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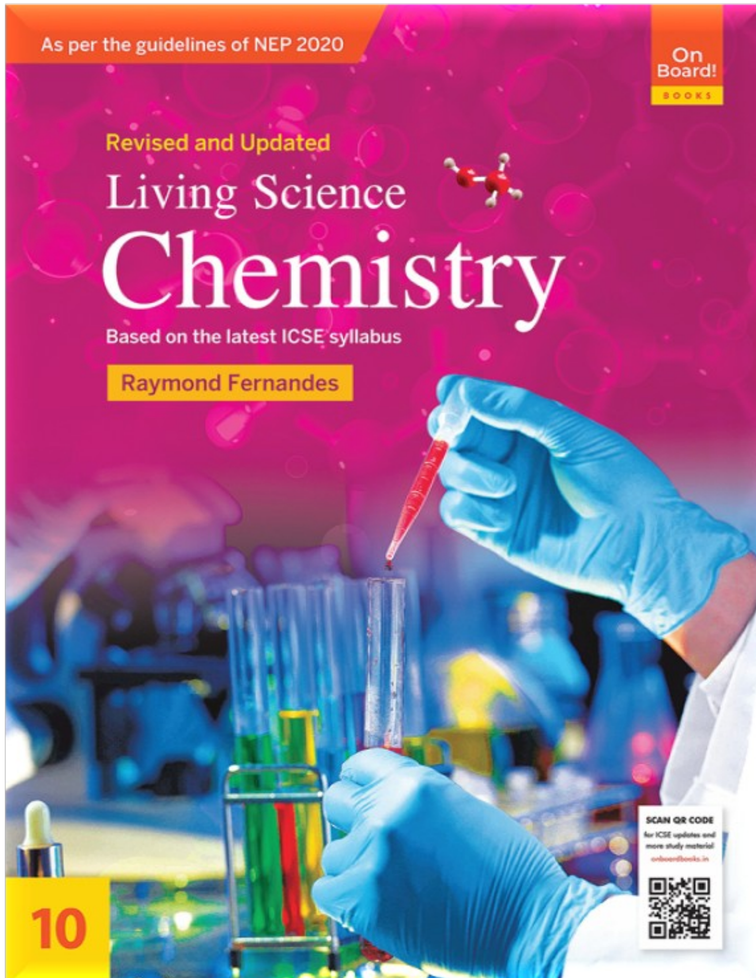
ICSE
Living Science
Chemistry

Class 10

Chapter-3 Acids, Bases and Salts

On Board! BOOKS



LEARNING OBJECTIVES

Acids

- ❖Classification of acids
- ❖Preparation of acids
- ❖Physical properties of acids
- ❖ Chemical properties of acids
- ❖ Acid Rain
- ❖ Tests for acids
- ❖ Uses of acids

Bases and Alkalis

- ❖ Classification of bases
- ❖ Preparation of bases
- ❖ Physical properties of bases
- ❖ Chemical properties of bases
- ❖ Test and uses of alkalis

pH and pH Scale

Indicators

Salts

- ❖ Types of salts
- ❖ Preparation and properties of salts

What do we do to temporarily reduce the acidity in our stomach?

To temporarily reduce the acidity in the stomach, we have to take an antacid. The primary function of the antacid is to neutralize the excess hydrochloric acid in the gastric juice.

Acid

An **acid** is a compound which when dissolved in water yields hydronium ion [H_3O^+] as the only positive ion. Hydrochloric acid, sulphuric acid and nitric acid when dissolved in water undergo dissociation to produce hydronium ions.

$$HCl + H_2O \rightleftharpoons H_3O^+ + Cl^-$$

$$H_2SO_4 + 2H_2O \rightleftharpoons 2H_3O+ + SO_4^{\ 2-}$$

Note: All characteristic properties of acids are due to the H^+ ions they give when dissolved in water. However, the H^+ ion can never exist independently. Instead, it combines with a water molecule to form the hydronium ion, i.e.

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

Classification of acids

Acids can be classified on the following basis:

1. On the basis of sources

2. On the basis of constituent elements

3. On the basis of strength

4. On the basis of concentration in solution

5. On the basis of basicity of an acid

Classification on the basis of sources

Organic acids are derived from organic matter like plants and animals. All organic acids contain carbon as one of the elements. For example, formic acid, malic acid, citric acid, etc.

Inorganic acids are obtained from minerals. These acids are also called **mineral acids**. For example, hydrochloric acid, sulphuric acid, nitric acid, etc. They are strong acids.

Classification on the basis of constituent elements

Oxyacids are those acids that contain hydrogen and oxygen along with a non-metallic element in their molecules. For example, sulphuric acid (H_2SO_4), nitric acid (HNO_3), nitrous acid (HNO_2), etc.

Hydracids are those acids that contain only hydrogen and a non-metallic element in their molecules. For example, hydrochloric acid (HCl), hydrobromic acid (HBr), etc.

Classification on the basis of strength

Strong acids: Acids, which undergo complete dissociation in aqueous solution producing a high concentration of hydronium ions, are called **strong acids**. For example, HCl, H_2SO_4, HNO_3, etc. These acids are good conductors of electricity.

b. Weak acids: Acids, which do not dissociate completely in aqueous solution thereby producing a low concentration of hydronium ions, are called **weak acids**. For example, H_2CO_3, HCOOH, CH_3COOH, etc.

Classification on the basis of concentration in solution

Concentrated acids are those acid solutions that contain a high percentage (or amount) of the acid in their aqueous solutions.

Dilute acids are those acid solutions that contain a low percentage (or amount) of the acid in their aqueous solutions.

Classification on the basis of basicity of an acid

Monobasic acids: An acid which produces one hydronium ion by the ionization of its one molecule is called a **monobasic acid**. Some examples of monobasic acids are HCl, HNO_3, HCOOH (formic acid), CH_3COOH (acetic acid).

Dibasic acids: An acid which produces two hydronium ions by the ionization of its one molecule is called a **diabasic acid**. For example, sulphuric acid.

Tribasic acids: An acid which produces three hydronium ions by the ionization of its one molecule is called a **tribasic acid**. Some examples of tribasic acids are H_3PO_4 (phosphoric acid), $C_6H_8O_7$ (citric acid).

Preparation of acids

1. Direct combination or synthesis

Hydracids are prepared by direct combination of non-metals with hydrogen.

$$H_2 + Cl_2 \rightarrow 2HCl$$

2. Action of water on acidic oxides

Non-metallic oxides are acidic in nature. Therefore, oxyacids are generally prepared by dissolving their respective corresponding non-metallic oxides in water.

$$CO_2 + H_2O \rightarrow H_2CO_3$$

3. Using a less volatile acid

Hydrochloric acid and nitric acid can be prepared by displacement of more volatile acid from their salts by a less volatile acid. In this case, it is concentrated sulphuric acid.

$$NaCl + H_2SO_4 \rightarrow NaHSO_4 + HCl$$

4. From non-metals

Some acids can be obtained by the oxidation of nonmetals like sulphur and phosphorus using a strong oxidizing agent like concentrated nitric acid.

$$S + 6HNO_3 \rightarrow H_2SO_4 + 2H_2O + 6NO_2$$

General properties of acids

Physical properties of acids

1. Acids are sour to taste. Mineral acids like $H_2SO_{4,}$ HNO_3 and HCl are corrosive in nature. Therefore, they should not be tasted.

2. Acids can be present in the liquid or solid state

3. Aqueous solutions of acids conduct electricity, hence, they are electrolytes.

4. Acids like H_2SO_4, HNO_3 and HCl have corrosive action on the skin and cause burns if spilled on skin. Concentrated HNO_3 makes the skin yellow and concentrated H_2SO_4 stains skin black.

5. Acids change the colour of indicators. They turn blue litmus red, methyl orange solution from orange to red and pink coloured alkaline phenolphthalein solution colourless.

Chemical properties of acids

1. **Reaction with active metals:** Dilute acids react violently with active metals like Na, K, Ca and moderately reactive metals like Mg and Zn to liberate hydrogen gas.

$$Zn + 2HCl \longrightarrow ZnCl_2 + H_2\uparrow$$

$$Mg + H_2SO_4 \longrightarrow MgSO_4 + H_2\uparrow$$

2. Reaction with bases (Neutralization reaction):

Acids neutralize bases like metal oxides and hydroxides to form salt and water. The interaction of an acid and a base invariably results in the formation of salt and water as the only products and is called **neutralization**.

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

$$NaOH + HNO_3 \rightarrow NaNO_3 + H_2O$$

3. Reaction with carbonates and bicarbonates (Hydrogen carbonates):

Acids react with carbonates and bicarbonates (or hydrogen carbonates) to liberate carbon dioxide gas and form water and their respective salts.

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2\uparrow$$

$$NaHCO_3 + HNO_3 \rightarrow NaNO_3 + H_2O + CO_2\uparrow$$

4. Reaction with sulphites and bisulphites: Acids react with sulphites and bisulphites to liberate sulphur dioxide, water and their respective salts.

$$ZnSO_3 + 2HCl \rightarrow ZnCl_2 + H_2O + SO_2\uparrow$$

$$2KHSO_3 + H_2SO_4 \rightarrow K_2SO_4 + 2H_2O + 2SO_2\uparrow$$

5. Reaction with sulphides: Acids react with sulphides to liberate hydrogen sulphide gas and form their respective salts.

$$ZnS + 2HCl \rightarrow ZnCl_2 + H_2S\uparrow$$

$$FeS + H_2SO_4 \rightarrow FeSO_4 + H_2S\uparrow$$

6. Reaction with chlorides: Chlorides do not react with dilute acids. They react with only concentrated sulphuric acid when heated and liberate hydrogen chloride gas.

$$2NaCl + H_2SO_4 \xrightarrow{heat} Na_2SO_4 + 2HCl$$

7. Reaction with nitrates: Nitrates do not react with dilute acids except lead nitrate which reacts with both dilute HCl and dilute H_2SO_4 to form insoluble lead chloride and sulphate respectively.

$$Pb(NO_3)_2 + 2HCl \longrightarrow PbCl_2\downarrow + 2HNO_3$$

white precipitate(insoluble salt)

8. Action with metallic oxides: All metal oxides react with dilute mineral acids to form their metallic salts and water.

$$K_2O + 2HNO_3 \rightarrow 2KNO_3 + H_2O$$

Acid Rain

When oxides of sulphur (SO_x) and nitrogen (NO_x) present in the atmosphere react with rain water, they form acids and come down with rain water. The rain containing acids like H_2SO_4, HNO_3 is called **acid rain**.

Acid rain has many harmful effects:

- It is harmful for agriculture, trees and plants as it dissolves and washes away nutrients needed for their growth.
- It causes respiratory ailments in human beings.
- It corrodes water pipes resulting in dissolving of metals like iron, copper and lead into the drinking water.
- It damages buildings and other structures made of stone or marble or metal as it reacts with them.

Tests for acids

1. To show that acids contain hydrogen: Add a piece of magnesium ribbon to the acid. Hydrogen gas is liberated.

2. To show that a substance is an acid: Add any metal carbonate to the acid. CO_2 gas is evolved.

Uses of acids

1. Acids are used in the manufacture of drugs, dyes and paints.

2. Acids are very important laboratory reagents. Acids like HCl, H_2SO_4 and HNO_3 are used in dilute as well as concentrated forms.

3. Acids are also used in preserving food (citric acid), in aerated drinks (carbonic acid), in cooking (vinegar), etc.

4. Hydrochloric acid is used in pickling metals.

Bases

A **base** is a substance which combines with a hydronium ion to form salt and water only. Bases are oxides or hydroxides of metals. Ammonium hydroxide is an exception. Examples of bases are:

Oxides: CaO, MgO, Na_2O

Hydroxides: $Ca(OH)_2$, $NaOH$, KOH

Alkalis

The bases which are soluble in water are called alkalis. For example, $NaOH$, KOH, NH_4OH, CuO, MgO and $Fe(OH)_2$ are bases. Out of these, only $NaOH$, KOH and NH_4OH are soluble in water, and hence, they are alkalis since these are soluble in water. Bases do not dissolve in water. All alkalis are bases, but all bases are not alkalis.

Classification of bases

Bases can be classified **a.** on the basis of strength **b.** on the basis of acidity **c.** on the basis of concentration of bases.

Classification on the basis of strength

On the basis of their strength in terms of dissociation bases are classified into:

a. Bases or alkalis which undergo complete dissociation producing a high concentration of hydroxyl ions in aqueous solutions are called **strong bases** or **alkalis**. For example, KOH, NaOH and LiOH.

b. Bases or alkalis which undergo partial dissociation producing a low concentration of hydroxyl ions in aqueous solutions are called **weak bases** or **alkalis**. For example, NH_4OH, $Mg(OH)_2$ and $Ca(OH)_2$.

Classification on the basis of acidity

Bases can be classified as:

a. Monoacidic bases are those bases which give only one hydroxyl ion per molecule of the base in aqueous solution. Some examples of monoacidic bases are NaOH and KOH.

b. Diacidic bases are those bases which give two hydroxyl ions per molecule of the base in aqueous solution. Some examples of diacidic bases are $Ca(OH)_2$, $Mg(OH)_2$ and $Cu(OH)_2$.

c. Triacidic bases are those bases, that gives three hydroxyl ions per molecule of the base in aqueous solution. Some examples of triacidic bases are $Al(OH)_3$, $Fe(OH)_3$ and $Cr(OH)_3$

Classification on the basis of concentration

On the basis of concentration (or amount) of bases or alkalis present in its aqueous solution, bases or alkalis are classified into :

a. **Concentrated bases** or **alkalis** are those alkaline solutions that contain a high percentage of the base or alkali in solution.

b. **Dilute bases** or **alkalis** are those alkaline solutions that contain a low percentage of the base or alkali in solution.

Preparation of bases

1. Direct combination

Direct combination of metals with oxygen forms the corresponding basic oxides.

$$2Ca + O_2 \rightarrow 2CaO \qquad 2Zn + O_2 \rightarrow 2ZnO$$

2. Action of water on soluble metallic oxides

Metallic oxides dissolve in water to form their corresponding hydroxides.

$$K_2O + H_2O \rightarrow 2KOH \qquad Na_2O + H_2O \rightarrow 2NaOH$$

3. Action of water on ammonia

Ammonia dissolves in water rapidly to form ammonium hydroxide.

$$NH_3 + H_2O \rightarrow NH_4OH$$

General properties of bases

Physical properties of bases

1. Bases have a bitter taste.
2. Alkalis are soapy to feel.
3. The caustic alkalis such as NaOH and KOH are highly corrosive and they react with fats and oils in the skin.
4. Similar to acids, the solutions of bases in water also conduct electricity.
5. Alkalis turn red litmus blue, change red colour of methyl orange to yellow and colourless phenolphthalein to pink.

Chemical properties of bases

1. Action with acids: Bases neutralize acids to form salt and water.

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

2. Action with carbon dioxide: Caustic alkali absorbs carbon dioxide from the air to form carbonates and water.

$$2KOH + CO_2 \rightarrow K_2CO_3 + H_2O$$

3. Action with ammonium salts: All alkalis react with ammonium salts to liberate ammonia.

$$NH_4Cl + NaOH \rightarrow NaCl + H_2O + NH_3\uparrow$$

4. Double decomposition (Precipitation reactions): Solutions of alkalis precipitate insoluble metal hydroxides from the solutions of their salts.

$PbSO_4 + 2NH_4OH \rightarrow (NH_4)_2SO_4 + Pb(OH)_2\downarrow$

5. Amphoteric behaviour of some bases: The hydroxides of aluminium, zinc and lead behave as amphoteric substances and they react with both acids and bases to form salts.

$Al(OH)_3 + 3HCl \quad AlCl_3 + 3H_2O$

Test for alkalis

To test for an alkali: Add NH_4Cl to the alkali and heat. Evolution of pungent smelling ammonia gas shows the presence of alkali.

Uses of alkalis

1. Alkalis are used in the manufacture of soaps.

2. Alkalis such as ammonium hydroxide are used to remove grease stains from clothes.

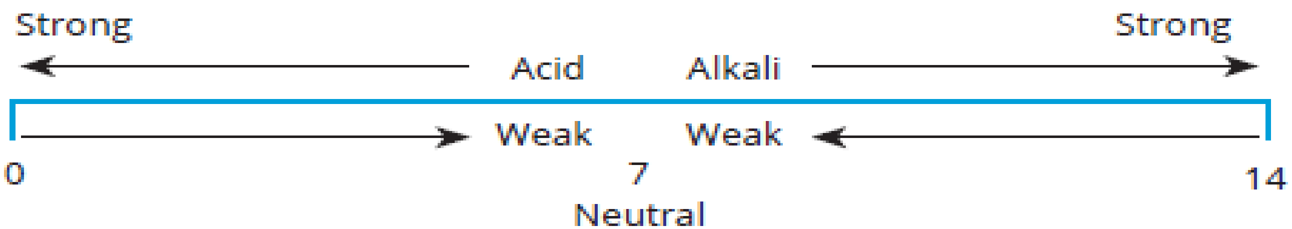
3. Calcium hydroxide is used in the manufacture of bleaching powder.

4. Magnesium hydroxide is used as an antacid.

pH and pH scale

pH is defined as the negative logarithm to the base 10 of the hydrogen ion concentration in solution. The strength of an acid or an alkali is expressed in terms of pH value or hydrogen ion concentration.

A scale ranging from 0 to 14, showing the relative strength of an acid and an alkali, is called the pH scale.



Lower is the pH value, stronger is the acid. Higher is the pH value, stronger is the alkali. On the pH scale, higher the hydrogen ion concentration, lower is the pH value.

In neutral solutions, $[H]^+ = [OH]^-$ pH = 7 whereas,

in acidic solutions, $[H]^+ > [OH]^-$ $pH < 7$ and in

alkaline solutions, $[H]^+ < [OH]^-$ $pH > 7$

Pure water is neutral and contains equal number of H^+ and OH^- ions, hence, it has a pH of 7.

Indicator

An indicator is a chemical compound used to detect the acidic or basic nature of a solution by a sharp change in its colour. But each indicator can work effectively within certain limits of pH.

Some common acid–base indicators

1. **Litmus paper:** There are two types of litmus paper – red litmus and blue litmus. If a drop of solution of acid or base is added to the paper, the colour may change as follows:

Solution tested	Red litmus	Blue litmus
Acidic	Stays red	Turns red
Neutral	Stays red	Stays blue
Alkaline (or basic)	Turns blue	Stays blue

2. **Methyl orange:** It is an orange coloured dye. The addition of a drop of methyl orange to an acidic solution turns the solution red and addition to a basic solution turns the solution yellow.

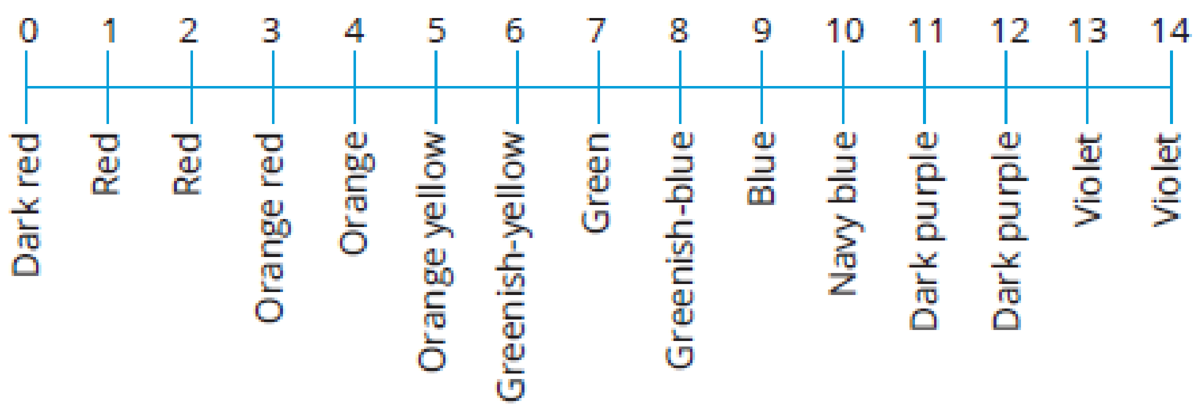
Solution tested	Colour changes
Acidic	Red
Neutral	Orange
Alkaline (or basic)	Yellow

3. Phenolphthalein: It is a colourless substance. In acidic solution, it remains colourless, but in basic solution, it turns the solution pink.

Solution tested	**Colour changes**
Acidic	Colourless
Neutral	Colourless
Alkaline (or basic)	Pink

Universal indicator

A universal indicator is a mixture of many specific indicators, each of which gives a sharp colour change at specific intervals of pH. It gives different colours at different pH values of the solution. Therefore, it can be used to differentiate between acidic or basic solutions of different pH values. A paper impregnated with universal indicator is called **pH paper**. The colour changes at different values of pH for a universal indicator are given below:



Importance of pH in Daily Life

1. pH in digestive system: Hydrochloric acid present in gastric juice released by stomach walls helps in the digestion of food.

2. pH in getting relief from bee sting: Bee sting leaves acid (mainly formic or methanoic acid) on the skin. To get relief from pain, baking soda, a base is applied on the stung area which neutralizes the acid.

3. Functions of enzymes at definite pH: The enzymes function effectively only in the region of 7–7.5 pH.

4. pH in humans and animals: Most of the reactions taking place in our body are in the narrow pH range of 7.0 to 7.8.

5. pH in dairy industry: Fresh milk is slightly acidic with a pH of around 6.5–6.7 because it contains lactic acid. Thus, it turns sour easily to become more acidic. In order to prevent souring of milk, small amount of baking soda is added to milk. Milk becomes alkaline and does not turn sour easily.

Salts

A **salt** is a compound formed by partial or complete replacement of the ionizable hydrogen ions of an acid by a metal ion (or ammonium ion).
Also, a salt is an ionic compound which dissociates in solution to give a cation other than H^+ ion and an anion other than OH^- ion.

For example

$$NaCl \longrightarrow Na^+ + Cl^-$$

The examples of salts are $NaCl$, KCl, Na_2CO_3, $MgSO_4$, CH_3COONa, NH_4NO_3

Types of salts

Salts are of various types:

Normal salts

A salt formed by the complete replacement of ionizable hydrogen ions of an acid by a cation is called **normal salt**. For example, $NaCl$, KCl, Na_2SO_4, Na_3PO_4, etc.

Acid salts

A salt formed by the partial replacement of the ionizable hydrogen ions of an acid by a metal ion is called **acid salt**. For example, $NaHSO_4$, $KHSO_4$, $NaHCO_3$,

Basic salts

A salt formed by the partial replacement of hydroxyl ion (OH^-) of a base by an acidic radical (or anion) is called **basic salt**. For example,
$Pb(OH)NO_3$, $Pb(OH)Cl$, $Cu(OH)NO_3$,

Double salts

Double salts are formed by mixing saturated solutions of two simple salts and crystallizing them. Double salts undergo complete dissociation in aqueous solutions. Mohr's salt, $FeSO_4 \cdot (NH_4)_2SO_4 \cdot 6H_2O$, Potash alum, $K_2SO_4 \cdot Al2(SO_4)_3 \cdot 24H_2O$ are some examples of double salts.

Complex salts

These salts dissociate in solution to form a simple ion and a complex ion. $K_4[Fe(CN)_6]$, $[Cu(NH_3)_4]SO_4$,and $[Ag(NH_3)_2]Cl$ are some examples of complex salts.

Mixed salts

A mixed salt generates more than one positive or negative ion in solution. For example, $CaOCl_2$ contains two negative ions OCl^- and Cl^-. $NaKSO_4$ contains two positive ions Na^+ and K^+.

General properties of salts

1. **Physical state:** Salts are non-volatile solids and forms crystals.
2. **Electrical conductivity:** Salts being ionic compounds are good conductors of electricity in molten or aqueous state because they dissociate into ions.

3. Solubility: Generally, most of the salts are soluble in water but some of them are insoluble.

4. Hydrolysis of salts: A salt as defined earlier is an ionic compound formed when an acid reacts with a base. Salts that dissolve in water are called electrolytes.

5. Action of dilute acids on salts: Dilute acids tend to decompose salts of hydrogencarbonates, bicarbonates, sulphites, bisulphites and sulphides to liberate gases. For example

$$K_2CO_3 + H_2SO_4 \longrightarrow K_2SO_4 + H_2O + CO_2\uparrow$$

$$KHCO_3 + HCl \longrightarrow KCl + H_2O + CO_2\uparrow$$

Preparation of normal salts

Preparation of normal salts is based on the solubility of the salt in water. Soluble salts are prepared in solution only. These are obtained by the evaporation of a solution of salt followed by crystallisation.

Soluble salts are prepared by:

1. direct combination (reaction of metal with nonmetals)

2. displacement (action of dilute acids on active metals)

3. neutralization of insoluble base by an acid

4. neutralization of soluble base (or alkali) by an acid

5. decomposition of soluble carbonates by acid

Preparation of insoluble salts

1. Direct combination: Metals like zinc, iron and lead generally form insoluble salts on reaction with nonmetals.

2. Precipitation (Double decomposition): It is the most common method to prepare insoluble salts. In this method, solution of two soluble salts on reactionwith each other gives an insoluble salt (in the form of precipitate) as one of the products.

SUMMARY

1. Acids are the compounds which when dissolved in water yield hydronium ions, H_3O+ as the only positively charged ions. They turn blue litmus paper red. Their aqueous solution conducts electricity due to the presence of ions.

2. Basicity is the number of hydronium ions produced by the ionization of one molecule of acid in a solution. Acids having a basicity of 1, 2 and 3 are called monobasic, dibasic and tribasic acids respectively.

3. **Bases** are the metal oxides or metal hydroxides or aqueous ammonia which combine with acids to form salt and water. They turn red litmus paper blue. Their aqueous solution conducts electricity.

4. Alkalis are soluble bases like KOH, NaOH and NH_4OH. The insoluble bases like CuO, MgO, $Fe(OH)_3$, $Fe(OH)_2$, $Cu(OH)_2$ and $Mg(OH)_2$ are not called alkalis as they are insoluble in water.

5. A **strong base** produces a high concentration of hydroxyl ions in solution while a **weak base** produces a low concentration of hydroxyl ions in solution.

6. pH is defined as the negative logarithm of the hydrogen ion concentration in solution. pH shows the relative strength of an acid or an alkali. An acidic solution has a pH less than 7, basic solution has pH greater than 7 and neutral solution has a pH equals to 7.

7. An indicator is a chemical compound used to detect the acidic or basic nature of a solution by a sharp change in its colour.

8. A **salt** is an ionic compound formed by the partial or complete replacement of ionizable hydrogen ions by a metal cation or ammonium ion.

9. Acidic salt is formed when H^+ ions of an acid are partially replaced by a metal cation or ammonium ion.

10. Basic salt is formed when OH^- ions of a base are partially replaced by an anion.

11. Normal salt is formed by the complete replacement of ionizable hydrogen ions of an acid by a metal cation or ammonium ion.

12. Salt hydrolysis is the phenomenon of interaction of the cations and anions of a salt with H^+ and OH^- ions of water.

THANK YOU