8. Acids, Bases and Salts

- Acids are the substances which taste sour, change **blue litmus red**, are corrosive to metals and furnish H^+ ions in their aqueous solutions.
- Bases are the substances which taste bitter, change **red litmus blue**, feel slippery and furnish OH^- ions in their aqueous solutions.
- Indicators are the substances that show one colour in an acidic medium and another colour in a basic medium. Litmus, phenolphthalein and methyl orange are commonly used indicators.
- Acids are presents in many unripe fruits, vinegar, lemon, sour milk etc., while bases are present in lime water, window pane cleaners, many drain cleaners etc.
- Aqueous solutions of acids and bases both conduct electricity as they dissociate on dissolving in water and liberate cations and anions which help in conducting electricity.
- Strong acids and bases dissociate completely in water.
- Weak acids and bases dissociate partially in water.
- Acids and bases react with each other to produce salt and water. Such reactions are called **neutralization** reactions.
- Water itself undergoes dissociation and furnishes H^+ and OH^- ions in equal numbers. This is called self dissociation of water.
- Concentrations of H^+ and OH^- ion formed by the self dissociation of water are 1.0×10^{-7} molar each at 25°C.
- In pure water or in any aqueous solution pH + pOH = pKw = 14 at 25°C.
- In pure water $[H^+] = [OH^-]$. It is also true in any neutral aqueous solution. In terms of pH, pH = pOH = 7 in water and any neutral solution.
- In acidic solution $[H^+] > [OH^-]$ and pH < pOH. Also pH < 7 at 25°C.
- In basic solutions $[H^+] < [OH^-]$ and pH > pOH. Also pH > 7 at 25°C.
- If pH of rain water falls below 5.6, it is called acid rain and is quite harmful.

Learner Guide

Build Your Understanding

Characteristics of Acids and Base

The term acid comes from Latin term 'accre' which mean sour. We can characterise the acids and bases as

Acids	Bases
• taste sour	• taste bitter
• corrosive metals	• feel slippery or soapy
• change blue litmus red	• change red litmus blue

- An acid is a substance which furnishes hydrogen ion (H^+) when dissolved in water

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

- A base is a substance which furnishes hydroxide ions (OH^-) when dissolved in water.

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

The term '**alkali**' is often used for water soluble bases.

- A salt is the product of neutralization process when acid is added into base or vice versa salt and water are formed.

$$\underset{\text{Acid}}{HCl\ (aq)} + \underset{\text{Base}}{NaOH\ (aq)} \longrightarrow \underset{\text{Salt}}{NaCl} + \underset{\text{Water}}{H_2O\ (l)}$$

Indicator

There are many substances that show one colour in an acidic medium and another colour in a basic medium. Such substances are called acid-base indicators.

The colour of these indicator in acidic, neutral and basic solutions are given below

Indicator	Colour in acidic solutions		Colour in neutral solutions		Colour in basic solutions	
Litmus		red		purple		blue
Phenolphthalein		colourless		colourless		pink
Methyl orange		red		orange		yellow

Chemical Properties of Acids and Bases

Corrosive nature of acids

- Acids attack various substances such as metals, metal oxide, metal hydroxides called as corrosive nature of acids.
- Not related to strength of acids but depends on negatively charged part of acid

  HF is a weak acid but reacts with glass

  $$\underset{\text{glass}}{SiO_2} + 4HF \longrightarrow SiF_4 + 2H_2O$$

Neutral, acidic and basic solution and pH

Ionic product of water

$$Kw = [H^+]\,[OH^-]$$
$$Kw = (1.0 \times 10^{-7}) \times (1.0 \times 10^{-7})$$
$$= 1.0 \times 10^{-14}$$

Nature of solution	concentration of H^+ ion at 298 K
Neutal	$[H^+] = 1.0 \times 10^{-7}$ mol L^{-1}
Acidic	$[H^+] > 1.0 \times 10^{-7}$ mol L^{-1}
Basic	$[H^+] < 1.0 \times 10^{-7}$ mol L^{-1}

pH

The pH is the logarithm of the reciprocal of the hydorgen ion concentration. It is written as

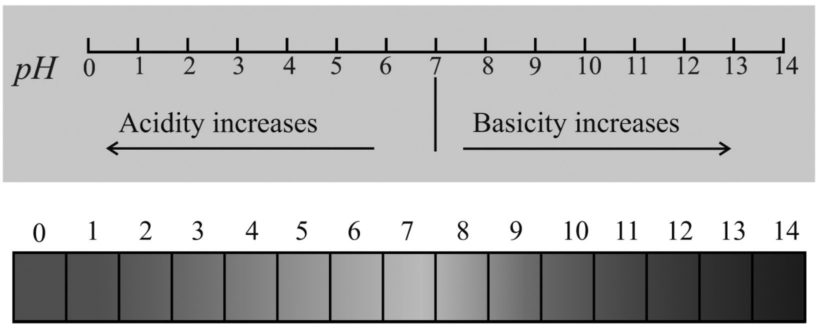
$$pH = \log \frac{1}{[H^+]}$$

or $\qquad pH = -\log\,[H^+]$.

Because of the negative sign in the expression, if $[H^+]$ increases, pH would decrease and if it decreases, pH would increase.

pH Scale

The pH scale ranges from 0 to 14 on this scale.



Important Compounds

Baking Soda ($NaHCO_3$)

Raw materials

- Lime stone ($CaCO_3$)
- Concentrated NaCl Solution (brine)
- Ammonia (NH_3)

Solvey's process

$$CaCO_3 \xrightarrow{heat} CaO + CO_2$$

$$NaCl + CO_2 + NH_3 + H_2O \longrightarrow NaHCO_3 + NH_4Cl(aq)$$

Use

(i) Cooking (baking powder)

(ii) in medicine

(iii) Fir extinguisher

Washing soda ($Na_2CO_3.10H_2O$)

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

$$\underset{\text{sodium carbonate}}{Na_2CO_3} + 10H_2O \longrightarrow \underset{\text{washing soda}}{Na_2CO_3.10H_2O}$$

Uses

- removing permanent hardness of water.
- domestic purpose (cleaning)
- Manufacture of NaOH, glass borax etc.

Plaster of Paris $2CaSO_4.H_2O$ or $CaSO_4.½H_2O$

$$\underset{\text{gypsum}}{CaSO_4.2H_2O} \xrightarrow[100°C(373\ K)]{heat} \underset{\text{plaster of paris}}{CaSO_4.1/2H_2O + 3/2H_2O}$$

or $2CaSO_4.H_2O$

Uses

- For making toys and statues.
- Fire proof materials.
- Chalk, in medicine
- Homes (design)

Bleaching Powder ($CaOCl_2$)

- Slaked lime, $Ca(OH)_2$
- Chlorine gas, Cl_2

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

Uses

1. bleaching of cotton and linen.
2. Manufacture $CHCl_3$
3. germicide
4. oxidising agent

Stretch Yourself

1. Lemon and orange juices changes the colour of blue litmus paper to red but the aqueous solution of ammonia and sodium hydroxide changes red litmus paper to blue. Explain the nature of all.
2. How will you differentiate between acids and bases on the basis of pH?
3. Write down the chemical composition of baking powder.
4. What will happen if a dry litmus paper come in contact with dry HCl gas?
5. Why HF is not stored in glass bottle?

Test Yourself

1. What happens when $H_2SO_4(aq)$ and $KOH(aq)$ are mixed
2. Corrosive nature of acid is dependent on the strength of acid or not
3. Classify the following into strong and weak acids and bases

   $RbOH, HClO_4, HNO_3, HCOOH, HF, NH_4OH$
4. Choose acidic, basic and neutral from the following

Solution A	pH < pOH
Solution B	pH = pOH
Solution C	pH > pOH