CHAPTER-3
ACIDS, BASES AND SALTS

Topic-1

Acids and Bases

Concepts covered: • *Acids - Physical and chemical properties*, • *Bases - Physical and chemical properties*, • *pH and its application.*

Revision Notes

- **Acids:** The 'acid' comes from the Latin word 'acidus' meaning 'sour'.
- Acids are defined as compounds which contain one or more hydrogen atoms and when dissolved in water, produces hydronium ions (H_3O^+), the only positively charged ions, for example, hydrochloric acid (HCl), sulphuric acid (H_2SO_4), nitric acid (HNO_3).
- **Ions present in acids:** Mineral acids (inorganic acids) like HCl, H_2SO_4 and HNO_3 ionises completely in the solution. So, they contain high concentration of hydronium ion (H_3O^+). Hydronium ion is hydrated hydrogen ion. Organic acids like acetic acid (CH_3COOH), oxalic acid $(COOH)_2$ do not ionise completely in solution. So, they contain ions as well as molecules.
- **Classification of Acids:**
  1. **Depending on their sources -** (i) Organic acids (ii) Inorganic acids
     - **(i) Organic acids:** Acids which are obtained usually from plants are called **organic acids.** They contain carbon atom also along with hydrogen atom.
       Example: CH_3COOH (Acetic acid).
     - **(ii) Inorganic acids:** Acids which are obtained usually from minerals are known as **inorganic acids.** They do not contain carbon (except carbonic acid H_2CO_3).
       Example: H_2SO_4 (Sulphuric acid), HCl (Hydrochloric acid)
  2. **Depending on their strength –** (i) Strong acid (ii) Weak acid
     - **(i) Strong acid:** A strong acid vigorously ionises in aqueous solution, there by producing a high concentration of hydronium ion $[H_3O]^+$.
       Example: HCl, H_2SO_4
     - **(ii) Weak acid:** Weak acid ionises only partially in aqueous solution, and thus they produce ions as well as molecules.
       Example: CH_3COOH (Acetic acid).

3. **Depending on their concentration :**
   (i) Concentrated acid (Contains less water)
   (ii) Dilute acid (Contains more water)
4. **Depending on molecular composition:** (i) Oxy-acids (ii) Hydro-acids
   (i) Oxy-Acids : Oxy-acids are those acids, which contain oxygen along with hydrogen and some other element.
   Example: Nitric acid, Sulphuric acid
   (ii) Hydro-acids : Hydro-acids are those acids which contain hydrogen and a non-metallic element, and no oxygen.
   Example: Hydrochloric acid.
5. **Depending on their basicity -** The **basicity** of an acid is defined as the number of hydronium ions $(H_3O)^+$ that can be produced by ionisation of one molecule of that acid in aqueous solution.

Acid	Basicity
$HCl \longrightarrow H^+ + Cl^-$	Monobasic acid
$H_2SO_4 \longrightarrow 2H^+ + SO_4^{2-}$	Dibasic acid
$H_3PO_4 \longrightarrow 3H^+ + PO_4^{3-}$	Tribasic acid

➢ **Physical properties of acids :**
(a) Acids have a sour taste in their aqueous solutions.
(b) Acids turn blue litmus paper or solution red, orange or yellow colour of methyl orange solution pink and deep red colour of phenolphthalein colourless.
(c) The aqueous solution of all mineral acids contains hydrogen ions.
(d) Mineral acids such as HCI, HNO_3, H_2SO_4, etc., are highly corrosive and cause painful burns on the skin. Conc. H_2SO_4 stains the skin black while conc. HCl stains the skin amber-coloured.

➢ **Chemical properties of acids :**
(a) Metals which are more electropositive than hydrogen, react with dil. HCl and dil. H_2SO_4 to liberate hydrogen gas.

$$Zn(s) + 2HCl(aq) \longrightarrow ZnCl_2(aq) + H_2(g)$$

Nitric acid (HNO_3) does not liberate hydrogen gas on reaction with metals. However, Mg and Mn react with very dilute nitric acid to produce hydrogen gas.

(b) Acids react with metal oxides to form the corresponding salt and water.

$$CaO(s) + 2HCl(aq) \longrightarrow CaCl_2(aq) + H_2O(l)$$

When MnO_2 is heated with conc. HCl, a greenish-yellow, chlorine gas, is produced.

$$MnO_2(s) + 4HCl(aq) \longrightarrow MnCl_2(aq) + 2H_2O(l) + Cl_2(g)$$

(c) Bicarbonates and carbonates are decomposed by dilute acids with the liberation of carbon dioxide (CO_2) gas.

$$NaHCO_3(s) + HCl(aq) \longrightarrow NaCl(aq) + H_2O(l) + CO_2(g)$$

$$CaCO_3(s) + 2HNO_3(aq) \longrightarrow Ca(NO_3)_2(aq) + H_2O(l) + CO_2(g)$$

(d) Bisulphites and sulphites are decomposed by dilute acids to liberate sulphur dioxide (SO_2) gas.

$$NaHSO_3(s) + HCl(aq) \longrightarrow NaCl(aq) + H_2O(l) + SO_2(g)$$

$$Na_2SO_3(s) + H_2SO_4(aq) \longrightarrow Na_2SO_4(aq) + H_2O(l) + SO_2(g)$$

(e) Dilute acids react with metal sulphides and liberate hydrogen sulphide gas.

$$FeS(s) + H_2SO_4(aq) \longrightarrow FeSO_4(aq) + H_2S(g)$$

(f) Hydrogen chloride gas is produced when concentrated sulphuric acid is added to common salt.

$$2\,NaCl(s) + H_2SO_4(aq) \longrightarrow Na_2SO_4(aq) + 2HCl(g)$$

(g) When sodium or potassium nitrate is heated with concentrated sulphuric acid, vapours of nitric acid are evolved.

$$KNO_3(s) + H_2SO_4(aq) \longrightarrow KHSO_4(aq) + HNO_3(g)$$

General Uses of Some Acids:
(a) Boric acid - Antiseptic for Eye-wash
(b) Oxalic acid - Ink stain remover
(c) Tartaric acid - Baking powder
(d) Citric acid - Food preservative
(e) Carbonic acid - Flavoured drink
(f) Phosphoric acid - Fertilizers.

- **Bases :** A base is either a metallic oxide or a metallic hydroxide which reacts with hydronium ions of an acid to form salt and water only.
- **Alkali :** An alkali is a basic hydroxide which when dissolved in water produces hydroxyl (OH^-) ions as the only negatively charged ions.

$$NaOH\ (aq) \longrightarrow Na^+ + OH^-$$

- **Classification of Bases :**

1. On the basis of strength

(i) A Strong base : It undergoes almost complete ionisation in aqueous solution to produce a high concentration of OH^-.

Example: Sodium hydroxide (NaOH), potassium hydroxide (KOH).

(ii) A Weak base : A weak base is a substance which ionises only to a small extent when dissolved in water

Example: NH_4OH, $Ca(OH)_2$, etc.

2. On the basis of acidity : The number of hydroxyl ions $[OH]^-$ which can be produced per molecule of the base in aqueous solution or the number of hydrogen ions (of an acid) with which a molecule of that base will react to produce salt and water is known as **acidity of the base**.

Base	Acidity
$NaOH \longrightarrow Na^+ + OH^-$	Monoacidic base
$Ca(OH)_2 \longrightarrow Ca^{2+} + 2OH^-$	Diacidic base
$Al(OH)_3 \longrightarrow Al^{3+} + 3OH^-$	Triacidic base

3. Concentration of a base depends on the amount of water present in it. A concentrated base has more quantity of base and a little or no water while a dilute base has more water and less base.

Preparation of Bases : The common methods of preparing bases are as follows:

(i) From Metals : Metals when react with oxygen give bases.

$$4Na + O_2 \longrightarrow 2Na_2O$$
$$2Mg + O_2 \longrightarrow 2MgO$$

(ii) By the action of water on metals; like sodium, potassium and calcium :

$$2Na + 2H_2O \longrightarrow 2\,NaOH + H_2 \uparrow$$
$$2K + 2H_2O \longrightarrow 2\,KOH + H_2 \uparrow$$
$$Ca + 2H_2O \longrightarrow Ca(OH)_2 + H_2 \uparrow$$

(iii) By the action of water on soluble metallic oxides :

$$Na_2O + H_2O \longrightarrow 2\,NaOH$$
$$K_2O + H_2O \longrightarrow 2\,KOH$$

(iv) By Double Decomposition: Aqueous solution of salts with a base (alkali) precipitate the respective metallic hydroxide.

$$FeCl_3 + 3NaOH \longrightarrow Fe(OH)_3 \downarrow + 3\,NaCl$$
$$CuSO_4 + 2\,NaOH \longrightarrow Cu(OH)_2 \downarrow Na_2SO_4$$

(v) By the action of oxygen on metal sulphides :

$$2\,ZnS + 3O_2 \longrightarrow 2\,ZnO + 2SO_2$$
$$2\,PbS + 3O_2 \longrightarrow 2\,PbO + 2SO_2$$

(vi) By Decomposition of salts :

$$CaCO_3 \longrightarrow CaO + CO_2 \uparrow$$
$$CuCO_3 \longrightarrow CuO + CO_2 \uparrow$$
$$2Ca\,(NO_3)_2 \longrightarrow 2CaO + 4\,NO_2 + O_2 \uparrow$$
$$2Zn(NO_3)_2 \longrightarrow 2ZnO + 4NO_2 + O_2$$

- **Physical Properties of Bases**

(a) Alkalis have a bitter taste and are soapy to touch.

(b) Alkalis turn red litmus paper or solution blue, colourless phenolphthalein pink, pink colour of methyl orange to yellow colour and turmeric powder to brown colour.

➢ **Chemical Properties of Bases**

(a) Alkalis react with acids to from salt and water.

$$2\,NaOH\,(aq) + H_2SO_4\,(aq) \longrightarrow Na_2SO_4\,(aq) + 2H_2O$$
$$CuO\,(s) + H_2SO_4\,(aq) \longrightarrow CuSO_4\,(aq) + H_2O\,(l)$$

(b) Alkalis react with ammonium salts to liberate ammonia gas with a pungent smell.

$$2\,NaOH\,(aq) + (NH_4)_2SO_4\,(aq) \longrightarrow Na_2SO_4\,(aq) + 2\,H_2O\,(l) + 2NH_3\,(g)$$

(c) Alkalis react with solutions of salts of heavy metals (copper, iron, zinc, lead, etc.) to form insoluble precipitates of metal hydroxides.

$$CuCl_2\,(aq) + 2\,NaOH\,(aq) \longrightarrow Cu(OH)_2\downarrow + 2\,NaCl\,(aq)$$
$$FeCl_3\,(aq) + 3\,NaOH\,(aq) \longrightarrow Fe(OH)_3\downarrow + 3\,NaCl\,(aq)$$
$$ZnCl_2(aq) + 2\,NaOH\,(aq) \longrightarrow Zn(OH)_2\downarrow + 2\,NaCl\,(aq)$$

(d) Hydroxides of zinc, lead and aluminium behave like acids in the presence of strong alkalis, while they behave like bases in the presence of strong acids, so as to from salt and water.

$$Zn(OH)_2\,(aq) + 2\,NaOH\,(aq) \longrightarrow Na_2ZnO_2\,(aq) + 2H_2O\,(l)$$
$$Zn(OH)_2\,(aq) + H_2SO_4\,(aq) \longrightarrow ZnSO_4\,(aq) + 2H_2O\,(l)$$
$$Al(OH)_3\,(aq) + NaOH\,(aq) \longrightarrow NaAlO_2\,(aq) + 2H_2O\,(l)$$
$$Al(OH)_3\,(aq) + 3\,HCl\,(aq) \longrightarrow AlCl_3\,(aq) + 3H_2O\,(l)$$

(e) All bases except NaOH and KOH decompose on heating to from their respective oxides.

$$Ca(OH)_2\,(aq) \xrightarrow{Heat} CaO\,(aq) + H_2O\,(l)$$
$$2Al(OH)_3\,(aq) \xrightarrow{Heat} Al_2O_3\,(aq) + 3\,H_2O\,(l)$$

(f) Caustic alkalis (NaOH and KOH) are corrosive to the skin as they combine with the oils and fats in the skin.

➢ **Uses of Bases**

(1) Aluminium hydroxide is used as a foaming agent in fire extinguishers.

(2) Sodium hydroxide is used in the manufacture of soaps.

(3) Ammonium hydroxide is used for removing grease and stains from woollen clothes.

(4) Potassium hydroxide is used in the manufacturing of soft soaps and alkaline batteries.

(5) Calcium hydroxide is used in the manufacture of bleaching powder, softening of hard water, neutralising acidity of soil, as a general germicide and in making mortar.

➢ **Neutralisation Reaction:** The reaction between an acid and a base to form salt and water is known as a **neutralisation** reaction.

$$HCl\,(aq) + NaOH\,(aq) \longrightarrow NaCl\,(aq) + H_2O\,(l)$$
$$H^+ + Cl^- + Na^+ + OH^- \xrightarrow{Water} Na^+ + Cl^- + H_2O\,(l)$$
$$H^+ + OH^- \longrightarrow H_2O\,(l)$$

Or,

When ammonia is dissolved in water, it acts as a base and water as an acid. The following are the applications of neutralisation reaction:

(a) Farmers reduce acidity of the soil by adding slaked lime (calcium hydroxide) to it.

(b) Antacid tablets containing magnesium hydroxide are given to person suffering from acidity to neutralise excess acid produced in the stomach.

(c) Cold milk which is alkaline also helps a person in neutralising the hydrochloric acid present in the stomach.

(d) The sting of ants and bees contains formic acid. This can be neutralised by rubbing soap which contains free sodium hydroxide, on the affected area of the skin.

(e) The sting of yellow wasps contains an alkali. This is neutralised by rubbing acetic acid (vinegar) on the affected area of the skin.

➢ The acidity or alkalinity of a liquid is expressed in terms of pH. It is a measure of hydrogen ion concentration of the solution.

pH of a solution is the number by which negative power of 10 has to be raised in order to express the hydrogen ion concentration of the solution.

$$\left[H^+\right] = 10^{-x}\,; \quad \therefore\ pH = x$$

It is also defined as the negative logarithm to the base 10 of the hydrogen ion concentration, i.e.,

$$pH = -\log\,[H^+]$$

A pH of 7 indicates a neutral solution, i.e., pure water. Numbers less than 7, i.e., pH 6, 5, 4, ..., 1, indicate **acidic solutions.** The acidity increases as the pH number decreases. Numbers greater than 7, i.e., pH 8, 9, 10, ..., 14, indicate **alkaline solutions.** The alkalinity increases as the pH number increases.

A reasonably accurate value of the pH of the solution can be determined by putting two or three drops of the solution on a wide range pH paper. A colour will appear and by matching this colour with the chart provide by the supplier, the pH can be determined.

Mnemonics

1. **Concept :** Uses of acid
   Mnemonics:
   BEW
   FPCA
   ISRO
   FDCA
   BPT
   Interpretation:
   Boric acid -eye wash (BEW)
   Food preservative -citric acid (FPCA)
   Ink Stain Remover -Oxalic acid (ISRO)
   Flavouring Drinks -carbonic acid(FDCA)
   Baking Powder –Tartaric acid (BPT)

2. **Concept :**
   Properties of acid
   Mnemonics:
   A student **t**old **t**eacher **B**us **R**ider **c**alled "**HI**"
   Interpretation:
   A—Acid
   S—Sour
   T—taste
   T—turns
   B—blue
   R—red
   C—contains
   HI—hydrogen ion

Key Words

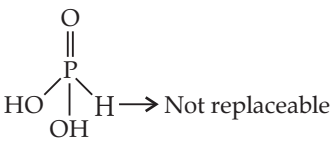
- The bases having an acidity of 1, 2 and 3 are called monoacidic, diacidic, triacidic bases respectively.
- **Concentration of Acid :** It means the amount of acid present in a definite amount of its aqueous solution.
- **Monobasic Acid :** It is an acid which on ionisation in water produces hydronium ion per molecule of the acid.
- **Dibasic Acid:** It is an acid which on ionisation in water produces two hydronium ions (H_3O^+) per molecule of the acid.
- **Tribasic Acid:** It is an acid which on ionisation in water produces three hydronium ions per molecule of the acid.
- **Indicator:** It is a complex substance that indicates separate colour in acidic and basic medium.
- **Monoacidic Base:** It is a base that dissociates in molten (fused) state or in aqueous solution to produces one OH^- ion per molecule of that base.
- **Diacidic Base:** It is a base that dissociates in molten (fused) state or in aqueous solution to produce two OH^- ions per molecule of that base.
- **Triacidic Base:** It is a base that dissociates in molten (fused) state or in aqueous solution to produce three OH^- ions per molecule of that base.
- **pH:** The pH of solution is the negative logarithm to the base 10 of the hydrogen ion concentration expressed in moles per litre.

Key Terms

- The hydrated hydrogen ion that exists in the solutions of acids is known as hydronium ion (H_3O^+).

$$H^+ + H_2O \longrightarrow H_3O^+$$

- Carbonic acid (H_2CO_3) is a weak mineral acid. It contains ions as well as molecules. It turns blue litmus pink. It is non-corrosive and so used in soft drinks.
- Basicity of an acid depends not on the number of hydrogen atoms in one molecule of that acid, but on the number of ionizable hydrogen atoms that it has per molecule.
- H_3PO_3 is a dibasic acid because in oxyacid of phosphorus, hydrogen atoms which are attached to oxygen atoms are replaceable. Hydrogen atoms directly bonded to phosphorus atoms are not replaceable.



- In order to dilute an acid, pour acid into water in small amounts and stir constantly.
  It is noted that water is not added to acid as it is an exothermic process.
- Strength of an acid is the measure of concentration of hydronium ion, it produces in its aqueous solution.
- Dilute HCl is stronger acid than highly concentrated acetic acid.
- The strength of an acid depends on the degree of ionisation (α) and concentration of H_3O^+ ions produced by that acid in aqueous solution.
- Degree of ionisation (α) = $\frac{\text{Number of acid molecules ionised}}{\text{Total number of acid molecules present in aqueous solution}} \times 100$
- If the value of α for an acid or base is greater than 30%, it is strong and if it is less then 30%, it is weak.
- All mineral acids have corrosive action on the skin and cause painful burns.
  For example, Conc. H_2SO_4 — stains the skin black
  Conc. HNO_3 — stains the skin yellow
  Conc. HCl — stains the skin amber
- Those substances whose smell changes in acidic or basic solutions are known as **olfactory indicators**. For example, onion, vanilla and clove oil.
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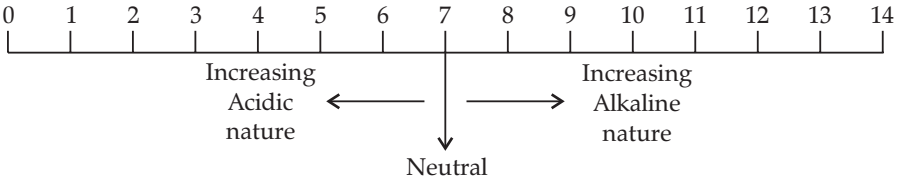
Indicator	Colour change in acidic medium	Colour change in basic medium
Litmus	Blue to red	Red to blue
Methyl orange	Orange to pink	Orange to yellow
Phenolphthalein	Remains colourless	Colourless to pink

- Nitric acid is a very strong oxidising agent so it is not used in the preparation of hydrogen. It oxidises hydrogen and form water. Only magnesium and manganese can produce hydrogen with very dil. HNO_3 (1%).
  $Mn + \underset{(1\%)}{2HNO_3} \longrightarrow Mn(NO_3)_2 + H_2\uparrow$
- An alkali is a base soluble in water.
- All alkalis form OH^- ions in aqueous solution as the only negative ions. They turn red litmus blue.
- All alkalis are bases but all bases are not alkalis.
  For example, $Fe(OH)_3$ and $Cu(OH)_2$ are bases, but not alkalis because they are insoluble in water.
- **pH Scale :**



- The **universal indicator** is a mixture of indicator dyes that gives a spectrum of colours depending on how acidic or alkaline a solution is.
- Universal indicators give different colours at different concentration of hydrogen ions in a solution.
  For example, a universal indicator produces green colour in a neutral solution, i.e., when pH = 7. It changes in a basic solution progressively from 7 to 14.
- If the pH is less then 5.6 of rain water, it is said to be **acid rain**.
- To get rid of acidity in stomach, antacids like milk of magnesia [$Mg(OH)_2$] is generally used to adjust the pH.
- When the pH of mouth falls to 5.5, tooth decay starts.
- Bee sting leaves acid in the body. If baking soda ($NaHCO_3$), a base, is applied on the stung area, it gives relief.

Topic-2 Salts

Concepts covered: • *Classification of salts,* • *Preparation and properties of different types of salts.*

Revision Notes

- **Salts:** The chemical compounds which on dissolving in water produce positively charged particles other than hydrogen ions and negatively charged particles other than hydroxyl ions are called salts.

$$NaCl \rightleftharpoons Na^+ + Cl^-$$
$$KCl \rightleftharpoons K^+ + Cl^-$$

➢ **Classification of Salt :** There are six kinds of salts.

(a) Normal salt : The salt formed by complete replacement of replaceable hydrogen ions of an acid by a basic radical or metallic ion. Some examples of normal salts are sodium chloride (NaCl), potassium nitrate (KNO_3), copper sulphate ($CuSO_4$) and sodium acetate (CH_3COONa).

$$\text{Acid + Base} \longrightarrow \text{Salt + Water}$$

$$HCl + NaOH \longrightarrow NaCl + H_2O$$

$$HNO_3 + KOH \longrightarrow KNO_3 + H_2O$$

$$H_2SO_4 + Cu(OH)_2 \longrightarrow CuSO_4 + 2H_2O$$

$$CH_3COOH + NaOH \longrightarrow CH_3COONa + H_2O$$

These salts on dissolving in water dissociate into their constituent ions. Normal salts have no ionizable hydrogen atoms.

(b) Acid Salt: A salt formed by incomplete or partial replacement of replaceable hydrogen ions of an acid by a basic radical or metallic ion. Some examples of acid salt are sodium hydrogen sulphate ($NaHSO_4$), potassium bisulphate ($KHSO_4$), sodium hydrogen sulphite ($NaHSO_3$).

$$\text{Acid + Alkali} \longrightarrow \text{Salt + Water}$$

$$H_2SO_4 + NaOH \longrightarrow NaHSO_4 + H_2O$$

$$H_3PO_4 + NaOH \longrightarrow NaH_2PO_4 + H_2O$$

$$H_2SO_3 + NaOH \longrightarrow NaHSO_3 + 2H_2O$$

Acid salts are formed when the basicity of the acid taken is more than the acidity of a base. In aqueous solution, acid salts furnish hydrogen ion or hydronium ion (H_3O^+).

(c) Basic Salt: The salt formed by the partial or incomplete replacement of replaceable hydroxyl ions of diacidic or triacidic base by an acid radical. Some example of basic salts are basic lead chloride [Pb(OH)Cl], basic copper chloride [Cu(OH)Cl], basic magnesium chloride [Mg(OH)Cl].

$$\text{Base + Acid} \longrightarrow \text{Salt + Water}$$

$$Pb(OH)_2 + HCl \longrightarrow Pb(OH)Cl + H_2O$$

$$Cu(OH)_2 + HCl \longrightarrow Cu(OH)Cl + H_2O$$

$$Mg(OH)_2 + HCl \longrightarrow Mg(OH)Cl + H_2O$$

The basic salts are only formed when the acidity of the the base taken is more than the basicity of an acid. The basic salts contain a metallic cation, a hydroxyl ion from base and an anion obtained from the acid.

(d) Double salt: The salts that contain more than one cation or anion are known as double salt. They are obtained by the combination of two different salts but differ in their crystalline structure. For example, potash alum, ($K_2SO_4 . Al_2(SO_4)_3 . 24H_2O$), (Mohr's salt).

(e) Mixed salts: The salt that consists of a fixed proportion of two salts, often sharing either a common cation or common anion is known as **mixed salt.**

e.g., bleaching powder ($CaOCl_2$), sodium potassium carbonate ($NaKCO_3$).

(f) Complex salts : The salts which contain different types of metal atoms which on hydrolysis produces complex ions along with simple ions are called complex salts. For example, silver amino chloride $[Ag(NH_3)_2]Cl$, tetraammine copper (II) sulphate $[Cu(NH_3)_4]SO_4$, sodium argentocyanide $\{Na[Ag(CN)_2]\}$.

➢ **Preparation of Soluble Salts :**

(a) By synthesis: Several soluble salts are prepared by heating the constituent elements together.

$$2Fe + 3Cl \longrightarrow 2FeCl_3$$

$$2Na + Cl_2 \longrightarrow 2NaCl$$

(b) Simple displacement: Soluble salts of active metals like Mg, Zn, Fe etc. can be prepared by the simple displacement reactions involving an active metal and dilute acid.

$$Mg + \text{dil. } 2HCl \rightarrow \underset{\text{(magnesium chloride)}}{MgCl_2} + H_2\uparrow$$

$$Zn + \text{dil.} H_2SO_4 \rightarrow \underset{\text{Zinc sulphate}}{ZnSO_4} + H_2\uparrow$$

(c) Double decomposition: Insoluble or soluble bases react with acids to form salt and water. By this reaction only soluble salts are prepared. (Neutralisation reaction)

$$NH_4OH + \text{dil.}HCl \rightarrow \underset{\text{(Ammonium chloride)}}{NH_4Cl} + H_2O$$

$$2KOH + \text{dil.}H_2SO_4 \rightarrow \underset{\text{Potassium sulphate}}{K_2SO_4} + 2H_2O$$

(d) By the reaction of metallic carbonates, bicarbonates, sulphites, bisulphites, sulphides and bisulphides with dilute acids**:**

$$CaCO_3 + \text{dil.}2HCl \rightarrow \underset{\text{Calcium chloride}}{CaCl_2} + H_2O + CO_2\uparrow$$

$$ZnSO_3 + \text{dil.}H_2SO_4 \rightarrow \underset{\text{Zinc sulphate}}{ZnSO_4} + H_2O + SO_2\uparrow$$

(e) By the reaction of metals with alkali:

$$Zn + 2NaOH \xrightarrow{\text{Boiling}} \underset{\substack{\text{Sodium}\\\text{Zincate}}}{Na_2ZnO_2} + H_2\uparrow$$

$$Pb + 2KOH \xrightarrow{\text{Boiling}} \underset{\substack{\text{Potassium}\\\text{metaplumbate}}}{K_2PbO_2} + H_2\uparrow$$

$$2Al + 2NaOH + 2H_2O \xrightarrow{\text{Boiling}} \underset{\substack{\text{Sodium}\\\text{aluminate}}}{2NaAlO_2} + 3H_2\uparrow$$

➢ **Preparation of Insoluble Salts :**

(i) By direct combination

$$Pb + S \longrightarrow PbS$$

(ii) Combination of an acidic oxide with a basic oxide

$$CO_2 + CaO \longrightarrow CaCO_3$$

(iii) By the precipitation reaction (double decomposition)

$$BaCl_2 + H_2SO_4 \longrightarrow BaSO_4\downarrow + 2HCl$$

➢ **Laboratory Preparation of Some Salts :**

(Normal and Acid Salts)

- **Preparation of an Acid Salt (Sodium bicarbonate)**

  Method of preparation: Sodium bicarbonate is obtained by passing carbon dioxide gas into a cold solution of sodium carbonate (Na_2CO_3).

  $$Na_2CO_3 + CO_2 + H_2O \longrightarrow 2NaHCO_3$$

  Procedure: Dissolve anhydrous sodium carbonate (5g) in distilled water (nearly 25 cm^3) in a flask. Cool the solution by keeping the flask in a freezing mixture, then pass CO_2 gas in the solution. After sometime crystals of sodium bicarbonate will precipitate out, filter the crystals and dry it.

- **Preparation of Sodium sulphate crystals ($Na_2SO_4 . 10H_2O$)**

  Method of preparation: By neutralisation of caustic soda with dilute sulphuric acid.

  $$2NaOH + H_2SO_4 \longrightarrow Na_2SO_4\downarrow + 2H_2O$$

  Titration is conducted to determine the completion of the neutralisation reaction because the reactants as well as the products are soluble.

➢ **General Properties of Salts:**

(i) Salts are electrovalent compounds, which conduct electricity in molten state as well as in their aqueous solution.

(ii) Non-volatile solids that form crystals.

(iii) Most of the salts are soluble in water. Degree of solubility in water varies with temperature.

(iv) Hydrolysis of salts

Salt formed by a strong acid and weak base or by a weak acid and a strong base, reacts with water to give acidic or basic solution, is known as **hydrolysis of salts.**

(a) Salts of strong acids and weak bases on hydrolysis give acidic solution. (pH<7), e.g., iron (III) chloride ($FeCl_3$), copper sulphate ($CuSO_4$).

(b) Salts of weak acids (H_2CO_3, CH_3COOH) and strong bases (KOH, NaOH) on hydrolysis give alkaline solution (pH > 7).

(c) Salts of strong acids and weak bases on hydrolysis give neutral solution.

(d) Salts of weak acids and weak bases on hydrolysis may give acidic, alkaline or neutral solution depending upon the dissociated ions and undissociated molecules. For example ammonium acetate [CH_3COONH_4] and ammonium carbonate [$(NH_4)_2\ CO_3$].

- **Water of Crystallisation:**

  It is that definite amount of water with which the substance is associated when crystallising out from an aqueous solution, e.g., copper (II) sulphate crystallises out as a pentahydrate, $CuSO_4 . 5H_2O$. Thus, one mole of copper (II) sulphate is associated with five moles of water.

- **Hydrated Salts - Water of Crystallisation:**
  - The compounds which crystallise out of their saturated solutions with fixed number of molecules of water of crystallisation are called **hydrated salts.**
  - These molecules of water of crystallisation are in loose chemical combination with the salt.
  - The hydrated salts owe their crystalline nature to the molecules of water of crystallisation.

Salts containing water of crystallisation

Common Name	Chemical Name	Formula
White vitriol	Zinc sulphate heptahydrate	$ZnSO_4.7H_2O$
Glauber's salt	Sodium sulphate decahydrate	$Na_2SO_4.10H_2O$
Washing soda	Sodium carbonate decahydrate	$Na_2CO_3.10H_2O$
Potash alum	Potassium aluminium sulphate	$KAl(SO_4)_2.12H_2O$
Epsom salt	Magnesium sulphate heptahydrate	$MgSO_4.7H_2O$
Green vitriol	Iron(II) sulphate heptahydrate	$FeSO_4.7H_2O$
Blue vitriol	Copper(II) sulphate pentahydrate	$CuSO_4.5H_2O$
Lime saltpetre	Calcium nitrate	$Ca(NO_3)_2.4H_2O$

Hygroscopic Substances: Certain substances when exposed to the atmosphere at ordinary temperature, absorb moisture from the atmosphere without dissolving in it. These are called **hygroscopic substances** and this property is called **hygroscopy.** These substances are generally used for drying of gases in laboratory, e.g., conc. sulphuric acid (H_2SO_4), quick lime (CaO), silica gel, phosphorus pentaoxide (P_2O_5).

Drying or desiccating agents: Certain substances remove moisture from other substances and are therefore called **desiccating agents** or **drying agents** or **desiccants.** Almost all hygroscopic substances are desiccating agents.

For example, Conc. sulphuric acid, phosphorus pentaoxide, quick lime.

Dehydrating agents: The substances that can remove water molecules even from compounds are called dehydrating agents. For example, concentrated sulphuric acid can remove water molecules from blue vitriol ($CuSO_4.5H_2O$), so it is a dehydrating agent.

$$\underset{\text{Hydrated Salt}}{CuSO_4.5H_2O} + \underset{\text{Conc.}}{H_2SO_4} \rightarrow \underset{\text{Anhydrous Salt}}{CuSO_4} + 5H_2O$$

Key Words

- **Displacement:** It is a chemical change in which a more active element displaces a less active element from its salt solution.
- **Decomposition:** It is a chemical change in which a compound breaks up into its elements or simpler compounds.
- **Hydrolysis:** The phenomenon due to which salt formed by a weak acid and a strong base, or by a strong acid and a weak base, reacts with water to give an acidic or alkaline solution is called hydrolysis.

Key Terms

- Acid salts ionise in water solution to give hydronium ions and hence, they exhibit all the properties of an acid.
- Soluble slats are obtained by the evaporation of water, followed by crystallisation.

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  their pure forms by crystallisation.
- An insoluble salt can be obtained from another insoluble salt, by double decomposition.
- If at least 1 g of a substance can be dissolved in 100 mL of water at 298 K, it is called **a soluble salt.**
- If 0.1 g to 1 g of a substance can be dissolved in 100 mL of water at 298 K, it is called a **partially soluble salt.**
- If less than 0.1 g of a substance can be dissolved in 100 mL of water at 298 K, it is called an **insoluble salt.**
- All metallic oxides and hydroxides are insoluble except of sodium, potassium and ammonium. Calcium hydroxide is slightly soluble. $NaHCO_3$ is sparingly soluble, but $KHCO_3$ is fairly soluble in water.
- Efflorescent substances lose their weight while hygroscopic and deliquescent substances gain weight when exposed to atmosphere.
- Table salt (NaCl) turns moist and ultimately forms a solution, on exposure to air, especially during the rainy season. Though, pure sodium chloride is not deliquescent, the commercial version of the salt contains impurities like $MgCl_2$ and $CaCl_2$, which are deliquescent substances.

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