ACIDS, BASES AND SALTS

On the basis of **chemical behaviour**, all compounds can be classified into the following groups:-

- Acids
- Bases
- Salts

→ Acids and bases are everywhere. Some foods contain acid, like the **critic acid in lemons** and the **lactic acid in diary** products. **Cleaning products** like bleach and **ammonia are bases**.

→ **Acid-Base indicators** or simply as **indicators**.

I. Litmus:-

→ Litmus is **a natural dye** extracted from **lichen**, a plant belonging to the **Thallophyte** division. Litmus solution is prepared by boiling the litmus dye in distilled water and finally filtering the solution. Neutral litmus solution is purple in colour. It is used as an indicator for testing acids and baes. It is **red in acids** and **blue in bases**.

It is of two types: **Blue Litmus** and **Red Litmus.**

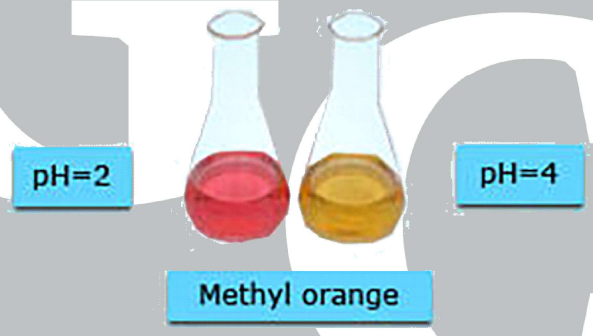
(i) An acid changes **blue litmus to red.**

(ii) A base (or alkali) changes **red litmus to blue**.

II. Methyl Orange:-

(i) Methyl orange indicator gives **red colour in acid solution.**

(ii) It gives **yellow colour in basic solution.**



III. Phenolphthalein:-

(i) Phenolphthalein indicator remains **colourless in acid solution.**

(ii) It gives **pink coour in basic solution.**

IV. Natural indicators (other than litmus):-

→ There are many other natural materials obtained from the **plant kingdom**, such as **red cabbage leaves, turmeric,** coloured petals of plants such as **Hydrangea, Petunia and Geranium.**

→ The **red cabbage** extract remains **red in acidic solutions.** It turns **green in basic solutions.**

V. Olfactory Indicators:-

→ The substances whose **smell (or odour) changes** in acidic or basic solutions are called **olfactory indicators**. Onion and vanilla extracts are olfactory indicators.

(i) **Onion** has a charasteristic **pungent smell**.If the basic solution is added to onion extract, the smell of onion cannot be detected. **An acidic solution does not destroy the smell onions**.

(ii) **Vanilla** extract has a characteristic **pleasant smell**. If a **basic solutions** is added to vanilla extract, the characteristic **smell of vanilla vanishes**. An **acidic solution does not destroy the smell of vanilla**.

Acids:-

The **swedish chemist Svante Arrhenius** published his **theory of acids** and bases in **1887**.

● Arrhenius Theory of Acids:-

→ An acid is a substance which on dissolution, dissociates in water to produce **hydrogen ions (H^+).**

Based on this definition, we can say that Arrhenius acids are soluble in water. Arrhenius theory, **'an acid dissociate in water producing hydrogen ions'.**

Example:- $\underset{\text{Hydrogen chloride}}{HCl(g)} + \underset{\text{Water}}{H_2O} \longrightarrow \underset{\text{Hydronium ion}}{H_3O^+} + \underset{\text{Chloride ion}}{Cl^-(aq)}$

→ **'H_3O^+' is hydronium ion.** H+ (proton from acid) combines with water to from hydronium ion.

● Strong Acids and Weak Acids:-

(i) The acids which **completely dissociate into ions** when dissolved in water are called **strong acids.**

(ii) The acids which **partially ionise when dissolved** in water are called **weak acids.**

(iii) Hydrochloric acid, sulphuric acid and nitric acid are strong acids.

(iv) Acetic acid (ethanoic acid), formic acid, critic acid, tartaric acid and carbonic acid are weak acids.

→ The organic acids are generally "**weak acids**" mineral acids are generally "**strong acids**".

→ The **acids** obtained **from plants** and **animals** are called **organic acids**. Acetic acid is found in vinegar, citric acid is present in citrus fruits such as lemon and orange, **lactic acid** is present in **curd, tartaric acid** is present in **tamarind** and unripe **grapes**, **oxalic acid** is present in **tomatoes** and **formic acid** or **methanoic acid** is present in **ant sting**. Organic acids are **weak acids**. These acids are **safe to eat** and drink.

→ **Phosphoric acid (H_3PO_4)** and **carbonic acid (H_2CO_3)** are moderately weak acids.

Note:- The **solutions of weak acids** in water are **poor conducting** due to low concentration of H_3O^+ (or H^+) ions. The solutions of weak acids contain its ions as well as molecules of the acid.

→ **Concentrated acids,** as the same suggests, contains **high amount** of the **acid** dissolved in minimum volume of water. When water is added to a concentrated acid, a dilute acid is formed. thus a **dilute acid contains much more of water in it.**

Bluestar, Patther Ki Masjid, Patna-800006, Mob - 7004166363, 7717752909
Opp. Kulhariya Complex, Pillar Number-09

→ An acid can be diluted by adding water to it. Generally it is an **exothermic process**. However, dilution of an acid must always be done by adding concentrated acid to water, very slowly with continuous stirring. When **acid (concentrated) is added to water, heat is evolved** gradually which is absorbed by the water and continuous stirring also assists in better absorption of energy.

Properties of Acids:-

1. Taste:-

Acids have a **Sour taste.**

2. Action on Indicators:-

(i) Acids turn **blue litmus red**.

(ii) Acids turn **methyl orange red**.

(iii) **Phenolphthalein** remains **colourless** in **acidic** solutions.

3. Corrosive Nature:-

→ They can corrode the metal vessels they are kept in. Hence it is **advised to keep** them in vessels made up of **glass**.

4. Dissolution:-

→ On **dissolving in water all acids dissociate into ions producing H^+** ions (H_3O^+, due to the combination with water molecules). One point to be noted is that strong acids dissociate completely, while weak **acids dissociate** partially, hence their reaction is shown with a **reversible arrow** ($\rightleftharpoons$).

Strong Acids.

$$\underset{\text{Hydrogen chloride}}{HCl(g)} + \underset{\text{Water}}{H_2O} \longrightarrow \underset{\text{Hydronium ion}}{H_3O^+} + \underset{\text{Chloride ion}}{Cl^-(aq)}$$

$$\underset{\text{Concentrated sulphuric acid}}{H_2SO_4(aq)} + \underset{\text{Water}}{2H_2O(l)} \longrightarrow \underset{\text{Hydronium ion}}{2H_3O^+} + \underset{\text{Sulphate ion}}{SO_4^{2-}(aq)}$$

→ Weak acids ionise to very small extent.

For Example:-

$$\underset{\text{Acetic acid}}{CH_3COOH(s)} + \underset{\text{Water}}{H_2O(l)} \rightleftharpoons \underset{\text{Hydronium ion}}{H_3O^+} + \underset{\text{Acetate ion}}{CH_3COO^-(aq)}$$

$$\underset{\text{Carbonic acid}}{H_2CO_3(aq)} + \underset{\text{Water}}{H_2O(l)} \rightleftharpoons \underset{\text{Hydronium ion}}{H_3O^+} + \underset{\text{Bicarbonate ion}}{HCO_3^-(aq)}$$

→ **Dilution results in lowering the amount of H^+(aq) ions of an acid per unit volume.**

5. Electrical Conductivity:-

→ The solutions of **strong acids** in water have **high electrical conductivity** due to high concentration of hydrogen ion (H^+) in the solution. the solutions of strong acids contain only **ions**.

Bluestar, Patther Ki Masjid, Patna-800006, Mob - 7004166363, 7717752909
Opp. Kulhariya Complex, Pillar Number-09

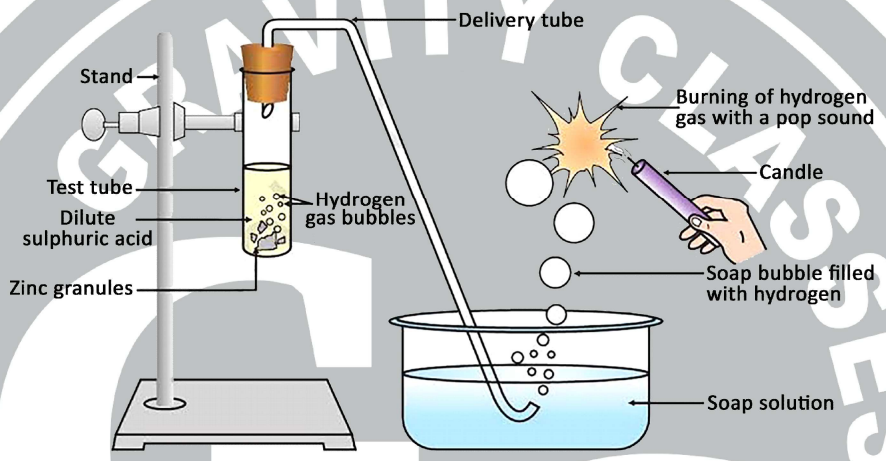
6. Reaction with Metals:-

→ Metals (such as magnesium, aluminium, zinc and iron) on treatment with dilute mineral acids, displace hydrogen from acids in the form of **hydrogen gas.** The metals combine with the remaining part of the acid to form compound called **Salt**.

For Example:-

$$\text{Metal} + \text{Acid} \longrightarrow \text{Metal salt} + \text{Hydrogen}$$

$$\underset{\text{Zinc}}{Zn(s)} + \underset{\text{Dilute sulphuric acid}}{H_2SO_4(aq)} \longrightarrow \underset{\text{Zinc sulphate}}{ZnSO_4(aq)} + \underset{\text{Hydrogen}}{H_2(g)}$$



Note:- Nitric acid (HNO_3) [that is also a mineral acid], in dilute or concentrated form does not produce hydrogen gas with metals, except in case of **magnesium** and **manganese**. It is because, **nitric acid is a powerful oxidising agent**. Thus initially the hydrogen displaced by it gets oxidised. So, **nitric acid** produces **nitrogen dioxide** or nitric oxide gases when treated with metals.

→ Less reactive and **noble metals** such as copper, silver and gold **do not displace hydrogen** from acids.

7. Reaction with Metal Carbonates and Metal Hydrogen Carbonates:-

Metal carbonate or Metal hydrogen carbonate + Acid → Metal salt + Water + Carbon dioxide gas

For Example:-

$$\underset{\text{Calcium carbonate}}{CaCO_3(s)} + \underset{\text{Hydrochloric acid}}{2HCl(aq)} \longrightarrow \underset{\text{Calcium chloride}}{CaCl_2(aq)} + \underset{\text{Water}}{H_2O(l)} + \underset{\text{Carbon dioxide}}{CO_2(g)}$$

$$\underset{\text{Calcium bicarbonate}}{Ca(HCO_3)_2(aq)} + \underset{\text{Sulphuric acid}}{H_2SO_4(aq)} \longrightarrow \underset{\text{Calcium sulphate}}{CaSO_4(aq)} + \underset{\text{Water}}{2H_2O(l)} + \underset{\text{Carbon dioxide}}{2CO_2(g)}$$

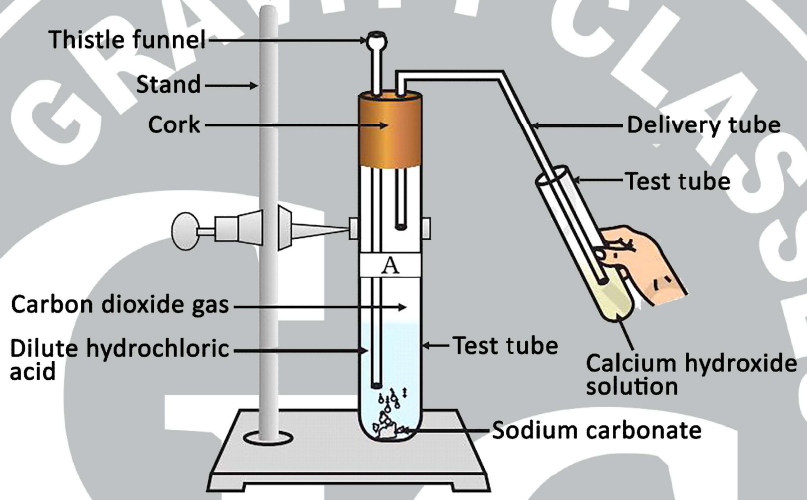
→ **Pickles, jams** and jellies are stored either in **glass vessels** or **plastic vessels**. They are **never stored** in **tin cans** for the simple reason that all of them **contain organic acids**. These acids react with the metals to **form harmful salts**. Furthermore, they **corrode** the container.

→ You must have seen people getting their copper or brass **cooking vessels coated with tin metal (Kalai)**. Why do they do so ?

→ The organic acids present in the food materials, react with copper and **corrode** it. Furthermore, the **copper salts** formed by acids are **poisonous in nature**. Prevents food poisoning.

→ However, these days quite a number of people use **stainless steel** cookinng vessels, because it is not affected by the acids present in food materials.

✳ Action of acids on metal carbonates/hydrogen carbonates and testing the carbon dioxide gas with limewater.



- **Reaction in test tube A:-**

$$\underset{\text{Sodium carbonate}}{Na_2CO_3(s)} + \underset{\text{Dilute hydrochloric acid}}{2HCl(aq)} \longrightarrow \underset{\text{Sodium chloride}}{2NaCl(aq)} + \underset{\text{Water}}{H_2O(l)} + \underset{\text{Carbon dioxide}}{CO_2(g)}$$

- **Reaction in test tube B:-**

(i) $$\underset{\text{Limewater}}{Ca(OH)_2(aq)} + \underset{\text{Carbon dioxide}}{CO_2(g)} \longrightarrow \underset{\text{Carbon carbonate}}{CaCO_3(s)} + \underset{\text{Water}}{H_2O(l)}$$

It is the formation of insoluble calcium carbonate that gets suspended in water and hence, the **limewater turns milky**. The milkiness is due to the fact that **calcium carbonate is white in colour**.

(ii) $$\underset{\text{Calcium carbonate}}{CaCO_3(s)} + \underset{\text{Water}}{H_2O(l)} + \underset{\text{Carbon dioxide}}{CO_2(g)} \longrightarrow \underset{\text{Calcium hydrogen carbonate}}{Ca(HCO_3)_2(aq)}$$

Excess of carbon dioxide reacts with insoluble calcium carbonate to form soluble calcium hydrogen carbonate, and hence, the **milkiness disappears**.

→ If the activity is **repeated** with **sodium hydrogen carbonate** all the above observations take place. The reaction between sodium hydrogen carbonate and dilute hydrochloric acid is represented as under:

$$\underset{\text{Sodium hydrogen carbonate}}{NaHCO_3(s)} + \underset{\text{Hydrochloric acid}}{HCl(aq)} \longrightarrow \underset{\text{Sodium chloride}}{NaCl(aq)} + \underset{\text{Water}}{H_2O(l)} + \underset{\text{Carbon dioxide}}{CO_2(g)}$$

Bluestar, Patther Ki Masjid, Patna-800006, Mob - 7004166363, 7717752909
Opp. Kulhariya Complex, Pillar Number-09

8. Reaction with Bases:-

→ A chemical reaction in which an acid reacts completely with a base to form salt and water as the only products is called **neutralisation reaction.**

Acid + Base ⟶ Salt + Water

(i) Sodium hydroxide and potassium hydroxide are **soluble in water**.

(ii) Calcium hydroxide and magnesium hydroxide are **partially soluble in water**.

(iii) All other metal hydroxides are **insoluble in water**.

Metal hydroxide + Acid ⟶ Metal Salt + Water

$Al(OH)_3(s) + 3HCl(aq) \longrightarrow AlCl_3(aq) + 3H_2O(l)$
Aluminium hydroxide — Hydrochloric acid — Aluminium chloride — Water

$Zn(OH)_2(s) + H_2SO_4(aq) \longrightarrow ZnSo_4(aq) + 2H_2O(l)$
Zinc hydroxide — Sulphuric acid — Zinc sulphate — Water

$Fe(OH)_3(s) + 3HCl(aq) \longrightarrow FeCl_3(aq) + 3H_2O(l)$
Ferric hydroxide — Hydrochloric acid — Ferric chloride — Water

9. Reaction with Metal Oxides:-

Metal oxide + Acid ⟶ Metal Salt + Water

$CuO(s) + 2HNO_3(aq) \longrightarrow Cu(NO_3)_2(aq) + H_2O(l)$
Copper (II) oxide — Nitric acid — Copper (II) nitrate — Water

$Al_2O_3(s) + 3H_2SO_4(aq) \longrightarrow Al_2(SO_4)_3(aq) + 3H_2O(l)$
Aluminium oxide — Sulphuric acid — Aluminium sulphate — Water

● Not all Hydrogen-Containing compounds are Acids:-

→ **All acids give hydrogen gas** as a result of the reaction with metals. This shows that all acids contain hydrogen. But **all hydrogen-containing** compound are **not categorised as acid**.

→ **Conclusions:- Ethanol** (CH_3CH_2OH) and **glucose** ($C_6H_{12}O_6$) solutions are not acidic in nature while dilute **sulphuric acid** (H_2SO_4) is acidic in nature. So the conclusion is that not all compounds containing hydrogen are acidic in nature. This happened because **ethanol and glucose do not produce H^+(aq)** in solutions. So, these compounds do not show acidic character.

✳ Acids do not Dissociate in the Absence of Water:-

● Uses of some Common Acids:-

1. Sulphuric acid (H_2SO_4):-

- For manufacture of **fertilisers** such as ammonium sulphate, **detergents, plastics, paints, dyes,** synthetic fibres, **car batteries** and **explosives**.

2. Nitric acid (HNO_3):-

- For preparation of **fertilisers** (such as ammonium nitrate), **dye, drugs** and **explosives.**
- For the refining of **gold** and **silver**.
- For the cleaning of **gold** and **silver ornaments**.

3. Hydrogchloric acid (HCl):-

- For removing oxide film from steel before the galvanisation process.
- Descaling.
- **Textile**, Leather industries.

4. **Critic acid ($C_6H_8O_7$):-** Used for **food preservation**.
5. **Carbonic acid (H_2CO_3):-** Used for making **aerated drinks**.
6. **Boric acid (H_3BO_3):-** Used as an antiseptic.

BASE

Arrhenis Theoy of Bases:- A base is a substance which on dissolution, dissociates in water to **produce hydroxide ions (OH^-)**.

→ **Base:-** A compound which **reacts** with an **acid to form salt and water** is called a base.

(a) **Metallic oxides** are bases:-
(i) Na_2O (ii) K_2O (iii) MgO
(iv) Cao (v) CuO

(b) **Metallic hydroxides** (also ammonium hydroxide) are bases:-
(i) NaOH (ii) KOH (iii) $Mg(OH)_2$
(iv) $Ca(OH)_2$ (v) $Zn(OH)_2$

(c) **Metal carbonates** and **metal hydrogen carbonates** are bases:-

Metal carbonate	Metal hydrogen carbonates
(i) Na_2CO_3	$NaHCO_3$
(ii) K_2CO_3	$KHCO_3$
(iii) $MgCO_3$	$Mg(HCO_3)_2$
(iv) $CaCO_3$	$Ca(HCO_3)_2$

Alkali:-

A base which is soluble in water is called an **alkali**.

→ **Modern concept of alkali:-** A compound which on dissolving in water furnishes **OH^- ions** as the only negative ions is called an alkali.

✳ **Note:- (All alkali are bases, but all bases are not alkalis)**. For example, potassium hydroxide **[KOH] is a base**. However as it dissolves in water to furnish OH^- ions, hence it is an alkali.

→ Examples of alkalis:-

$$\text{Sodium oxide}: Na_2O(s) + H_2O(l) \rightleftharpoons 2Na^+(aq) + 2OH^-(aq)$$

$$\text{Potassium oxide}: K_2O(s) + H_2O(l) \rightleftharpoons 2K^+(aq) + 2OH^-(aq)$$

✳ Strong and Weak Bases:-

- Bases that almost completely ionise in water are called **strong base**. Strong bases are also called **alkaline**. Sodium hydroxide (NaOH) and potassium hydroxide (KOH) have **high electrical conductivity** because they contain high concentration of $OH^-(aq)$ ions.
- Bases that partially ionise in their aqueous solutions or in water are called **weak bases**. Ammonium hydroxide (NH_4OH), magnesium hydroxide [$Mg(OH)_2$].
- **Conductivity** of solutions of weak bases is **very poor**.

Bluestar, Patther Ki Masjid, Patna-800006, Mob - 7004166363, 7717752909
Opp. Kulhariya Complex, Pillar Number-09

✳ Properties of Bases:-

(1) Touch:- They have a **soapy touch (slippery)**.

(2) Taste:- Bitter taste.

(3) Corrosive Nature.

(4) Dissolution.

Ex. (a) Strong Base:- $\underset{\text{Sodium hydroxide}}{NaOH(s)} \xrightarrow{H_2O} \underset{\text{Hydroxide ion}}{OH^-(aq)} + \underset{\text{Sodium ion}}{Na^+(aq)}$

(b) Weak Base:- $\underset{\text{Ammonium hydroxide}}{NH_4OH(s)} \xrightarrow{H_2O} \underset{\text{Hydroxide ion}}{OH^-(aq)} + \underset{\text{Ammonium ion}}{NH_4^+(aq)}$

(5) Action on Indicator:-

(a) A base changes **red litmus to blue**.

(b) **Methyl** orange to **yellow**.

(c) Phenolphthalein **colourless to pink**.

(d) Turmeric solution to **red**.

(6) Reaction with Metals:-

Base + Metal ⟶ Metal salt + Hydrogen gas

Ex. $\underset{\text{Sodium hydroxide}}{2NaOH(aq)} + \underset{\text{Zinc}}{Zn(s)} \longrightarrow \underset{\text{Sodium zincate}}{Na_2ZnO_2(aq)} + \underset{\text{Hydrogen}}{H_2(g)}$

(7) Reaction with Acids (Neutralisation Reactions):-

Base + Acid ⟶ Salt + Water

$\underset{\text{Sodium hydroxide}}{NaOH(aq)} + \underset{\text{Hydrochloric acid}}{HCl(aq)} \longrightarrow \underset{\text{Sodium chloride}}{NaCl(aq)} + \underset{\text{Water}}{H_2O(l)}$

(8) Reaction with Non-metal Oxides (Acidic Oxides):- As non-metal oxides are **acidic in nature**.

$\underset{\text{Sodium hydroxide}}{2NaOH(aq)} + \underset{\text{Sulphur dioxide}}{SO_2(g)} \longrightarrow \underset{\text{Sodium sulphite}}{Na_2SO_3(aq)} + \underset{\text{Water}}{H_2O(l)}$

$\underset{\text{Sodium hydroxide}}{2NaOH(aq)} + \underset{\text{Carbon dioxide}}{CO_2(g)} \longrightarrow \underset{\text{Sodium carbonate}}{Na_2CO_3(aq)} + \underset{\text{Water}}{H_2O(l)}$

✳ Uses of Bases:-

(i) Sodium hydroxide (caustic soda) is used in the **manufacture of soap**. It is used in petroleium-refining; in making **medicines, paper, pulp, rayon** etc.

(ii) Manufacture of bleaching powder.

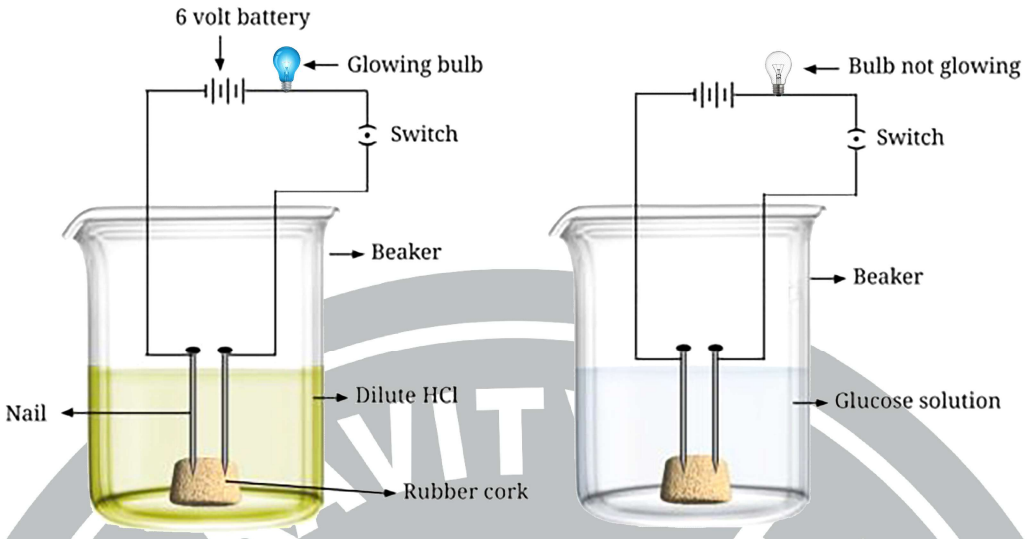
(iii) An antidote for food poisoning.

(iv) It is mixed with sand and water to make **mortar** which is used in the construction of buildings.

(v) Farmers in the fields to neutralise the **harmful acidic** effects of **acid** rain.

Bluestar, Patther Ki Masjid, Patna-800006, Mob - 7004166363, 7717752909
Opp. Kulhariya Complex, Pillar Number-09

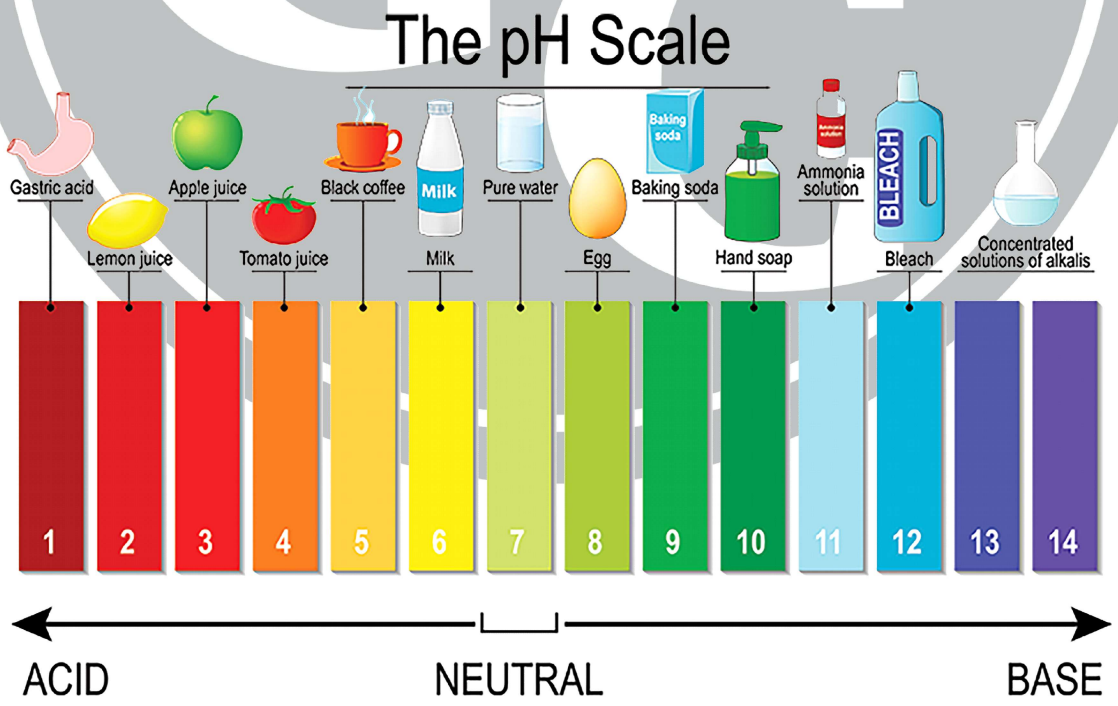
- **Common Factor of Acids and Bases:-**



→ **Ethanol** and **glucose** solutions **do not conduct electricity**.
Dil. hydrochloric acid (or dil. sulphuric acid) and dil. solution of sodium hydroxide conduct electricity.

- **Universal Indicator:-**
- **pH Scale:-**

→ Sorensen, a Danish chemist in 1909 introduced the concept of **measuring** the **concentration of H^+(aq) ions** in a particular solution. This concept is **called pH scale**. Thus, pH stands for "**power of H^+(aq) ions**" or "concentration of H^+(aq) ions".



- **Acids in the Living World:-**

Acids in living world	
Natural source	**Organic acid**
(i) Vinegar	Acetic acid
(ii) Citrus fruits (oranges, lemons)	Citric acid
(iii) Rancid butter	Butyric acid
(iv) Sting of bees, brown ants	Formic acid
(v) Sour milk, curd, etc	Lactic acid
(vi) Apples	Maleic acid
(vii) Olive oil	Oleic acid
(viii) Fats	Stearic acid
(ix) Grapes, tamarind	Tartaric acid
(x) Urine	Uric acid
(xi) Tomatoes	Oxalic acid
(xii) Proteins	Amino acid
(xiii) Chromosomes	Nucleic acid
(xiv) Nettle sting	Methanoic acid

- **Importance of pH in Everyday Life:-**

Importance of pH to Aquatic life:-

→ **Human body** works efficiently within a **pH range of 7 and 7.8**. The **pH** of **rainwater is less than 5.6,** on account of dissolution of acidic gases, such as **sulphur dioxide** and **nitrogen dioxide**. Such a rain with pH less than 5.6 is called **acid rain**.

- **Importance of pH in Soil:-**

→ **Citrus fruit plants** grow better in **alkaline soil**. **Sugarcane** grows better in **neutral soil**. The **soils** get **acidic** when **plant roots** and **plant residues** are not removed from the soil. The acidic soil can be brought back **to normal** health by **spraying slaked lime [$Ca(OH_2)$]** in the fields. The alkaline soils can be cured by **spraying gypsum powder ($CaSo_4.2H_2O$)** Calcium sulfate dihydrate.

→ The pH of soil must be 7 for proper growth of plants.

- **Importance of pH in our Digestive System:-**

→ The excess acid damage the **walls of the stomach** and **causes stomach ulcers**.

→ The acidity of the stomach can be **reduced by taking antacid tablets**. These tablets generally consist of **magnesium hydroxide** and **aluminium hydroxide,** which are **mild bases**.

- **pH of the Mouth and Tooth Decay:-**

→ Normally, the **pH in the mouth** is **more than 7** as the **saliva produced** in the mouth is **basic in nature**.

→ **Teeth** in our mouth are coated with an enamel of **calcium phosphate** that is the **hardest substance** in our body. If the pH of mouth falls **below 5.5**, the acids produced in the mouth attack the enamel, thereby **creating tooth cavities**.

- **Importance of pH in Dairy Industry:-**

→ **Milk goes sour** by **bacterial action** if **its pH falls below 6.6**. Thus, milk is treated in milk plants with Baking Soda ($NaHCO_3$ = Sodium bicarbonate), that its pH does not fall below 6.6.

- **Self-Defence of Animals and Plants Through Chemical:-**

→ Honeybee contains **formic acid.** The **pain can be reduced** by applying **baking soda paste**. **Nettle (Bichu Booti)** is a herbaceous plant that grows in **wild.** Its leaves have **very fine hairs**, that **contain methanoic acid**.

→ A traditional **rubbing** of the affected area with the leaf of **dock plant (Palak Patti)**.

- **Salts:-**

→ A compound formed by the partial or complete replacement of H^+ (aq) ions of an acid by a metal ion or an electropositive ion is called a **salt**.

- **Definition of Family of Salts:-**

→ Salts belonging to the same positive or negative radicals are said to belong to a family.

(i) **Positive radicals**, that is **metallic ions**.

(ii) **Negative radicals**, that is **non-metallic ions**.

Na_2So_4, $NaNO_3$, Na_2CO_3 belong to the family of **sodium salts**.

Similarly, NH_4Cl and $(NH_4)_2SO_4$ belong to the **family of ammonium salts**.

- **pH of Salts:-**

→ The salts of strong acids and strong bases are neutral, such that their **pH is 7**.

- **Common Salt-A Raw Material for Chemicals:-**

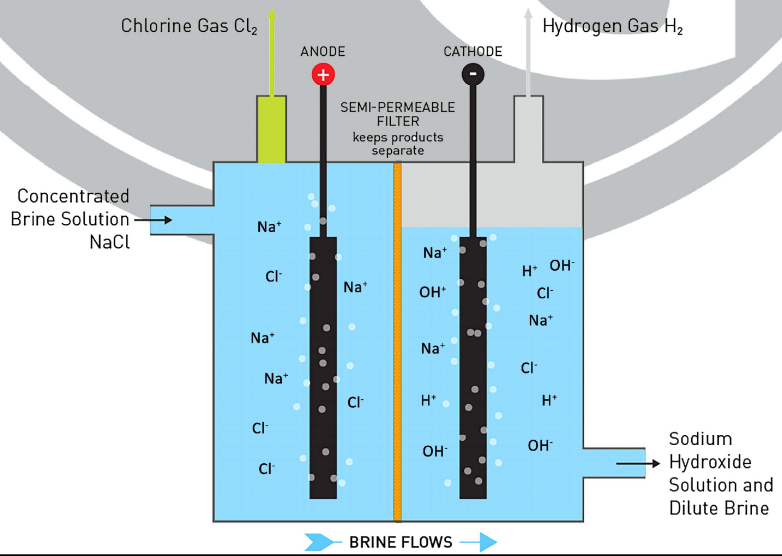
→ Common salt obtained from **sea or mines** in a raw material for the manufacture of the following important chemicals.

(i) Chlorine (ii) Hydrogen (iii) Sodium hydroxide

(iv) Baking soda (v) Washing soda (vi) Bleaching powder

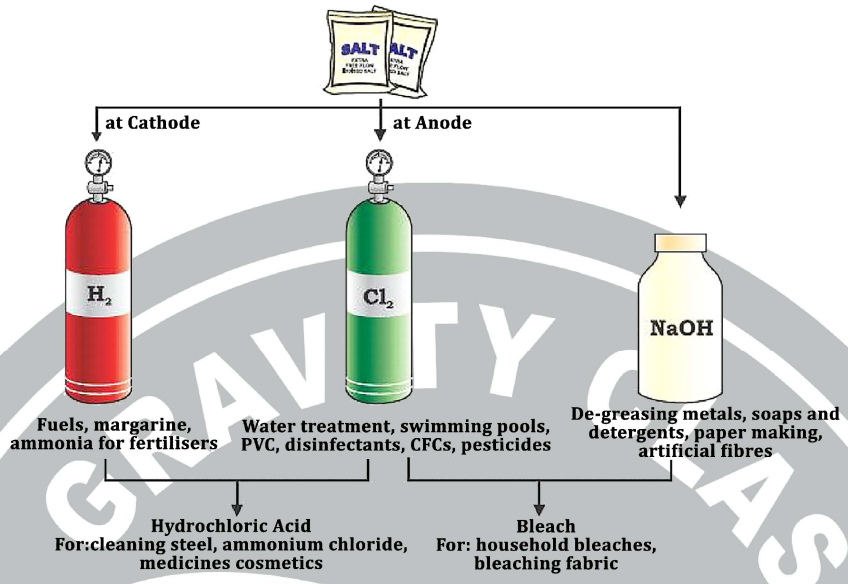
- **Sodium Hydroxide-Chlor-alkali Process:-**

→ A saturated slution of **sodium chloride** is prepared in water. This solution is commonly called **brine solution**.



→ When the electric current is switched on the following reactions take place.

$$\underset{\text{Brine}}{2NaCl(aq)} + \underset{\text{Steam}}{2H_2O(l)} \xrightarrow[\text{Current}]{\text{Electric}} \underset{\text{Sodium hydroxide}}{2NaOH(aq)} + \underset{\text{Hydrogen}}{H_2(g)} + \underset{\text{Chlorine}}{Cl_2(g)}$$



Uses of Hydrogen:-

1. It is used in hydrogenating **vegetable oil** to make **vanaspati ghee** (margarine).
2. It is used in **oxy-hydrogen flames** for cutting and **welding purposes**.
3. It is used in the **manufacture of ammonia gas** that is further used for making important fertilisers, such as **ammonium nitrate**, **calcium ammonium nitrate** and **urea**.
4. When combined with chlorine, it forms hydrogen chloride gas. The hydrogen chloride gas is dissolved in water to form hydrochloric acid, which is further used in cleaning the surface of metals, in the manufacturing drugs and cosmetics.
5. **Liquid hydrogen** is used as a **fuel for rocket engines**.

● Uses of Chlorine:-

1. It is used as a **disinfectant for drinking water** and for **cleaning swimming pools**.
2. In the manufacture of various kinds of **pesticides**.
3. **Bleaching cotton fabrics** and **paper pulp**.
4. Making plastics such a polyvinyl chloride **(PVC)**.
5. Making refrigerant, such as chlorofluorocarbons **(CFC)**.
6. In the manufacture of **bleaching powder** and **hydrochloric acid**.

● Uses of Sodium Hydroxide:-

1. In the manufacture of all kinds of **soaps** and **detergents**.
2. Making paper pulp in the **paper industry**.
3. Making artificial fibres such as **rayon** and **nylon**.
4. **Degreasing** the surface of metals.

5. Making **bleaching agents** such as sodium hypochlorite for household bleaching.

→ The electrolysis of brine solution to obtain products such as chlorine and sodium hydroxide is called **chlor-alkali process**, because the products formed are chlorine (chlor) and sodium hydroxide (an alkali).

- **Bleaching Powder ($CaOCl_2$):-**

→ **Bleaching powder** is **calcium oxychloride [$CaOCl_2$]**. It is commonly called **chloride of lime**. It is prepared by **passing chlorine gas** through **freshly prepared slaked lime paste**, till **the gas stop reacting** with it. The following chemical reaction takes place.

$$\underset{\text{Slaked lime}}{Ca(OH)_2(s)} + \underset{\text{Chlorine}}{Cl_2(g)} \longrightarrow \underset{\text{Bleaching powder}}{CaOCl_2(s)} + \underset{\text{Water}}{H_2O(l)}$$

→ In the above reaction, slaked lime **does not react completely with chlorine**. So **bleaching powder is always a mixture** of **calcium oxychloride** and **calcium hydroxide**.

- **Properties of Bleaching Powder:-**

→ It is **yellowish white powder** which **smells exactly like chlorine**.

→ It is **soluble in water**. However, some amount of white residue is always left on account of the presence of unreacted slaked lime.

→ Bleaching powder on coming in contact with moist air containing carbon dioxide, liberates chlorine gas.

$$\underset{\text{Bleaching powder}}{CaOCl_2(s)} + \underset{\text{Carbond dioxide}}{CO_2(g)} \xrightarrow{\text{Moisture}} \underset{\text{Calcium carbonate}}{CaCO_3(s)} + \underset{\text{Chlorine}}{Cl_2(g)}$$

- **Uses of Bleaching Powder:-**

1. For bleaching white cotton clothes in **laundry** and **cotton fabric in textile mills**.
2. For Bleaching **wood pulp in paper industry**.
3. For **disinfecting** lavatories, **drains** and **ditches**.
4. For making **unshrinkable wool**.
5. In the manufacture of chloroform.
6. As an **oxidising agent** in various organic and inorganic reactions.

→ Quality of bleaching powder is measured by the percentage of chlorine it can liberate when treated with dilute hydrochloric acid. A standard bleaching powder contain 35% of **chlorine**.

- **BAKING SODA ($NaHCO_3$):-**

→ Baking soda is sodium hydrogen carbonate ($NaHCO_3$). It is a fine **white, crystalline solid**. It is sometimes called "**mitha soda**".

→ The **raw materials** required for its manufacture are:

(i) **Sodium chloride**

(ii) **Ammonium chloride**

(iii) **Limestone** or **calcium carbonate**.

→ Following steps re involved in the manufacture of baking sodas.

Bluestar, Patther Ki Masjid, Patna-800006, Mob - 7004166363, 7717752909
Opp. Kulhariya Complex, Pillar Number-09

$$\underset{\text{Limestone}}{CaCO_3(s)} \xrightarrow{\text{heat}} \underset{\text{Quicklime}}{CaO(s)} + \underset{\text{Carbon dioxide}}{CO_2(g)}$$

$$\underset{\text{Quicklime}}{CaO(s)} + \underset{\text{Water}}{H_2O(l)} \longrightarrow \underset{\text{Slaked lime}}{Ca(OH)_2(s)}$$

→ The slaked lime is mixed with ammonium chloride and heated when it liberates ammonia gas.

$$\underset{\text{Ammonium chloride}}{2NH_4Cl(aq)} + \underset{\text{Slaked lime}}{Ca(OH)_2(aq)} \xrightarrow{\text{heat}} \underset{\text{Ammonia}}{2NH_3(g)} + \underset{\text{Calcium chloride}}{CaCl_2(aq)} + \underset{\text{Water}}{2H_2O(l)}$$

→ Ammonia gas is passed through brine solution to form ammoniacal brine solution.

→ Carbon dioxide is passed through ammoniacal brine solution when a chemical reaction takes place with formation of sodium hydrogen carbonate as shown by the equation below.

$$\underbrace{\underbrace{NaCl(s) + H_2O(l)}_{\text{Brine solution}} + NH_3(g)}_{\text{Ammoniacal brine solution}} + \underset{\text{Carbon dioxide}}{CO_2(g)} \longrightarrow \underset{\substack{\text{Sodium}\\\text{hydrogen}\\\text{carbonate}}}{NaHCO_3(s)} + \underset{\substack{\text{Ammonium}\\\text{chloride}}}{NH_4Cl(aq)}$$

→ Thus,to put it briefly, we can say that when **carbon dioxide gas** is passed through **ammoniacal brine**, it forms **sodium hydrogen carbonate** and **ammonium chloride**.

→ Sodium hydrogen carbonate is a fine **white crystalline salt basic in nature**. On heating, it decomposes to form sodium carbonate as is shown in the following equation:-

$$2NaHCO_3(s) \xrightarrow{\text{heat}} Na_2CO_3(s) + H_2O(l) + CO_2(g)$$

- **Uses of Baking Soda:-**

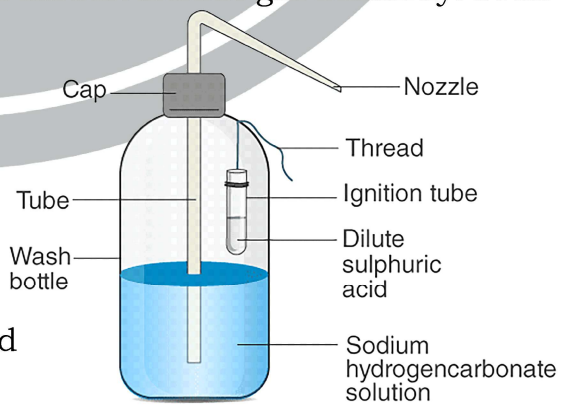
→ Baking powder is a mixture of baking soda and some organic acid, such as critic acid, tartaric acid etc. When baking powder comes in contact with the water present in dough.

$$\underset{\text{Baking soda}}{NaHCO_3(aq)} + \underset{\substack{\text{Hydrogen ion}\\\text{(from tartaric acid)}}}{H^+(aq)} \longrightarrow \underset{\substack{\text{Sodium ion}\\\text{(from sodium salt}\\\text{of tartaric acid)}}}{Na^+(aq)} + \underset{\text{Carbon dioxide}}{CO_2(g)} + \underset{\text{Water}}{H_2O(l)}$$

→ It is used in fire extinguishers to produce carbon dioxide gas instantly. Soda-acid fire extinguisher.

- **WASHING SODA ($Na_2CO_3.10H_2O$):-**

→ The chemical name of wshing soda is **sodium carbonate-decahydrate** or **hydrated sodium carbonate** ($Na_2CO_3.10H_2O$).It is in the form of **white crystals** and the water molecules are not free, but are attached to the molecule of sodium carbonate. These molecules of water are commonly called **water of crystallisation**.



- **Preparation:-**

$$\underset{\text{Sodium hydrogen carbonate}}{2NaHCO_3(s)} \xrightarrow{\text{heat}} \underset{\substack{\text{Sodium carbonate}\\ \text{or}\\ \text{soda ash}}}{Na_2CO_3(s)} + \underset{\text{Water}}{H_2O(l)} + \underset{\text{Carbon dioxide}}{CO_2(g)}$$

→ The soda ash is dissolved in a large amount of water. The solution so formed is evaporated, when washing soda crystallises out. It is then filtered and dried.

$$\underset{\text{Anhydrous sodium carbonate}}{Na_2CO_3(s)} + \underset{\text{Water}}{10H_2O(l)} \longrightarrow \underset{\text{Hydrated sodium carbonate}}{Na_2CO_3.10H_2O(s)}$$

→ Washing soda crystals are white and transparent in nature. When exposed to air they lose their water of crystallisation to form a **white powdery** mass of sodium carbonate monohydrate.

$$\underset{\text{Sodium carbonate decahydrate}}{Na_2CO_3.10H_2O(s)} \xrightarrow{\text{Exposure to air}} \underset{\text{Sodium carbonate monohydrate}}{Na_2CO_3.H_2O(s)} + 9H_2O(g)$$

- **Uses of Washing Soda:-**

1. It is used in **softening hard water**.
2. It is used in the manufacture of **glass**, dry soap powders (detergents).
3. It is a common household cleansing agent.
4. It is used in the manufacture of **caustic soda, borax**, sodium phosphate and water glass.

- **PLASTER OF PARIS [$(CaSO_4)_2.H_2O$]:-**

→ Egyptians are credited with discovering Plaster of Paris **(POP)** about 5000 years ago. They prepared this powder by **heating gypsum** in an open air fire. They **used this powder** for **cementing big stone blocks** that were used in the construction of monuments.

→ The term Plaster of Paris (POP) comes from **Montmartre** in Paris, because the gypsum found there was converted into cementing powder by heating. Initially, Plaster of Paris was used in the **construction of houses**.

→ The **chemical name** of **Plaster of Paris** is **calcium sulphate hemihydrate**.

$$\mathbf{CaSO_4.\frac{1}{2}H_2O \text{ or } (CaSO_4).H_2O}$$

 # Preparation:-

→ Gypsum is crushed to a fine powder and heated a controlled **temperature of 100°C (373 K)** for a long time when each molecule of it **loses three-fourths of water crystallisation** to form **Plaster of Paris**.

$$\underset{\text{Gypsum}}{CaSO_4.2H_2O(s)} \xrightarrow[100^\circ C]{\text{Heat}} \underset{\text{Plaster of paris}}{CaSO_4.\frac{1}{2}H_2O(s)} + \underset{\text{Water}}{\frac{3}{2}H_2O(g)}$$

$$\underset{\text{Gypsum}}{2CaSO_4.2H_2O(s)} \xrightarrow[100^\circ C]{\text{Heat}} \underset{\text{Plaster of paris}}{(CaSO_4)_2.H_2O(s)} + \underset{\text{Water}}{3H_2O(g)}$$

→ When gypsum is heated above 100°C (373 K), it completely **loses its water** of crystallisation and forms **anhydrate calcium sulphate ($CaSO_4$)**. It is commonly called **dead burnt plaster**.

Bluestar, Patther Ki Masjid, Patna-800006, Mob - 7004166363, 7717752909
Opp. Kulhariya Complex, Pillar Number-09

- **Properties of Plaster of Paris:-**

(i) It is a **white-powder** having **very fine crystals**.

(ii) It gets hydrated, when treated with water and sets into a hard mass in about **half an hour**.

$$\underset{\text{Plaster of Paris}}{(CaSO_4)_2.H_2O(s)} + 3H_2O(l) \longrightarrow \underset{\text{Gypsum crystals}}{2CaSO_4 2H_2O(s)}$$

→ It is excellent for making casts in moulds.

✳ **Note:-** Plaster of Paris should be stored in a moisture proof containers because the presence of moisture can cause slow setting of Plaster of Paris.

- **Uses of Plaster of Paris:-**

(i) **Fractured Bones**.

(ii) **Casting statues, toys** and **decorative showpieces**.

(iii) **Panelling of the roofs** in houses.

(iv) **Fireproof Materials**.

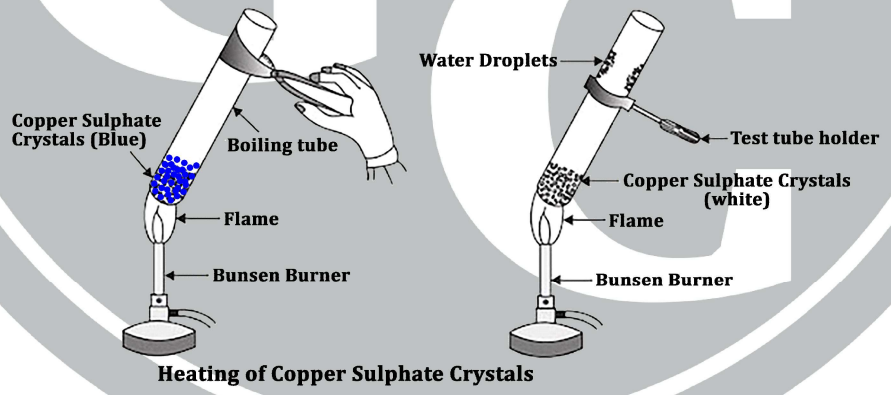
(v) **Blackboard chalk**.

- **WATER OF CRYSTALLISATION:-**

→ The fixed number of water molecules, that are in loose combination with one molecule of a salt, is called **water of crystallisation**.

Name of Salt	Chemical Formula
Gypsum or calcium sulphate bihydrate	$CaSO_4.2H_2O$
Washing soda or sodium carbonate decahydrate	$Na_2CO_3.10H_2O$
Copper (II) sulphate pentahydrate (Blue vitriol) ↓ fungicide → (grapevines)	$CuSO_4.5H_2O$

→ Heat the crystals of copper sulphate strongly. You will notice:-



Heating of Copper Sulphate Crystals

$$\underset{\substack{\text{Hydrated copper}\\ \text{sulphate (blue)}}}{CuSO_4.5H_2O(s)} \xrightarrow{\text{heat}} \underset{\substack{\text{Anhydrous copper}\\ \text{sulphate (white)}}}{CuSO_4(s)} + \underset{\text{Water}}{5H_2O(g)}$$

→ Allow the apparatus to cool. Remove the test tube containing anhydrous copper sulphate. Add a few drops of water to the anhydrous copper sulphate. You will notice that copper sulphate regains its colour.

$$\underset{\substack{\text{Anhydrous copper}\\ \text{sulphate (white)}}}{CuSO_4(s)} + \underset{\text{Water}}{5H_2O(g)} \longrightarrow \underset{\substack{\text{Hydrated copper}\\ \text{sulphate (blue)}}}{CuSO_4.5H_2O(s)}$$

→ The activity proves that hydrated copper sulphate contains water.