CHAPTER 3
ACIDS, BASES AND SALTS

NOTES

Acids:

- Sour in taste
- Corrosive in nature

Types of acids:

1. Organic acids: acids present in food materials.
   Examples: Citric acid ($C_3H_4OH(COOH)_3$); Malic acid $C_2H_3(OH)_2(COOH)_2$; Tartaric acid $C_2H_2(OH)_2(COOH)_2$ etc.
2. In-organic Acids (Mineral acids): Acids prepared from minerals
   Examples: Sulphuric acid (H_2SO_4), Hydrochloric acid (HCl), Nitric acid (HNO_3) etc.

Bases:

- Bitter in taste
- Soft and slippery to touch
- Strong bases are corrosive
- Oxides and Hydroxides generally constitute bases.
  Examples: Sodium hydroxide (NaOH), Potassium hydroxide (KOH); Calcium hydroxide [$Ca(OH)_2$]

Acid Base Indicators:

- Chemical substances which indicate the presence of an acid or base in a solution.

Types of Indicators:

1. Natural indicators. **Example:** Litmus, Turmeric, etc.
2. Man-made (Synthetic) Indicators. **Example:** Methyl Orange, Phenolphthalein.

Table : Colouration of indicators

Sl. No.	Name of the indicator	Colour change with acid	Colour change with base
1.	Blue litmus solution	Red	No change
2.	Red litmus solution	No change	Blue
3.	Methyl orange	orange red	Yellow
4.	Phenolphthalein	Colourless	Pink

Indicators tell us the nature of a solution whether it is acidic or basic by a change in their colour in different solutions

Chemical Properties of Acids and Bases

1. Acid + Metal → Salt + Hydrogen gas

Examples:

i. H_2SO_4 (aq) + Zn (s) ⟶ $ZnSO_4$ (aq) + H_2 (g)
Sulphuric acid — Zinc — Zinc sulphate — Hydrogen

ii. 2HCl (aq) + Zn (s) ⟶ $Zn Cl_2$ (aq) + H_2 (g)
Hydrochloric acid — Zinc — Zinc chloride — Hydrogen

Pop Test (Test for Hydrogen Gas):

When a burning candle is brought near a test tube containing H_2 gas, it burns with a pop sound. This test is conducted for examining the presence of H_2 gas.

2. Base + Metal → Salt + Hydrogen

Examples:

i. 2NaOH + Zn ⟶ Na_2ZnO_2 + H_2
Sodium Hydroxide — Zinc — Sodium Zincate — Hydrogen

ii. NaOH + Al + H_2O ⟶ $2NaAlO_2$ + H_2
Sodium Hydroxide — Aluminium — water — Sodium meta aluminate — Hydrogen

- Aluminium powder and Sodium hydroxide solution is used to prepare hydrogen for gas balloon sold in the market.
- Tin and silicon also react with sodium hydroxide to liberate Hydrogen gas.

NOTE: Such reactions are not possible with all the metals.

3. Reactions of acids with metal carbonates and metal hydrogen carbonates (metal bicarbonates)

(a) Metal carbonate + Acid → Salt + Water + Carbon dioxide

Example:

i. Na_2CO_3 (s) + 2 HCl (aq) → NaCl (aq) + H_2O (l) + CO_2 (g)
Sodium Carbonate — Hydrochloric Acid — Sodium Chloride — Water — Carbondioxide

(b) Metal hydrogen carbonate + Acid → Salt + Water + Carbondioxide

Example:

$NaHCO_3$ (s) + HCl(aq) → NaCl (aq) + H_2O (l) + CO_2(g)
Sodium hydrogen Carbonate — Hydrochloric acid — Sodium Chloride — Water — Carbondioxide

Lime Water Test (Test for CO_2 Gas)

When the evolved carbon dioxide is passed into lime water the clear solution becomes milky due to the formation of insoluble calcium carbonate.

$Ca(OH)_2$ (aq) + CO_2 (g) → $CaCO_3$ (s) + H_2O(l)

Lime water (Calcium Hydroxide) — Milky Calcium carbonate (insoluble)

When carbon dioxide is passed into lime water for a longer time, the insoluble calcium carbonate is converted into soluble calcium hydrogen carbonate.

$CaCO_3$(s) + H_2O(l) + CO_2(g) → $Ca(HCO_3)_2$ (aq)

(insoluble) — Calcium hydrogen carbonate (soluble)

4. Neutralization Reaction

Acid + Base → Salt + water

Example: HCl (aq) + NaOH (aq) → NaCl (aq) + H_2O(l)

Neutralisation reaction takes place when the effect of a base is neutralised by an acid and *vice-versa* to give salt and water.

5. Reaction of Metal Oxides with Acids

Metal oxide + Acid → Salt + Water

Example:

i. ZnO (s) + HCl (aq) → $ZnCl_2$ (aq) + H_2O (l)

Zinc oxide (white) — Zinc chloride (colourless)

ii. CuO (s) + 2 HCl (aq) → $CuCl_2$ (aq) + H_2O (aq)

Copper(II)oxide (black colour) — Copper(II)chloride (bluish green)

Hydrogen is common in all acids:

Examples: HCl (Hydrochloric acid); H_2SO_4 (Sulphuric acid); HNO_3(Nitric acid); HCOOH (Formic acid); CH_3COOH(Acetic acid) etc.

The hydrogen present in acids can be replaced by metals. But in case of organic acids the hydrogen atoms present only in the form of –COOH can be replaced.

Example: $2CH_3COOH$ (aq) + 2 Na (s) → 2 CH_3COONa (aq) + H_2 (g)

Acetic acid — Sodium acetate

Table: Some of the acids found naturally in plants, fruits and insects which have acidic properties.

Plants and animal sources	Name of the acid present	Chemical formula
Lemon and oranges etc (citrus fruits)	Citric acid	$C_3H_4(OH)(COOH)_3$
Apple, Peach etc	Malic acid	$C_2H_3(OH)_2(COOH)_2$
Tamarind and grapes	Tartaric acid	$C_2H_2(OH)_2(COOH)_2$
Oxalis	Oxalic acid	$(COOH)_2$
Sour Milk (Curd)	Lactic acid	$C_2H_4(OH)COOH$
Vinegar	Acetic acid	CH_3COOH
Ants, Bees, Wasp	Formic acid	HCOOH
Cabbage, green leafy vegetables etc.	Ascorbic acid (Vitamin C)	$C_6H_8O_6$ or $C_5H_3(OH)_4COOH$

Alkalis:

All bases do not dissolve in water. An alkali is a base that dissolves in water.

Example: NaOH ; KOH ; $Ca(OH)_2$; NH_4OH etc.

Note: All alkalis are bases but all bases are not alkalis.

Acids or bases in a water solution

- Acids produce hydrogen ions (H^+ ions) or Hydronium ions (H_3O^+) in the presence of water.

$H^+ + H_2O \rightarrow H_3O^+$

Hydrogen ion → Hydronium ion

Examples:

i. $HCl\ (g) + H_2O \rightarrow H_3O^+\ (aq) + Cl^-\ (aq)$

ii. $H_2SO_4\ (l) + 2H_2O\ (l) \rightarrow 2H_3O^+ + SO_4^{2-}\ (aq)$

Sulphate ion

The acidic reactions of acids are due to the presence of ionisable or replaceable hydrogen in them. Actually it is the reaction of hydronium ion (H_3O^+) in solution.

- Bases provide hydroxide ion (OH^-) in water.

$NaOH\ (s) + H_2O \rightarrow Na^+\ (aq) + OH^-\ (aq)$

- NaOH also known as caustic soda and KOH also known as caustic potash are highly corrosive.

Dissolution of acids and alkalis in water involve heat change:

When an acid or a base is mixed with water they become dilute. This results in the decrease in the concentration of hydronium ion or hydroxide ion per unit volume in acids and bases respectively.

Strength of an acid or a base

- Strength of an acid depends on the number of hydronium ions (H_3O^+) it can produce in equimolar solutions.
- Strength of a base (alkali) depends upon the number of hydroxide ion (OH^-) it can produce in equimolar solutions.
- With the help of a universal indicator the strength of an acid or base can be determined. It is known as p^H scale. The scale of p^H value ranges from 0 to 14.
- Acidic solutions have p^H value less than 7 and that of basic solutions above 7.
- Stronger Acid → Higher concentration of hydronium ion → Lesser p^H value
- Solutions with lower p^H values are stronger acids.
- Stronger Base → Higher concentration of hydroxide ion→ Higher p^H value
- Solutions with higher p^H values are more alkaline.

Different kinds of salts:

1. **Normal salts:** Salts formed by the complete neutralization of a strong acid with a strong base.

Example: HCl (aq) + $NaOH$ (aq) → $NaCl$ (aq) + H_2O (l)
Strong acid — strong base — normal salt

Some other normal salts are Na_2SO_4, $MgCl_2$, KNO_3 , $CuSO_4$ etc.

2. **Acid salts:** Salts which can behave as an acid and react with a base to give normal salt. They are formed by incomplete neutralisation of an acid by a base.

Example: Reaction between dilute NaOH and dilute H_2SO_4

H_2SO_4 (aq) + $NaOH$ (aq) → $NaHSO_4$ (aq) + H_2O (l)
Sodium hydrogen sulphate (acidic salt)

$NaHSO_4$ (aq) + $NaOH$ (aq) → Na_2SO_4 (aq) + H_2O (l)
Sodium sulphate

(normal salt)

3. **Basic salts:** Salts which contains replaceable OH group and can behave as a base and can react with an acid to give normal salt. They are formed by incomplete neutralization of a base with an acid.

Examples: Reaction between $Mg(OH)_2$ and HCl

$Mg(OH)_2$ + HCl → $Mg(OH)Cl$ + H_2O

Magnesium hydroxychloride (basic salt)

$Mg(OH)Cl$ + HCl → $MgCl_2$ + H_2O

Magnesium chloride (normal salt)

Hydrolysis of salt with water

When a salt is dissolved in water, the solution obtained may be neutral, acidic or alkaline.

1. Souble normal salts derived from strong acids and strong bases give neutral solution. **Example:** NaCl solution

2. Salt derived from weak acid and a strong base on hydrolysis give an alkaline solution. **Example:** Na_2CO_3

Na_2CO_3 + $2H_2O$ ⇋ $2NaOH$ (strong base) + H_2CO_3 (weak acid)

3. Salt derived from strong acid and weak base on hydrolysis give an acidic solution. **Example:** $AlCl_3$

$AlCl_3$ + $3H_2O$ ⇋ $Al(OH)_3$ (weak base) + 3HCl (strong acid)

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