Acids, Bases, Salts

- **On the basis of their chemical properties, all the compounds can be classified into three groups :**

1. Acids,
2. Bases,
3. Salts

- **An indicator is a 'dye' that changes colour when it is put into an acid or a base.**

- **an indicator tells us whether the substance we are testing is an acid or a base by change in its colour.**
- **The three most common indicators to test for acids and bases are : Litmus, Methyl orange and Phenolphthalein**

Litmus test:

(i) **An acid turns litmus to red .**
(ii) **A base (or alkali) turns litmus to blue.**

Methyl orange:

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

Phenolphthalein

(*i*) Phenolphthalein indicator is *colourless* in *acid* solution.
(*ii*) Phenolphthalein indicator gives *pink* colour in *basic* solution.

- **Litmus is a natural indicator obtained from the plant named 'lichen'.**

Natural indicator

- **Turmeric is also a natural indicator. Turmeric (*haldi*) contains a yellow dye. It turns red in basic solutions.**

- **The red cabbage extract (obtained from red cabbage leaves) is also a natural indicator. It is red in colour. The red cabbage extract remains red in acidic solutions but turns green on adding to basic solutions.**

- **Acids are those chemical substances which have a sour taste.**
- **The acids present in plant materials and animals are called organic acids.**
- **It is not harmful to eat or drink substances containing naturally occurring acids in them.**
- **The acids prepared from the minerals of the earth are called mineral acids. Hydrochloric acid, Sulphuric acid and Nitric acid.**

- **all the mineral acids are strong acids.**
- **The organic acids are weak acids.**
- **A concentrated acid is one which contains the minimum possible amount of water in it.**
- **a dilute acid is one which contains much more of water in it. The dilution of a concentrated acid should always be done by adding concentrated acid to water gradually with stirring.**
- **Not by adding water to concentrated acid because this heat changes some of the water to steam explosively which can splash the acid on our face or clothes and cause acid burns.**

Properties of acid

1. Acids have a sour taste

2. Acids turn blue litmus to red

3. Acid solutions conduct electricity (They are electrolytes)

4. Acids react with metals to form hydrogen gas

Metal + Acid ----------→ Salt + Hydrogen gas
Most of the acids react with metals to form salts and evolve hydrogen gas. hydrogen is common to all acids.

1.

$$\underset{\text{Zinc (A metal)}}{Zn\,(s)} + \underset{\text{Sulphuric acid (Dilute)}}{H_2SO_4\,(aq)} \longrightarrow \underset{\text{Zinc sulphate (A salt)}}{ZnSO_4\,(aq)} + \underset{\text{Hydrogen}}{H_2\,(g)}$$

- **curd and other sour foodstuffs such as vinegar, lemon juice and orange juice, etc., should not be kept in metal vessels (like copper vessels or brass vessels) because it reacts with the metal.**

5. Acids react with metal carbonates (and metal hydrogen carbonates) to form carbon dioxide gas

- **Metal carbonate + Acid ----------→ Salt + Carbon dioxide + Water**

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

- **Metal hydrogen carbonate + Acid ----------→ Salt + Carbon dioxide + Water**

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

- **Carbon dioxide gas reacts with lime water (calcium hydroxide solution) as follows :**
- **When carbon dioxide gas is passed through lime water, the lime water *turns milky* due to the formation of a white precipitate of calcium carbonate :**

$$\underset{\text{Calcium hydroxide (Lime water)}}{Ca(OH)_2\,(aq)} + \underset{\text{Carbon dioxide}}{CO_2\,(g)} \longrightarrow \underset{\text{Calcium carbonate (White ppt.) (Makes lime water milky)}}{CaCO_3\,(s)} + \underset{\text{Water}}{H_2O\,(l)}$$

- **If *excess* of carbon dioxide gas is passed through lime water, then the white precipitate formed first *dissolves* due to the formation of a soluble salt calcium hydrogen carbonate, and the solution becomes clear again :**

$$\underset{\text{Calcium carbonate (White ppt.) (Insoluble in water)}}{CaCO_3\,(s)} + \underset{\text{Carbon dioxide}}{CO_2\,(g)} + \underset{\text{Water}}{H_2O\,(l)} \longrightarrow \underset{\text{Calcium hydrogencarbonate (Soluble in water)}}{Ca(HCO_3)_2\,(aq)}$$

- **If someone is suffering from the problem of acidity after overeating, we can suggest taking baking soda solution as remedy.**
- **limestone, marble and chalk are the different form of the same chemical compound 'calcium carbonate'.**
- **the egg-shells are made of calcium carbonate.**
- **carbon dioxide gas can extinguish a burning substance.**

- **Acid + Base ----------→ Salt + Water**
- **the reaction between an acid and a base to form salt and water is called a neutralisation reaction.**

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

- **Metal oxide + Acid ----------→ Salt + Water**

$$\underset{\text{Copper (II) oxide (Black)}}{CuO\,(s)} + \underset{\text{Hydrochloric acid}}{2HCl\,(aq)} \longrightarrow \underset{\text{Copper (II) chloride (Blue-green)}}{CuCl_2\,(aq)} + \underset{\text{Water}}{H_2O\,(l)}$$

- **The acids also react with metal hydroxides to form salt and water. The mineral acids cause severe burns on the skin and attack and eat up**

materials like cloth, wood, metal structures and stonework, so they are said to be corrosive.

- **Acids are never stored in metal containers because they gradually corrode and eat up the metal container. the strong bases (or alkalis) such as sodium hydroxide are also very corrosive, and attack and destroy our skin.**

- **An acid is a substance which dissociates (or ionises) on dissolving in water to produce hydrogen ions [H (aq) ions].**

- **A common thing in all the acids is that they produce hydrogen ions [H(aq) ions] when dissolved inwater.**
- **The aqueous solutions of glucose and alcohol do not show acidic character because their hydrogen does not separate out as hydrogen ions [H (aq) ions] on dissolving in water.**
- **hydrochloric acid solution taken in the beaker conducts electricity. sulphuric acid solution also conducts electricity. glucose solution does not conduct electricity. alcohol solution also does not conduct electricity.The aqueous solution of an acid conducts electricity due to the presence of charged particles called ions in it. due to the absence of ions, glucose solution and alcohol solution do not conduct electricity. Distilled water does not conduct electricity because it does not contain any ionic compound (like acids, bases or salts) dissolved in it. due to the presence of carbonic acid (which provides ions to rain water), the rain water conducts electricity.**
- **in the absence of water, a substance will not form hydrogen ions and hence will not show its acidic behaviour.**
- **Dry HCl gas does not change the colour of dry blue litmus paper because it has no hydrogen ions [H(aq)ions] in it.**

- **The HCl gas turns 'wet' blue litmus paper red because it dissolves in the water present in wet litmus paper to form hydrogen ions, H (aq) ions, which can turn blue litmus paper to red.**

- **An acid which is completely ionised in water and thus produces a large amount of hydrogen ions is called a strong acid. hydrochloric acid strong acid .**

- **Sulphuric acid(H2SO4) and nitric acid (HNO3) are also strong acids**
- **Strong acids react very rapidly with other substances (such as metals, metal carbonates and metal hydrogen carbonates, etc.).**

- **An acid which is partially ionised in water and thus produces a small amount of hydrogen ions is called a weak acid. acetic acid weak acid.**

- **Carbonic acid and sulphurous acid are also weak acids.**
- **weak acids react quite slowly with other substances (such as metals, metal carbonates and metal hydrogen carbonates, etc.).**
- **when the concentrated solution of an acid is diluted by mixing water, then the concentration of hydrogen ions H(aq) or hydronium ions, [HO] per unit volume decreases.**

Properties of Bases

- **Bases are those chemical substances which have a bitter taste.**
- **Bases are the chemical opposites of acids.**
- **A base is a chemical substance which can neutralise an acid.**
- **a base which is soluble in water is called an alkali.**

- **when we talk of a base in these discussions, it will actually mean a water soluble base or alkali. whether we call it a base or an alkali, it will mean the same thing.**
- **A base is a substance which dissolves in water to produce hydroxide ions (OH ions) in solution. a common property of all the bases (or alkalis) is that they all produce hydroxide ions (OH ions) when dissolved in water.**

- **Bases are of two types : strong bases and weak bases.**

- **A base which completely ionises in water and thus produces a large amount of hydroxide ions (OH ions) is called a strong base (or a strong alkali).**

- **A base which is partially ionised in water and thus produces a small amount of hydroxide ions (OH ions) is called a weak base (or weak alkali).**

1. Bases have bitter taste

2. Bases feel soapy to touch

3. Bases turn red litmus to blue

4. Bases conduct electricity in solution (They are electrolytes)

5. Bases react with some metals to form hydrogen gas all the metals do not react with bases to form salts and hydrogen gas.

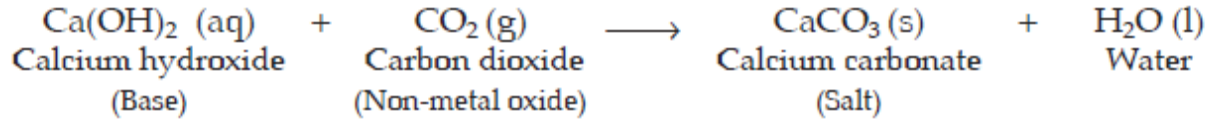
$$\underset{\text{Sodium hydroxide (Base)}}{2NaOH\ (aq)} + \underset{\text{Zinc}}{Zn\ (s)} \xrightarrow{\text{Heat}} \underset{\text{Sodium zincate (Salt)}}{Na_2ZnO_2\ (aq)} + \underset{\text{Hydrogen}}{H_2\ (g)}$$

6. Bases react with acids to form salt and water when an acid and a base combine then the real neutralization. reaction occurs due to the combination of hydrogen ions present in acid and hydroxide ions present in base to form water.

$$\underset{\text{Sodium hydroxide (Base)}}{2NaOH\ (aq)} + \underset{\text{Sulphuric acid (Acid)}}{H_2SO_4\ (aq)} \longrightarrow \underset{\text{Sodium sulphate (Salt)}}{Na_2SO_4\ (aq)} + \underset{\text{Water}}{2H_2O\ (l)}$$

7. Bases react with non-metal oxides to form salt and water

Non-metal oxide + Base ----------→ Salt + Water



- **In 1909 Sorenson devised a scale (known as pH scale) on which the strength of acid solutions as well as basic solutions could be represented by making use of the hydrogen ion concentrations in them.**

- **The pH of a solution is inversely proportional to the concentration of hydrogen ions in it.**

- **The strength of an acid or base is measured on a scale of numbers called the pH scale. The pH scale has values from 0 to 14.**

1. Neutral substances have a pH of exactly 7. the pH of pure water is 7.

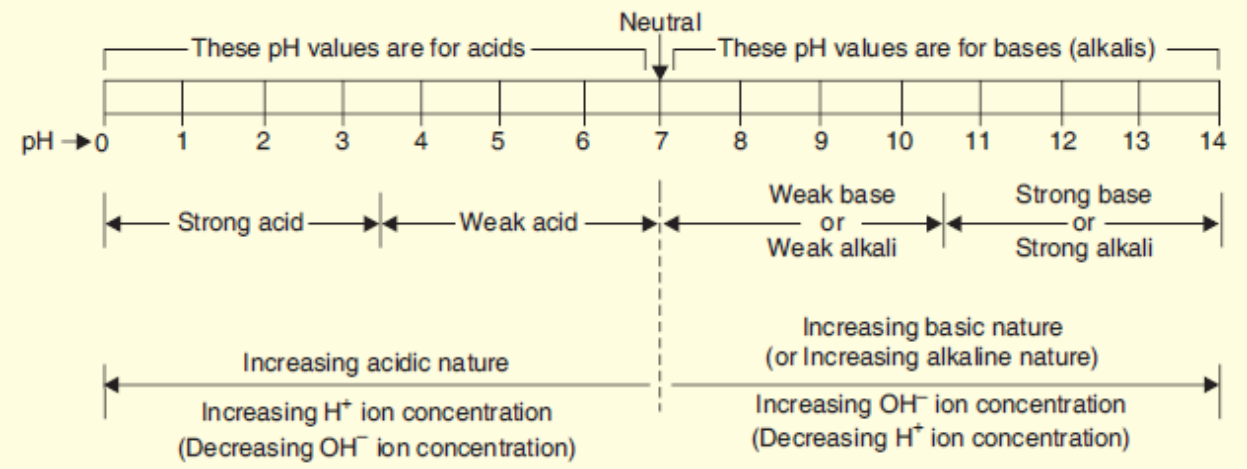
2. Acids (or acidic solutions) have a pH of less than 7 . more acidic a solution is, the lower will be its pH. lower the pH, the stronger the acid.

3. Bases (or basic solutions) have a pH of more than 7. the more basic a solution
is, the higher will be its pH. the higher the pH, the stronger the base (or alkali).

- **the common indicators cannot tell us the relative strengths of acids or bases.**

- **To obtain an idea of how acidic or basic a substance is, universal indicator is used. Universal indicator is a mixture of many different indicators (or dyes) which gives different colours at different pH values of the entire pH scale.**
- **water will produce a green colour with universal indicator**

PH SCALE



IMPORTANCE OF PH IN OUR DAILY LIFE

- **PH in our digestion**
- **dilute hydrochloric acid helps in digesting our food. The excess acid in the stomach causes indigestion.**
- **Being basic in nature, antacids react with excess acid in the stomach and neutralise it.**

- **Magnesium hydroxide (Milk of Magnesia), Sodium hydrogen carbonate (Baking soda)**
- **PH in our mouth**
  - **the bacteria present in our mouth break down the sugar to form acids**

- **Tooth decay starts when the pH of acid formed in the mouth falls below 5.5.**
- **The best way to prevent tooth decay is to clean the mouth thoroughly after eating food.**

➢ **PH in our soil**

- **Soil pH and Plant Growth. If the soil is too acidic (having low pH), then it is treated with materials like quicklime (calcium oxide) or slaked lime (calcium hydroxide) or chalk (calcium carbonate).**

➢ **pH for Survival of Animals in the self defence.**

- **when a honey-bee stings a person, it injects an acidic liquid into the skin . Baking soda is used to neutralise the effect.**

- **When a wasp stings, it injects an alkaline liquid into the skin vinegar is used to neutralise the effect.**

- **An ant's sting injects methanoic acid into the skin of a person causing burning pain. Baking soda is used to neutralise the effect.**

- **When a person happens to touch the leaves of a nettle plant accidently, the stinging hair of nettle leaves inject methanoic acid into the skin of the person causing burning pain. Baking soda is used to neturalise the effect.**

SALTS

- **A salt is a compound formed from an acid by the replacement of the hydrogen in the acid by a metal. A 'salt' is a general name and it does not refer only to sodium chloride.**
- **Salts are formed when acids react with bases.**

➢ **The salts of 'hydrochloric acid' are called 'chlorides'.**

➢ **The salts of 'sulphuric acid' are called 'sulphates'.**

- **The salts of 'nitric acid' are called 'nitrates'.**
- **The salts of 'carbonic acid' are called 'carbonates'.**
- **The salts of 'acetic acid' are called 'acetates',**

- **Just like acids and bases, solutions of salts in water conduct electricity. Salts are ionic compounds.**
- **The salts having the same positive ions (or same negative ions) are said to belong to a family of salts.**

- **Though the aqueous solutions of many salts are neutral (having a pH of 7), but some salts produce acidic or basic solutions (alkaline solutions) when dissolved in water.**

- **The acidic nature and basic nature of some salt solutions can be explained on the basis of hydrolysis of salts.**
    - **The salts of strong acids and strong bases give neutral solutions**
    - **The salts of strong acids and weak bases give acidic solution**
    - **The salts of weak acids and strong bases give basic solutions (or alkaline solutions)**

The chemical name of common salt is sodium chloride (NaCl)

- **Common salt is obtained from sea-water by the process of evaporation.**
- **Rock salt is mined from the underground deposits just like coal.**

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

CHEMICALS FROM SODIUM CHLORIDE

SODIUM HYDROXIDE (NaOH)

- **Sodium hydroxide is commonly known as caustic soda**
- **Sodium hydroxide is produced by the electrolysis of a concentrated aqueous solution of sodium chloride (which is called brine).**

Preparation

$$\underset{\text{Sodium chloride (Brine)}}{2NaCl\,(aq)} + \underset{\text{Water}}{2H_2O\,(l)} \xrightarrow[\text{(Electrolysis)}]{\text{Electricity}} \underset{\text{Sodium hydroxide (Caustic soda)}}{2NaOH\,(aq)} + \underset{\text{Chlorine}}{Cl_2\,(g)} + \underset{\text{Hydrogen}}{H_2\,(g)}$$

- **chlorine gas is produced at the anode**
- **hydrogen gas is produced at the cathode**
- **Sodium hydroxide solution is formed near the cathode**
- **The process of electrolysis of sodium chloride solution is called chlor-alkali process**

- **The three very useful products obtained by the electrolysis of sodium chloride solution called brine (or chlor-alkali process) are sodium hydroxide, chlorine and hydrogen.**

- **Uses of Sodium Hydroxide**

1. Sodium hydroxide is used for making soaps and detergents.
2. Sodium hydroxide is used for making artificial textile fibres (suchas rayon).
3. Sodium hydroxide is used in the manufacture of paper.
4. Sodium hydroxide is used in purifying bauxite ore from which aluminium metal is extracted.
5. Sodium hydroxide is used in de-greasing metals, oil refining, and making dyes and bleaches.

- **Uses of Chlorine**

1. Chlorine is used to sterilise drinking water supply, and the water in swimming pools. This is because chlorine is a disinfectant (which kills germs like bacteria present in water and makes it safe).
2. Chlorine is used in the production of bleaching powder.
3. Chlorine is used in the production of hydrochloric acid.
4. Chlorine is used to make plastics such as polyvinyl chloride (PVC), pesticides, chlorofluorocarbons.(CFCs), chloroform, carbon tetrachloride, paints and dye-stuffs.
5. Chlorine is used for making solvents for drycleaning (such as trichloroethane).

- **Uses of Hydrochloric Acid**

1. Hydrochloric acid is used for cleaning iron sheets before tinplating or galvanisation.
2. Hydrochloric acid is used in the preparation of chlorides such as ammonium chloride (which is used in dry cells).
3. Hydrochloric acid is used in medicines and cosmetics.
4. Hydrochloric acid is used in textile, dyeing and tanning industries.
5. Hydrochloric acid is used in making plastics like polyvinyl chloride (PVC).

WASHING SODA (Na2CO3.10H2O.)

Washing soda is sodium carbonate containing 10 molecules of water of crystallization.

Preparation

STEP 1

$$\underset{\substack{\text{Sodium chloride}\\\text{(Common salt)}}}{NaCl} + \underset{\text{Ammonia}}{NH_3} + \underset{\text{Water}}{H_2O} + \underset{\substack{\text{Carbon}\\\text{dioxide}}}{CO_2} \longrightarrow \underset{\substack{\text{Sodium hydrogen-}\\\text{carbonate}}}{NaHCO_3} + \underset{\substack{\text{Ammonium}\\\text{chloride}}}{NH_4Cl}$$

STEP 2

$$2NaHCO_3 \xrightarrow{Heat} Na_2CO_3 + CO_2 + H_2O$$

Sodium hydrogencarbonate → Sodium carbonate (Soda ash) + Carbon dioxide + Water

STEP 3

$$Na_2CO_3 + 10H_2O \longrightarrow Na_2CO_3.10H_2O$$

Anhydrous sodium carbonate (Soda ash) + Water → Sodium carbonate decahydrate (Washing soda)

- **Properties of Washing Soda**

1. Washing soda is a transparent crystalline solid.
2. Washing soda is one of the few metal carbonates which are soluble in water.
3. The solution of washing soda in water is alkaline which turns red litmus to blue.
4. Detergent Properties (or Cleansing Properties).

- **Uses of Sodium Carbonate (or Washing Soda)**

1. Sodium carbonate (or washing soda) is used as a "cleansing agent" for domestic purposes like washing clothes.
2. Sodium carbonate is used for removing permanent hardness of water.
3. Sodium carbonate is used in the manufacture of glass, soap and paper.
4. Sodium carbonate is used in the manufacture of sodium compounds such as borax.

BAKING SODA (NaHCO3)

The chemical name of baking soda is sodium hydrogen carbonate. The formula of baking soda is NaHCO3.

Preparation

$$NaCl + NH_3 + H_2O + CO_2 \longrightarrow NaHCO_3 + NH_4Cl$$

Sodium chloride (Common salt) + Ammonia + Water + Carbon dioxide → Sodium hydrogen-carbonate (Baking soda) + Ammonium chloride

- **Uses of Sodium Hydrogen carbonate (or Baking Soda)**

1. Sodium hydrogen carbonate is used as an antacid in medicine to remove acidity of the stomach.
2. Sodium hydrogen carbonate (or baking soda) is used in making baking powder (used in making cakes, bread, etc.).
3. Sodium hydrogen carbonate (or baking soda) is used in fire extinguishers.

- **A substance which removes colour from coloured substances and makes them colourless is called a bleaching agent.**
- **A substance which is used to kill germs or bacteria is called a disinfectant.**

BLEACHING POWDER ($CaOCl_2$)

Bleaching powder is calcium oxychloride. The chemical formula of bleaching powder is $CaOCl_2$. It is also called chloride of lime.

Preparation

$$\underset{\text{Calcium hydroxide (Slaked lime)}}{Ca(OH)_2} + \underset{\text{Chlorine}}{Cl_2} \longrightarrow \underset{\text{Calcium oxychloride (Bleaching powder)}}{CaOCl_2} + \underset{\text{Water}}{H_2O}$$

- **Properties of Bleaching Powder**

1. Bleaching powder is a white powder which gives a strong smell of chlorine.
2. Bleaching powder is soluble in cold water. The small insoluble portion always left behind is the lime present in it.
3. **Bleaching powder reacts with dilute acids to produce chlorine.**

$$\underset{\text{Calcium oxychloride (Bleaching powder)}}{CaOCl_2} + \underset{\text{Sulphuric acid (Dilute)}}{H_2SO_4} \longrightarrow \underset{\text{Calcium sulphate}}{CaSO_4} + \underset{\text{Chlorine}}{Cl_2} + \underset{\text{Water}}{H_2O}$$

Uses of Bleaching Powder

1. Bleaching powder is used for bleaching cotton and linen in textile industry and for bleaching wood pulp in paper industry.

2. Bleaching powder is used for disinfecting drinking water supply. That is, for making drinking water free from germs.
3. Bleaching powder is used for the manufacture of chloroform (CHCl3).
4. Bleaching powder is used for making wool unshrinkable.
5. Bleaching powder is used as an oxidising agent in many chemical industries.

PLASTER OF PARIS

Plaster of Paris is calcium sulphate hemihydrate (calcium sulphate half-hydrate).

Preparation

$$\underset{\text{Gypsum}}{CaSO_4.2H_2O} \xrightarrow[(373K)]{\text{Heat to } 100^\circ C} \underset{\text{Plaster of Paris}}{CaSO_4.\tfrac{1}{2}H_2O} + \underset{\text{Water}}{1\tfrac{1}{2}H_2O}$$

Properties of Plaster of Paris

1. Plaster of Paris is a white powder.
2. Plaster of Paris has a very remarkable property of setting into a hard mass on wetting with water.

$$\underset{\text{Plaster of Paris}}{CaSO_4.\tfrac{1}{2}H_2O} + \underset{\text{Water}}{1\tfrac{1}{2}H_2O} \longrightarrow \underset{\substack{\text{Gypsum}\\(\text{sets as hard mass})}}{CaSO_4.2H_2O}$$

Plaster of Paris should be stored in a moisture-proof container.

- **Water of crystallisation**
- **The water molecules which form part of the structure of a crystal (of a salt) are called water of crystallization or hydrated salts.**
- **It shouldbe noted that water of crystallisation is a part of 'crystal structure' of a salt. Since water of crystallisation is not free water, it does not wet the salt.**

- **The water of crystallisation gives the crystals of the salts their 'shape' and, in some cases, imparts them 'colour'.**
- **When hydrated salts are heated strongly, they lose their water of crystallisation.**
- **The salts which have lost their water of crystallisation are called anhydrous salts.**
- **On strong heating, blue copper sulphate crystals turn white**
- **The dehydration of copper sulphate crystals is a reversible process.**
- **Anhydrous copper sulphate turns blue on adding water.**