume of Nitrogen and three volumes of Hydrogen.

The mixture of gases are then carefully purified dried and compressed to 200 atmospheres. The compressed gases are then sent into the Catalyst Chamber containing finely divided Iron with traces of Molybedenum which acts as a promoter.

The chamber is heated to 500°C. the gases combine to produce Ammonia. The reaction is exothermic and as a result much heat is produced which is sufficient to continue the reaction without heating externally.

$$N_2 + 3H_2 = 2NH_3 + \text{K cals}$$

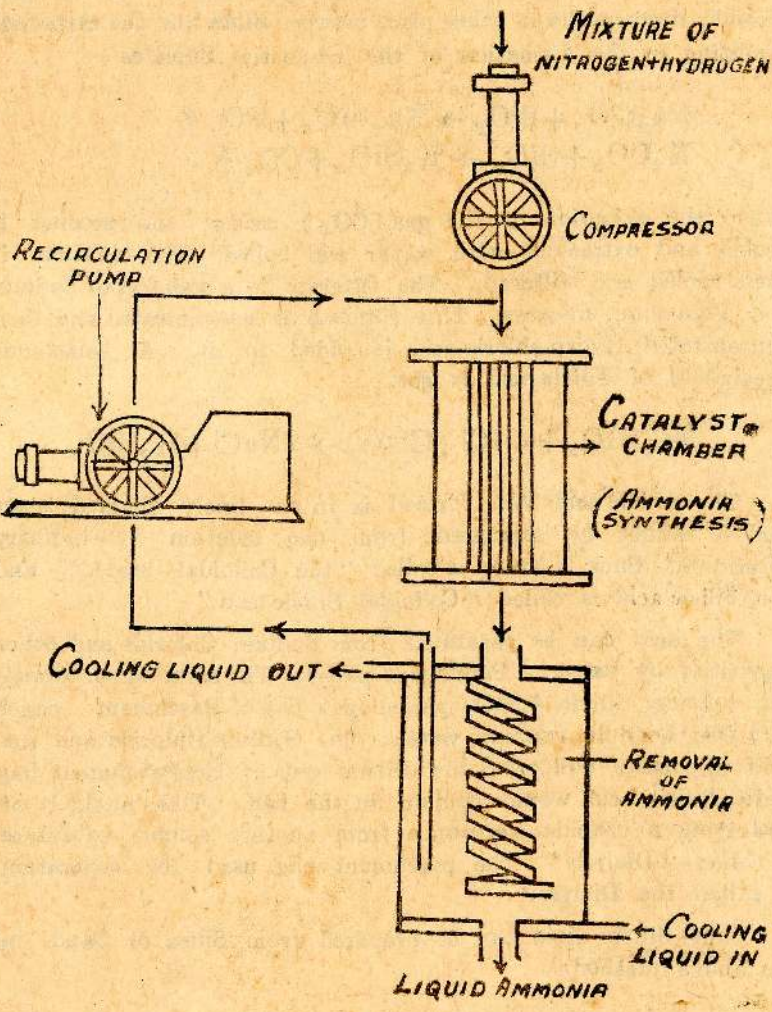
The uncombined gases are again cooled, compressed and sent to the Chamber. (The Ammonia gas is dissolved in water). This cycle of operation is repeated until the Hydrogen and Nitrogen are completely used up.

— Diagram on facing page.

45. Starting from Silica (SiO_2) how will you prepare Silicic Acid H_2SiO_3.

To prepare Silicic acid from Silica or Silican - di - oxide; the Silica must be first converted to Sodium Silicate and then it must be allowed to react with concentrated Hydro - chloric acid to get Silicic acid.

Manufacture of Ammonia



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To begin with sand (an impure form of Silica) is mixed with four times its weight of fusion mixture containing Carbonates of Sodium and Potassium and strongly heated in a dish. Double decomposition takes place between Silica and the carbonate resulting in the formation of the respective Silicates

$$Na_2CO_3 + SiO_2 \rightarrow Na_2SiO_3 + CO_2 \uparrow$$
$$K_2CO_3 + SiO_2 \rightarrow K_2SiO_3 + CO_2 \uparrow$$

When the evloution of the gas (CO_2) ceases, the product is cooled and extracted with water and boiled. The solution is then cooled and filtered.. The filterate is a solution of Sodium and Potassium silicates. This filterate is concentrated and then concentrated Hydro-chloric acid is added to it. A gelatinous precipitate of Silicic acid is got.

$$Na_2SiO_3 + 2HCl\ (Conc) \rightarrow 2NaCl + H_2SiO_3.$$

The Silicic acid thus formed is in a finely divided state and it cannot be separated from the solution by ordinary filteration. Such a state is called "the Colloidal state." and the Silicic acid is called "Colloidal Silicic acid."

The acid can be separated from Sodium Chloride and other impurities by using a Parchment paper. The solution containing the colloidal Silicic Acid is placed in a bag of Parchment paper and suspended in running water. The Sodium Chloride and the acid impurities will gradually diffuse out of the Parchment bag while Silicic Acid would remain in the bag. This method of separating a colloidal substance from another soluble substance is called "Dialysis." The parchment bag used for separation is called the Dialyser.

Thus Silicic Acid can be prepared from Silica or Sand by the above method.

(b) How can you prepare a Silica Garden in your Lab.

To prepare this in the Lab. A dilute solution of Sodium Silicate called Water glass with a density of 1·1 gram / cc. is used. The filtered clear solution of Sodium Silicate is taken in a tall, narrow, (glass) gas jar, and to this solution is added

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crystals of Magnesium chloride, Cobalt chloride, Ferrous sulphate Copper Sulphate etc. The solution is allowed to stand undisturbed. Gradually, from these above *coloured* crystals fantastic coloured and variously shaped structures grow and assume the form of a much branched tree. These are the *Silicates* of the respective metals and they are beautifully coloured. From Manganese a pink outgrowth, from Copper a blue one, and from Ferrous a green one grows.

46. (a) How can you use Sodium Silicate or Water glass to preserve eggs from decay?

The shells of eggs are generally made up of Calcium Carbonate which contains numerous minute pores or openings through which microscopic organisms such as Bacteria can easily penetrate and putrify the eggs and make them decay. To prevent this the eggs are immersed in a solution of Sodium Silicate or Water glass. Double decomposition takes place between the Calcium carbonate of the egg shell and the Sodium Silicate resulting in the formation of Calcium Silicate which seals all the minute pores in the shell and prevents the entry of microscopic organisms such as Bacteria, thereby they prevent the putrefaction and decay of eggs.

$$CaCO_3 + Na_2SiO_3 = CaSiO_3 + Na_2CO_3$$

(b) How will you prepare Sodium Silicate or Water glass from sand.

It is prepared by fusing together a mixture of Sodium Carbonate, finely powdered white Sand and Charcoal in a small reverberatory furnace

$$Na_2CO_3 + SiO_2 + C = Na_2SiO_3 + 2CO.$$

(c) What are the uses of Sodium Silicate?

1. It is used as a mordant in textile, dyeing and printing
2. It is used as a filler in cheap soap.
3. It is used for preserving eggs and as a cement substitute.

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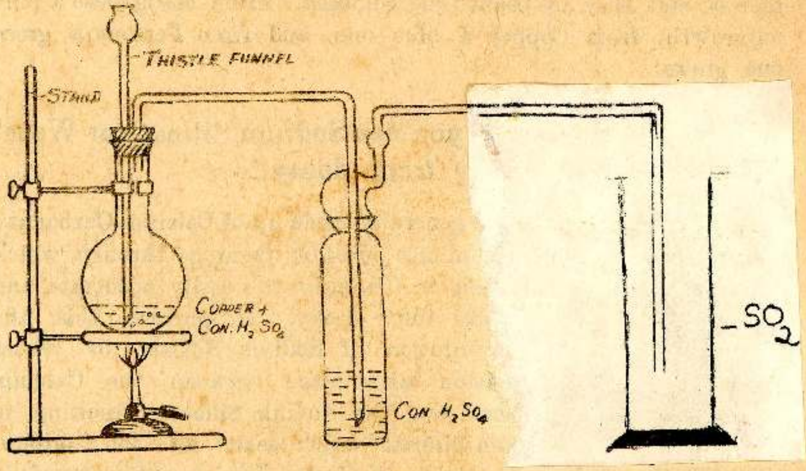
47. How will you prepare a pure dry sample of Sulphur-di-oxide in the laboratory? Explain the action of the gas on

(1) $KMno_4$ (2) $K_2Cr_2O_7$ (3) $FeCl_3$ (4) $Fe_2(SO_4)_3$



Sulphur-di-oxide is prepared in the laboratory by the action of concentrated Sulphuric acid on Copper turnings. Copper turnings are taken in a round-bottomed flask fitted with a cork carrying a delivery tube and a thistle funnel. Conc. H_2SO_4 is poured in to the flask through the thistle funnel and the flask is heated. On heating the mixture Copper and Sulphuric acid react to produce SO_2, $CuSO_4$ and H_2O. The reaction can be represented by the following equation

$$Cu + 2H_2SO_4 \rightarrow CuSO_4 + SO_2 + 2H_2O.$$

The gas is passed through a bottle containing Con. H_2SO_4 to dry it and then it is collected ~~over Mercury~~. Anhydrous $CaCl_2$ or P_2O_5 also can be used to dry the gas.

(1) Sulphur-di-oxides *in the presence of water* acts as a very good reducing agent. It reduces a *neutral* solution of $KMnO_4$ and renders it colourless with the formation of Potasium sulphate, Manganese sulphate and Sulphuric acid. The reactions involved in the process can be represented by the following equations;

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$SO_2 + H_2O \rightarrow H_2SO_3$ Sulphurous acid

$5 \times$ (unstable) $H_2SO_3 + H_2O = H_2SO_4 + 2H$ (nascent state)

The acid produced by SO_2 with H_2O reacts with $KMnO_4$ and liberates nascent oxygen.

$$2KMnO_4 + 3H_2SO_4 \rightarrow K_2SO_4 + 2MnSO_4 + 3H_2O + 5[O]$$
$$5[O] + 10H \rightarrow 5H_2O.$$

Adding the above equations we get

$$2KMnO_4 + 5SO_2 + 2H_2O = K_2SO_4 + 2MnSO_4 + 2H_2SO_4.$$

(2) Sulphur-di-oxide being a powerful reducing agent reduces an acidified *orange* solution of $K_2Cr_2O_7$ to *green* Chromic salt. The following equations show the various stages of the reaction.

$$3 \times \quad SO_2 + H_2O \rightarrow H_2SO_3$$
$$3 \times \quad H_2SO_3 + H_2O \rightarrow H_2SO_4 + 2[H] \text{ Nascent state}$$
$$K_2Cr_2O_7 + 4H_2SO_4 \rightarrow K_2SO_4 + Cr_2(SO_4)_3 + 4H_2O + 3[O]$$
$$3[O] + 6H \rightarrow 3H_2O$$

Adding we get

$$K_2Cr_2O_7 + H_2SO_4 + 3SO_2 \rightarrow K_2SO_4 + Cr_2(SO_4)_3 + H_2O.$$

The green colour of the solution is due to the formation of green Chromium-sulphate.

(3) SO_2 reduces a reddish brown solution of Ferric sulphate to a pale green solution of Ferrous sulpate according to the following equation

$$Fe_2(SO_4)_3 + 2H_2O + SO_2 \rightarrow 2FeSO_4 + 2H_2SO_4$$

(4) If Sulphur-di-oxide is passed through an *orange coloured* solution of Ferric Chloride it will be reduced almost to a *colourless* solution of Ferrous Chloride.

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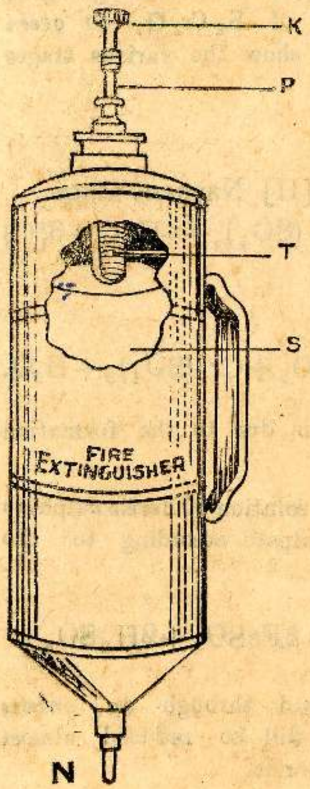
$$2\,FeCl_3 + 2\,H_2O + SO_2 = 2\,FeCl_2 + H_2SO_4 + 2\,HCl$$

It must be noted that Sulphur-di-oxide requires water to exhibit its reducing property because it is in the presence of water Sulphurous Acid is formed (H_2SO_3) which being unstable gets converted to H_2SO_4 (Sulphuric Acid) and nascent Hydrogen which is responsible for the reducing action of Sulphur-di-oxide.

48. Draw the diagram of a Fire-Extinguisher and explain how it works.

Soda acid fire extinguisher



It consists of a strong metal vessel containing a solution **S** of Sodium Carbonate or bicarbonate and a glass bottle **T** (supported inside) containing Sulphuric Acid or a solution of Alum. A Metal plunger **P** with a knob **K** outside rests over the bottle. When required for use the knob is struck against a hard surface breaking the bottle, and the acid Solution comes in contact with the Carbonate or bicarbonate, reacts with it and liberates Carbon-di-oxide, *under sufficient pressure.*

$$Na_2CO_3 + H_2SO_4 \rightarrow Na_2SO_4 + H_2O + CO_2 \uparrow$$

The gas thus produced forces out through the nozzle **N** and is directed against the fire and is put off or brought under control.

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Write brief notes on (1) **Water gas**
(2) **Producer gas**

Water gas is produced by passing steam over red hot coke heated to a temperature of ($1000^\circ C$). It is a mixture of nearly equal volumes of Carbon - monoxide and Hydrogen with some Carbon - di - oxide.

$$H_2O+C=CO+H_2$$
$$C+2H_2O=CO_2+2H_2$$

It burns with the production of a large quantity of heat but no light. In order that it may be used as an illuminating gas, it is either (1) Carburetted *i.e.* mixed with small amounts of oil gas or (2) Walsbach Mantles are used. It is used as a fuel and in the manufacture of Hydrogen.

Producer gas:— It is obtained by passing a current of air through a layer of red hot coke. At first Carbon - di - oxide is produced but is decomposed into Carbon - monoxide as it passes upwards; so that the resulting mixture consists of Carbon - monoxide and Nitrogen. This Carbon - monoxide is then burnt when required

$$C+O_2=CO_2$$
$$CO_2+C=2CO$$

This gas is used as a substitute for petrol in Motor Vehicles when there is a shortage of petrol.

49. (1) **State the laws of chemical Combinations.**

On passing a current of Hydrogen over 2·173 grams of Litharge (PbO), 1·949 grams of PbO_2, and 2·315 grams of Red - Lead, 2·017 grams, 1·688 grams and 2·1000 grams of Lead were left behind respectively. To which law of Chemical combination does this particular reaction refers to. State the law and explain.

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(a) Law of Conservartion of Mass :—

This law states that in a Chemical reaction the total weight (or quantity) of the reactants is equal to the total weight of the products formed. In other words matter is indistructible and it can neither be created nor destroyed.

(b) Law of Constant proportions *or* definite proportion :—

This law of chemical combination states that a chemical compound, in whatever manner it is formed always contain the same elements united together in the same fixed proportion by weight.

(c) Law of Multiple proportion :

This law states **that** when two elements combine to form more than one compound, the different weights of one which combine with a definite weight of the other bear a simple ratio to one another.

(d) Law of reciprocal proportions :

This law states that the weights of two or more elements which separately combine with a definite weight of the third are either the same as or are simple multiples of the weights of these different elements when they combine amongst themselves.

Problem

In litharge the amount of oxygen per gram of Lead

$$=\frac{2\cdot173-2\cdot017}{2\cdot017}=0\cdot0773 \text{ grams of } O_2 / \text{gram of Lead.}$$

In Lead peroxide the amount of Oxygen per gram of Lead

$$=\frac{1\cdot949-1\cdot688}{1\cdot688}=0\cdot1546 \text{ grams}$$

In Red-Lead the amount of oxygen per gram of Lead

$$=\frac{2\cdot316-2\cdot1}{2\cdot1}=0\cdot1029 \text{ grams}$$

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Hence in all these 3 cases the ratio of the weights of oxygen that combines with a definite weight of Lead is

$$= \cdot 0773 : 0 \cdot 1546 : 0 \cdot 1029$$
$$1 : 2 : \tfrac{3}{4}$$
$$= 4 : 8 : 3$$

These reactions illustrate the law of multiple proportions which states that "when 2 elements combine to form more than one compound, the different weights of one which combine with a definite weight of the other bear a simple ratio to one another." Here the weight of Lead is constant and the weights of Oxygen that separately combine with a definite weight of Lead are in a simple ratio 4:8:3.

(2) PH_3 contains 91·1% of Phosphorus and 8·9% of Hydrogen. Water contains 88·8% of Oxygen and 11·2% of Hydrogen and P_4O_6 contains 56·4% of Phosphorus and 43·6% of Oxygen; state the Law implied in the formation of these compounds and explain.

In these 3 compounds PH_3, H_2O and P_4O_6. Phosphorus and Oxygen separately combine with Hydrogen. So if Phosphorus and Oxygen were to combine with each other they should do so in the same ratio in which they have separately combined with the *same* amount of Hydrogen.

Taking into consideration the weights

91·1 gms of Phosphorus combines with 8·9 gms of H_2
11·2 ,, ,, Hydrogen ,, ,, 88·8 ,, ,, O_2
∴ 8·9 gram of Hydrogen ,, ,, $\frac{88 \cdot 8}{11 \cdot 2} \times 8 \cdot 9$,, O_2
$= 70 \cdot 56$ gms

So if Phosphorus and Oxygen were to combine they should do so in the ratio of 91·1 : 70·56.
$= 4 : 3$

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In P_4O_6 the weight of Phosphorus = 56·4 grams
" " " " " Oxygen = 43·6. "

These weights are approximately in the ratio of 4:3. Hence the law implied here is the law of reciprocal proportions which states that the weights of two or more elements which separately combine with a definite weight of the third are either the same as or are simple multiples of the weights of these different elements when they combine against themselves.

(3) 1·2 grams of an oxide of Iron on complete reduction by Hydrogen gave 0·84 grams of Iron. In another experiment 1·4 grams of the oxide prepared by another method yielded on similar treatment 0·98 grams of the metal. What law does these experiments illustrate.

In the first case

1·2 grams of the Oxide yielded 0·84 gram of Iron
∴ 0·84 grams of Iron combines with
1·2 — ·84 grams of Oxygen = ·36 grams

In the second case

1·4 grams of the oxide yielded 0·98 grams of Iron
∴ 0·98 grams of Iron combines with
1·4 — ·98 grams of Oxygen = 0·42 grams

In the first case iron and oxygen are combined in the ratio of ·84 : ·36.
7 : 3.

In the second case Iron and Oxygen are combined in the ratio of ·98 : ·42
7 : 3

Hence in both cases we find that the composition of the Iron oxide remains the same. In whatever manner the oxide is

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formed it always contains the same elements united together in the same fixed proportion by weight i.e. 7 : 3. Hence the above experimental details illustrate the law of constant proportions or definite proportions which states that a chemical compound, in whatever manner it is formed always contain the same elements united together in the same fixed proportion by weight.

50. Differentiate between

(1) Ion, Atoms and Molecules

(2) Nascent and Molecular states

An Ion is an electrically charged atom or groups of atoms. It may either carry a negetive charge or positive charge. The number of charges carried by an Ion is equal to the valency of an Ion. The positively charged Ions are called the *Cations* and they are attracted towards the Cathode (the — ve electrode). The negetively charged Ions are called *Anions* and they are attracted towards the Anode (the + ve electrode).

An Atom may be defined as the ultimate particle of an element capable of taking part in a chemical reaction *but has no free existence*, whereas a Molecule of a substance is formed by the union of atoms and it is the ultimate particle of an element that *has free existance*. The atoms of the same elements have the same weight and similar properties. Atoms of different elements have different weights and different properties. A chemical reaction always takes place between atoms of different elements. An Atom has its Characteristic properties but an Ion which is an Atom charged with positive or negetive electricity behaves quite differently from an atom of the same element. Thus an atom of Sodium reacts with water producing Sodium Hydroxide and Hydrogen. But an Ion of Sodium represented as Na^+ does not behave in a similar manner until it is discharged on the Cathode. Thus by a study of the above characters Atoms, Ions and Molecules can be distinguished from one another.

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Nascent and Molecular States

An element is said to be in the "Nascent state" when it is just liberated from a compound. It is otherwise called the "Atomic State" or "New born" state. In the atomic state it possess an extra amount of energy which explains its greater activity. Molecules are produced by the union of atoms and this union generally takes place with a loss of energy. Therby they don't display so much activity as they display when they were in the Atomic State or Nascent State.

As an example we can take the case of Hydrogen. Nascent Hydrogen is a more powerful reducing agent than ordinary Molecular Hydrogen. Thus Hydrogen (Molecular) from a Kipps apparatus passed into a pink $KMnO_4$ solution *the latter remains unaffeectd*; while the pink colour disappears or decolourises if a piece of zinc and dil. H_2SO_4 are added into the tube containing $KMnO_4$. This is because the Hydrogen produced inside the tube is in the Nascent state as soon a it is liberated and so it decolourises $KMnO_4$.

Another example is that of $FeCl_3$. Hydrogen from the Kipps apparatus when passed into a yellow or orange Ferric Chloride Solution the latter remains unaffected while the reddish orange colour of $FeCl_3$ disappears if a piece of zinc and dil. H_2SO_4 are added to it directly.

$$Zn+H_2SO_4\ (\text{dil}) \rightarrow ZnSO_4+2H \quad \text{Nascent}$$

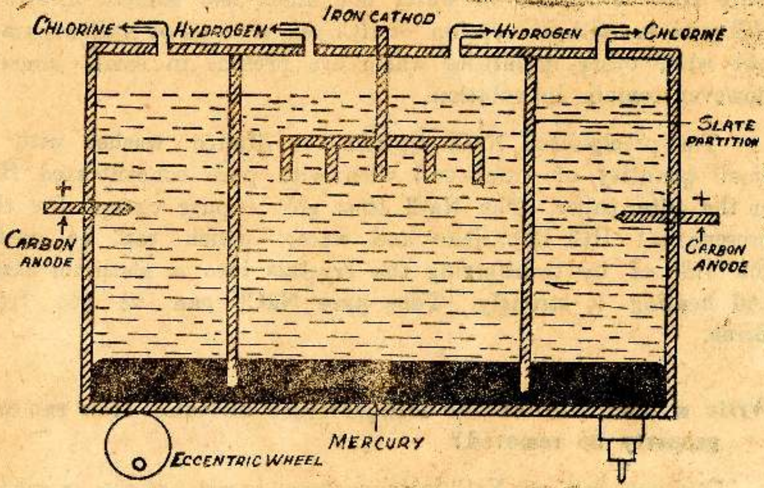
$$(1) \quad 2KMnO_4+3H_2SO_4+10H=K_2SO_4+2MnSO_4+8H_2O$$

$$(2) \quad FeCl_3+2H \rightarrow 2FeCl_2+2HCl$$

51. Starting from Brine how will you get Sodium Hydroxide?

—Diagram on facing page.

Sodium Hydroxide is got from Brine by electrolysis using Castner-Kellner cell. The cell is an iron tank divided into 3 compartments by slate partitions which hang from the top



and reach almost the bottom of the tank and dip into a layer of Mercury on the floor of the tank. The 2 outer compartments are provided with Carbon anodes and the central compartment is fitted with an Iron cathode. The tank is placed upon an eccentric wheel. The outer chambers are filled with Brine solution and the central chamber is filled with a dilute Sodium hydroxide solution. When a current is passed, Chlorine is set free at the anode chambers (outer chambers), and passes out through the exit pipes at the top while Sodium is liberated at the cathode. The Sodium thus formed combines or dissolves in Mercury and forms Sodium amalgam. A slow rocking motion of the cell resting upon the eccentric wheel brings the Sodium amalgam into contact with the water in the central chamber. NaOH is formed here, with the liberation of Hydrogen. The solution is evaporated to dryness and NaOH is fused and cast into sticks, balls or pellets.

NOTE : This method can be employed to manufacture Chlorine from Sodium chloride or Brine by electrolysis.

How will you prepare Pure Sodium Chloride from Brine.

A saturated solution of Brine or Common salt is taken in a beaker and HCl gas is passed into it. The gas dissolves.

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in the water present in Brine forming Hydro-chloric acid. Pure NaCl is soluble in water but much less soluble in strong HCl and so with absorption of HCl gas, crystals of NaCl separate out while other impurities which are present in small amount however remain in solution.

The precipitated NaCl crystals are filtered washed with a small quantity of water and then with pure concentrated HCl on the filter paper. The NaCl thus got is pure except for the presence of HCl impurities and water, which can be easily got rid of by transferring the crystals into a platinum basin and heating it strongly. Thus pure NaCl can be got from Brine.

Write a brief note on the Deliquescence of NaCl. How can that property be removed?

Common salt or NaCl is deliquescent because of the presence of $CaCl_2$ and $MgCl_2$. If these salts are present as impurities the salt NaCl absorbs water from the atmosphere and dissolves in that to form a solution. This property of absorbing water can be got rid of by;

(1) Washing the heaps of Sea-salt with occasional showers of water which dissolve off $CaCl_2$ and $MgCl_2$.

or (2) by mixing some "damp-proof" salts with the impure sample,

or (3) by a chemical process

or (4) by repeated crytallisation from water.

52. Outline briefly the steps by which Ammonium sulphate may be obtained on a large scale using atmospheric Nitrogen as the starting material. Give one important use of the compound.

Ammonium sulphate can be prepared on a large scale using atmospheric Nitrogen as the starting material. Nitrogen of the atmosphere is made to combine with thrice its own volume of

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Hydrogen at about 500°C. and in the presence of heated catalyst such as finely divided iron containing Molybdenum as promoter to form Ammonia.

$$N_2+3H_2=2NH_3+K\ \text{Cals. (Exothermic)}$$

The reaction is 'exothermic' as much heat is produced during the reaction. The Ammonia is then allowed to react with Sulphuric acid

$$2NH_3+H_2SO_4=(NH_4)_2SO_4.$$

It can also be prepared by passing the Ammonia gas into water in which Calcium sulphate is suspended and a current of CO_2 is passed.

$$2NH_3+CaSO_4+CO\ +H_2O=CaCO_3+(NH_4)_2SO_4.$$

The purpose of using $CaSO_4$ instead of H_2SO_4 is that it is cheaper than Sulphuric acid.

Ammonium sulphate is a white crystalline solid, soluble in water.

It is largely used as an artificial manure and in fermentation industries.

(b) What two tests would you perform to show that this Compound is Ammonium Sulphate.

i. Action of Heat

When crystals of Ammonium sulphate is heated it decomposes by two stages. In the first stage NH_3 and NH_4HSO_4 are formed. The NH_4HSO_4 further decomposes into NH_3 and Sulphuric acid. The liberation of NH_3 can be tested with the help of Con. HCl with which it forms dense white fumes of Ammonium Chloride.

$$(NH_4)_2SO_4 \rightarrow NH_4\cdot HSO_4+NH_3\uparrow$$
$$NH_4\cdot HSO_4 \rightarrow NH_3\uparrow+H_2SO_4$$
$$NH_3+HCl\ \text{(Conc.)} \rightarrow NH_4Cl\ \text{(Dense white fumes)}$$

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ii. By adding Barium chloride to a solution of Ammonium sulphate we get a white precipitate of Barium sulphate by double decomposition.

$$(NH_4)_2 SO_4 + BaCl_2 \rightarrow BaSO_4 \downarrow + 2 NH_4Cl$$

The precipitate of $BaSo_4$ is insoluble in Hydro-chloric acid.

These 2 tests can be applied to detect the presence of Ammonium Sulphate.

53. Select a suitable drying agent for the following gases from the list given below giving reasons for your selection.

The gases are,

1. NH_3; 2. CO_2; 3. H_2S; 4. Chlorine.

The drying agents are

1. P_2O_5; 2. H_2SO_4; 3. $CaCl_2$ (anhydrous); 4. CaO.

1. Ammonia can be dried only by Quick lime CaO. Ammonia being an alkaline gas cannot be dried by passing it through Conc H_2SO_4 or P_2O_5 as it forms Ammonium sulphate and Ammonium phosphate respectively.

$$CaCl_2 + 8 NH_3 \rightarrow CaCl_2 \cdot 8 NH_3 \text{ (Addition compound)}$$
$$2 NH_3 + H_2SO_4 \rightarrow (NH_4)_2SO_4$$
$$6 NH_3 + P_2O_5 + 3 H_2O = 2 (NH_4)_3PO_4$$

The gas is then collected by the downward displacement of air (as NH_3 is lighter than air) or Mecury upon which it has no action.

2. Hydrogen sulphide is dried by $CaCl_2$ (anhydrous). H_2SO_4 cannot be used as it reduces the acid to SO_2 and water and gets itself oxidised to sulphur.

$$H_2SO_4 + H_2S \rightarrow S \downarrow + 2 H_2O + SO_2$$

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P_2O_5 also can be used to dry the gas and then it is collected by the upward displacement of air.

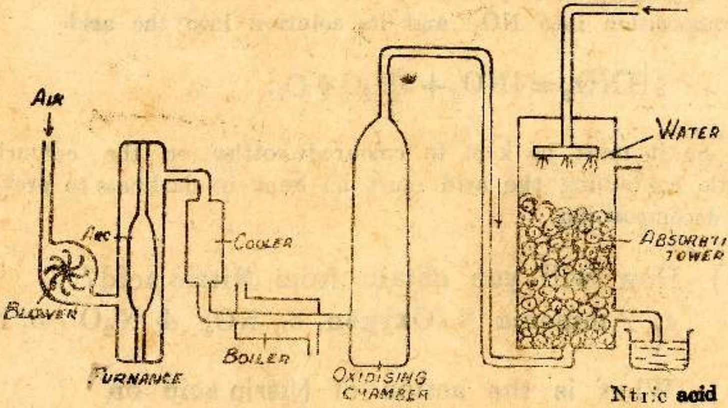
3. Cl_2 can be dried by passing the gas through a wash bottle containing Conc. H_2SO_4 and the gas is collected by the upward displacement of air. It cannot be dried by P_2O_5 and CaO as it reacts with them (as these are basic in nature) to form the respective chlorides.

4. Carbon - di - oxide can dried by bubbling the gas through Conc. H_2SO_4. We cannot use $CaCl_2$ or CaO to dry the gas as it reacts with it to form $CaCO_3$.

$$CaO + CO_2 \rightarrow CaCO_3$$

54. Starting from Nitrogen how will you prepare Nitric acid. Why do you store Nitric acid in coloured bottles in the laboratory?

Nitric acid from Air - Electric Process.



In this process air is freed from Carbon - di - oxide and moisture and passed through an electric arc furnace when the Nitrogen and Oxygen of the air combine to form Nitric oxide (NO). The gas mixture (N_2, O_2 and NO) in a highly heated condition (800° — 1000°) is cooled to about 500°C by passing through the cooler. The gas is further cooled to about 50°C. when it enters the oxidation tower, where Nitric oxide (NO) is converted into Nitrogen per oxide (NO_2) in the presence of Oxygen of the air. Nitrogen per oxide is then absorbed in water in the absorption tower producing Nitric acid, [which may be absorbed in Lime stone producing Calcium Nitrate,] (This is otherwise called Norge saltpetre.)

The reactions involved in the process can be represented by the following equations

$$N_2 + O_2 = 2NO \text{ (Spark)}$$
$$2NO + O_2 = 2NO_2.$$
$$3NO_2 + H_2O = 2HNO_3 + NO$$

Nitric acid is stored up in coloured bottles in the labs because the acid is decomposed by the action of light. A colourless bottle filled with the acid and left exposed to light will gradually turn yellow or yellowish brown as a result of decomposition into NO_2 and its solution into the acid.

$$4HNO_3 = 4NO_2 + 2H_2O + O_2.$$

So it must be kept in coloured bottles or the colourless bottle containing the acid must be kept in darkness to prevent its decomposition.

(2) How will you obtain from Nitric acid?

1. Ammonia 2. Oxygen 3. NO_2 4. N_2O 5. NO

(3) What is the action of Nitric acid on

1. A silver coin 2. A brass plate 3. Gold ornaments

(1) Ammonia can be prepared from Nitric acid by reducing the acid by nascent Hydrogen. Nascent hydrogen is produced by the action of Caustic soda on Iron filings. The nascent Hydrogen thus produced reduces the acid to water and Ammonia. The reaction involved can be represented thus:

$$HNO_3 + 8H = 3H_2O + NH_3$$

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2. Oxygen from Nitric acid

Pure Nitric acid practically decomposes when heated to boiling or the concentrated acid dropped over heated pumice stone or passed through a heated clay pipe decomposes into NO_2 O_2 and water. The mixture of NO_2 and O_2 can be separated from one another by shaking the mixture of gases with water when NO_2 disolves to form a mixture of Nitrous and Nitric acid.

$$2NO_2+H_2O=HNO_2+HNO_3$$

The undissolved oxygen can be separated and collected.

3. Nitrogen per oxides from Nitric acid

·Concentrated Nitric acid when dropped over heated pumice stone taken in a flask decompose producing NO_2. The evolved gases are passed through a U tube placed in freezing mixture when NO_2 collects as a liquid

$$4HNO_3=2H_2O+O_2+4NO_2$$

It can also be prepared when Nitric acid reacts with certain metals like Tin and Copper.

$$Sn+4HNO_3=SnO_2+2H_2O+O_2+4NO_2$$
$$Cu+4HNO_3=Cu(NO_3)_2+2H_2O+2NO_2.$$

4: Nitrous oxide from Nitric acid: N_2O

It can be prepared from Nitric acid by treating the *dilute* acid with metals like Copper Zinc or by reducing the acid with Stannous chloride.

$$4Cu+10HNO_3\text{(dilute)}=4Cu(NO_3)_2+5H_2O+N_2O\uparrow$$
$$4Zn+10HNO_3\text{(dilute)}=4Zn(NO_3)_2+5H_2O+N_2O\uparrow$$
$$2HNO_3+4SnCl_2+8HCl=4SnCl_4+5H_2O+N_2O\uparrow$$

5. Nitric oxide from HNO_3

It is prepared from Nitric acid by treating the concentrated acid with Copper. Copper turnings are taken in a Wolfes'

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bottle fitted air tight with a thistle funnel and a delivery tube. A mixture of equal volumes of concentrated Nitric acid and water is poured down the funnel keeping the lower end of the funnel dipped into the liquid. Brown fumes of NO_2 are seen in the bottle due to the combination of NO and the Oxygen of the air in the bottle $2NO + O_2 = 2NO_2$. The fumes are allowed to escape first and the Nitric oxide produced later is collected by the downward displacement of water.

$$3Cu + 8HNO_3\,(\text{Conc}) = 3Cu(NO_3)_2 + 4H_2O + 2NO \uparrow$$

3.

1. **Action of Nitric acid on Silver Coin**

A Silver coin is usually made of an alloy of Ag, Cu and Zn. On adding Nitric acid to the coin a mixture of $AgNO_3$ $Cu(NO_3)_2$, $Zn(NO_3)_2$ together with Oxides of Nitrogen are produced and the *Silver coin gets blackened.*

$$4Cu + 10HNO_3\,(\text{dil}) = 4Cu(NO_3)_2 + 5H_2O + N_2O$$
$$4Zn + 10HNO_3\,(\text{dil}) = 4Zn(NO_3)_2 + 5H_2O + N_2O$$

$$Ag + 2HNO_3\,(\text{dil}) = AgNO_3 + H_2O + N_2O$$

2. **Action of Nitric acid on Brass plate**

As Brass is an alloy of Copper and Zinc, Nitric acid acts upon the plate forming Zinc and Copper nitrate with the evolution of oxides of Nitrogen. The plate is etched. The green colour of the solution is due to Copper nitrate.

$$\text{Metal} + \text{Nitric acid} \rightarrow \underset{\text{Metal}}{\text{Nitrate of the}} + \underset{\text{(Nitrogen)}}{\text{Oxides of}} + H_2O$$

$$4Cu + 10HNO_3\,(\text{dil}) = 4Cu(NO_3)_2 + 5H_2O + N_2O$$
$$4Zn + 10HNO_3\,(\text{dil}) = 4Zn(NO_3)_2 + 5H_2O + N_2O$$

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3. Action of Nitric acid on Gold Ornaments

Gold ornaments are attacked by the acid and sometimes they break due to the corrosive action of the acid. The reaction involved can be represented thus.

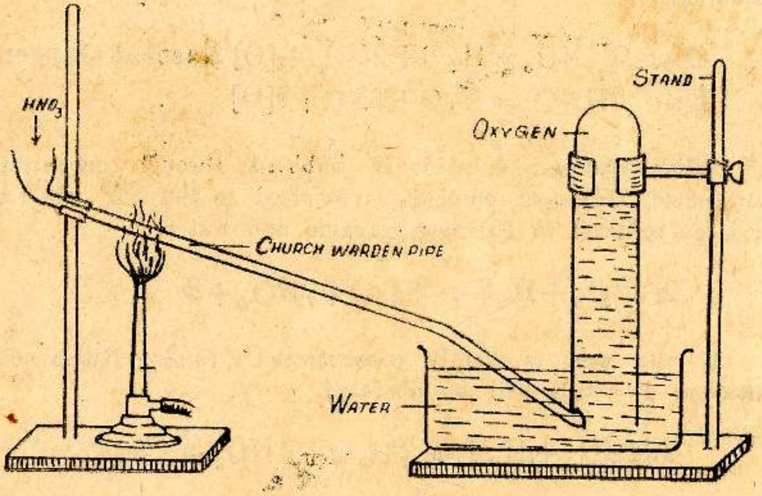
$HNO_3 + 3\,HCl \rightarrow 2\,H_2O + NOCl$ (**Nitrosyl chloride**) $+ 2Cl$

$2\,Au + 6\,Cl \rightarrow 2\,AuCl_3$

or $2\,Au + 3HNO_3 + 9\,HCl = 6\,H_2O + 3\,NOCl + 2\,AuCl_3$

Pure Gold is not attacked by Nitric acid. It can dissolve only in a mixture of Nitric and Hydro chloric acid in the ratio of 1 : 3. It is called **Aqua Regia.** Gold that is used for making ornaments is usually alloyed with Copper to make it strong and hence the Nitric acid reacts with the Copper and forms Copper nitrate, Oxides of Nitrogen and water.

55. Explain the action of heat on Nitric Acid



When concentrated Nitric acid is heated in the stem of a Church warden's pipe it decomposes into brown fumes of Nitrogen per oxide and Oxygen. When the gases are led into water, Nitrogen per oxide dissolves in water and Oxygen gets collected in the gas jar which can be identified with the help of a glowing splinter. The decomposition can be represented by the following equation

$$4HNO_3 \rightarrow 2H_2O + 4NO_2 \text{ (Brown)} + O_2$$

The quickness and readyness with which Nitric acid yields Oxygen on decomposition by heat explains the fact that it is a powerful oxidising agent.

2. Give reactions to show that Nitric acid is a good Oxidising agent ?

Nitric acid is a powerful Oxidising agent because of the ease with which it decomposes with the evolution of Oxygen. Concentrated Nitric acid produces NO_2 while dilute Nitric acid yields Nitric oxide. The decomposition can be illustrated by the following equations.

$$\text{Conc. } 2HNO_3 = H_2O + 2NO_2 + [O] \text{ Nascent Oxygen}$$
$$\text{Dil. } 2HNO_3 = H_2O + 2NO + 3[O] \quad \text{,,} \quad \text{,,}$$

When Hydrogen sulphide is bubbled through concentrated Nitric acid, Hydrogen sulphide is oxidised to Sulphur while the acid gets reduced to Nitrogen peroxide and water.

$$2HNO_3 + H_2S \rightarrow 2H_2O + 2NO_2 + S$$

If the acid is highly concentrated (fuming Nitric acid) Nitrogen di-oxide will be liberated.

$$2HNO_3 + H_2S \rightarrow 2H_2O + 2NO_2 + S\downarrow$$

The concentrated acid liberates Iodine from Potassium Iodide.

$$6KI + 8HNO_3 = 6KNO_3 + 3I_2 + 4H_2O + 2NO$$

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Again the acid oxidises a pale green solution of Ferrous sulphate (acidified with dil H_2SO_4) to a reddish brown solution of Ferric sulphate.

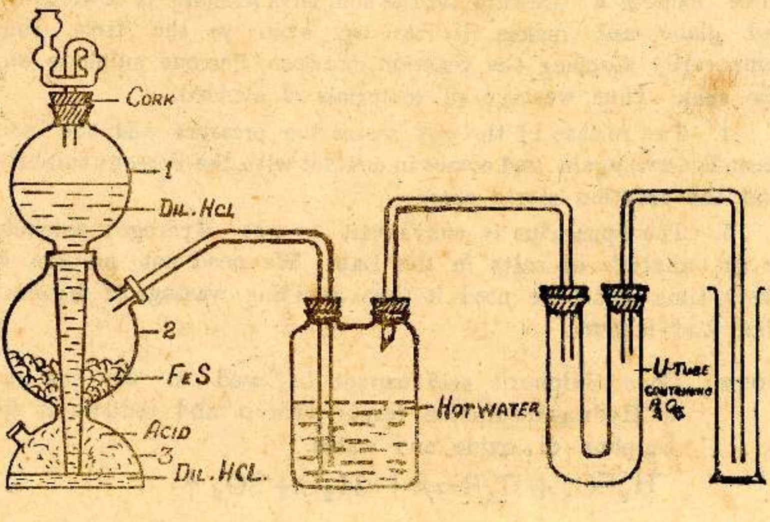
$$6FeSO_4 + 3H_2SO_4 + 2HNO_3 = 3Fe_2(SO_4)_3 + 2NO + 4H_2O$$

Non - Metals such as Sulphur, Phosphorus and Carbon are oxidised by Nitric acid to their respective oxides or to their oxy-acids.

$$S + 6\,HNO_3\,(\text{Conc.}) = H_2SO_4 + 6\,NO_2 + 2\,H_2O$$
$$S + \text{hot dilute } 2HNO_3 = H_2SO_4 + 2\,NO$$
$$P + 5\,HNO_3\,\text{Con} = H_3PO_4 + 5\,NO_2 + H_2O$$
$$\text{Warm charcoal } C + \text{hot Conc. } 4\,HNO_3 = CO_2 + 4\,NO_2 + 2\,H_2O$$

56. Outline a method to prepare Hydrogen sulphide in the Lab. What are the advantages of using the Kipps apparatus. What tests will you apply to identify the gas.

Preparation of Hydrogen sulphide in the Laboratory using Kipps apparatus.



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Hydrogen sulphide can be prepared in the Laboratory using the Kipps apparatus. It consists of 3 globes. Ferrous Sulphide is taken in the middle globe and dilute Hydro - chloric acid is poured into the first globe. The acid first reaches the 3rd globe and then rises up and comes in contact with the Ferrous - sulphide in the second globe, reacts with it and liberates Hydrogen sulphide.

$$FeS + 2HCl \rightarrow FeCl_2 + H_2S$$

The gas thus produced is contaminated with acid impurites like Hydrogen chloride, and moisture. So it is first led into a wash bottle containing hot water in which the HCl vapours dissolve and then it is led through a U tube containing Phosphorus pentoxide or dehydrated Silica to remove water vapour and then the pure dry gas can be collected by the upward displacement of air.

Advantages of using the Kipps apparatus.

1. Kipps apparatus is very convenient to get a continuous supply of the gas.

2. The gas can be got whenever we like and if not wanted it can be conveniently stored up in the apparatus itself.

3. The gas that is allowed to accumulate in the second globe excerts a pressure on the acid thus pushing it down to the 3rd globe and makes it rise up even to the first, thus temporarily stopping the reaction between Ferrous sulphide and the acid. Thus wastage of materials is avoided.

4. The release of the gas lowers the pressure and the acid decends down again and comes in contact with the Ferrous sulphide and the reaction starts again.

5. The apparatus is convenient to get Hydrogen sulphide to do analysis of salts in the Lab. We need not prepare it every time when we need it thus avoiding wastage of material, time and labour.

NOTE : Conc. Sulphuric acid cannot be used to dry the gas as Hydrogen sulphide reacts with it and reduces it to Sulphur - di - oxide and water.

$$H_2SO_4 + H_2S = S + 2H_2O + SO_2 \uparrow .$$

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Tests to identify the gas

1. Hydrogen sulphide is easily identified by its characteristic rotten egg smell which is highly repulsive.

2. It blackens a Silver coin. This is due to the formation of Silver sulphide.

3. It blackens a Lead acetate paper.

$$(CH_3-COO)_2Pb+H_2S \rightarrow PbS+2CH_3-COOH.$$

4. A piece of filter paper dipped in Ammonical Sodium Nitro - prusside solution is coloured violet on exposure to Hydrogen sulphide.

57. Explain how the following substances are made.

(1) Petromax mantles. (2) Lead pencils.
(3) Oil paints. (4) Chalk (Black board chalk)
(5) Ink. (6) Asbestos. (7) Electric Bulbs.
(8) Photo-flash bulbs.

(1) Petromax Mantle:—

The incandescent mantle is prepared by saturating a gauze made of artificial silk with solutions of Thoruim and Cerium nitrates in the required proportions, Then the organic matter of which the mantle is made is destroyed and the nitrates converted to the oxide by igniting the mantle. In this conditions the mantle is very fragile and to protect it from breaking before use, it is coated with an inflammable varnish which gets burnt off, when the mantle is left on the burner.

(2) Lead pencils:—

The name Lead pencil is a misnomer for there is no Lead in the pencil. This name is derived because it marks paper like lead. Lead pencils are generally made of a mixture of Graphite and Koalin. A higher percentage of Graphite makes the pencil soft and black where as a higher percentage of Kaolin makes it hard and less black.

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(3) Oil paints:—

The base for the oil paints is White Lead which is a basic carbonate of Lead: $2PbCO_3 \cdot Pb(OH)_2$. Pure white Lead is amorphous. This mixes readily and well with Linseed oil and has a good covering property. To make the paint quick drying boiled - Linseed oil is used. To give it various shades and colours, diffrent dyes are mixed.

(4) Black Board Chalk:—

This is made from Gypsum. Gypsum is heated to make it anhydrous; $CaSO_4$ is cast into sticks and dried. Coloured chalks are made by mixing various dyes with the material.

(5) Ink:—

The basic substances used in the manufacture of Ink are Tannic acid, Gallic acid and Ferrous sulphate. The Ferrous Tannate is oxidised by the atmospheric air. to Ferric Tannate which is black in colour If a blue colour like Methyl blue is added to the Ink it writes blue and on drying turns black. Thus this type of ink is called blue black Ink and is permanent. A small percentage of Carbolic acid is added to prevent mould forming in the ink. It can be made quick drying by adding a little alcohol (Methyl or Ethyl alcohol).

If only colouring matter, Carbolic acid and a little alcohol are added, we get a washable ink which is non - permanent·

(6) Asbestos: —

It is a mixture of Magnesium silicate and Calcium silicate It forms fibrous crystals which can be split into fine threads and pressed into paper and boards. The roofing Asbestos, is a mixture of Asbestos Cement and Sand. It is non inflammable and heat resistant.

(7) Electric Bulbs:—

Electric bulbs are made with Platinite leads, fused into glass which acts as the two terminals connecting the Tungston filament which is capable of withstanding high temperatures of the order of 3000°c and above

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Platinite itself is an alloy of Nickel and Steel containing about 40% Nickel. This gives the alloy a "co-efficent of expansion" similar to that of glass and so can be fitted into it without any difficulty.

The atmosphere in the bulb around the filament is inert and sometimes it is a vaccum. When inert gases like Argon or Neon are filled in the bulb the light becomes coloured. Sometimes bulbs are also filled with Nitrogen gas.

(8) **Photo flash bulbs:—**

Photoflash bulbs usually contain pieces of fine Magnesium wire and an oxiding agent like $KClO_3$ which supplies the required Oxygen for combustion of the Magnesium ribbon. Magnesium filament is preferred to any other metal because it emits a very shiny and brilliant light suitable for photography.

It must be noted that a Photoflash bulb cannot be used twice because the Magnesium ribbon gets burnt off when it is used once. This is the difference between a Photoflash bulb and an ordinary electric bulb.

How are safty matches made, and explain in what way they afford safty. In what way do they differ from the other matches.

Safty matches are tipped with a paste of Potassium chlorate, Potassium dichromate, Sulphur Iron oxide, Manganese di oxide Ground glass and Glue, *but no Phosphorus.* They are ignited by rubbing them on *specially prepared surfaces* on the sides of the box. The sides are coated with red Phosphorus, Antimony sulphide, powderd glass and Gum. The Phosphrous ignites the Sulphur on the head.

These matches are safe in the sense that they don't cause Phosphorus poisoning, as Phosphorus does not go into its composition. Besides they ignite only in specially prepared surfaces. "Strike anywhere" matches or friction matches are those which may be ignited by rubbing them on to a rough surface. They are tipped with a paste of Paraffin and a mixture of Tetra Phosphorus tri sulphide, Potassium chlorate or Manganese dioxide, oxide of Iron, ground glass and glue When the match is struck on a rough surface the local

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heat caused by friction ignites the combustible Phosphorus sulphide. They have a great disadvantage in that they get ignited when struck at any rough surface which is rather dangerous. Besides they cause Phosphorus poisoning unlike the safety matches, as Phosphours goes into its composition.

58. Two descriptions of the same chemical reaction are given in 1 and 2 below:

1. Steam over red hot Iron gives Ferreso-Ferric oxide and Hydrogen.
2. $3Fe + 4H_2O \rightleftharpoons Fe_3O_4 + 4H_2$

What additional information is supplied by (2) which is not fouud in (1)

The description of the chemical reaction between steam and red hot Iron given in (1) merely gives us an idea of the reactants and the products and the conditions under which they were kept during the reaction (i. e. water in the form of steam and iron in the red hot condition). They don't give us an idea of *what type of chemical reaction* it is. In (2) the $\rightleftharpoons$ mark indicates that the reaction between Iron and Steam is reversible. A reversible reaction is a chemical reaction in which the products formed may react under certain, altered conditions to form or give back the original reactants. Therefore this reactions includes a forward reaction and a backward reaction.

If Steam is passed over red hot Iron Magnetic Oxide of Iron or Ferreso-Ferric Oxide and Hydrogen will be formed according to the equation.

$$(1) \quad 3\,Fe + 4H_2O = Fe_3O_4 + 4H_2 \uparrow$$

If however Hydrogen is passed over Magnetic oxide of Iron the products formed will be Iron and Steam accordiug to the equation.

$$(2) \quad Fe_3O_4 + 4H_2 = 3Fe + 4H_2O$$

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Combining the equations (1) & (2) the above reaction can be represented as follows.

$$3Fe + 4H_2O \rightleftharpoons Fe_3O_4 + 4H_2.$$

This type of representation of the chemical reaction between Iron and Steam gives us the idea that both the reactants and the products are present in chemical equilibrium. So for the forward reaction to go to completion the hydrogen formed should be isolated from Iron oxide as soon as it is formed. To do it we can pass a current of steam in excess so as to sweep off the Hydrogen formed. Similarly, for the back-ward reaction to proceed (i.e. $Fe_3O_4 + 4H_2 = 3Fe + 4H_2O$) Hydrogen should be in excess.

If however the reaction were to be carried out in a closed vessel it would not go to completion. We will get only an equilibrium mixture of Iron, Iron oxide steam and Hydrogen represented by the equation.

$$3Fe + 4H_2O \rightleftharpoons Fe_3O_4 + 4H_2\uparrow$$

59. Certain properties of elements are used to classify them broadly as Metals and Non . metals.

Mention two chemical characteristics and one physical property of an element or its simple compounds which you would employ to classify a group of elements into Metals and Non - metals.

Certain properties of elements both physical and chemical are made use of to classify them broadly into Metals and Non-metals. For example, their nature, (solid liquid or gas) Metallic Lustre the sound they emit, their conductivity, malleability ductility reaction with acids, Specific gravity, their action with Hydrogen Oxygen and Chlorine are taken into cosideration when classifying them into Metals and Non - metals. It must be

always borne in mind that this type of classification is not rigid and it is always subject to alterations and variations. (In other words there are exceptions to this general rule of classification.)

We shall now choose 2 important chemical characteristics and one physical property to classify a group of elements into Metals and Non-metals.

1. The reaction of the element with acids.

Metals *generally* displace Hydrogen from mineral acids. Where as Non-metals do not do so,

For example $Zn + dil\ H_2SO_4 \rightarrow ZnSO_4 + H_2 \uparrow$

$$Cu + 2HNO_3 \rightarrow Cu(NO_3)_2 + H_2 \uparrow$$

There are a number of exceptions to this rule. For example Gold Silver and Platinum do not do so. But we can say 85 — 90% of the metals react with acids and liberate Hydrogen. So by taking into consideration this particular chemical property an element can be identified to be a Metal or a Non-metal.

2. Another chemical property which we can take into consideration for classification is the type of Oxides they form on combining with Oxygen. Metals generally form basic oxides. Basic oxides behave like bases and react with acids to produce water and salt. As examples we can take

$$CuO + H_2SO_4 \rightarrow CuSO_4 + H_2O$$
$$MgO + H_2SO_4 \rightarrow MgSO_4 + H_2O$$
$$MgO + 2HCl \rightarrow MgCl_2 + H_2O.$$

Non-metals produce Acidic oxides which are acidic in nature and they react with bases to produce salts. (Water is an exception to this rule). As examples we can take

Sulphur (S) $SO_2 + 2NaOH = Na_2SO_3 + H_2O$

Carbon (C) $CO_2 + 2NaOH = Na_2CO_3 + H_2O$

Sand (SiO_2) $SiO_2 + 2NaOH = Na_2SiO_3 + H_2O$

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So by a study of the nature of the oxides we can classify elements into Metals and Non-metals.

3. One physical property which we can make use of is *conductivity of heat and electricity.* Metals are generally good conductors of heat and electricity. That is why they are generally used in making wires and electrodes. Where as Non-metals are bad conductors of heat and electricity. That is why they are generally used as insulators.

By taking into consideration the above two chemical and one physical property elements can be easily classified into Metals and Non-metals.

60. Describe what you would observe when a small quantity of the following substances is heated in a test tube with a Bunsen flame.

(1) Ammonium chloride.

(2) Ferrous sulphate (Crystals) and Anhydrous $FeSO_4$.

(3) Zinc carbonate.

(4) Silver nitrate.

(5) Ammonium nitrate.

In each case, give equations, colour change if any, effect of gentle heat and strong heat.

(1) Ammonium chloride is a white crystalline solid When it is *gently heated* in a test tube it undergoes a process of sublimation giving fumes of Hydrogen chloride and Ammonia gas. It is a reversible reaction and if heated in closed vessel the decomposition will not proceed to completion. But if one of the gases is swept off the decomposition can effected to completion

$$NH_4Cl \rightleftharpoons NH_3 + HCl$$

NH_3 can be detected by its smell and it produces dense white fumes with Conc. HCl and turns red litmus blue showing that it is basic in nature. HCl is acidic and hence it turns blue litmus red. There is no characteristic colour change in this reaction.

(2) When *green* Ferrous sulphate crystals are heated in a test tube *strongly*, it first loses six molecules of water of

crystallisation. On further heating it decomposes into ***reddish brown*** Ferric **oxide, Sulphur** - di - oxide and **Sulphur - tri - oxide.** Reddish brown Ferric oxide remains in the test tube and the other gaseous products escape out.

$$FeSO_4 \cdot 7H_2O \rightarrow \underset{\text{Monohydrate}}{FeSO_4 \cdot H_2O} + 6H_2O$$

$$2FeSO_4 \cdot H_2O \rightarrow Fe_2O_3 + SO_2 + SO_3 + 2H_2O$$

When a *white* powder of *Anhydrous* Ferrous sulphate is heated it turns brown due to the formation of Ferric oxide. The other products are SO_2, SO_3 which escape out as gases.

$$2FeSO_4 \rightarrow Fe_2O_3 + SO_2 \uparrow + SO_3 \uparrow$$

(3) When white powder of Zinc **carbonate** is strongly heated a colourless gas evolves. A white powder remains in the test tube. The white powder is Zinc oxide and the gas produced is Carbon - di - oxide which turns lime water **milky**

$$ZnCO_3 \rightarrow ZnO + CO_2 \uparrow$$
$$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$$

On further heating the white powder, **it turns** yellow and on cooling turns white.

<u>This is a test for Zinc salts.</u>

(4) When white crystalline solid of Silver nitrate is strongly heated, brown fumes of Nitrogen peroxide are evolved with the formation of Ag_2O. On further heating Ag_2O it decomposes into metallic Silver and Oxygen. The Silver gets deposited on the cooler parts of the test tube as a mirror.

$$2AgNO_3 \rightarrow Ag_2O + 2NO_2 \uparrow$$
$$2Ag_2O \rightarrow 4Ag + O_2 \uparrow$$

(5) Ammonium nitrate is a colourless solid which when gently heated decomposes into N_2O and water.

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$$NH_4NO_3 \rightarrow N_2O + 2H_2O$$

There is no characteristic colour change in this reaction N_2O (Nitrous oxide or Laughing Gas) is also a colourless gas.

61. Give an account of the varieties of glasses given below giving special importance to their mode of preparation aud Components (composition).

(1) Soft Soda glass
(2) Potash (hard) Lime glass
(3) Common glass or Bottle glass
(4) Ground glass
(5) Crook's glass
(6) Pyrex glass

(1) Soft soda glass:—

Soda lime glass or Soda glass is a mixture of Sodium and Calcium silicate. As it is easily fusible it is called soft glass. It melts at a lower temperature and can be easily welded and blown. It is used in making Glass tubes, Plate glass and common glass ware.

(2) Potash Lime glass:—

It is a mixture of Potassium and Calcium silicates. As it fuses with difficulty, it is called Hard glass. It requires a higher temperature for melting. It is more resistant to water and acids than soft glass. It is used to make apparatus required to withstand a high temperature.

(3) Common Glass:—

It is made from cheap raw materials such as Sodium and Calcium silicates with varying amounts of Ferrous and Ferric silicates responsible for its green or brown tint. It melts at a higher temperature than soft glass and is readily attacked by water acids and alkalis. The goods made from common glass are found to contain free alkali. It is used for making cheap common phials and bottles.

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(4) Ground glass:—

It is soft glass, the surface of which have been ground with Emery powder and Water or Turpentine. It is also made by using HF Vapours.

(5) Crook's glass:—

It is a special type of Optical glass used in Lenses and spectacles and contains the Oxides of rare earths like Cerium. It cuts off Ultra violet rays detrimental to the eye.

(6) Pyrex glass;—

It is a mixture of Sodium, Aluminium and Boro - silicates containing an excess of Silica It is also extreamly resistant to reagents, heat and shock. Both Jena and Pyrex glasses have special formulae and highly purified ingredients are employed.

62. What test will you apply in the lab. to identify the libration of the following gases.

(1) **Carbon - di - oxide** (2) **Hydrogen sulphide**
(3) **Sulphur - di - oxide** (4) **Oxygen**
(5) **Hydrogen** (6) **Chlorine**

(1) To identify Carbon - di - oxide, the gas is led into a test tube containing lime water [$Ca(OH)_2$]. The carbon - di - oxide reacts with it and turns lime water milky. This is due to the precipitation of Calcium carbonate which is insoluble.

$$Ca(OH)_2 + CO_2 + \rightarrow CaCO_3 \downarrow + H_2O$$

If excess of carbon di - oxide is passed into the solution the milkyness disappears due to the formation of soluble bi-carbonate.

$$CaCO_3 + CO_2 + H_2O \rightarrow Ca(HCO_3)_2 \text{ (soluble)}$$

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If the solution is boiled Carbon - di - oxide is expelled off and the bicarbonate gets converted into the carbonate and gets precipitated again.

(2) Hydrogen sulphide turns Lead acetate paper black. Lead acetate paper is filter paper dipped in Lead acetate solution. The Lead acetate in the paper reacts with Hydrogen sulphide and forms Lead sulphide. Thus the paper gets blackened due to the formation of Lead sulphide.

$$(CH_3-COO)_2Pb + H_2S \rightarrow 2\,CH_3\cdot COOH + \underset{\text{black}}{PbS}$$

This is the reason why oil paintings which contain chiefly a basic carbonate of Lead blacken on exposure to air. The Hydrogen sulphide present in the air reacts with the Lead salt and produces Lead sulphide and thus the paintings blacken.

Hydrogen sulphide when led into a test tube containing reddish brown solution of Ferric chloride renders it almost colourless by reducing it to the ferrous state.

$$\underset{\text{(Reddish brown)}}{2\,FeCl_3} + H_2S \rightarrow \underset{\text{colourless}}{2\,FeCl_2} + 2\,HCl + S\downarrow$$

(3) Sulphur di - oxide turns acidified dichromate paper green due to the formation of Chromium sulphate. Dichromate paper is filter paper dipped in an acidified solution of Potassium dichromate.

$$K_2Cr_2O_7 + H_2SO_4 + 3\,SO_2 \rightarrow K_2SO_4 + \underset{\text{green}}{\underline{Cr_2(SO_4)_3}} + H_2O$$

Initially the dichromate paper will be orange in colour When exposed to the influence of Sulphur di - oxide Potassium. dichromate is reduced in the presence of an acid to green Chromic salt and thus the paper turns green. By this test Sulphur di oxide can be detected.

(4) Burning substances burn more brightly. 1. in oxygen; for example a burning Magnesium ribbon when introduced into a jar of Oxygen burns with extra brilliance. 2. Oxygen rekindles

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a glowing splinter. 3. When Oxygen is led into a tube containing Pyrogallic acid, the acid turns brown owing to the absorption of the gas. 4. If Nitric oxide is produced and mixed with oxygen reddish brown fumes of Nitrogen per oxide will be produced.

(5) Hydrogen can be detected by means of introducing a lighted taper into the gas when it will be put off with a 'Pop' sound.

Besides it burns in Oxygen with a pale blue flame producing water.

(6) Chlorine can be detected from its colour and its bleaching action. It is a greenish yellow gas with a characteristic pungent smell. Besides it bleaches moist petals, litmus and indigo. The bleaching action can be explained thus. Chlorine first reacts with water and forms a mixture of HCl and Hypo-chlorous acid The HClO (hypochlorous acid) being very unstable decomposes to HCl and nascent Oxygen. The oxygen liberated, being in a very active state (atomic or nascent state) bleaches the organic colouring matter and renders them colourless. Since the bleaching action is actually due to Oxygen, it is generally said that Chlorine bleaches by oxidation.

But this Oxygen has been released from Water by Chlorine Hence we arrive at the conclusion that Chlorine needs water or moisture for its bleaching action, This property can be made use of to detect the presence of the gas.

$H_2O + Cl_2 \rightarrow HCl + HClO$

$HClO \rightarrow HCl + [O]$ **nascent.**

$[O] +$ **coloured matter → colourless.**

63. **State Grahams Law of diffusion.**

The relative rates of diffusion of Chlorine and Ozone were found to be in the ratio of 0·227 : 0·271 The relative density of Chlorine is 35·5. What is the relative density of Ozone?

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The relative speeds of diffusion of gases are inversely proportional to the square roots of their relative densities. If V_1 and V_2 are the relative speeds of diffusion of two gases of densities d_1 and d_2 respectively, then according to the law.

$$\frac{V_1}{V_2} = \sqrt{\frac{d_2}{d_1}}$$

Problem

According to the law of gaseous diffusion

$$\frac{\text{Rate of diffusion of chlorine}}{\text{,, ,, ,, ,, ozone}} = \sqrt{\frac{\text{Density of Ozone}}{\text{,, Chlorine}}}$$

Substituting values for the above

$$\frac{0{\cdot}227}{0{\cdot}271} = \frac{\sqrt{D}}{\sqrt{35.5}}$$ where D = relative density of Ozone

$$\therefore \sqrt{D} = \frac{\sqrt{35{\cdot}5} \times 0{\cdot}227}{0{\cdot}271}$$

or $$D = \frac{35{\cdot}5 \times (0{\cdot}227)^2}{(0{\cdot}271)^2} = 24{\cdot}9$$

64. What part is played by manganese-di-oxide in the preparation of Oxygen from $KClO_3$. How will you prove experimentally that the weight of MnO_2 remains unchanged after the reaction.

Potassium chlorate alone gives off Oxygen *when strongly heated to high temperature.* The reaction takes place in two stages. At first when the temperature is lower, the chlorate is converted into the per chlorate which then decomposes into Chloride and Oxygen at a higher temperature.

$$(1)\quad 4KClO_3 \xrightarrow{380°C} KCl + 3KClO_4$$

$$(2)\quad KClO_4 \xrightarrow{620°C} KCl + 2O_2$$

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In both cases note the high temperatures to which the masses should be heated.

But by the addition of Manganese-di-oxide Oxygen is evolved at a *lower temperature* and at an *accelerated* rate, Manganese-di-Oxide is found to remain chemically unchanged at the end of the reaction. Hence it acts as a ***positive catalyst***.

$$KClO_3 + 2\,MnO_2 \rightarrow KCl + Mn_2O_7 \text{ (unstable)}$$
$$2\,Mn_2O_7 \rightarrow 4\,MnO_2 + 3\,O_2 \downarrow$$

It can be experimentally proved that the weight of MnO_2 remains unaffected in the reaction.

A weighed amount of Potassium-chlorate mixed with a known weight of MnO_2 is heated in a test tube till no more Oxygen is evolved. The melt is then cooled and extracted with water. After filtering and drying, the black residue, it is found to weigh exactly as the weight of MnO_2 taken initially. The experiment is repeated with different weights of $KClO_3$ and MnO_2 and in every case the weight of manganese-di-oxide after the experiment is found to be the *same as before* the experiment.

NOTE: The principle that is made use of in the experiment is that KCl is soluble in water (all K & Na salts are generally soluble in water) whereas MnO_2 is insoluble. This helps us to separate KCl from MnO_2.

65. Explain "**Hardness of water**".

How can you get rid of both temporary and permanent hardness?

What are the disadvantages of using hard water?

Hardness of water: Water is said to be hard when it does not yield a ready and permanent lather with soap. Hardness can be detected only with soap. The Bicarbonates, Chlorides and Sulphates of Calcium and Magnesium are the common substances conferring hardness on a sample of water.

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Soap is a Sodium or Potassium salt of a weak organic acid like Stearic acid. When it comes in contact with water it is immediately hydrolysed into Sodium hydroxide and the corresponding organic acid. The formation of Sodium hydroxide is signalled by the appearence of lather. If a cake of soap is rubbed to the water containing Calcium or Magnesium salts, double decomposition takes place between the soap and these salts resulting in the precipitation of the Calcium or Magnesium salt of the fatty acid.

$$\underset{\text{(Sodium stearate)}}{2C_{17}H_{35}-COO-Na} + CaCl_2 \rightarrow (C_{17}H_{35}-COO)_2Ca + 2NaCl$$

The precipitate appears as a white scum. It is only after all the calcium and magnesium salts are precipitated, the hydrolysis of salt takes place. Sodium hydroxide is liberated and the lather is formed. Thus it is seen that Calcium and Magnesium salts in a specimen of water delay lather formation with soap. It is evident that the amount of soap consumed by a sample of water for the formation of a permanent lather is a measure of its *degree* of *hardness*.

Removal of hardness:

Hardness is of two kinds: 1. Temporary hardness and 2. Permanent hardness.

Temporary hardness is that caused by the Bicarbonates of Calcium and Magnesium. It can be removed by boiling. Permanent hardness is due to the Chlorides and Sulphates of Calcium and Magnesium and it cannot be removed by boiling.

Removal of temporary hardness:

A sample of temporary hard water may be softened by boiling. On boiling the water, the soluble Calcium bicarbonate decomposes into water, carbon-di-oxide and insoluble Calcium carbonate.

$$Ca(HCO_3)_2 \rightarrow CaCO_3\downarrow + H_2O + CO_2\uparrow.$$

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The precipitated $CaCO_3$ can be filtered off and the filtered water is soft. This method of boiling cannot be employed in the case of temporary hard water containing Magnesium bicarbonate because magnesium carbonate formed is soluble in water.

Clark's process :

This is a very satisfactory method for the removal of temporary hardness. In this process the requisite amount of slaked lime [$Ca(OH)_2$] or lime water is added to the water. Calcium bicarbonate reacts with Calcium hydroxide and precipitate Calcium carbonate thus

$$Ca(HCO_3)_2 + Ca(OH)_2 \rightarrow 2\,CaCO_3 \downarrow + 2\,H_2O.$$

The Calcium carbonate is filtered off and the filtered water is soft. If Magnesium bicarbonate is present in the water, *enough* Calcium hydroxide is added to convert it to the sparingly soluble Magnesium hydroxide.

$$Mg(HCO_3)_2 + Ca(OH)_2 \rightarrow \underset{\text{Incompletely precipitated.}}{MgCO_3 \downarrow} + CaCO_3 \downarrow + 2\,H_2O.$$

$$MgCO_3 + Ca(OH)_2 \rightarrow Mg(OH)_2 \downarrow + CaCO_3 \downarrow .$$

Excess of slaked lime must be avoided since it will dissolve in water and introduce hardness. Permanent hardness is removed by adding Sodium carbonate (washing soda) to water. Double decomposition sets in and the Calcium and the Magnesium salts in solution are precipitated as carbonates.

$$CaCl_2 + Na_2CO_3 \rightarrow CaCO_3 \downarrow + 2\,NaCl$$

$$MgSO_4 + Na_2CO_3 \rightarrow MgCO_3 \downarrow + Na_2SO_4$$

Temporary as well as permanent hardness can be removed easily and effectively by the Permutit process. A tower is packed with alternate layers of gravel and permutit. (sodium aluminium silicate) The hard water is allowed to perculate through this tower. The permutit reacts with calcium and magnesium salts in the water thus

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$$CaSO_4 + \text{Sodium permutit} \rightarrow \text{Ca permutit} + Na_2SO_4$$

$$Mg(HCO_3)_2 + \text{Sodium permutit} \rightarrow \text{Mg permutit} + NaHCO$$

The Calcium and Magnesium permutit remains in the tower and the water collecting at the bottom of the tower is completely free from calcium and magnesium salts. It is therefore soft when the sodium permutit has been in use for sometime it loses its activity due to conversion into calcium and magnesium permutit. It is then said to be exhausted. It can be revivified by perculating a strong solution of common salt through it. The following changes leading up to the formation of sodium permutit takes place.

$$\text{Ca permutit} + NaCl \rightarrow \text{Na permutit} + CaCl_2$$

$$\text{Mg permutit} + NaCl \rightarrow \text{Na permutit} + MgCl_2$$

The Sodium permutit is washed with a little soft water to remove the calcium and magnesium salts. It can be used to soften more water. Thus with a limited amount of permutit large amount of hard water can be softened. This method is very cheap and it has the advantage that it can remove both kinds of hardness. Also no special filtering arrangments are needed. This is the most popular and the modern method.

Disadvantages of using hardwater:—

1. There is considerable wastage of soap, when hardwater is used for washing purposes. Some of the soap is consumed in the wasteful double decomposition before forms lather.

$$2(C_{17}H_{35}-COO-Na) + CaCl_2 \rightarrow (C_{17}H_{35}COO\cdot)_2Ca + 2NaCl$$

Sodium stearate

2. It is unfit for use in boilers. It induces the formation of boiler scales inside them. The Calcium sulphate in hard water is deposited on boiling the water. Besides the bicarbonates of calcium and magnesinm decompose into CO_2 water and the insoluble normal carbonates when water containing them is boiled.

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$$Ca(HCO_3)_2 \rightarrow CaCO_3 \downarrow + H_2O + CO_2 \uparrow$$

$$Mg(HCO_3)_2 \rightarrow MgCO_3 \downarrow + H_2O + CO_2 \uparrow$$

These insoluble carbonates form part of the boiler scales which entail a considerable wastage of fuel. On account of this boiler explosions take place most unexpectedly. Besides the Calcium chloride ($CaCl_2$) undergoes hydrolysis, when boiled producing a corrossive acid, hydrochloric acid which corrodes the boiler.

3. In dyeing industries as well as in dairies hardwater cannot be used. Hard water tends to change the colour of dyes by reacting with them.

66. What is a Candle flame: Describe the structure of a Candle flame. What are products of a burning Candle:

The Candle flame is produced by the Combustion of hydrocarbons present in the candle. When lighted the solid wax melts down into a flind and is sucked up by the wick by capillary rise and is converted into vapour which when sufficiently heated catches fire and continues to burn.

The Candle flame is found to consist of the following zone.

1. **The dark central zone 'a'** of unburnt and partly decomposed gases or vapours, surrounding the wick or issuing out of the burner jet, the zone of no combustion.

2. **The Luminous zone 'b'** appears yellow or brightly luminous and occupies most of the flame. The gases from the lower zone are partially decomposed and oxidised forming free carbon, CO, CO_2 and water vapour.

3. **The bright blue zone 'c'** at the base.

4. **The faintly luminous outer zone 'd'** surrounding the entire flame is the zone of complete combustion. The air supply being in excess. All CO, H_2 and free carbon from lower zones are completely oxidised producing the maximum amount of heat. So this outer most non-luminous flame is the hottest part of the flame.

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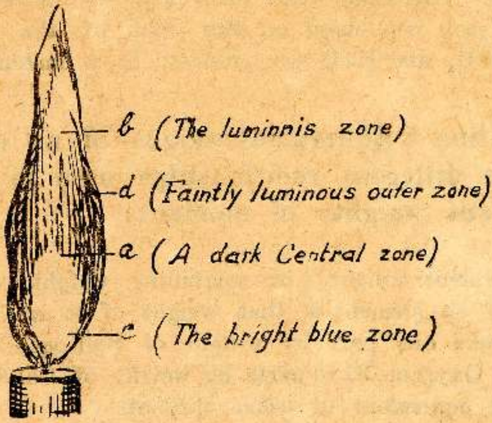
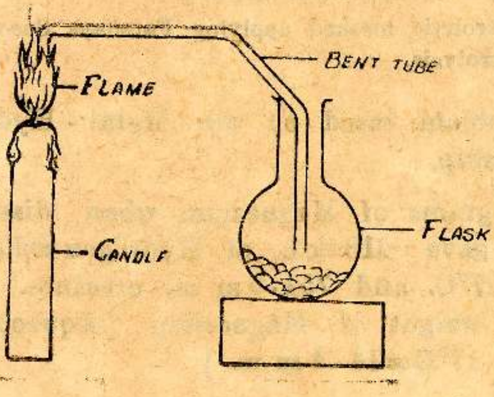
A Candle Flame



The products of a burning candle are (1) Vapour of wax (2) Particles of free carbon (3) CO_2 (4) and water. These may be shown by the following experiment.

A candle is lighted and the shorter end of a twice bent glass tube is held just above the wick while the longer end is led into a flask. White vapours of wax issuing out condence in the flask. The shorter limb is again held in the Luminous part of the flame. Particles of carbon issue out in the form of a dense smoke and are deposited in the flask.

Products of combustion of a burning candle



A clean flask with a little clear lime water is taken and the shorter end of the tube is held above the top of the Luminous zone. The Lime water turns milky and minute particiles of water are seen condensed on the wall of the flask thus proving that CO_2 and H_2O are produced by a burning candle.

67. Define "Equivalent weight of an element". Mention the different relationships used to calculate the equivalent weights of elements.

The Equivalent weight (or combining weight or chemical equivalent) of an element is that weight of it which combines with or displaces one part by weight of Hydrogen, eight parts by weight of Oxygen, 35·5 parts by weight of Chlorine or any other chemical equivalent of other elements

The different relationships used to calculate that equivalent weights of elements are:

1. Metal — Hydrogen relationship
2. Metal — Oxygen „ „
3. Metal — Chlorine „ „
4. Displacement of Metals by one another.

   (An element occupying a higher position in the electro-chemical series will displace one occupying a lower position)
5. Double decomposition method.
6. Electrolytic method applying Faradays Second Law of Electrolysis.

I. A Problem based on the Metal - Hydrogen relationship.

0·218 grams of Magnesium when dissolved in HCl acid gave 218·2c.c. of Hydrogen collected over water at 17°C. and 754·5 m.m. pressure. Find the equivalent weight of Magnesium [Aqueous vapour tension at 17°C = 14·4 m.m.]

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The volume of Hydrogen evolved $= 218 \cdot 2$ c.c.
Temperature $= 17°C.$
Pressure $= 754 \cdot 5$ m.m.
Aqueous tension at 17°C. $= 14 \cdot 4$ m.m.
∴ actual pressure $= 754 \cdot 5 - 14 \cdot 4$ m.m.
$= 740 \cdot 1$ m.m.

Let V_0 be the volume of Hydrogen at N. T. P.

Then by applying the gas laws $\frac{P_0 V_0}{T_0} = \frac{P_1 V_1}{T_1}$

We have $\frac{V_0 \times 760}{273} = \frac{218 \cdot 2 \times 740 \cdot 1}{(17 + 273)}$

$$\therefore V_0 = \frac{218 \cdot 2 \times 740 \cdot 1 \times 273}{760 \times 290}$$

$$= 200 \text{ c.c.}$$

1 c.c. of Hydrogen weighs $= \cdot 000089$ grams
∴ Weight of 200 cc. " $= 200 \times \cdot 000089$ grams
$= \cdot 0178$

Hence $\cdot 0178$ grams of Hydrogen is displaced by $0 \cdot 218$ grams of Magnesium.

∴ Equivalent weight of

$$\text{Magnesium} = \frac{\cdot 218}{\cdot 0178} \times 1$$

$$= 12 \cdot 24.$$

III. (a) Problem based on Metal - Oxygen relationship

$0 \cdot 399$ grams of Copper on Oxidation gave $0 \cdot 5$ grams of CuO. Calculate the equivalent weight of Copper.

The weight of Oxygen that combined with $0 \cdot 399$ grams of Copper $= (0 \cdot 5 - \cdot 399)$ grams
$= 0 \cdot 101$ grams

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0.101 grams of Oxygen combines with 0·399 grams of Copper

$\therefore$ 8 gms of O_2 will combine with $\frac{0{\cdot}399 \times 8}{0 \cdot 101}$

$= 31 \cdot 6$ grams of Copper.

$\therefore$ The equivalent weight of Copper is 31·6.

(b) Problem based on Metal chloride relationship.

0·2732 grams of a metal when reacted upon by HCl acid produced 0·3632 grams of dry Chloride. Calculate the chemical equivalent of the metal

Weight of the Metal = 0·2732 gms.
Weight of the Chloride = 0·3632 gms.
$\therefore$ the weight of the Chloride that has combined with 0·2732gms. of the Metal = ·3632 – ·2732
= ·0900 gms.

$\therefore$ The equivalent weight of the metal $= \frac{\cdot 2732}{\cdot 09} \times 35 \cdot 5$

$= 107 \cdot 76.$

IV. Problem based on displacement method.

3·78 grams of a metal A displaced 4·32 grams of another metal B from its salt solution. If the equivalent weight of metal B is 32. What is the equivalent weight of A.

Let X be the equivalent weight of metal A.

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Applying the law

$$\frac{\text{Weight of Metal A used}}{\text{Weight of Metal B displaced}} = \frac{\text{Eq. wt. of A}}{\text{Eq. wt. of B}}$$

Substituting values for this

$$\frac{3 \cdot 78}{4 \cdot 32} = \frac{X}{32}$$

$$\therefore X = \frac{3 \cdot 78 \times 32}{4 \cdot 32} = 28$$

∴ The Equivalent weight of metal A = 28.

V. Problem based on Electrolytic method

For this the second law of Faraday (Electrolysis) is applied The law states that when the *same current is passed* through different electrolytes for the *same time or period*, the masses of elements liberated at their respective electrodes are proportional to their chemical equivalents

Problem

When an electric current is passed between platinum electrodes through solutions of Copper Sulphate and dilute H_2SO_4, 0·25 grams of Copper is deposited in the first cell. Calculate the volume of Hydrogen measured at 27°C and 760 m.m. pressure which is liberated from the second solution of dil H_2SO_4.

Let the weight of Hydrogen liberated be equal to **W** grams. According to the Second law of Faraday.

$$\frac{\text{Weight of Copper deposited}}{\text{Weight of Hydrogen liberated}} = \frac{\text{Eq. wt. of Copper}}{\text{Eq. wt. of Hydrogen}}$$

Applying values for this

$$\frac{0 \cdot 25}{W} = \frac{31 \cdot 75}{1}$$

$$W = \frac{\cdot 25 \times 1}{31 \cdot 75} = 0 \cdot 007 \text{ grams}$$

2 grams of Hydrogen occupies 22 · 4 litres at N. T. P.

∴ ·007 grams of Hydrogen occupy

$$\frac{22 \cdot 4}{2} \times 0 \cdot 007$$

$$= \cdot 0784 \text{ litres at N. T. P.}$$
$$= 78 \cdot 4 \text{ cc. at N. T. P.}$$

To find the volume of Hydrogen at 27°c and 760 mm. pressure the gas laws are applied *i.e.* $\frac{P_0 V_0}{T_0} = \frac{P_1 V_1}{T_1}$

Let the Volume at 27°C and 760 mm. pressure be X cc.

$P_0 = 760$ mm. $V_0 = 78 \cdot 4$ cc. $T_0 = 273°A$

$P_1 = 760$,, ,, $V_2 = X$ $T_1 = 300°A$

$$\textit{i.e.} \quad \frac{760 \times 78 \cdot 4}{273} = \frac{760 \times X}{300}$$

$$\therefore X = \frac{760 \times 300 \times 78 \cdot 4}{760 \times 273} = 86 \cdot 15 \text{ cc.}$$

∴ The volume of Hydrogen evolved when 0 · 25 grams of Copper deposited is 86 · 15 cc.

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68. **How will you distinguish the following classes of Compounds?**

1. **Ferrous and Ferric salts**
2. **Nitrous oxide and Oxygen**
3. **Nitrites and Nitrates**
4. **Carbonates and bicarbonates**
5. **Yellow and Red Phosphorus**

(I) The differences between Ferrous and Ferric salts:

EXPERIMENTS OR TESTS	FERROUS	FERRIC
1. General properties	Anhydrous salts are colourless. Hydrated salts green, oxidise, into ferric state by HNO_3 · Cl_2, H_2O_2 and $KMnO_4$.	Anhydrous salts are COLOURED. While the hydrated salts are yellow, brown, or red. Reduced to ferrous state by H_2S, SO_2 $SnCl_2$ and nascent H_2,
2. Added NH_4OH, KOH or NaOH.	Green precipitate of $Fe(OH)_2$, it is white in absence of air.	Reddish brown precipitate of $Fe(OH)_3$.
3. Added $K_3Fe(Cn)_6$ (Potassium Ferri cyanide.)	Light blue precipitate.	Dark blue precipitate The blue colour produced is called Prussian Blue.
4. Added ammonium sulpho-cyanide $(NH_4)CNS$.		A blood red colouration is produced.

(2) The differences between Nitrous Oxide and Oxygen

EXPTS. OR TESTS	NITROUS OXIDE	OXYGEN
1. Smell	Characteristic faint sweet smell	Odourless.
2. Solubility in cold water	Readily soluble	Sparingly soluble
3. Solubility in Alcohol	More soluble than Oxygen	Moderately soluble
4. Mixed with Nitric oxide	No change in colour	Brown fumes of NO_2.
5. Treated with alkaline pyrogallate solution	Not absorbed	Readily absorbed to give a dark brown solution.
6. Treated with Ammonical Cuprous Chloride solution.	Not absorbed	Readily absorbed to form a deep blue solution.
7. Burning a piece of phosphorus in a confined volume of the gas.	Residual Nitrogen is left; equal in volume to that of N_2O taken.	Oxygen almost completely combines leaving only very little or no residual gas.

(3) Difference between Nitrites and Nitrates

TESTS & REAGENTS	NITRITES	NITRATES
1. Action of heat	In the case of Na and K we get the Nitrites only. (remain unchanged)	Nitrates of K and Na decompose into the Nitrites. $2KNO_3 = 2NO_2 + O$ Nitrates other than K and Na give oxides. NO_2 and O_2 $2Pb(NO_3)_2 \longrightarrow 2PbO + 4NO_2 + O_2$ $Hg(NO_3)_2 \longrightarrow Hg + 2NO_2 + O_2$
2. Con. H_2SO_4 added and warmed.	No red fumes.	Reddish fumes produced NO_2.
3. Dil HCl added and warmed.	Brown fumes.	No brown fumes
4. Dil HCl and $KMnO_4$ added (and warmed if necessary)	Pink colour gradually fades away. $KMnO_4$ decolourised.	Pink colour of $KMnO_4$ is not decolorized.
5. Con. Sulpuric acid + Brucine added.	No colouration.	Red colour.
6. Acetic acid, KI solution and starch added.	Blue colour	No colouration
7. Brown ring test :— HNO_3, $FeSO_4$ and Con. H_2SO_4 (in drops)	The solution turns Brown.	Brown ring at the junction. (1) $3H_2SO_4 + 6FeSO_4 + 2HNO_3 = 3Fe_2(SO_4)_3 + 2NO + 4H_2O$. (2) $FeSO_4 + NO = FeSO_4 \cdot NO$ (Brown ring)

(4) **The differences between Carbonates and bicarbonates**

TEST	CARBONATES	BICARBONATES
1. Any dilute acid	Efferversence due to the liberation of CO_2.	Same.
2. Action of heat	Carbonates except carbonates of Na and K decompose on heating to the normal oxide and CO_2	The bicarbonates of K and Na decompose into the normal carbonate and Carbon-di-oxide, They don't decompose further. The other bicarbonates decompose first to the normal carbonate and then to the oxide with the evolution of CO_2
3. With $MgSO_4$ or $MgCl_2$.	An immediate precipitate in the cold.	A precipitate is got only on warming
4. With Mercuric chloride.	A Reddish precipitate is got.	No precipitate
5. Solubility in water.	Carbonates except carbonates of Na and K are insoluble.	Generally soluble

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(5) **Difference between Yellow and Red Phosphorus**

PROPERTIES	YELLOW PHOSPHORUS	RED PHOSPHORUS
1. Colour	Almost colourless *or* slight yellowish tinge	Violet red
2. Smell	Garlic smell	No characteristic smell
3. Specific gravity	1·8 (lighter)	2·2 (heavier)
4. Melting point	44°C (lower M. Pt.)	500—600°C (higher M. Pt.)
5. Solubility in water	Almost insoluble	insoluble
6. ,, ,, CS_2	Easily and readily soluble	insoluble
7. Temperature of ignition.	30°C	250°C
8. Action of air at ordinary temp.	Oxidation with phosphorescence or glow	No oxidation and no phosphorescence or glow.
9. Action of hot alkalis like KOH or NaOH solutions	Reaction takes place with the evolution of Phosphene PH_3	No action at all
10. Action of Cl_2	Spontaneous combustion	Ignites on heating
11. Physiological effect	Highly poisonous causing a disease called Phossy-Jaws	Non-poisonous

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(6) Distinguish between Cast Iron, Steel and Wrougt Iron

PROPERTIES	CAST IRON	STEEL	WROUGHT IRON
1. Carbon content	2—2·5%.	0·5 — 1·5%	·12—·25%
2. Impurities	Maximum impurities	Intermediate impurity	Purest
3. Melting point	1200°C	1300°—1400°C	1500°C (purest)
4. Hardness	Hard	Moderate	Hard
5. Malleability	Brittle	Malleable and Brittle	Malleable
6. Appearance	Crystalline	Crystalline	Fibrous
7. Tempering	Cannot be tempered	Cannot be tempered	Cannot be tempered
8. Magnetisation	Cannot be permanently magnetised	Can be permanently magnetised	Cannot be permanently magnetised
9. Forging and Welding	Cannot be forged or welded	Can be welded or forged with difficulty	Can be forged or welded
10. USES	1. Casting 2. Manufacture of steel & wrought Iron	1. Cutlery 2. Surgical instruments 3. Armour plates 4. Rails 5. Locomotives 6. War & agricultural implements 7. Tools for cutting magnets and springs	1. Cores of electro-magnets 2. Chains 3. Wires 4. Wire-netting 5. Used by black smiths

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69. What are Oxy-gas flames? Discuss the uses and applications of Oxy-gas flames.

Oxy-gas flames are intensely hot flames **produced by the** complete **combustion** of combustible gases such as Hydrogen, Acetylene, Coal gas, Carbon monoxide etc. Blow pipe jets made of heat resisting alloys, in the form of concentric tubes or **Y** tubes are used. In the former H_2 from the reservoir passes through the outer tube and Oxygen is supplied through the inner tube. In the latter, two limbs are connected to Hydrogen and Oxygen supply respectively. Hydrogen is opened first and allowed to escape for some time. It is then ignited and Oxygen is opened later. Both the gases are supplied under pressure and different forms of blow-pipes are used for different purposes.

Uses and applications of the Oxy-gas flames.

(1) Welding, cutting and melting of metals.

In welding, two pieces of the same metal are melted by the flame and joined by pressure. But in soldering, the two pieces are joined by a solder - an alloy of lower melting point.

By using a narrow and pointed flame, thick metal plates can be clearly and rapidly cut. Quarts and platinum are melted from which various chemical wares are made.

(2) Lime — Light

When an Oxy-gas flame impinges upon a stick of quick lime (CaO) it becomes incandescent without melting and emits an intensely bright white light known as lime - light, calcium light or Drummond's light. It is used in search - lights and projection apparatus (Bioscopes, Magic lanterns).

70. The carbonates of Lead, Sodium, Copper and Magnesium were heated over a bunsen flame to constant weight. The heating was continued and dry Hydrogen was passed over the heated residues. Two of these carbonates behaved similarly. Select the other two and describe fully their behaviour?

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Mention two other carbonates which behave like the two you have selected?

Among the different Carbonates mentioned above, Lead and Copper carbonates behave similarly. The other two carbonates are Sodium carbonate and Magnesium carbonate which behave differently. The carbonates of Lead and Copper decompose first into their oxides and CO_2. The oxides are further reduced to the metal.

(1) $PbCO_3 \rightarrow PbO + CO_2 \uparrow$.

$PbO + H_2 \rightarrow Pb + H_2O$.

(2) $CuCO_3 \rightarrow CuO + CO_2 \uparrow$.

$CuO + H_2 \rightarrow Cu + H_2O$.

Sodium carbonate is not decomposed by heat. A similar example is (K_2CO_3) Potasium carbonate. Magnesium carbonate is decomposed to the Oxide and CO_2 by heat but the Magnesium oxide is not reduced by H_2 to the metal; a similar example is Zinc carbonate.

II. Explain why?

(a) **Sulphuric acid and not Hydro-chloric acid is used in the preparation of HNO_3 from $NaNO_3$.**

(b) **HCl and not HNO_3 is used in the preparation of H_2S.**

(c) **Dil H_2SO_4 and not Con. H_2SO_4 is used in the preparation of Hydrogen.**

(d) **For obtaining O_2 by electrolysis of acidulated water, H_2SO_4 and not HCl is used.**

(a) Sulphuric acid and not HCl acid is used in the preparation of HNO_3 from $NaNO_3$ because of the 3 acids, H_2SO_4 has the highest boiling point. The boiling points of the other two acids are nearly the same since HNO_3 is much more volatile than H_2SO_4 It can be easily displaced from Nitrates by H_2SO_4. HCl acid also cannot be used to prepare HNO_3 from Nitrates as HCl has a boiling point slightly less than that of HNO_3.

(b) Dilute HCl and not HNO_3 is used in the preparation of H_2S from Ferrous sulphide because, HNO_3 as we know is a good oxidiser and H_2S is a powerful reducer. They both react and HNO_3 gets reduced to NO_2, Sulphur and water according to the equation

$$2HNO_3 + H_2S \rightarrow 2H_2O + 2NO_2 + S.$$

Hence HCl is used to prepare H_2S from FeS.

(c) Dilute H_2SO_4 and not Con. H_2SO_4 is used in the preparation of H_2 from metals like Zinc and Iron because if Con. H_2SO_4 is used reduction takes place and Sulphur-di-oxide is evolved instead of H_2 according to the following equation

$$Zn + 2H_2SO_4 \rightarrow ZnSO_4 + 2H_2O + SO_2.$$

Hence Dilute H_2SO_4 is used to prepare H_2 from metals such as Zinc and Iron.

(d) Usually, in order to prepare O_2 by electrolysing water, we acidify the water with dil. H_2SO_4 and not with HCl acid because if H_2SO_4 is used the anode or the positive electrode attracts the negatively charged OH^- & $\overline{SO_4}$ Ions The OH^- Ions gets discharged.

$$OH^- + OH^- \rightarrow H_2O + O$$
$$O + O \rightarrow O_2$$

and Oxygen is evolved.

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If HCl acid is used the anode attracts.

$$HCl \rightarrow \overset{+}{H} + \overset{-}{Cl}$$

the negatively charged Cl^- Ions & the OH^- Ions. Though OH^- Ions gets preferentially discharged. Yet a few Chlorine Ions also get discharged and the Oxygen thus gets contaminated with traces of Cl_2 nd thus it becomes impure. So to get a pure sample of O_2, free from chlorine dil. H_2SO_4 is used to acidify water to electrolyse it to get O_2.

71. You are given unlabelled bottles containing the following substances

Some of these are easily identified by a direct observation of their appearance. State which of these substances you could so identify. How will you confirm your identifications applying simple tests? How will you identify rest?

(1) ZNO (2) PbO_2 (3) CaO (4) Fe_2O_3 (5) CuO

Out of the different classes of Oxides mentioned above there are only 2 white substances namely ZnO & CaO. But ZnO is white powdery whereas CaO exists as lumps. If dil. HCl is added to ZnO it disolves in that to form $ZnCl_2$.

$$ZnO + 2HCl \rightarrow ZnCl_2 + H_2O$$

Besides ZnO as we know is an amphoteric Oxide (having both acidic and basic properties) reacts with both an Acid and a Base

$$ZnO + 2NaOH \rightarrow Na_2ZnO_2 + H_2O$$

ZnO dissolves in dil. HCl to form $ZnCl_2$. When NaOH is added to the $ZnCl_2$ solution a white precipitate is formed which redissolves in excess.

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$$ZnO + 2HCl \rightarrow ZnCl_2 + H_2O$$
$$ZnCl_2 + 2NaOH \rightarrow Zn(OH)_2 \downarrow + 2NaCl.$$
$$Zn(OH)_2 + 2NaOH \rightarrow Na_2ZnO_2 + 2H_2O$$

CaO is white in colour and is found as lumps. If water is sprinkled on it, it crumbles to a paste with production of steam accompanied by a hissing noise.

$$CaO + H_2O \rightarrow Ca(OH)_2$$

This is called slaked lime. $Ca(OH)_2$ is a base.

CuO is a black powder. It reacts with dil. H_2SO_4 to give a blue solution of $CuSO_4$. If Ammonium Hydroxide is added to the above solution a pale blue precipitate is got which redissolves in excess. The reactions involved can be represented thus:

$$CuO + H_2SO_4 \rightarrow CuSO_4 + H_2O$$
$$CuSO_4 + 2NH_4OH \rightarrow Cu(OH)_2 \downarrow + (NH_4)_2SO_4$$
$$Cu(OH)_2 + NH_4OH \rightarrow \text{a deep blue solution is produced.}$$

Lead per oxide is a chocolate brown powder and it resembles Fe_2O_3 which is also a brown powder. To distinguish them the chocolate brown powder is warmed with Con. HCl when Cl_2, a greenish Yellow gas is evolved which bleaches moist petals. Then it is confirmed to be PbO_2.

$$PbO_2 + 4HCl \rightarrow PbCl_2 + Cl_2 + 2H_2O$$

If Cl_2 is not produced a reddish orange coloured solution of $FeCl_3$ is produced to which when NaOH is added a reddish brown precipitate of $Fe(OH)_3$ is got.

$$Fe_2O_3 + 6HCl \rightarrow 2FeCl_3 + 3H_2O$$
$$FeCl_3 + 3NaOH \rightarrow 3NaCl + Fe(OH)_3 \downarrow$$

Thus by the above 2 tests the two brown powders can be identified and labelled.

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72. A bright piece of a metal was placed in the solution as indicated below.

1. Iron in Copper sulphate.
2. Copper in Magnesium sulphate.
3. Zinc in Copper sulphate.
4. Iron in Silver Nitrate.

All the pieces of metal appeared to behave in similar fashion except one. Explain this and identify the metal.

To answer this question one must have a knowledge of the electro-chemical series — at least the position of the most important elements in the series. The general rule is that an element occupying a higher position in the electro chemical series can displace another one found below from its salt solution. Accordingly

1. Iron can displace Copper from Copper sulphate.
2. Zinc can displace Copper from $CuSO_4$
3. Iron can displace silver from $AgNO_3$

But in the case of the 2nd one Copper is found in a lower position then Magnesium hence it cannot displace Magnesium from $MgSO_4$

$$CuSO_4 + Fe \rightarrow FeSO_4 + Cu$$
$$Zn + CuSO_4 \rightarrow ZnSO_4 + Cu$$
$$Fe + 2AgNO_3 \rightarrow He(NO_3)_2 + 2Ag.$$

73. **Describe what happens**

(a) **When Copper sulphate crystals are heated?**

(b) **When Sodium hydroxide is added to a solution of Copper sulphate.**

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(c) Ammonium Hydroxide is added a little at a time to it.

(d) Hydrogen sulphide is passed.

(a) Blue crystalline Copper sulphate has the formula $CuSO_4 \cdot 5H_2O$ when these crystals are heated they loose the water of crystallisation and crumbles down into a white powdery substance called anhydrous Copper sulphate of the composition $CuSO_4$.

$$CuSO_4 \cdot 5H_2O \xrightarrow{heat} CuSO_4 + 5H_2O$$

If the anhydrous salt is heated beyond 750°C it decomposes further into CuO, SO_2 and O_2 according to the equation.

$$2CuSO_4 \rightarrow 2CuO + 2SO_2 \uparrow + O_2 \uparrow$$

(b) If a solution of NaOH is added to blue Copper sulphate solution double decomposition takes place with the precipitation of pale blue $Cu(OH)_2$

$$CuSO_4 + 2NaOH \rightarrow Na_2SO_4 + Cu(OH)_2 \downarrow \text{ pale blue}$$

(c) If Ammonium Hydroxide is added little by little to a solution of $CuSO_4$, first a light blue precipitate of $Cu(OH)_2$ is formed which gradually redissolves in excess of Ammonium Hydroxide to form a deep blue solution of Cuprammonium sulphate of the composition $Cu(NH_3)_4SO_4$.

(d) If H_2S gas is passed into a blue solution of $CuSO_4$ a brownish black precipitate of CuS will be precipitated with the formation of H_2SO_4.

$$CuSO_4 + H_2S \rightarrow CuS \downarrow + H_2SO_4$$

74. Describe the precautions that must be taken to prepare H_2O_2 in the lab. The label on a bottle of H_2O_2 has the words "20 volumes" written on it What do you understand by this statement? How will you determine the strength of a solution of H_2O_2 in the lab.

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H_2O_2 is prepared in the lab. by the action of dilute Sulphuric acid on Barium peroxide

$$BaO_2 + H_2SO_4 \text{ (dilute)} \rightarrow BaSO_4 + H_2O_2 .$$

The reaction is exothermic and much heat is produced which is likely to decompose the unstable H_2O_2. So dilute Sulphuric acid (10% solution) is taken in a beaker and it is first kept immersed in a freezing mixture. Hydrated BaO_2 is taken and it is made into a thin paste with water. It is then added little by little to the well cooled acid with constant stirring with a glass rod. Care is taken to see that the resulting solution remains slightly acidic. [As the presence of excess of BaO_2 is likely to decompose the H_2O_2 formed. If needed the excess of acid can be neutralized by the addition of a few drops of $Ba(OH)_2$. Then the solution of H_2O_2 will be neutral.]

It is then allowed to settle and the clear solution of H_2O_2 is filtered off.

If a bottle containing H^2O_2 is labelled as "20 volume solution' it means that 1 c.c. of the solution of H_2O_2 on being *completely decomposed* yields 20c.c. of Oxygen at normal temperature and pressure.

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

The strength of a solution of H_2O_2 can be determined in the laboratory qualitatively by titrating the H_2O_2 solution against a standard solution of $KMnO_4$.

A known volume of the given H_2O_2, say (25 c.c.) solution is taken in a clean dry conical flask and it is acidified with dil. H_2SO_4 and titrated against $KMnO_4$ solution taken in the burette. The end point is the appearance of a permanent light pink colour in the solution.

$$2KMnO_4 + 3H_2SO_4 + 5H_2O_2 \rightarrow K_2SO_4 + 2MnSO_4 + 8H_2O + 5O_2$$

$\therefore$ $2KMnO_4$ (10 equivalents of O_2) $= 5H_2O_2$

$\therefore$ 10 litres of normal $KMnO_4 = 5 \times 34$ gms of H_2O_2

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If X c.c. of N/10 $KMnO_4$ were required, the weight of H_2O_2 it neutralises is

$$= 5 \times 34 \times \frac{X}{10{,}000} \times \frac{1}{10} \text{ grams}$$

This weight is present in 25 c c. of H_2O_2

∴ Number of grams per litre

$$= 5 \times 34 \times \frac{X}{10{,}000} \times \frac{1}{10} \times \frac{1000}{25}$$

75. What is a Catalyst?

Mention the Characteristics of a catalyst?

What Catalysts are used in the manufacturing process of (i) NH_3 (ii) H_2SO_4

A Catalyst is a substance which is added to a chemical reaction either to accelerate or retard the speed of it. It is usually added in small quantities. It does not chemically react with the reactants or the products. It remains unchanged both in composition and weight at the end of the reaction. It does not affect the chemical equilibriums in reversible reactions, as it influences the forward and the backward reactions equally. A Catalyst that accelerates the speed of a chemical reaction is called a positive Catalyst. and the one that retards the speed is called a Negative Catalyst.

eg:— (i) MnO_2 used in the preparation of O_2 from $KClO_3$ is a positive Catalyst.

(ii) H_2SO_4 or Glycerine used to prevent the decomposition of H_2O_2 is a Negative Catalyst.

The Catalyst that is used in the preparation of NH_3 is finely divided Iron containing traces of Molybdenum as promoter (a promoter is a substance that is used to activate a Catalyst) The Catalyst used in the manufacture of H_2SO_4 is Platinised Asbestos, or Vanadium pentoxide.

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76. What are the principal substances used in the making of the following:—

1. Ordinary Brass. 2. Cigarette packet foil.
3. Lime mortar. 4. Water glass. 5. Mild Steel
6. Super phosphate. 7. Solder. 8. Battery Acid.
9. Torch Batteries.

1. Ordinary Brass —— Copper, Zinc.
2. Cigarette packet foil —— Tin
3. Lime Mortar —— $Ca(OH)_2$ & SiO_2.
4. Water glass —— Na_2SiO_3.
5. Mild steel —— Iron, traces of carbon
6. Super Phosphate —— $CaSO_4$ and $Ca_3(PO_4)_2$
7. Solder —— Lead & Tin
8. Battery acid —— H_2SO_4
9. Torch Batteries —— Carbon & Zinc

77. A clean piece of Iron wire is kept,

(1) exposed to air.
(2) in a tightly corked bottle filled with freshly boiled distilled water.
(3) Inside a desiccator over quick-lime

Explain the changes that the Iron wire undergoes in each case. What conclusions do you draw from these Observations.

If an Iron wire is kept exposed to air it rusts in the presence of moisture (present in air) and O_2 to form Iron oxide according to the equatian.

$$4Fe + 3O_2 \rightarrow 2Fe_2O_3$$

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If it is kept inside an air tight bottle containing freshly boiled distilled water, it will not rust as there is no oxygen or air in the freshly boiled distilled water. All the dissolved gases have been driven off during boiling.

Again if the wire is kept inside a desiccator containing Quick lime (CaO) it will not rust because there is no moisture. All the water vapour found inside the desiccator has been absorbed by the Quick lime as such the iron wire will not rust.

The conclusions that can be drawn from these above observations are that Iron will not rust in the presence of water alone or air alone. Both air and water are necessary for the Iron to rust.

78. What is Allotropy? Give an account of the different allotropes of Carbon?

Allotrophy is a property shown by some elements especially Non-metals like Carbon Phosphorus and Sulphur. By virtue of this property these elements exist in different forms with different physical and often chemical properties. This property is accounted for by variations in the number and arrangements of atoms within the molecule. The different allotropes of an element are interconvertable and they all contain the same basic element.

Carbon exhibits allotropy. It exists in different forms. Both crystalline and amorphous varieties of Carbon are found. The two chief crystalline varieties are Diamond and Graphite and the Amorphous forms are, Charcoal, Lamp black, Coal, Coke and Gas carbon.

Diamond:

It is the densest form of Carbon and has a refractive index of 2·417. It is the hardest substance known and it is this property combined with its brilliance that make it so valuable a gem. It is very stable, not attacked by acids and alkalis. When heated to high temperatures in air or oxygen (700°—930°)

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it gets oxidised to CO_2. This can be artificially prepared by dissolving Graphite in molten Iron at 3000°C. and rapidly cooling the Iron in molten Lead. An outer layer of solid Iron will be formed and this will exert great pressure on the still liquid metal inside. Under these conditions the carbon will be crystallised in the form of Diamond. The Iron can be dissolved out by Hydrochloric acid. It is used as a gem, and as a diamond glass cutter. It is a bad conductor of heat and electricity.

Graphite :

Graphite is a grey soft crystalline solid with a greasy feel. It can be artificially prepared by heating a mixture of powdered coke dust and sand in an electric furnace to white heat for 24—30 hrs.

It is chemically inactive. It is a good conductor of heat and electricity. It is used for making carbon electrodes Lead pencils, heat resisting crucibles and as a lubricant. A colloidal solution of Graphite, obtained by triturating the substance with tannin and water is used as a lubricant under the name Aquadag. A suspension of Graphite in oil is called Oildag. Powdered Graphite is rubbed on casts to make them conductors of electricity in electro plating processes. Graphite is unattacked by acids but oxidised by $K_2Cr_2O_7$ and Con. H_2SO_4 to form CO_2. It can be converted into diamond.

Amorphous Carbon :

CHARCOAL Charcoal is formed when organic substances such as wood sugar or bones of animals are heated *in the absence of air* or when dehydrating substances such Con. H_2SO_4 act on them. Charcoal is a black amorphous, porous solid that floats on water because it contains air in its pores. This can be removed by heating. It can *absorb* large volumes of gases— Coconut charcoal is very active in this respect. The adsorbed gases can be expelled by heating. Charcoal has also the power of activating gases (it acts as catalyst) for eg. CO and Cl_2 combine in the presence of charcoal to form Phosgene or arbonyl chloride ($COCl_2$). This property is used in deodourising

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and disinfecting sewers etc, It also absorbs many colouring matter from solutions, such as dyes, alkalloids and certain metalic salts. Animal charcoal is most efficient in this respect. It burns readily and forms CO_2. It is a good reducing agent at high temperatures,

$$Fe_2O_3 + 3C \rightarrow 2Fe + 3CO$$
$$2CuO + C \rightarrow Cu + CO_2$$
$$Na_2SO_4 + 4C = Na_2S + 4CO$$
$$4NaNO_3 + 5C = 2Na_2CO_3 + 2N_2 + 3CO_2.$$

Lamp - black :

When substances rich in Carbon such as Wax Oils, Turpentine Coal etc, are burnt in a *limited* supply of air, clouds of Carbon particles are produced which can be collected on blankets held in the smoke and later they can be scrapped off. This is called Lamp black. It is used as a pigment to prepare Indian ink and as a filter for rubber. Soot is a similar substance but contains much tarry matter and Ammonium compounds.

Coal:

This is formed by the gradual decomposition of vegetable matter, ***under pressure in the absence of air.*** It contains very little free Carbon. It is soluble in Pyridine. It is not homogenous and contains Durain, Fusain, Vitrain and Clarain as its constituents. Much of the Carbon in Coal is combined with H_2 in the form of complex Hydro - carbons.

Coke :

It is the residue left behind in the manufacture of coal gas. It contains 85—90% Carbon and is used in many metallurgical operations. It is a good reducing agent. Gas carbon is the residue left on the sides and roofs of the resorts and it is pure carbon.

79. Compound A contains Hydrogen and Oxygen only. Compound B contains Oxygen and Carbon only. What perediction may be made about the

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number of grams of Hydrogen that are likely to combine with 36 grams of Carbon to form a stable Chemical compound.

COMPDS:	COMPOSITION IN GRAMS		
	O_2	H_2	C
A	9·6	1·2	———
B	3·2	———	1·2

Taking into consideration the elements present in A and B and also their weights we find that 9·6 grams of O_2 combines with 1·2 grams of Hydrogen in A. and 3·2 grams of Oxygen combines with 1·2 grams of Carbon in B.

If we equalize the weights of Oxygen in both A and B we can say that

9·6 grams of O_2 Combines with the 1·2 grams of H_2 in A
3·2×3 ,, ,, O_2 ,, ,, 1·2×3 ,, ,, C in B

Now the weights of O_2 in A & B is constant or same. But in A 1·2 grams of H_2 combines with 9·6 grams of O_2 and in B, 3·6 grams of Carbon combines with 9·6 grams of O_2. So if Carbon and Hydrogen were to combine with each other they should do so in the ratio of $\underset{(C)}{3·6} : \underset{(H_2)}{1\,2}$ because these are the weights which separately combine with a constant weight of Oxygen. So 3·6 grams of carbon can combine with 1·2 grams of H_2.

∴ 3·6 grams of carbon can combine with.

$$\frac{36}{3·6} \times 1·2 = 12 \text{ grams of } H_2$$

The law that is used to arrive at this prediction is the law of Reciprocal proportions which states that the weights of A & B which separately combine with a constant weight of C are also the weights by which they combine with each other or are simple multiples of it.

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80. (a) Name three relatively pure crystalline substances met with in a Ceylon home.

(b) For 2 of these give one simple chemical change in each case which you could observe safely at home.

(a) NaCl, $Na_2CO_3 \cdot 10\,H_2O$ and Sugar (Cane sugar—a carbohydrate) are 3 crystalline white substances found in Ceylon homes.

(b) NaCl is a deliquescent substance. It absorbs water from the atmosphere and dissolves in that to form a solution. This deliquescence is due to the presence of traces of impurities like $CaCl_2$ and $MgCl_2$. However if it is kept in air tight bottles this phenomenon will not occur.

$Na_2CO_3 \cdot 10\,H_2O$ is an efflorescent substance. When left exposed to air it gradually loses its water of crystallisation and crumbles down to a white powder. This is the reason why the Na_2CO_3 that we buy in the shops for washing purposes is powdery, whereas the air-tightly kept specimen is crystalline.

Problem

2 grams of a sample of fresh Soda lime containing 80% NaOH and 20% $Ca(OH)_2$ were dissolved in 400 ml. distilled water at room temperature. How many ml. of 1N HCl acid would be required to neutralise 100 ml. of this solution.

1, Weight of soda lime = *2* grms.

The percentage of

$Ca(OH)_2$ in the soda lime = 20%

" NaOH " " = 80%

∴ the wt. of $Ca(OH)_2$ " $= \frac{20 \times 2}{100} = \cdot 4$ grms.

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$\therefore$ The weight of NaOH in the soda lime $= 2 - \cdot 4 = 1 \cdot 6$ gms.

Equivalent wt. of $Ca(OH)_2 = \dfrac{40+32+2}{2} = 37$

" " NaOH $= 23+16+1 = 40$

Normal solutions contain one gm. equivalent of dissolved substance in each litre of the solution.

$\therefore$ 40 grms. of NaOH is equivalent to 37 grms. of $Ca(OH)_2$.

$\therefore$ 1·6 gm. of NaOH is equivalent to $= \dfrac{37}{40} \times 1 \cdot 6 = \dfrac{7 \cdot 4}{5}$

$= 1 \cdot 48$ gms. of $Ca(OH)_2$

$\therefore$ 2 gms of soda lime is equivalent to $= 1 \cdot 48 + \cdot 4$

$= 1 \cdot 88$ grms of $Ca(OH)_2$

400 c.c. contains 1·88 grms. of $Ca(OH)_2$

$\therefore$ 1000 c.c. " $= \dfrac{1 \cdot 88}{400} \times 1000$

$= 4 \cdot 7$ grms. of $Ca(OH)_2$

$\therefore$ Normality of $Ca(OH)_2 = \dfrac{4 \cdot 7}{37}$

$$V_1 N_1 = V_2 N_2$$

Volume of $Ca(OH)_2 = 100$ c.c.

Normality of HCl $= 1N$

Let X c.c. be the volume of HCl required.

$\therefore \quad 100 \times \dfrac{4 \cdot 7}{37} = 1 \times X$

$\therefore X = 12 \cdot 7$ c.c.

The volume of HCl required $= 12 \cdot 7$ c.c.

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80 A white crystalline solid B decrepitated on heating and gave off brown - fumes and a gas which rekindled a glowing splinter. When a solution of KI was added to an aqueous solution of B a yellow precipitate was formed. This precipitate dissolved on heating and shining yellow crystals appeared on cooling. Identify B and explain the reactions involved?

From the above statements solid B is identified to be Lead nitrate It is a white crystalline substance which decrepitates on heating and decomposes to Lead monoxide Nitrogen peroxide and oxygen.

$$2\,Pb(NO_3)_2 \rightarrow 2\,PbO + 4\,NO_2 + O_2$$

NO_2 is brown in colour and O_2 being a supporter of combustion rekindles a glowing splinter. When KI is added to an aqueous solution of Lead nitrate a yellow precipitate of Lead Iodide is formed which dissolves on heating and on cooling produces golden yellow sprangles.

$$Pb(NO_3)_2 + 2\,KI \rightarrow \underset{\downarrow}{PbI_2} + 2KNO_3$$

yellow precipitate dissolves on heating
and produces shining yellow
crystals on cooling

II. From a liquid air factory 10,000 cu ft. of Nitrogen at room temperature and 100 atmosphere pressure are available What volume of Hydrogen at the same temperature and pressure will unite with this Nitrogen to form 20, 000 Cu ft of NH_3?

Nitrogen and Hydrogen combine with each other to form NH_3 in the ratio of 1:3 as can be shown by the equation

$$N_2 + 3\,H_2 \rightarrow 2\,NH_3$$
$$1:3 \rightarrow 2$$

Substituting the corresponding values for the above as given in the Problem

$$N_2 + 3\,H_2 \rightarrow 2\,NH_3$$
$$10,000 + x \rightarrow 20,000$$
$$\therefore x \quad = 30,000 \text{ cu ft.}$$

(Temperature and pressure being same for all volumes taken into consideration).

ADDITIONAL MODEL QUESTIONS

(1) **What chemical reasons may be given for the following statements.**

(a) A thin film of grease on a knife-blade prevents rusting.

(b) Sodium bicarbonate is used in making bread and hoppers.

(2) How would you show that air is a mixture and water is a compound.

(3) How would you show the properties of acids using substances found in homes.

(4) When you touch HNO_3 your skin in the palm turns yellow in colour. Why?

Give the name of the substance formed.

(5) Why do you add a few drops of $CuSO_4$ to Zn when you prepare H_2 from Zn and dilute H_2SO_4.

(6) When Con. H_2SO_4 is poured on your shirt the place immediately turns black and then tears. Why?

(7) $$MnO_2 + 2\,NaCl + 3\,H_2SO_4 = MnSO_4 + 2\,NaHSO_4 + 2\,H_2O + Cl_2$$

In the reaction Cl_2 does not evolve directly from NaCl. What chemical changes take place in liberating Cl_2 from NaCl.

(9) Write the equation only for the reactions between the substances in each of the following pairs.

(a) Magnesium Ribbon and Copper Sulphate Solution.

(b) Sodium bi-sulphite and H_2SO_4.

(c) MnO_2 powder and H_2O_2 solution.

(d) Sodium Thiosulphate solution and HCl gas.

(e) Copper Oxide and Ammonia gas.

Give the colour change in (a).

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(10) What are the principal substances used in the making of the following substances.

(a) Torch Battery

(b) Cigarette packet foil.

(c) Lime - Mortar

(d) Cement

(e) Concrete.

(11) Why do you call,

(a) NaOH as a strong Alkali.

(b) Na_2CO_3 as a weak Alkali.

(c) HCl as a strong Acid

(d) H_2CO_3 as a weak Acid.

(12) How would you show that Cl_2, Br_2 and I_2 belong to the same family?

(13) How can you prepare CO_2 from substances found in your homes without using any substances from the lab.

(14) Why CO_2 is used in Aerated water?

(15) Describe the main features and the physical and chemical processes involved in a refrigerator where CO_2 is used.

(16) Give the names of 3 different fire extinguishers. Name the chemicals used in each.

(17) When a sugar solution or toddy is kept exposed for a long time it forms foam and gives a hissing sound, why? Why the solution becomes sour.

(18) What is Mortar. How does it harden?

(19) What are the raw - matrials necessary for the manufacture of Cement.

(20) Discuss the use of NH_4OH in Analytical chemistry.

(21) What is Sal-Ammonia. How can you obtain it?

(22) (a) "All thermal dissociations are examples of reversible reactions. But all reversible reactions are not Thermal dissociations"

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(b) All normal solutions are standard solutions. But all standard solutions are not normal solutions.

Discuss the validity or the meanings of these above statements with suitable examples.

(23) What is Nessler's solution? What action has NH_3^- with it.

(24) What is Money metal.

(25) When water is added to Con. H_2SO_4 explosion takes place, why? Explain.

(26) In CO 12 grams of Carbon combines with 16 grams of Oxygen. In CO_2 12 grams of Carbon combines with 32 grams of Oxygen. What inference do you draw from these statements?

(27) A solution of $Ca(NO_3)_2$ should not be stored in a Lead lined tank, why?

(28) A water solution of alcohol conducts electricity, why?

(29) Certain gases are collected by the downward displacement of air, why?

(30) Why $AgNO_3$ is kept in brown coloured bottles in the lab?

(31) Describe the physical properties of 2 Chemical substances found in Ceylon homes.

(32) Window Iron bars on the outer walls of a house rust more quickly than those of the inner walls, why?

(33) What happens when a burning candle is introduced into a jar of Cl_2.

(34) Describe the action of NH_4OH on the following salt solutions :— $CuSO_4$, $ZnSO_4$, $FeCl_3$. $Al_2(SO_4)_3$, $FeSO_4$ $MnCl_2$ and Nessler's solution.

Describe the colour changes and the conditions under which they react.

(35) Why you should add NH_4Cl before NH_4OH in the qualitative analysis of certain salts using NH_4OH.

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(36) Give equations only for the changes that Plaster of Paris undergoes when it is used to immobilize fractured legs or arms.

(37) Compare the bleaching action of Cl_2 and SO_2.

(38) How would you show experimentally that

(a) Air contains 1/5 of its volume of O_2.

(b) HCl gas is very soluble in water.

(c) HNO_3 contains N_2.

(d) Air will burn in Coal gas.

(39) What is meant by '20' vol. of H_2O_2

(40) You are given unlabelled bottles containing ZnO, PbO_2, CaO, FeO and CuO.

Some of them can be easily identified by direct observation of their appearance. State which of these substances you could so identify? Give details of simple tests by which you could confirm your observation. How would you identify the remaining substances.

(41) Describe all that you would observe, and explain the reactions which takes place when,

(a) Finely divided Copper is treated with dil. HNO_3 and the resulting solution evaporated to dryness and heated gently.

(b) Red lead is heated gradually to a dull red heat and then allowed to cool.

(c) Cleaned Magnesium is immersed in Copper sulphate solution.

(42) State one chemical reaction in each case to show the resemblences which exists between

(a) CO and H_2.

(b) CO_2 and SO_2

(c) dil. HNO_3 and HCl.

Give one chemical test in each case to distinguish them from one another.

(43) $FeSO_4$ contained in an open bottle turns brown in colour, why?

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What happened to the solution.

In order to prevent this a few drops of H_2SO_4 are added. Explain how does H_2SO_4 prevents this colour formation.?

(44) What is the action of heat on Gypsom?

(45) Theoritically $KMnO_4$ is supposed to consist of the following substances.

(a) K_2O
(b) 2 MnO
(c) 5 [O]

Illustrate or prove this, taking its action with SO_2.

(46) What are the following ?

(a) D. D. T.
(b) T. N. T.
(c) Formalin.

(b) Give labelled diagrams to show the preparations of
(i) Cl_2 (ii) H_2 (iii) O_2 (iv) H_2S (v) SO_2
(vi) SO_3 (vii) NH_3 (viii) CO_2 (ix) CO.

(47) State clearly what you would observe and explain, the chemical reactions that occur when

(a) Na is dropped on Cold water.
(b) Con. H_2SO_4 is warmed with crystals of KI
(c) SO_2 is passed into Br_2 water.
(d) H_2S is passed into acidified $KMnO_4$.

(48) What is the difference between a complex and a double salt.

(49) Why pure water does not conduct electricity? How can you make it conduct electricity ? Explain the process.

(50) How will you show that HNO_3 acid contains H_2, N_2, and O_2 ?

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