CHAPTER 2

ACID, BASE AND SALTS

Acid-An acid is a substance which gives H^+ ions or H_3O^+ ions when dissolved in water. Acids are sour in taste. They change the colour of blue litmus to red.

Based on origin Acids may be :-

Natural acids or organic acids-.

These are obtained from natural sources like lemon juice, orange juice, ant sting (methanoic acid),Vinegar(Acetic acid)etc

Mineral acids- These are prepared in the laboratory. Examples are Hydrochloric acid, Sulphuric acid, Nitric acid ,Acetic acid etc

Mineral acids are stronger than organic acids.

Based on their strength acids may be :-

Strong acids-Which completely ionize and produce good amount of H^+ ions in water.E.g HCl, H_2SO_4, HNO_3 etc

Weak acids-Which do not ionize completely and produce less no of H^+ ions.E.g Acetic acid(CH_3COOH) ,Carbonic acid(H_2CO_3)

Based on dilution ,acids may be dilute or concentrated.

Dilute Acid: Contains only a small amount of acid and a large amount of water.

Concentrated Acid: Contains a large amount of acid and a small amount of water.

* **Acid – Base Indicators** – Substances which Indicate the presence of an acid or base in a solution.

*** Natural indicators-** Litmus is a natural indicator. It is a purple dye extracted from Lichens. Other examples of natural indicators are Red Cabbage and coloured petals of Petunia and turmeric.

* **Olfactory indicators** – Show odour changes in acidic or basic media. e.g. onion and clove.

Universal indicator -It shows different colour over the range of pH value from 1 to 14 for a given solution. Universal indicator is available both in the form of strips and solution. Universal indicator is the combination of many indicators(dyes)

***Acid – Base Indicators**

S.No.	Name of the Indicator	Color Change with Acid	Color Change with Base
A.	Blue litmus solution/paper	To red	No change
B.	Red litmus solution/paper	No change	To blue
C.	Turmeric	No change	To red
D.	Methyl Orange	To Red	Yellow
E.	Phenolphthalein (colorless)	No Change	Pink

BASES -Base is a substance which releases hydroxide ions when dissolved in water. It is a substance which is bitter in taste and soapy to touch (e.g. Washing soda, caustic soda and caustic potash). They change red litmus to blue.

Bases may be strong or weak, concentrated or dilute

Strong bases: - These are bases which ionise completely in aqueous solution eg. NaOH, KOH.

Weak bases: - These are bases which ionise partially in aqueous solution eg. NH_4OH, $Ca(OH)_2$.

- Chemical Properties of Acids and Bases
- REACTION OF ACIDS WITH METAL: Acids give hydrogen gas along with respective salt when they react with a metal.
- Metal + Acid → Salt + Hydrogen
- Example- Hydrogen gas and zinc chloride are formed when hydrochloric acid reacts with zinc metal.

$2HCl + Zn \rightarrow ZnCl_2 + H_2$

Hydrogen gas and sodium chloride are formed when hydrochloric acid reacts with sodium metal.

$2Na + 2HCl \rightarrow 2NaCl + H_2$

Hydrogen gas and zinc sulphate are formed when zinc metal reacts with sulphuric acid

- $Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$

Test for the evolution of Hydrogen gas(pop test)

When a burning candle is brought near a test tube containing

Hydrogen gas it burns with a 'Pop' sound. This test is conducted for examining the presence of hydrogen gas.

REACTION OF BASE WITH METALS:

When alkali (base) reacts with metal, it produces salt and hydrogen gas.

Alkali + Metal → Salt + Hydrogen

Example: Sodium aluminate and hydrogen gas are formed when sodium hydroxide reacts with Aluminium metal.

$2NaOH + 2Al + 2H_2O \rightarrow 2NaAlO_2 + 2H_2$

Sodium hydroxide gives hydrogen gas and sodium zincate when reacts with zinc metal.

$2NaOH + Zn \rightarrow Na_2ZnO_2 + H_2$

REACTION OF ACID WITH HYDROGEN CARBONATES (BICARBONATES):

Acids give carbon dioxide gas, respective salt and water when they react with metal hydrogen carbonate.

MetalCarbonate + Acid → Salt + Carbondioxide + Water

$Na_2CO_3 + 2HCl_{(aq)} \rightarrow 2NaCl_{(aq)} + H_2O(l) + CO_{2(g)}$

Metal bicarbonate +Acid →Salt +Carbon dioxide +Water

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

* **Lime water Test for evolution of CO_2 gas**

On passing the CO_2 gas evolved through limewater, limewater turns milky

$Ca(OH)_2(aq) + CO_{2(g)} \rightarrow CaCO_{3(s)} + H_2O(l)$

Limewater White precipitate

On passing excess of CO_2, the following reaction takes place

$CaCO_{3(s)} + H_2O_{(l)} + CO_{2(g)} \rightarrow Ca(HCO_3)_2$

The milky colour of lime water disappears on passing excess of CO_2. This happens because of formation of calcium hydrogen carbonate. As calcium hydrogen carbonate is soluble in water, thus the milky colour of solution mixture disappears.

- NEUTRALISATION REACTION: An acid neutralizes a base when they react with each other and respective salt and water are formed.
- Acid + Base → Salt + Water
- Since in the reaction between acid and base both neutralize each other, hence it is also known as neutralization reaction.

$NaOH_{(aq)}+HCl_{(aq)}\rightarrow NaCl_{(aq)}+H_2O(l)$

- 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, respective salt and water are formed.
- Acid + Metal Oxide→ Salt + Water

CuO	+	HCl	-→	$CuCl_2$	+	H_2O
Copper oxide		Hydrochloric acid		Copper+ chloride		Water

Note: Appearance of blue green color of the solution is because of formation of $CuCl_2$.

Metallic oxides are said to be basic oxides because they give salt and water on reacting with acids.

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 in respective salt and water being produced.

Base + Non-metal oxide → Salt + Water

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

Note: Non-Metallic oxides are said to be acidic in nature because on reacting with a base they produce Salt and Water.

All acidic solutions conduct electricity

* Acids or bases in a Water Solution

Acids produce H^+ions in the presence of water

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

(H_3O^+ – Hydronium ion.)

– H^+ion cannot exist alone. It exists as $H^+(aq.)$or(H_3O^+) hydronium ion.

- $H^+ + H_2O \rightarrow H_3O^+$
- Bases provide (OH^-) ions in the presence of water
- $NaOH_{(s)} + H_2O \rightarrow Na^+_{(aq)} + OH^-_{(aq)}$

All bases do not dissolve in water. An alkali is a base that dissolves in water. Common alkalis are:

NaOH	Sodium hydroxide
KOH	Potassium hydroxide
$Ca(OH)_2$	Calcium hydroxide
NH_4OH	Ammonium hydroxide

Note: Alkalis are bases but all bases are not alkalis.

*Precaution must be taken while mixing acid or base with water. The acid must always be added to water with constant stirring as it is highly exothermic reaction.

When an acid or a base is mixed with water they become dilute. This results in the decrease in the concentration of H_3O^+ or OH^- per unit volume in acids and bases respectively.

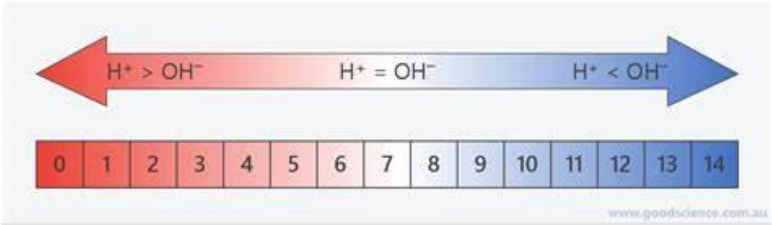
•Strength of an Acid or Base

The strength of acid or base depends upon the hydrogen ion concentration. If the concentration of hydrogen ion is greater than hydroxide ion, the solution is called acidic. If the concentration of hydrogen ion is smaller than the hydroxide ion, the solution is called basic. If the concentration of hydrogen ion is equal to the concentration of hydroxide ion, the solution is called neutral solution.

pH is a scale which quantifies the concentration of hydrogen ion in a solution. The range of pH scale is between 0 to 14. pH= Potenz in German means power.

This scale measures from 0 (very acidic) to 14 (very alkaline) 7 means Neutral (water is Neutral).

pH paper : Is a paper which is used for measuring pH.



The pH Scale – Hydrogen Ion and Hydroxide Ion Concentration

- Strong Acids give rise to more H^+ions. e.g. HCl, H_2SO_4 and HNO_3.
- Weak Acids give rise to less H^+ions eg.CH_3 COOH,H_2CO_3(Carbonic acid)

- Strong Bases – Strong bases give rise to more OH^-ions. eg. NaOH, KOH, $Ca(OH)_2$
- Weak Bases: give rise to less OH^-ions.eg.NH_4OH

Importance of pH in our daily life

- **Importance of pH in our digestive system**: pH level of our body regulates our digestive system. In case of indigestion our stomach produces acid in a very large quantity because of which we feel pain and irritation in our stomach. To get relief from this pain antacids are used. These antacids neutralizes the excess acid and we get relief.
- **pH of Acid Rain :** When pH of rain water is less than 5.6 it is called Acid Rain. When this acidic rain flows into rivers these also get acidic, which causes a threat to the survival of aquatic life.
- **pH of Soil :** Plants require a specific range of pH for their healthy growth. If pH of soil of any particular place is less or more than normal than the farmers add suitable fertilizers to it.
- Our body functions between the range of 7.0 to 7.8 living organisms can survive only in the narrow range of pH change.
- Tooth decay and pH: Bacteria present in the mouth produce acids by degradation of sugar and food particles remaining in the mouth. Using toothpaste which is generally basic can neutralize the excess acid and prevent tooth decay.
- Bee sting or Nettle sting contains methanoic acid which causes pain and irritation. When we use a weak base like baking soda on it we get relief.

MORE ABOUT SALTS

. **CHARACTERISTICS OF SALT:**

- Most of the salts are crystalline solid
  Salts may be transparent or opaque
- Most of the salts are soluble in water
- Solution of salts conducts electricity. Salts conduct electricity in their molten state also
- The salt may be salty, sour, sweet or bitter
- Neutral salts are odorless
- Salts can be colourless or coloured

Salts and their derivation

S.No.	Name of Salt	Formula	Derived from base	Derived from acid
1.	Potassium Sulphate	K_2SO_4	KOH	H_2SO_4
2.	Sodium Sulphate	Na_2SO_4	NaOH	H_2SO_4
3.	Sodium Chloride	NaCl	NaOH	HCl
4.	Ammonium Chloride	NH_4Cl	NH_4OH	HCl

Note: NaCl and Na_2SO_4 belong to the family of sodium salts as they have the same radicals.

Similarly NaCl and KCl belong to the family of chloride salts.

Neutral Salts: Strong Acid + Strong base combine to give neutral salt with pH value of 7
e.g. NaCl, $CaSO_4$

Acidic Salts: Strong Acid + weak base combine to give acidic salt with pH value less than 7 eq. NH_4Cl, NH_4NO_3

Basic Salts: Strong base +weak acid combine to give basic salt with pH value more than 7 e.g. $CaCO_3$, CH_3COONa

Chemicals from Common Salt

*Sodium chloride is called as common salt used in our food. It is derived from seawater.

*Rock Salt has brown coloured large crystals. It is mined like coal.

* Common Salt is an important raw material for many materials of daily use such as.

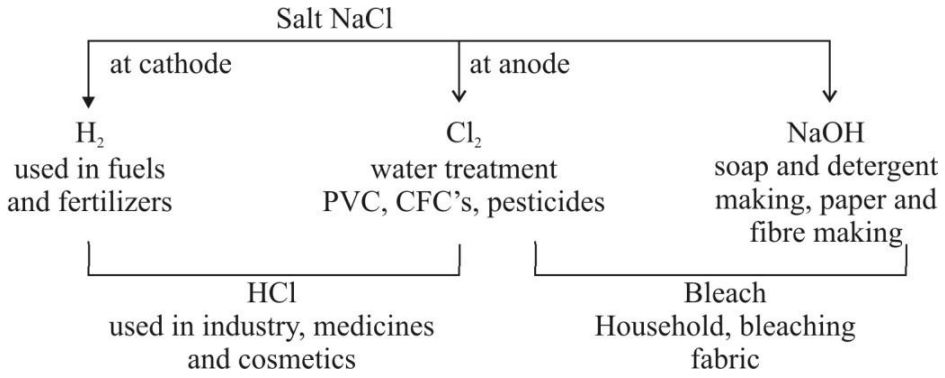
Sodium hydroxide, Washing Soda, Bleaching Powder.

Sodium Hydroxide

Preparation : Prepared by the method called chlor-alkali.

Called chlor-alkali because we get chlorine and an alkali NaOH in this.

$$2NaCl_{(aq)} + 2H_2O_{(l)} \rightarrow 2NaOH_{(aq)} + Cl_{2(g)} + H_{2(g)}$$



Bleaching Powder ($CaOCl_2$):-

Chemical name-Calcium oxychloride

Preparation: -$Ca(OH)_+ Cl_2 \rightarrow CaOCl_2 + H_2O$

Calcium hydroxide + chlorine → bleaching Powder + Water

Uses - in textile, factories and laundry, used as disinfectant

Baking Soda ($NaHCO_3$):-

Common name–Sodium Hydrogen Carbonate

Preparation: $NaCl + H_2O + CO_2 + NH_3 \rightarrow NH_4Cl + NaHCO_3$

On heating $NaHCO_3$ produces: $NaHCO_3 \rightarrow Na_2CO_3 + H_2O + CO_2$

CO_2 produced causes dough to rise and make cakes, pastries spongy.

Uses: In household, ingredients of antacid,

In making baking powder.(By combining baking soda with any weak acid like Tartaric acid to get H+ ions

$NaHCO_3 + H^+ \rightarrow CO_2 + H_2O +$ Sodium Salt of acid

Washing Soda

Preparation: Sodium carbonate is manufactured by the thermal decomposition of sodium hydrogen carbonate obtained by Solvay process.

$NaCl + CO_2 + NH_3 + H_2O \rightarrow NH_4Cl + NaHCO_3$

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.

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

Since there are 10 water molecules in washing soda, hence it is known as sodium bicarbonate decahydrate.

Uses:

Used in glass, soap and paper industry.

Cleaning agent for domestic purposes.

Removal of hardness of water.

Manufacturer of borax.

WATER OF CRYSTALLIZATION

Many salts contain water molecule and are known as hydrated salts. The water molecule present in salt is known as water of crystallization.

Examples: COPPER SULPHATE PENTAHYDRATE (CuSO4.5H2O)

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.

$CuSO_4.5H_2O$ + heat → CuSO4

FERROUS SULPHATE HEPTAHYDRATE ($FeSO_4.7H_2O$)

The green colour of Ferrous sulphate heptahydrate; commonly known as ferrous sulphate; is due to the presence of 7 molecules of water in it.

PLASTER OF PARIS [$CaSO_4.1/2\ H_2O$]

Gypsum also contains water of Crystallization. On heating gypsum at 373k it becomes $CaSO_4.½H_2O$ is plaster of Paris. $CaSO_4.2H_2O$ + Heat → $CaSO_4.1/2\ H_2O + 3/2\ H_2O$

After addition of water Plaster of Paris is again converted into gypsum.

$CaSO_4.1/2H_2O + 3/2H_2O \rightarrow CaSO_4.2H_2O$

Plaster of Paris is used in making of toys, designer false ceiling, etc. Doctors use Plaster of Paris to set the fractured bone.