CHAPTER-2

ACIDS, BASES AND SALTS

Topic-1 Acids and Bases

Concepts Covered • Definition of acids and bases, • Properties of acids and bases, • Indicators and its type, • pH scale and importance of pH in everyday life.

Revision Notes

Acids

- Acids are the substances that furnish H^+ ions in aqueous solution. Acids are sour in taste. They turn blue litmus red.
- The example includes Sulphuric acid (H_2SO_4), Acetic acid (CH_3COOH), Nitric acid (HNO_3) etc.
- If in an aqueous solution, concentration of acid is low, it is called **dilute solution** and if concentration of acid is high, it is called **concentrated solution**.
- Those acids which dissociates into ions completely are called strong acids, e.g., H_2SO_4, HCl.
- Those acids which do not dissociate into ions completely are called weak acids, e.g., citric acid, acetic acid.

> **Note:**
> Although we talk of 'taste' of acids and bases, it is not advisable to taste any acid or base. Most of them are harmful. Similarly touching the solutions of strong acids and bases should be avoided. They may harm the skin.

Some Naturally occurring acids :

Natural source	Acid	Natural source	Acid
Vinegar	Acetic acid	Sour milk (Curd)	Lactic acid
Orange	Citric acid	Lemon	Citric acid
Tamarind	Tartaric acid	Ant sting	Methanoic acid
Tomato	Oxalic acid	Nettle sting	Methanoic acid

Bases

- Bases are those chemical compounds which are bitter in taste, soapy in touch, turn red litmus blue and give OH^- ions in aqueous solution.
- The examples include Sodium hydroxide (NaOH), Potassium hydroxide (KOH), etc.
- The substances / bases which ionise completely to furnish OH^- ions are called strong bases, e.g., KOH, NaOH, etc.
- The bases which ionise only partially are called weak bases, e.g., $Mg(OH)_2$, $Cu(OH)_2$, etc.
- Both acids and bases conduct free electric current in their aqueous solution due to the presence of free ions.
- Strength of an acid or base depends on the number of H^+ ions or OH^- ions produced by them respectively. More the H^+ ions produced by an acid, stronger is the acid. More the OH^- ions produced by a base, stronger is the base.
- Chemical compounds can cause harm to our body, some are very lethal, and therefore, we cannot rely on physical tests such as taste and appearance. In laboratory, to test whether a compound has acidic character or basic character, indicators are used.
- **Indicators:** These are the substances which change their colour / smell in different types of substances.

- **Types of Indicators:**

	S. No.	Indicator	Smell/Colour In Acid Solution	Smell/Colour In Basic Solution
Natural Indicator	1.	Litmus	Red	Blue
	2.	Red cabbage leaf extract	Red	Green
	3.	Flowers of hydrangea plant	Blue	Pink
	4.	Turmeric	No change	Red
Synthetic Indicator	1.	Phenolphthalein	Colourless	Pink
	2.	Methyl orange	Red	Yellow
Olfactory Indicator	1.	Onion	Characteristic smell	No smell
	2.	Vanilla essence	Retains smell	No smell
	3.	Clove oil	Retains smell	Loses smell

- **Chemical Properties of Acids and Bases:**

1. Reaction of Metals with:

Acids	Bases
Acid + Metal $\rightarrow$ Salt + Hydrogen gas	Base + Metal $\rightarrow$ Salt + Hydrogen gas
e.g., $2HCl + Zn \rightarrow ZnCl_2 + H_2\uparrow$ (Zinc chloride)	e.g., $2NaOH + Zn \rightarrow Na_2ZnO_2 + H_2\uparrow$ (Sodium zincate)

Test for H_2 gas: Hydrogen gas released can be tested by bringing a burning candle near gas bubbles, it bursts with pop sound.

2. Reaction of Metal Carbonates / Metal Hydrogen Carbonates with:

Acids	Bases
Acid + Metal Carbonate / Metal hydrogen Carbonate $\downarrow$ Salt + CO_2 + H_2O	Base + Metal Carbonate / Metal Hydrogen Carbonate $\downarrow$ No Reaction

e.g., $2HCl + Na_2CO_3 \rightarrow 2NaCl + CO_2 + H_2O$

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

Test for CO_2: CO_2 can be tested by passing it through lime water. Lime water turns milky.

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

When excess CO_2 is passed, milkiness disappears.

$CaCO_3 + CO_2 + H_2O \rightarrow Ca(HCO_3)_2$

3. Reaction of Acids and Bases With Each Other

When an acid reacts with base, the hydrogen ion of acid combines with hydroxide ion of base and forms water. As these ions combine together, they form water instead of remaining free, thus both neutralize each other.

Acid + Base $\rightarrow$ Salt + Water

$HX + MOH \rightarrow MX + HOH$

$H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

Since, in the reaction between an acid and a base both neutralize each other, it is also known as neutralization reaction.

Example : Sodium hydroxide (a strong base) reacts with hydrochloric acid to form sodium chloride and water.

$NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$

Dilution of Acid and Base

When a concentrated acid or base is diluted, a vigorous reaction takes place. The process is called dilution. It is an exothermic process as a lot of heat is produced.

The process of forming ions in aqueous solution is called ionisation. All ionic compounds like NaCl, $NaNO_3$, Na_2SO_4 form ions in aqueous solution.

- We add acid to water. If we add water to acid, the high concentration of acid may produce a violent exothermic reaction.
- Concentrated acids and bases are corrosive; no person should touch it with bare hand or skin. In case a few drops spill on the body, a person should wash it with plenty of water.

Common property between all acids and all bases

- Acids give hydrogen gas when they react with metal. This shows that all acids contain hydrogen.
- When acids are dissolved in water they dissociate as H^+ ions. The dissociation as hydrogen ions in aqueous solution is the common property of all acids. As a result, an acid shows acidic behavior.

  $HCl\ (aq) \rightarrow H^+(aq) + Cl^-\ (aq)$

  $HNO_3(aq) \rightarrow H^+(aq) + NO_3^-\ (aq)$

  $CH_3COOH\ (aq) \rightarrow H^+\ (aq) + CH_3COO^-\ (aq)$
- As H^+ ion cannot exist alone so it combines with water molecules and forms H_3O^+ (hydronium) ions.

  Example :

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

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

  Thus, acids can also be defined as 'Substances which when dissolved in water ionize to produce hydrogen ions, H^+ (aq).
- Similarly, substances which when dissolved in water ionize to produce hydroxide ions, OH^- (aq).

  Examples : When sodium hydroxide is dissolved in water, it dissociates into hydroxide and sodium ion.

  $$NaOH(s) \xrightarrow{H_2O} Na^+(aq) + OH^-\ (aq)$$

4. Reaction of acids with metal oxides :

Metal oxides react with acids to give salt and water.

Metal oxide + Acid → Salt + Water

Example : Copper oxide reacts with dil. hydrochloric acid to form copper chloride (salt) and water.

$$\underset{\text{Copper oxide}}{CuO} + 2HCl \rightarrow \underset{\text{Copper chloride}}{CuCl_2} + H_2O$$

Copper oxide is black in colour. When dilute hydrochloric acid is added in it, the colour of the solution becomes blue green due to formation of copper chloride.

How strong are acid or base solutions?

- Strength of an acid or base depends on the number of H^+ ions or OH^- ions produced by them respectively.
- Based on its ability to dissociate into ions in solution, acids and bases are classified as strong acid or base and weak acid or base.

(i) Strong acids : Acid which completely dissociates in water to produce large amount of hydrogen ions are called strong acids. For example hydrochloric acid (HCl), sulphuric acid (H_2SO_4), nitric acid (HNO_3) are strong acids as they get completely ionized in water to form ions.

$$HCl\ (aq) \rightarrow H^+(aq) + Cl^-\ (aq)$$

(ii) Weak acids : Acids which are partially ionized in water to produces small amount of hydrogen ions are known as weak acids. For example, acetic acid partially dissociates in water to produce small amount of hydrogen ions.

$$CH_3COOH\ (aq) \rightarrow H^+\ (aq) + CH_3COO^-(aq)$$

(iii) Strong bases : Bases which completely ionize in water to produce large amount of hydroxide ions are called strong bases. Examples include NaOH, KOH, etc.

(iv) Weak bases : Bases which partially dissociate in water to furnish lesser amount of hydroxide ions are called weak bases. Examples include ammonium hydroxide (NH_4OH) and calcium hydroxide $Ca(OH)_2$

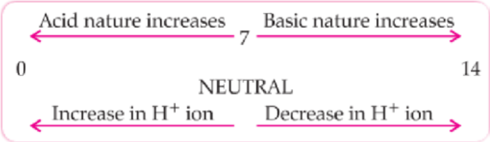
pH

- A scale for measuring H^+ ion concentration in a solution.
- The concentrations of H^+ are generally small, therefore concentrations of H^+ are expressed in terms of pH. pH is defined as negative logarithm of H^+ concentration or H_3O^+ concentration.

$$pH = -\log [H^+] \text{ or } pH = -\log [H_3O^+]$$

- pH = 7 → neutral solution
- pH < 7 → acidic solution
- pH > 7 → basic solution
- On diluting an acid: pH increases ↑
- On diluting a base: pH decreases ↓

Key Diagram



- **Importance of pH in everyday life:**
  - Plants and animals are pH sensitive.
  - Our body works within the pH range of 7 – 7.8.
  - When pH of rain water is less than 5.6, it is called **acid rain.**
  - Plants require a specific pH range for their healthy growth.

Key Fact

p in pH stands for 'potentz', a German word which means power.

- pH of stomach is 1.5-3.0 due to secretion of HCl. In case of indigestion, acidity increases, which can be neutralised by antacids like milk of magnesia.
- Tooth decay starts when pH of the mouth is lower than 5.5. To protect tooth decay, toothpastes which are basic in nature are used to neutralize the excess acid.
- Many plants and animals produce certain acids to defend themselves. For example, Bee stings leave an acid into the skin, which causes pain and irritation. If a mild base like baking soda is applied on the stung area, it gives relief.

Key Word

Acid rain: Acid rain is rain or any other form of precipitation that is unusually acidic, meaning that it has elevated levels of hydrogen ions (low pH).

- **Important Reaction of different solutions with different indicators:**

S. No.	Name of the solution	Colour change (if any) Phenolphthalein	Colour change (if any) Blue litmus
1.	Sodium carbonate	turns pink	no change
2.	Hydrochlroic acid	no change	turns red
3.	Sodium chloride	no change	no change

Topic-2 Salts, their Properties and Uses

Concepts Covered • Salts, • Types of salts, • Preparation and uses of Sodium Hydroxide, Bleaching powder, Baking soda, Washing soda and Plaster of Paris..

Revision Notes

- **Salts:** A salt is an ionic compound that results from the **neutralisation reaction** of an acid and a base. Salts are composed of related numbers of cations and anions, so that, the product is electrically neutral.
- **Types of Salts:**

(i) **Neutral salts :** Salts produced by reaction of strong acid and strong base are neutral in nature with pH value 7. For example, sodium chloride formed by reaction between sodium hydroxide (strong base) and hydrochloric acid (strong acid).

$$NaOH\ (aq) + HCl\ (aq) \rightarrow NaCl\ (aq) + H_2O\ (l)$$

(ii) **Acidic salts :** Salts formed by reaction between a strong acid and weak base are acidic in nature with pH value less than 7. For example, ammonium hydroxide. It is a salt of hydrochloric acid (strong acid) and ammonium hydroxide (weak base).

$$NH_4OH\ (aq) + HCl(aq) \rightarrow NH_4Cl\ (aq) + H_2O\ (l)$$

Key Word

Neutralisation reaction: The reaction in which base or basic oxide reacts with acid or acidic oxide is called neutralisation reaction.

Example : $NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O$.

(iii) Basic salts : Salts formed by reaction of strong base and weak acid are basic in nature with pH value more than 7. For example, sodium carbonates. It is a salt of carbonic acid (weak acid) and sodium hydroxide (strong base).

$$H_2CO_3\,(aq) + 2NaOH\,(aq) \rightarrow Na_2CO_3 + 2H_2O\,(l)$$

- **Common Salt (NaCl):**

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

Properties: $2NaCl\,(aq) + 2H_2O\,(l) \rightarrow 2NaOH\,(aq) + Cl_2\,(g) + H_2\,(g)$

Users of common salt:

(a) Used as daily food.

(b) Used as preservative.

(c) Used in manufacture of metal (Na) and gas (Cl_2) in molten state by electrolysis

- **Sodium hydroxide (NaOH)**

Preparation : $2NaCl\,(aq) + 2H_2O\,(l) \rightarrow 2NaOH\,(aq) + Cl_2\,(g) + H_2\,(g)$

The process is called chlor - alkali process because of the products formed- Chlor for chlorine and alkali for sodium hydroxide.

Uses :

(a) Sodium hydroxide is used in making of paper, soap and detergents, for de-greasing metals, etc.

(b) Chlorine gas is used in water treatment, manufacturing of PVC, pesticides, etc.

(c) liquid hydrogen is used as rocket fuel, in hydrogenation process of oil to produce vegetable *ghee* (margarine) and in making of ammonia for fertilizers..

- **Bleaching Powder ($CaOCl_2$):**

Preparation: It is produced by the action of chlorine on dry slaked lime.

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

Properties:

(a) It has a strong smell of chlorine.

(b) Soluble in water.

(c) It loses Chlorine by the action of carbon di oxide.

Uses:

(a) Bleaching cotton and linen in textile industry.

(b) Bleaching wood pulp in paper factories.

(c) Oxidizing agent in chemical industries.

(d) Disinfecting drinking water.

- **Baking Soda** (Sodium hydrogen carbonate) ($NaHCO_3$)**:**

Preparation: $NaCl + H_2O + CO_2 + NH_3 \rightarrow NH_4Cl + \underset{\text{Baking soda}}{NaHCO_3}$

Properties:

(a) It is mild non-corrosive base.

(b) When it is heated during cooking, the following reaction takes place.

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

Uses:

(a) For making baking powder (mixture of baking soda and tartaric acid). When baking powder is heated or mixed with water, CO_2 is produced which causes bread and cake to rise making them soft and spongy.

$NaHCO_3 + H^+$ ® $CO_2 + H_2O$ + Sodium salt of an acid

(b) An ingredient in antacid.

(c) Used in soda acids, fire extinguishers.

- **Washing Soda ($Na_2CO_3.10H_2O$):**

Preparation: Re-crystallization of sodium carbonate gives washing soda. It is a basic salt.

$$Na_2CO_3 + 10H_2O \rightarrow Na_2CO_3.10H_2O$$

Properties:

(a) Transparent crystalline solid.

(b) It has 10 molecules of water of crystallisation.

(c) It dissolves in water and the aqueous solution is alkaline.

(d) It liberates Carbon dioxide when treated with Hydrochloric acid and Sulphuric acid.

Uses:

(a) In glass, soap and paper industry.

(b) Manufacture of borax.

(c) It can be used as cleaning agent.

(d) It can be used for removing permanent hardness of water.

- **Plaster of Paris (Calcium sulphate hemihydrates) ($CaSO_4.\frac{1}{2}H_2O$):**

  Preparation: On heating gypsum $CaSO_4.2H_2O$ at 373K, it loses water molecules and becomes Plaster of Paris (POP). It is white powder and on mixing with water it changes to gypsum.

$$CaSO_4.2H_2O \rightarrow CaSO_4.\frac{1}{2}H_2O + 1\frac{1}{2}H_2O$$

Properties: $CaSO_4.\frac{1}{2}H_2O + 1\frac{1}{2}H_2O \rightarrow CaSO_4.2H_2O$

Uses:

(a) Doctors use POP for supporting fractured bones.

(b) For making toys and material for decoration.

Important salts :

Common name	Chemical name	Chemical formula	Uses
Washing soda	Sodium carbonate decahydrate	$Na_2CO_3.10H_2O$	Manufacture of borax, caustic soda, softening of hard water.
Baking soda	Sodium hydrogen carbonate	$NaHCO_2$	Used as antacid, ingredient of baking powder.
Bleaching powder	Calcium oxychloride	$CaOCl_2$	Bleaching clothes, used as oxidising agent, disinfecting water, manufacture of chloroform.
Plaster of Paris	Calcium sulphate hemihydrate	$CaSO_4.1/2\ H_2O$	Plastering fractured bones, making toys, decorative materials, statues.

Water of crystallization

- Water molecules present in the crystal structure of salt are called water of crystallization and such salts are called hydrated salts. Water of crystallization is the fixed number of water molecule present in one formula unit of a salt.

  Examples:

  - **Copper sulphate pentahydrate ($CuSO_4.5H_2O$) :** It has five water molecules in one formula unit of copper sulphate (blue vitriol).
  - **Sodium carbonate ($Na_2CO_3.10H_2O$) :** It has ten molecules of water as water of crystallization.
  - **Gypsum ($CaSO_4.2H_2O$) :** It has two molecules of water as water of crystallization.