CHAPTER 2: ACIDS, BASES AND SALTS

Introduction

Many substances we use in everyday life are **acids, bases or salts**.

Examples from daily life:

SUBSTANCE	NATURE	ACID/BASE PRESENT
LEMON JUICE	Acidic	Citric acid
VINEGAR	Acidic	Acetic acid
CURD	Acidic	Lactic acid
TAMARIND	Acidic	Tartaric acid
SOAP	Basic	Sodium salts
TOOTHPASTE	Basic	Mild bases

These substances show acidic or basic properties mainly when dissolved in water.

Acids

Acids are substances that produce hydrogen ions (H^+) in aqueous solution.

Example reaction:

$$HCl \rightarrow H^+ + Cl^-$$

The presence of **H^+ ions** gives acids their properties.

Examples of Acids

ACID	CHEMICAL FORMULA	SOURCE
HYDROCHLORIC ACID	HCl	Stomach
SULPHURIC ACID	H_2SO_4	Batteries
NITRIC ACID	HNO_3	Fertilizer industry
ACETIC ACID	CH_3COOH	Vinegar

CITRIC ACID	$C_6H_8O_7$	Citrus fruits
LACTIC ACID	$C_3H_6O_3$	Curd

Characteristics of Acids

1. Sour taste
2. Turn **blue litmus red**
3. Conduct electricity in aqueous solution
4. React with metals to produce **hydrogen gas**

3. Bases

Bases are substances that produce hydroxide ions (OH^-) in aqueous solution.

Example:

$$NaOH \rightarrow Na^+ + OH^-$$

Examples of Bases

BASE	FORMULA
SODIUM HYDROXIDE	NaOH
POTASSIUM HYDROXIDE	KOH
CALCIUM HYDROXIDE	$Ca(OH)_2$
MAGNESIUM HYDROXIDE	$Mg(OH)_2$

Characteristics of Bases

1. Bitter taste
2. Soapy touch
3. Turn red litmus blue
4. Conduct electricity in aqueous solution

4. Alkalis

Alkalis are bases that dissolve in water.

Examples:

ALKALI	FORMULA
SODIUM HYDROXIDE	NaOH
POTASSIUM HYDROXIDE	KOH
CALCIUM HYDROXIDE	$Ca(OH)_2$
AMMONIUM HYDROXIDE	NH_4OH

All alkalis are bases but all bases are not alkalis.

Example:
Copper oxide (CuO) is a base but **not soluble in water**, so it is not an alkali.

5. Indicators

Indicators are substances that change colour in acidic or basic solutions**.**

They help identify whether a substance is **acidic or basic**.

Types of Indicators

1. Natural Indicators

Obtained from plants.

Examples:

INDICATOR	ACIDIC COLOUR	BASIC COLOUR
LITMUS	Red	Blue
TURMERIC	Yellow	Reddish brown
CHINA ROSE	Dark pink	Green
RED CABBAGE	Red	Green

2. Synthetic Indicators

Prepared in laboratories.

Examples:

INDICATOR	ACIDIC	BASIC
PHENOLPHTHALEIN	Colourless	Pink
METHYL ORANGE	Red	Yellow

3. Olfactory Indicators

Substances whose **smell changes in acidic or basic medium**.

Examples:

- Onion (Onion smell **disappears in base** but remains in acid)
- Vanilla
- Clove oil

6. Chemical Properties of Acids

1. Reaction with Metals

Acids react with metals to produce **salt and hydrogen gas**.

General Reaction:

$$Acid + Metal \rightarrow Salt + H_2$$

Example:

$$Zn + 2HCl \rightarrow ZnCl_2 + H_2$$

Hydrogen gas test:
Burning matchstick gives **pop sound**.

2. Reaction with Metal Carbonates

Acids react with carbonates to produce:

- Salt
- Water
- Carbon dioxide

Reaction:

$$Acid + MetalCarbonate \rightarrow Salt + H_2O + CO_2$$

Example:

$$Na_2CO_3 + 2HCl \rightarrow 2NaCl + H_2O + CO_2$$

Test of Carbon Dioxide

CO_2 passed through **lime water**.

Reaction:

$$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$$

Result:
Lime water becomes **milky**.

3. Reaction with Metal Bicarbonates

Reaction:

$$Acid + MetalBicarbonate \rightarrow Salt + H_2O + CO_2$$

Example:

$$NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2$$

4. Reaction with Metal Oxides

Metal oxides are **basic in nature**.

Reaction:

$$Acid + MetalOxide \rightarrow Salt + Water$$

Example:

$$CuO + 2HCl \rightarrow CuCl_2 + H_2O$$

7. Chemical Properties of Bases

1. Reaction with Acids (Neutralization)

Neutralization reaction:

$$Acid + Base \rightarrow Salt + Water$$

Example:

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

2. Reaction with Non-metal Oxides

Non-metal oxides are acidic.

Example:

$$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$$

8. Acids and Bases in Aqueous Solutions

Acids and bases show their properties **only in aqueous solution**.

Example:

Dry HCl gas **does not show acidic nature**.

When dissolved in water:

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

Hydrogen ions exist as **hydronium ions (H_3O^+)**.

9. Strength of Acids and Bases

Strength depends on **degree of ionization in water**.

Strong Acids

Completely ionize in water.

Examples:

- HCl
- HNO_3
- H_2SO_4

Weak Acids

Partially ionize.

Examples:

- CH_3COOH
- H_2CO_3

Strong Bases

Completely ionize in water

Examples:

- NaOH
- KOH

Weak Bases

Partially ionize in water

Examples:

- NH_4OH
- NH_3
- $Al(OH)_3$

10. pH Scale

pH measures **strength of acid or base**.

Range: 0 – 14

PH	NATURE
0–3	Strong acid
4–6	Weak acid
7	Neutral
8–10	Weak base
11–14	Strong base

Example values:

SUBSTANCE	PH
LEMON JUICE	2
VINEGAR	3
WATER	7
BLOOD	7.4
SOAP	9–10

Importance of pH in Everyday Life

1. Tooth decay

Bacteria produce acids that lower pH **below 5.5**, damaging teeth.

Toothpaste is **basic** to neutralize acid.

2. Soil pH

If soil is too acidic:

Farmers add **quicklime** **(CaO)** or **slaked lime** **($Ca(OH)_2$)**.

3. pH of Digestive System

Stomach contains **hydrochloric acid**.

Excess acid causes indigestion.

Treatment: **Antacids**.

Example:

Magnesium hydroxide.

4. pH of Water Bodies

Acid rain lowers pH of rivers and lakes → harms aquatic life.

11. Salts

Salts are substances formed by neutralization reaction between an acid and a base.

Example:

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

NaCl is salt.

12. Nature of Salt Solution

Depends on **strength of acid and base used**.

ACID	BASE	SALT NATURE
STRONG	Strong	Neutral
STRONG	Weak	Acidic
WEAK	Strong	Basic

Examples:

SALT	NATURE
NACL	Neutral
NH_4CL	Acidic
NA_2CO_3	Basic

13. Family of Salts

Salts having **same positive or negative ion** belong to same family.

Example:

SALT	FAMILY

NACL	Chloride family
KCL	Chloride family

14. Chemicals from Common Salt (NaCl)

Common salt is used to prepare many chemicals:

1. Sodium hydroxide
2. Bleaching powder
3. Baking soda
4. Washing soda

15. Chlor-Alkali Process

Process used to produce **sodium hydroxide (NaOH)** by electrolysis of brine.

Brine = concentrated solution of NaCl.

Process Steps

1. Prepare concentrated NaCl solution (brine).
2. Pass electricity through brine.
3. Electrolysis occurs.

Products formed:

- Sodium hydroxide
- Hydrogen gas
- Chlorine gas

Reaction:

$$2NaCl + 2H_2O \rightarrow 2NaOH + H_2 + Cl_2$$

Uses of Products

Sodium hydroxide

- Soap manufacturing
- Paper industry
- Artificial fibres

Hydrogen gas

- Fuel
- Hydrogenation of oils

Chlorine gas

- Water purification
- PVC manufacturing

16. Bleaching Powder

Formula

$$CaOCl_2$$

Preparation

Step 1: Take **dry slaked lime**.

Step 2: Pass **chlorine gas** over it.

Reaction:

$$Ca(OH)_2 + Cl_2 \rightarrow CaOCl_2 + H_2O$$

Uses

- Disinfecting drinking water
- Bleaching cotton and linen
- Oxidizing agent
- Making chloroform

17. Baking Soda

Formula

$$NaHCO_3$$

Preparation

Step 1:
Pass **CO_2 gas through brine saturated with ammonia**.

Reaction:

$$NaCl + NH_3 + H_2O + CO_2 \rightarrow NaHCO_3 \downarrow$$

$NaHCO_3$ precipitates out.

Heating Baking Soda

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

Uses

- Baking powder
- Antacid
- Fire extinguishers
- Making soda acid fire extinguishers

Baking Powder

Mixture of:

- Baking soda
- Tartaric acid

CO_2 released makes cakes **soft and fluffy**.

18. Washing Soda

Formula

$$Na_2CO_3 \cdot 10H_2O$$

Preparation Steps

Step 1: Heat baking soda.

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

Step 2: Recrystallization with water forms washing soda.

Uses

- Cleaning agent
- Softening hard water
- Glass manufacturing
- Soap production

19. Water of Crystallization

Fixed number of water molecules present in a salt.

Example:

SALT	FORMULA
COPPER SULPHATE	$CuSO_4 \cdot 5H_2O$
GYPSUM	$CaSO_4 \cdot 2H_2O$
WASHING SODA	$Na_2CO_3 \cdot 10H_2O$

Example:

Heating copper sulphate:

Blue crystals → white powder.

Adding water restores blue colour.

20. Plaster of Paris (POP)

Plaster of Paris is a white powder obtained by heating **gypsum** at a high temperature.

Chemical Formula

$CaSO_4 \cdot \frac{1}{2}H_2O$
(Calcium sulphate hemihydrate)

Preparation of Plaster of Paris

Plaster of Paris is prepared by **heating gypsum** at about **100–120°C**.

Chemical reaction:

$CaSO_4 \cdot 2H_2O \rightarrow CaSO_4 \cdot ½H_2O + 1½H_2O$

Gypsum → Plaster of Paris + Water

If gypsum is heated above **120°C**, it loses all water and forms **anhydrous calcium sulphate**, which does not set properly.

Properties of Plaster of Paris

- It is a **white powder**.
- When mixed with water, it forms a **smooth paste**.
- The paste **hardens quickly** to form a solid mass.
- It sets into a **hard solid when water is added**.

Setting Reaction of Plaster of Paris

When Plaster of Paris is mixed with water, it converts back to **gypsum** and becomes hard.

Reaction:

$CaSO_4 \cdot ½H_2O + 1½H_2O \rightarrow CaSO_4 \cdot 2H_2O$

Plaster of Paris + Water → Gypsum

Uses of Plaster of Paris

- Making **statues and decorative items**
- Making **toys and models**
- Used in **hospitals for plaster casts** to support fractured bones
- Making **false ceilings and wall decorations**
- Used in **moulds and chalk**