Class 10th

CHEMISTRY

ACIDS BASES AND SALTS

Arrhenius's concept of acids and bases:

- An acid is a substance that produces H^+ or H_3O^+ ions in an aqueous solution
- A base is a substance that gives OH^- ions in the aqueous solution.
- The ionisation of hydrochloric acid in water:

$$HCl(aq) + H_2O(l) \rightarrow H_3O^+(aq) + Cl^-(aq)$$

- Ionisation of sodium hydroxide in water:

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

General characteristics of acids and bases:

Acids:

- They have a sour taste.
- Acids release H^+ ions in aqueous solution.
- They are corrosive in nature.
- They are good conductors of electricity in solution,
- They changed the blue litmus paper to red.

Bases:

- They are soapy to the touch.
- Bases release OH^- ions in aqueous solution.
- They taste bitter.
- Strong bases like sodium hydroxide are corrosive in nature.
- They changed the red litmus paper to blue.

Indicators:

- An indicator is a chemical compound which indicates the presence of an acidic, basic, or neutral substance either by a change in colour or odour.

Types of indicators:

- **Olfactory indicators:** Those substances whose odour changes in acidic or basic media are called olfactory indicators. For e.g., clove oil, vanilla extract, and raw onion.
- **Natural indicators**: Turmeric, litmus (obtained from lichen), China rose, and red cabbage.
- **Synthetic indicators**: Methyl orange, phenolphthalein.

Universal Indicator: A universal indicator is a mixture of indicators which shows a gradual but well-marked series of colour changes over a very wide range of changes in concentration of H^+ ions.

	Indicator	Acids	Bases
1.	Red litmus	No Colour change	Blue
2.	Blue litmus	Red	No colour change
3.	Phenolphthalein	Colourless	Pink
4.	Methyl orange	Red	Yellow

Classification of acids:

(A) On the **basis of origin**, acids are of two types:

1. Mineral acid:

- These are acids prepared from minerals present in the earth's crust.
- Example: HNO_3, HCl, H_2SO_4 etc.

2. Organic acid:

- These are acids produced by plants and animals.
- Example: lactic acid, citric acid etc.

(B) On the **basis of strength**, acids are of two types:

1. Strong acid:

- The acids which dissociate completely in aqueous solution are strong acids.
- Examples: HCl, HNO_3 etc.

2. Weak acids:

- The acids which do not dissociate completely in an aqueous solution are called weak acids.
- Examples: CH_3COOH, H_2CO_3 etc.

Chemical properties of acids and bases:

1. Reaction of acid and base with metals:

$$\text{Acid} + \text{Metal} \rightarrow \text{Salt} + \text{Hydrogen}$$

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

$$\text{Base} + \text{Metal} \rightarrow \text{Salt} + \text{Hydrogen}$$

$$NaOH + Zn \rightarrow Na_2ZnO_2 + H_2$$

Note – Such reactions are not possible with all the metals.

2. Detection of hydrogen gas:

- When a burning candle is brought near a test tube containing hydrogen gas it burns with a 'Pop' sound.

3. Action of Acids with metal Carbonates and metal bicarbonates

- Metal Carbonate/bicarbonates + Acid → Salt + Carbon dioxide + Water

$$Na_2CO_3(s) + 2HCl(aq) \rightarrow 2NaCl(aq) + CO_2(g) + H_2O(l)$$

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

4. Detection of Carbon dioxide gas (Lime water Test):

- On passing the CO_2 gas evolved through lime water,

$$Ca(OH)_2\,(aq) + CO_2(g) \rightarrow CaCO_3(s) + H_2O(l)$$

Lime water White precipitate

- On passing excess CO_2 the following reaction takes place

$$CaCO_3(s) + H_2O(l) + CO_2(g) \rightarrow Ca(HCO_3)_2\,(aq)$$

Soluble in water

5. Neutralisation Reaction

Base + Acid → Salt + Water + 57.1KJ

$NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l) + 57.1KJ$

6. **Reactions of metal oxides with acids**

Metal Oxide + Acid → Salt + Water

$CuO(s) + 2HCl(aq) \rightarrow CuCl_2(s) + H_2O(l)$

7. **Reaction of Non-Metallic Oxide with Base**

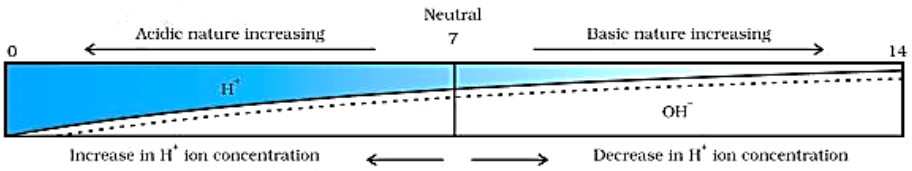
Non-metallic oxide + Base → Salt + Water

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

pH Scale:

- A negative logarithm of hydrogen ion concentration is known as pH.

  $pH = -\log[H^+]$
- According to the pH scale, the lesser the pH value, the stronger the acid and vice-versa.
- On Increasing $[H^+]$, the Value of pH will decrease.
- Mixing an acid or base with water results in a decrease in the concentration of ions (H_3O^+/OH^-) per unit volume. Such a process is called dilution.
- On dilution, the pH of the acidic solution increases and the basic solution decreases.



For water or neutral solutions: pH = 7
for acidic solutions: pH < 7
for basic solution: pH > 7

Significance of pH in everyday life:

(i) **pH in our digestive system:**

- Dilute HCl (Hydrochloric acid) helps in the digestion of food (proteins) in our stomach. Excess acid in the stomach causes acidity (indigestion). Antacids like magnesium hydroxide $[Mg(OH)_2]$ also known as milk of magnesia and sodium hydrogen carbonate (baking soda) are used to neutralize excess acid.

(ii) **Tooth decay caused by acids:**

- The bacteria present in our mouth converts the sugar into acids. When the pH of acid formed in the mouth falls below 5.5, tooth-decaying starts. The toothpastes contain some basic ingredients and they help neutralize the effect of acids and also increase the pH of the mouth.

(iii) **Soil of pH and plant growth:**

- Most plants have healthy growth when the soil has a specific pH (close to 7) range which should be neither alkaline nor highly acidic.

Salts: Salts are the ionic compounds which are produced after the neutralization reaction between acid and base.

Classification of Salts (based on pH values)

(i) **Neutral Salts:**

- Strong acid + Strong base → Neutral Salt + water
- **Examples:** Sodium chloride, potassium chloride etc

(ii) **Acidic Salts:**

- Strong acid +Weak base → Acidic Salt + water
- **Examples:** Ammonium sulphate, Ammonium chloride, etc.

(iii) **Basic Salts:**

- Weak acid + Strong base → Basic Salt + water
- **Example:** Sodium carbonate, potassium phosphate etc.

SOME IMPORTANT CHEMICAL COMPOUND

1. **Common Salt:**
   Common name: Table salt & rock salt
   Chemical name: sodium chloride
   Chemical formula: NaCl.

- In pure form, NaCl is a white crystalline solid, however, it is often brown due to the presence of impurities.

2. **Sodium Hydroxide:**
   Common name: Caustic soda
   Chemical name: Sodium hydroxide
   Chemical formula: NaOH

- **Preparation**: It is obtained by the electrolytic decomposition of a brine solution (NaCl + H_2O). This whole process is known as Chlor – Alkali process.

$$\underset{\text{Sodium chloride}}{2NaCl(aq)} + \underset{\text{Water}}{2H_2O(l)} \rightarrow \underset{\text{Sodium hydroxide}}{2NaOH(aq)} + \underset{\text{Chlorine}}{Cl_2(g)} + \underset{\text{Hydrogen}}{H_2(g)}$$

At anode = Chlorine gas,
At Cathode= Hydrogen gas,
Near the cathode = Sodium hydroxide

- **Uses of the products of the chlor-alkali process:**
  - Use of hydrogen gas
    - As fuel, margarine, in making of ammonia for fertilizer, etc.
  - Use of chlorine gas
    - Water treatment, manufacturing of PVC, disinfectants, CFC, and pesticides.
    - Manufacturing of bleaching powder and hydrochloric acid.

- Use of sodium hydroxide
    - De-greasing of metals, manufacturing of paper, soap, detergents, artificial fibres, etc.

3. Bleaching Powder:

Common name: Bleaching powder or Chloride of lime or Chlorinated lime.
Chemical name: Calcium oxychloride
Chemical formula: $CaOCl_2$

- **Preparation:** Bleaching powder is produced by the action of chlorine on dry slaked lime ($Ca(OH)_2$).

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

Note: Aqueous solution of bleaching powder is basic in nature. The term bleach means removal of colour. Bleaching powder is often used as a bleaching agent. It works because of oxidation. Chlorine in the bleaching powder is responsible for the bleaching effect.

- **Use of Bleaching Powder:**
    - to make drinking water free from germs.
    - for the bleaching of cotton in the textile industry, and the bleaching of wood pulp in the paper industry.
    - as an oxidizing agent in many industries,

4. **Baking Soda:**

Common name: Baking soda.
Chemical name: Sodium bicarbonate
Chemical formula: $NaHCO_3$

Preparation:

- Baking soda is obtained by the reaction of brine with carbon dioxide and ammonia. This is known as the **Solvay process**.

$$\underbrace{NaCl}_{\text{Sodium chloride}} + \underbrace{H_2O}_{\text{Water}} + \underbrace{CO_2}_{\text{Carbon dioxide}} + \underbrace{NH_3}_{\text{Ammonia}} \longrightarrow \underbrace{NH_4Cl}_{\text{Ammonium chloride}} + \underbrace{NaHCO_3}_{\text{Sodium bicarbonate}}$$

Brine

- **Properties of Sodium Bicarbonate:**
    - Sodium bicarbonate is a white crystalline solid that forms an alkaline solution with water.
    - When heated above 543K, it decomposes into sodium carbonate, carbon dioxide and water.

$$2NaHCO_3(s) + \text{heat} \rightarrow Na_2CO_3(s) + CO_2(g) + H_2O(l)$$

Use of Baking Soda:

- Baking soda is used in the making of baking powder(baking soda + mild edible acid like tartaric acid), which is used in cooking as it produces carbon dioxide causing bread or cake to rise making them soft and spongy.

$$\underset{\text{Baking soda}}{NaHCO_3} + \underset{\text{Tartaric acid}}{C_4H_6O_6} \longrightarrow \underset{\text{Carbon dioxide}}{CO_2} + \underset{\text{Water}}{H_2O} + \underset{\text{Sodium tartrate}}{Na_2C_4H_4O_6}$$

- Sodium hydrogen carbonate is also an ingredient in antacids.
- It is also used in soda-acid fire extinguishers.

5. Washing Soda:

Common name: washing soda

Chemical name: Sodium carbonate decahydrate

Chemical formula: $Na_2CO_3.10H_2O$

Preparation:

- **Recrystallization of Sodium carbonate:**
  - Sodium carbonate is recrystallized by dissolving in water to get washing soda

$$\underset{\text{Sodium carbonate}}{NaCO_3} + \underset{\text{Water}}{10H_2O} \longrightarrow \underset{\text{Sodium carbonate (Hydrated)}}{Na_2CO_3.10H_2O}$$

Use of washing soda:

- It is used as a cleaning agent for domestic purposes.
- It is used for removing the permanent hardness of water.
- It is used in glass, soap and paper industries.
- It is used in the manufacture of sodium compounds such as Borax ($Na_2B_4O_7.10H_2O$).

Water of Crystallization:

- Many salts contain water molecules and are known as Hydrated Salts. The water molecule present in salt is known as Water of crystallization.

Examples:

- **Blue vitriol** = $CuSO_4.5H_2O$
- **Green vitriol** = $FeSO_4.7H_2O$
- **White vitriol** = $ZnSO_4.7H_2O$

6. Plaster of Paris:

Common name: Plaster of Paris

Chemical name: Calcium Sulphate hemihydrate

Chemical formula: $CaSO_4.\frac{1}{2}H_2O$

Preparation:

- On heating gypsum at 373K, it loses water molecules and becomes $CaSO_4.\frac{1}{2}H_2O$.

$$CaSO_4.2H_2O \xrightarrow{373k} CaSO_4.\frac{1}{2}H_2O + 1\frac{1}{2}H_2O$$

POP Gypsum

Note: The temperature is carefully controlled, as at higher temperatures gypsum is fully dehydrated.

$$CaSO_4.2H_2O \xrightarrow{> 373k} CaSO_4\,(\text{anhydrous}) + 2H_2O$$

POP dead burnt plaster

Properties:

- When it is dissolved in water, it gets crystallized and forms gypsum

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

POP Gypsum

Uses:

- It is used for making toys, cosmetics and casts of statues.
- It is used as a cast for setting broken bones.
- It is used for making surfaces smooth and for making designs on walls and ceilings.