CHEMISTRY

CH – 2

Acids, Bases and Salts

* Acids:

- Acids are the substances which provide H_3O^+-ion [hydronium ion] in aqueous medium.For eg: HCl, HNO_3 etc.
- Acids have a sour taste.
- Turns blue litmus red.
- Acid solution conducts electricity.

• Chemical Properties of Acid:

(i) Reaction of acids with metal: Acids give hydrogen gas along with respective salt when they react with a metal.
Metal + Acid → Salt + Hydrogen
Examples:
Hydrogen gas and zinc chloride are formed when hydrochloric acid reacts with zinc metal.

$$\underset{\text{Zinc sulphate}}{Zn(s)} + \underset{\text{Hydrochloric acid}}{2HCl(aq)} \longrightarrow \underset{\text{Zinc chloride}}{ZnCl_2(aq)} + \underset{\text{Hydrogen}}{H_2(g)}$$

- Hydrogen gas and sodium sulphate are formed when sulphuric acid reacts with sodium metal.

$$\underset{\text{Sodium}}{2Na(s)} + \underset{\text{Sulphuric acid}}{H_2SO_4(aq)} \longrightarrow \underset{\text{Sodium sulphate}}{Na_2SO_4(aq)} + \underset{\text{Hydrogen}}{H_2(g)}$$

- Test For Hydrogen Gas: The gas evolved after reaction of acid with metal can be tested by bringing a lighted candle near it. If the gas bums with a pop sound, then it confirms the evolution of hydrogen gas. Burning with pop sound is the characteristic test for hydrogen gas.

(ii) Reaction of acids with metal carbonate: Acids give carbon dioxide gas and respective salts along with water when they react with metal carbonates.
Metal carbonate + Acid → Salt + Carbon dioxide + Water
Examples:
Hydrochloric acid gives carbon dioxide gas, sodium chloride along with water when

reacts with sodium carbonate.

$$\underset{\text{Sodium carbonate}}{Na_2CO_3(aq)} + \underset{\text{Hydrochloric acid}}{2HCl(aq)} \longrightarrow \underset{\text{Sodium chloride}}{2NaCl(aq)} + \underset{\text{Carbon dioxide}}{CO_2(g)} + \underset{\text{Water}}{H_2O(l)}$$

Sulphuric acid gives calcium sulphate, carbon dioxide gas, calcium sulphate and water when it reacts with calcium carbonate

$$\underset{\text{Calcium carbonate}}{CaCO_3(s)} + \underset{\text{Sulphuric acid}}{H_2SO_4(aq)} \longrightarrow \underset{\text{Calcium sulphate}}{CaSO_4(aq)} + \underset{\text{Carbon dioxide}}{CO_2(g)} + \underset{\text{Water}}{H_2O(l)}$$

Nitric acid gives sodium nitrate, water and carbon dioxide gas when it reacts with sodium carbonate.

$$\underset{\text{Nitric acid}}{2HNO_3(aq)} + \underset{\text{Sodium carbonate}}{Na_2CO_3(aq)} \longrightarrow \underset{\text{Sodium nitrate}}{Na_2NO_3(aq)} + \underset{\text{Water}}{H_2O(g)} + \underset{\text{Carbon dioxide}}{CO_2(l)}$$

(iii) Reaction of acid with hydrogen carbonates (bicarbonates): Acids give carbon dioxide gas, respective salt and water when they react with metal hydrogen carbonate.
Acid + Metal hydrogen carbonate → Salt + Carbon dioxide + Water
Example:
Sulphuric acid gives sodium sulphate, Carbon dioxide gas and water when it reacts with sodium bicarbonate.

$$\underset{\text{Sodium bicarbonate}}{2NaHCO_3(aq)} + \underset{\text{Sulphuric acid}}{H_2SO_4(aq)} \longrightarrow \underset{\text{Sodium chloride}}{NaCl(aq)} + \underset{\text{Carbon dioxide}}{CO_2(g)} + \underset{\text{Water}}{H_2O(l)}$$

Test For Evolution of Carbon Dioxide Gas: Carbon dioxide turns lime water milky when passed through it. This is the characteristic test for carbon dioxide gas.
The gas evolved because of reaction of the acid with metal carbonate or metal hydrogen carbonate turns lime water milky. This shows that the gas is carbon dioxide gas. This happens because of the formation of a white precipitate of calcium carbonate.

$$\underset{\text{Calcium hydroxide}}{Ca(OH)_2(aq)} + \underset{\text{Carbon dioxide}}{CO_2(g)} \longrightarrow \underset{\text{Calcium carbonate (Milky)}}{CaCO_3(aq)} + \underset{\text{Water}}{H_2O(g)}$$

$$\underset{\text{Calcium carbonate}}{CaCO_3(s)} + \underset{\text{Carbon dioxide}}{CO_2(g)} + \underset{\text{Water}}{H_2O(l)} \longrightarrow \underset{\text{Calcium hydrogen carbonate}}{Ca(HCO_3)_2(aq)}$$

But when excess of carbon dioxide is passed through lime water, it makes milky color of lime water disappear. This happens because of formation of calcium hydrogen carbonate. As calcium hydrogen carbonate is soluble in water, thus, the milky color of solution mixture disappears.

Ques: Why it is prefer that acid should be added to water?

Ans: Mixing of water and acid is highly exothermic reaction. When acid is added into water, water absorbs the heat produces due to exothermic reaction. In this case, there is no splashing out [coming out]. So, when acid is added into water, chances of accidents are less.

* Bases:

- Bases are the substances which provide OH^- ion [hydroxide ion] in aqueous medium.
- Have a bitter taste.
- Soapy to touch.
- Turns red litmus blue.
- Conducts electricity in solution.

• Chemical Properties of Bases:

(i) Reaction of Base with Metals: When alkali (base) reacts with metal, it produces salt and hydrogen gas.
Alkali + Metal → Salt + Hydrogen
Examples: Sodium hydroxide gives hydrogen gas and sodium zincate when reacts with zinc metal.

$$\underset{\text{Sodium hydroxide}}{2NaOH(aq)} + \underset{\text{Zinc}}{Zn(s)} \longrightarrow \underset{\text{Sodium zincate}}{Na_2ZnO_2(aq)} + \underset{\text{Hydrogen}}{H_2(g)}$$

Sodium aluminate and hydrogen gas are formed when sodium hydroxide reacts with aluminum metal.

$$\underset{\text{Sodium hydroxide}}{2NaOH(aq)} + \underset{\text{Aluminium}}{2Al(s)} + \underset{\text{Water}}{2H_2O(l)} \longrightarrow \underset{\text{Sodium aluminate}}{2NaAlO_2(aq)} + \underset{\text{Hydrogen}}{3H_2(g)}$$

(ii) Reaction of Base with Oxides of Non-metals: Non-metal oxides are acidic in nature. For example; carbon dioxide is a non-metal oxide. When carbon dioxide is dissolved in water it produces carbonic acid.
Therefore, when a base reacts with non-metal oxide, both neutralize each other resulting respective salt and water.
Base + Non-metal oxide → Salt + Water
(Non-metal oxides are acidic in nature)
Examples:
Sodium hydroxide gives sodium carbonate and water when it reacts with carbon dioxide.

$$2NaOH(aq) + CO_2(g) \longrightarrow Na_2CO_3(aq) + H_2O(l)$$

Sodium hydroxide | Carbon dioxide | Sodium Carbonate | Water

Calcium hydroxide gives calcium carbonate and water when it reacts with carbon dioxide.

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

Calcium hydroxide | Carbon dioxide | Calcium carbonate (salt) | Water

(iii) Reaction of Acid with Metal Oxides: Metal oxides are basic in nature. Thus, when an acid reacts with a metal oxide both neutralize each other. In this reaction, the respective salt and water are formed.

Acid + Metal Oxide → Salt + Water

(Metal oxides are basic in nature)

Examples:

Calcium is a metal, thus, calcium oxide is a metallic oxide which is basic in nature. When an acid, such as hydrochloric acid, reacts with calcium oxide, neutralization reaction takes place and calcium chloride, along with water is formed.

$$2HCl(aq) + CaO(s) \longrightarrow CaCl_2(aq) + H_2O(l)$$

Hydrochloric acid | Calcium oxide | Calcium chloride | Water

Similarly, when sulphuric acid reacts with zinc oxide, zinc sulphate and water are formed.

$$H_2SO_4(aq) + ZnO(aq) \longrightarrow ZnCl_2(aq) + H_2O(l)$$

Sulphuric acid | Zinc oxide | Zinc chloride | Water

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

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

Hydroxide ion | Hydrogen ion | Water

Example: When sodium hydroxide (a base) reacts with hydrochloric acid, sodium hydroxide breaks into a sodium ion and hydroxide ion and hydrochloric acid breaks into hydrogen ion and chloride ion.

Hydrogen ion and hydroxide ion combine together and form water, while sodium ion and chloride ion combine together and form sodium chloride.

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

Sodium hydroxide | Hydrochloric acid | Hydroxide ion | Sodium ion | Chloride ion | Sodium chloride

Dilution of Acid and Base: The concentration of hydrogen ion in an acid and hydroxide ion in a base, per unit volume, shows the concentration of acid or base.

By mixing of acid to water, the concentration of hydrogen ion per unit volume decreases. Similarly, by addition of base to water, the concentration of hydroxide ion per unit volume decreases. This process of addition of acid or base to water is called Dilution and the acid or base is called Diluted.

The dilution of acid or base is exothermic. Thus, acid or base is always added to water and water is never added to acid or base. If water is added to a concentrated acid or base, a lot of heat is generated, which may cause splashing out of acid or base and may cause severe damage as concentrated acid and base are highly corrosive.

* Indicators:

- An indicator is mostly organic substance which changes its color in either acidic or basic medium.

1. **Natural Indicators:** Indicators obtained from natural sources are called Natural Indicators. Litmus, turmeric, red cabbage, China rose, etc., are some common natural indicators used widely to show the acidic or basic character of substances.

   Litmus: Litmus is obtained from lichens. The solution of litmus is purple in color. Litmus paper comes in two color- blue and red.
   An acid turns blue litmus paper red.
   A base turns red litmus paper blue.

   Turmeric: Turmeric is another natural indicator. Turmeric is yellow in color. Turmeric solution or paper turns reddish brown with base. Turmeric does not change color with acid.

   Red Cabbage: The juice of red cabbage is originally purple in color. Juice of red cabbage turns reddish with acid and turns greenish with base.

2. Olfactory Indicator: Substances which change their smell when mixed with acid or base are known as Olfactory Indicators. For example; Onion, vanilla etc.

Onion: Paste or juice of onion loses its smell when added with base. It does not change its smell with acid.

Vanilla: The smell of vanilla vanishes with base, but its smell does not vanish with an acid.

Olfactory Indicators are used to ensure the participation of visually impaired students in the laboratory.

3. Synthetic Indicator: Indicators that are synthesized in the laboratory are known as Synthetic Indicators. For example; Phenolphthalein, methyl orange, etc.

Phenolphthalein is a colorless liquid. It remains colorless with acid but turns into pink with a base.

Methyl orange is originally orange in color. It turns into the red with acid and turns into yellow with base.

* pH:

- Negative logarithm of hydronium ion concentration is known as pH.
- Mathematical Formula: $pH = -\log[H_3O^+]$
- In pH, 'p' stands for potenz (German word) which means power or capacity and 'H' stands for hydronium ion.
- In 1909, pH scale was given by the scientist Sorenson.
- The pH of a neutral solution is 7.
- The pH of an acidic solution is < 7.
- The pH of a basic solution is > 7.
- Accurate value of pH can be measured by universal indicator.

* Importance of pH:

1. **Acid Rain:**
   - When pH of the rain is less than 5.6 , it is called acid rain.
   - When acid rain falls in the rivers, ponds and lakes, it adversely affect the aquatic life and aquatic plants.
2. **pH in our mouth:**
   - When ph is lower than 5.5, tooth decays start.
   - Enamel in our mouth is made up of Calcium phosphate.
   - Enamel reacts with acid and corrodes. Thus due to corrosion, the teeth loosens and teeth falls.
3. **pH in digestive system:**
   - Our stomach produces concentrated HCl which helps in digestion.
   - Due to malfunction, indigestion takes place and too much of acid is left in stomach. This causes pain and irritation. This situation is known as acidity.
   - To get rid of acidity, antacid is used. Eg: Digene, Rantac, etc.

* Salts:

- Salts are the ionic compounds which are produced after the neutralization reaction between acid and base. Salts are electrically neutral. There are number of salts but sodium chloride is the most common among them. Sodium chloride is also known as table salt or common salt. Sodium chloride is used to enhance the taste of food.

(i) **Neutral Salt:** Salts produced because of reaction between a strong acid and strong base are neutral in nature. The pH value of such salts is equal to 7, i.e. neutral.
Example: Sodium chloride, Sodium sulphate. Potassium, chloride, etc.

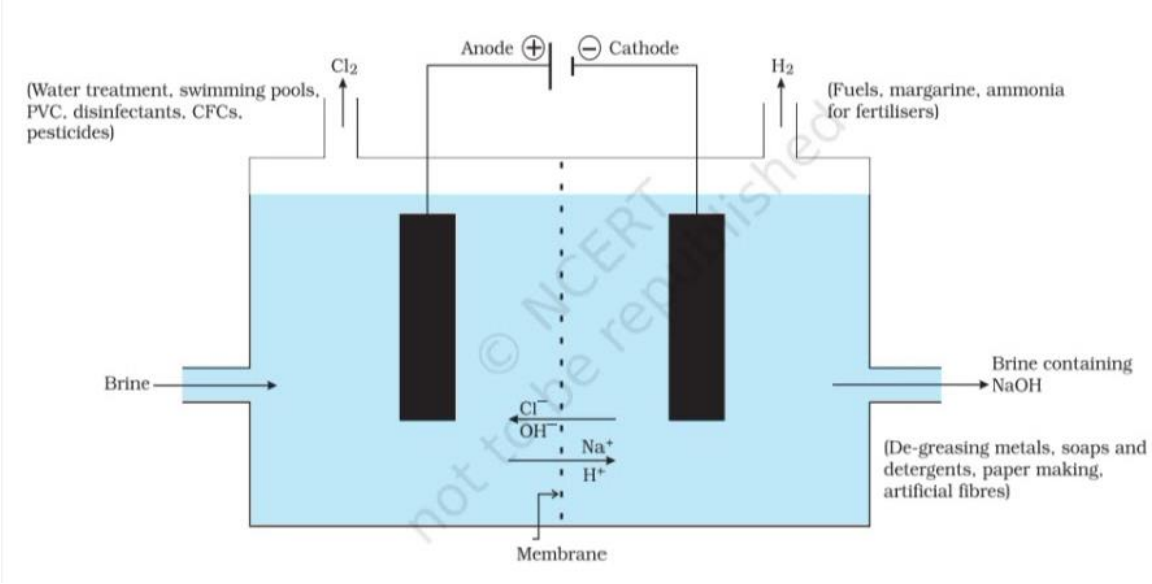
(ii) **Acidic Salts:** Salts which are formed after the reaction between a strong acid and weak base are called Acidic salts. The pH value of acidic

salt is lower than 7. For example Ammonium sulphate, Ammonium chloride, etc.

(iii) **Basic Salts:** Salts which are formed after the reaction between a weak acid and strong base are called Basic Salts. For example; Sodium carbonates, Sodium acetate, etc.

* Chlor-Alkali Process:

- An important chemical NaOH is obtained from sea water.
- It is obtained by process of electrolysis of brine. [brine= aqueous solution of NaCl]
- When electricity is passed, Cl_2 gas is produced at anode and H_2 gas is produced at cathode.
- The cation [Na^{+1}] and anion [OH^-], left unreacted. They both combine to give NaOH.
- This process is known as chlor-alkali.



* Some Imp Chemical Compounds:

- **Bleaching Powder ($CaOCl_2$):** Bleaching powder is also known as chloride of lime. It is a solid and yellowish white in color. Bleaching powder can be easily identified by the strong smell of chlorine.
  When calcium hydroxide (slaked lime) reacts with chlorine, it gives calcium oxychloride (bleaching powder) and water is formed.

$$\underset{\text{Slaked lime}}{Ca(OH)_2(aq)} + \underset{\text{Chlorine}}{Cl_2(aq)} \longrightarrow \boxed{\underset{\text{Bleaching powder}}{CaOCl_2(aq)}} + \underset{\text{Water}}{H_2O(l)}$$

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

Uses of bleaching Powder:

- It is used in cotton industry.
- It is used to bleach wood pulp.
- It is used as an oxidizing agent.
- It is used to make water free from germs.

- **Baking Powder:** Baking Powder is a mixture of baking soda and tartaric acid. Tartaric acid is added into baking powder to remove the bitter taste of baking soda.

- **Baking Soda ($NaHCO_3$):** Baking soda is another important product which can be obtained using byproducts of chlor – alkali process. The chemical name of baking soda is sodium hydrogen carbonate ($NaHCO_3$) or sodium bicarbonate. Bread soda, cooking soda, bicarbonate of soda, sodium bicarb, bicarb of soda or simply bicarb, etc. are some other names of baking soda.

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

$$\underset{\text{Sodium chloride}}{NaCl} + \underset{\text{Water}}{H_2O} + \underset{\text{Carbon dioxide}}{CO_2} + \underset{\text{Ammonia}}{NH_3} \xrightarrow[\text{Brain}]{} \underset{\text{Ammonium chloride}}{NH_4Cl} + \underset{\text{Sodium bicarbonate}}{NaHCO_3}$$

When baking soda is heated, it decomposes into sodium carbonate, carbon dioxide and water.

$2NaHCO_3 + \text{heat} \rightarrow Na_2CO_3 + CO_2 + H_2O$

Uses of Baking Soda:

- Baking soda is used in making of baking powder, which is used in cooking as it produces carbon dioxide which makes the batter soft and spongy.
- Baking soda is used as an antacid.
- Baking soda is used in toothpaste which makes the teeth white and plaque free.
- Baking soda is used in cleansing of ornaments made of silver.
- Since sodium hydrogen carbonate gives carbon dioxide and sodium oxide on strong heating, thus, it, is used as a fire extinguisher.

- **Washing Soda (Sodium Carbonate)**
  Preparation Method: Sodium carbonate is manufactured by the thermal decomposition of sodium hydrogen carbonate obtained by Solvay process.

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

$$\underset{\text{Sodium bicarbonate}}{NaHCO_3} \xrightarrow{\text{Heat}} \underset{\text{Carbon dioxide}}{CO_2} + \underset{\text{Water}}{H_2O} + \underset{\text{Sodium carbonate (anhydrous)}}{Na_2CO_3}$$

The sodium carbonate obtained in this process is dry. It is called Soda ash or Anhydrous sodium carbonate. Washing soda is obtained by rehydration of anhydrous sodium carbonate.

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

Since there are 10 water molecules in washing soda, hence, it is known as Sodium Bicarbonate Decahydrate.
Sodium carbonate is a crystalline solid and it is soluble in water when most of the carbonates are insoluble in water.

Use of sodium carbonate:

- **It is used in the cleaning of cloths, especially in rural areas.**
- **In the making of detergent cake and powder.**
- **In removing the permanent hardness of water.**
- **It is used in glass and paper industries.**

* Water of Crystallization:

- **The fixed amount of water molecule present in the formula of compound is known as water of crystallization.**
- **Examples:**
  Copper sulphate pentahydrate ($CuSO_4.5H_2O$): Blue colour of copper sulphate is due to presence of 5 molecules of water. When copper sulphate is heated, it loses water molecules and turns: into grey – white colour, which is known as anhydrous copper sulphate. After adding water, anhydrous copper sulphate becomes blue again.

$$\underset{\text{Copper sulphate (hydrated)}}{CuSO_4.5H_2O} + \text{heat} \longrightarrow \underset{\text{Copper sulphate (anhydrous)}}{CuSO_4}$$

* **Gypsum:**
  - **It is known as plaster of paris.**
  - **Formula: $CaSO_4.2H_2O$**
  - **On heating gypsum at 373K we get calcium sulphate hemi-hydrate.**

$$CaSO_4 2H_2O \xrightarrow{373\ K\ (Heat)} CaSO_4 . {}^1/_2 H_2O + 1{}^1/_2 H_2O$$

On mixing plaster of Paris with water, gypsum is obtained

$$CaSO_4 . {}^1/_2 H_2O + 1{}^1/_2 H_2O \longrightarrow CaSO_4 . 2H_2O$$

Uses of P.O.P:

- It is used in making toys.
- It is used in making decoration.
- It is used by doctors as a plaster for supporting fracture bones.

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	$NaHCO_3$	Used as antacid, ingredient of baking powder.
Bleaching powder	Calcium oxychloride	$CaOCl_2$	Bleaching clothes, used as oxidizing 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.