ACIDS:

"The word acid is derived from Latin word "acidus" meaning "sour".

Those compounds whose molecules contain one or more replaceable hydrogen atom and that produce hydrogen ion (H^+) or oxonium ion (H_3O^+) in water are called acids.

For Example:

Hydrochloric acid HCl, Sulphuric acid (H_2SO_4), Nitric acid (HNO_3).

PHYSICAL PROPERTIES OF ACID:

1. They have sour taste.
2. They turn blue litmus red.
3. Aqueous solution of acids conducts electricity.
4. Strong acids destroy fabrics and animal tissues.

CHEMICAL PROPERTIES OF ACIDS:

1. When acids are dissolved in water then they produce hydrogen ions (H^+) or oxonium ions (H_3O^+) in solution.

e.g
- i) $HCl \longleftrightarrow H^+ + Cl^-$
- ii) $HCl + H_2O \longleftrightarrow H_3O^+ + Cl^-$
- iii) $H_2SO_4 \longleftrightarrow 2H^+ + SO_4^{2-}$

2. Acids neutralize bases and produce salt and water.
   - i) $HCl + NaOH \longrightarrow NaCl + H_2O$
   - ii) $H_2SO_4 + 2KOH \longrightarrow K_2SO_4 + 2H_2O$

3. Most of the acids react with carbonates and bicarbonates of metals decompose them and produce corresponding salt, CO_2 gas and H_2O.
   - i) $2HCl + CaCO_3 \longrightarrow CaCl_2 + CO_2 + H_2O$
   - ii) $H_2SO_4 + CaCO_3 \longrightarrow CaSO_4 + CO_2 + H_2O$
   - iii) $HCl + NaHCO_3 \longrightarrow NaCl + CO_2\ H_2O$

4. Acids react with some metals like Zn, Mg, Fe, Al etc form their salts and liberates H_2 gas.
   - i) $2HCl + Zn \longrightarrow ZnCl_2 + H_2$
   - ii) $H_2SO_4 + Mg \longrightarrow MgSO_4 + H_2$

SOME COMMON ACIDS AND THEIR CHEMICAL FORMULAE

1	HCl	Hydrochloric Acid	5	HCOOH	Formic Acid
2	HNO_3	Nitric Acid	6	$H_2C_2O_4$	Oxalic Acid
3	H_2SO_4	Sulphuric Acid	7	H_3BO_3	Boric Acid
4	CH_3COOH	Acetic Acid	8	H_3PO_4	Phosphoric Acid

Some acids found in nature are given below.

1. Critic acid occurs in lemon, organs, grapes fruits etc.
2. Trataric acid occurs in grapes.

3. Acetic acid occurs in vinegar.
4. Ascorbic acid ($C_6H_8O_6$) or vitamin C occurs in all citreous fruits.

BASES

Those compounds whose molecules contain one or more hydroxyl (OH) group and that produce hydroxide ions (OH^-) in water are called bases.
For example Sodium hydroxide (NaOH), Potassium Hydroxide (KOH) and Calcium hydroxide $Ca(OH)_2$ are bases. They produce hydroxide ions OH^- in water.

e.g $NaOH \longrightarrow Na^+ + OH^-$

PHYSICAL PROPERTIES OF BASES

1. They have a bitter taste such as quinine.
2. They have slippery or soapy touch.
3. They change red litmus to blue, colorless phenolphthalein to pink and methyl orange to yellow.
4. Aqueous solutions of bases conduct electricity.

CHEMICAL PROPERTIES OF BASES

1. When bases are dissolved in water then they produce hydroxide ions (OH^-).
   $NaOH \longrightarrow Na^+ + OH^-$
2. Bases neutralize acids and produce salt and water.
   a) $HCl + NaOH \longrightarrow NaCl + H_2O$
   b) $H_2SO_4 + 2NaOH \longrightarrow Na_2SO_4 + 2H_2O$
3. They react with facts to form soap and glycerin.
   i.e Base + Fats $\longrightarrow$ Soap + Glycerin.
4. They can dissolve protein and certain other organic compounds.

SOME COMMON BASES AND THEIR CHEMICAL FORMULAE

1	NaOH	Sodium Hydroxide	4	$Mg(OH)_2$	Magnesium Hydroxide
2	KOH	Potassium Hydroxide	5	NH_4OH	Ammonium Hydroxide
3	$Ca(OH)_2$	Calcium Hydroxide			

ALKALIS:

Those bases which are soluble in water are called alkalis.
For Example: Sodium hydroxide (NaOH), Potassium Hydroxide (KOH) and calcium hydroxide $Ca(OH)_2$ are soluble in water, hence they are called alkalis. All alkalis are bases but all bases are not alkalis.

ARRHENIUS THEORY

Introduction:

In 1887 a young Swedish chemist Svante Arrhenius proposed a revolutionary concept about acids and bases which is given as under.

ACIDS:

Acids are substances which produce hydrogen ion (H^+) in aqueous solution.

$$HCl \longrightarrow H^+ + Cl^-$$

BASES:

Bases are substances which produce hydroxide ions (OH^-) in aqueous solution.

$$NaOH \longrightarrow Na^+ + OH^-$$

Arrhenius theory is not satisfactory about acids and bases because such compounds which do not produce H^+ ions in aqueous solution cannot be termed as acids or bases. Therefore broader concept was needed otherwise Arrhenius theory is simple and clear.

BRONSTED & LOWRY THEORY

Introduction:

In 1923, an English Scientist, T.M Lowry and a Danish Scientist J.N Bronsted independently proposed a new definition.

They stated that in a chemical reaction, “Any substance which donates a proton (H^+) is an acid and any substance which accepts a proton is a base.”

Example:

1. When hydrogen chloride gas is dissolved in water, ions are formed.

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

   In this reaction hydrogen chloride is an acid and water is a base.
2. When ammonia gas is added to water

   $$NH_3 + H_2O \longrightarrow NH_4^+ + OH^-$$

In this reaction water acts as an acid because it donates a proton to the ammonia molecule.

LEWIS THEORY:

According to Lewis, an acid is a substance that can accept a pair of electrons to form a covalent bond and a base is a substance that can donate a pair of electrons to form a covalent bond. It means an acid is an electron pair acceptor and a base is an electron pair donor. Lewis concept is more general then either the Arrhenius or the Bronsted Lowry theory. It applies to solutions and reactions which do not involve hydrogen or hydroxide ions.

For Example:

When ammonia molecule (NH_3) reacts with hydrogen ion to form ammonium ion (NH_4^+) then N-atom of NH_3 molecule donate a pair electron and H^+ accepts that pair of electron. Thus co ordinate covalent bond is formed between N atom and H^+.

In this case NH_3 is Lewis base and H^+ is Lewis acid.

NEUTRALIZATION REACTION

When an acid and a base are mixed they react and neutralize each other. The properties of both the acid and the base are lost. As a result of neutralization, salt and water are formed.

For Example:

$HCl + NaOH \longrightarrow NaCl + H_2O$

BASICITY OF ACIDS

The number of ionizable hydrogen atoms present in its molecules is called the basicity of the acid.

Example:

1. **Mono Protic Acid**

   Hydrochloric acid has one ionizable hydrogen atom so its basicity is one. Hydrochloric acid is a monoprotic acid.

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

2. **Di- Protic Acid**

   An acid which contains two ionizable hydrogen atoms are called di protic acid and sulphuric acid has two ionizable hydrogen atoms, so its basicity is two. Sulphuric acid is di protic acid.

   $H_2SO_4 + H_2O \longrightarrow H_3O^+ + HSO_4^-$

   $HSO_4^- + H_2O \longrightarrow H_3O^+ + SO_4^{-2}$

3. **Tri- Protic Acid**

   Phosphoric acid has three ionizable hydrogen atoms so its basicity is three. Phosophoric acid is a triprotic acid.

   $H_3PO_4 + H_2O \longrightarrow H_3O^+ + H_2PO_4^-$

   $H_2PO_4^- + H_2O \longrightarrow H_3O^+ + HPO_4^{-2}$

   $HPO_4^{-2} + H_2O \longrightarrow H_3O^+ + PO_4^{-3}$

4. **Poly Protic Acid**

   Acids which contain two or more replaceable hydrogen atom per molecule is called poly protic acid.

ACIDITY OF BASES

Acidity of bases is defined as the number of ionizable hydroxyl group present in a base.

Example:

1. **Mono Acid Bases**

   Bases that produce one hydroxyl group are called mono acid bases.

   $NaOH \longrightarrow Na^+ + OH^-$

2. **Di- Acid Bases**

   Bases that produce two hydroxyl groups are called di acid bases.

   $Ca(OH)_2 \longrightarrow Ca^{+2} + 2OH^-$

3. Tri- Acid Bases

Bases that produce three hydroxyl groups are called tri acid bases.

$Fe(OH)_3 \longrightarrow Fe^{+3} + 3OH^-$

4. Poly Acid Bases

Bases which contain two or more replaceable hydroxyl group per molecule is called poly acid bases.

STRENGTH OF ACIDS AND BASES OR DISSOCIATION OF ACIDS AND BASES:

Different acids and bases dissociate or ionize in water to different extent to produce H^+ ion and OH^- ions respectively.

❖ Strong Acids And Strong Bases:

Those acids or bases which are completely dissociate or ionized in water and produces large number of H^+ ions and OH^- ions respectively are called strong acids and strong bases.

For Example:

H_2SO_4, HCl are strong acids and NaOH, KOH and $Ba(OH)_2$ are strong bases.

❖ Weak Acids And Weak Bases:

Those acids or bases which are partially dissociate or ionized in water and produces comparatively low number of H^+ ions and OH^- ions respectively are called weak acids and weak bases.

For Example:

CH_3COOH (acetic acid), H_2CO_3 (carbonic acid) are weak acids and NH_4OH and $Mg(OH)_2$ are weak bases.

The extent of dissociation or ionization is expressed in term of degree of dissociation or percentage dissociation denoted by α (alpha).

$$\alpha = \frac{\text{No.'s of molecules dissociated}}{\text{Total No.'s of dissolved molecules}}$$

SALTS

Salts are formed whenever acids neutralize bases or alkalis and also when an acid reacts with a metal or metal carbonate. Different acids form different salts and each acid can have its hydrogen replaced by different metals. A salt is an ionic crystalline compound.

CLASSIFICATION OF SALTS

Salts can be classified into four different classes according to their chemical properties.

1. NORMAL SALTS:

Salts which have neither replaceable hydrogen atom nor hydroxyl group are called normal salts. They are formed from complete neutralization of acids and bases.

For Example:

$$HCl + NaOH \longrightarrow NaCl + H_2O$$

$$H_2SO_4 + NaOH \longrightarrow Na_2SO_4 + 2H_2O$$

2. ACIDIC SALTS:

Salts which are formed by the partial replacement of hydrogen atom atoms present in the acids are called acidic salt. An acidic salt is formed by a partially neutralized acid. It still contains ionizable hydrogen ion.

For Example:

$$H_2SO_4 + NaOH \longrightarrow NaHSO_4 + H_2O$$

$$H_2CO_3 + KOH \longrightarrow KHCO_3 + H_2O$$

Acidic salts can react with bases to form normal salt

$$NaHSO_4 + NaOH \longrightarrow Na_2SO_4 + H_2O$$

3. BASIC SALTS:

Salts which are formed by the partial replacement of hydroxyl groups present in the bases are called basic salt. A basic salt is formed by a partially neutralized base. It still contains ionizable hydroxyl groups.

For Example:

$$Mg(OH)_2 + HCl \longrightarrow Mg(OH)Cl + H_2O$$

Basic salts can react with more acids to form normal salt.

4. DOUBLE SALTS:

When two specific salts are crystallized by dissolving them in water in simple whole number ratio, the crystals thus obtained have definite chemical composition. The chemical properties of these crystals remain the same as the component salts but the physical properties change. These crystalline compounds are called double salts. Double salts usually have definite number of water molecule attached with their crystals. These water molecules are called water of crystallization.

For Example:

1	Chrome Alum	$K_2SO_4.Cr_2(SO_4)_3.24H_2O$
2	Dolomite	$MgCO_3.CaCO_3$
3	Carnallite	$KCl.MgCl_2.6H_2O$
4	Mohr's Salt	$FeSO_4.(NH_4)_2SO_4.6H_2O$
5	Ferric Alum	$K_2SO4.Fe_2(SO_4)_3.6H_2O$
6	Potash Alum	$K_2SO_4.Al_2(SO_4)_3.24H_2O$

PREPARATION OF SODIUM CARBONATE (Na_2CO_3) BY AMMONIA SOLVAY PROCESS

Sodium carbonate is manufactured from common salt by solvay process.

Step #1:

Lime stone ($CaCO_3$) is heated to produce quick lime (CaO) and carbon dioxide (CO_2) gas.

$$CaCO_3 \longrightarrow CaO + CO_2$$

Step # 2:

The slaked lime $Ca(OH)_2$ is prepared from quick lime CaO

$$CaO + H_2O \longrightarrow Ca(OH)_2$$

Step # 3

Excess carbon dioxide is passed into a solution of ammonia

$$NH_3 + H_2O + CO_2 \longrightarrow NH_4HCO_3$$

Step # 4

Ammonium hydrogen carbonate (NH_4HCO_3) reacts with brine (a solution of NaCl) at 15°C.

$$NH_4HCO_3 + NaCl \longrightarrow NaHCO_3 + NH_4Cl$$

Step # 5

The crystal of $NaHCO_3$ are filtered off, washed to remove ammonium salts and heated to form sodium carbonate (Na_2CO_3), which is called soda ash.

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

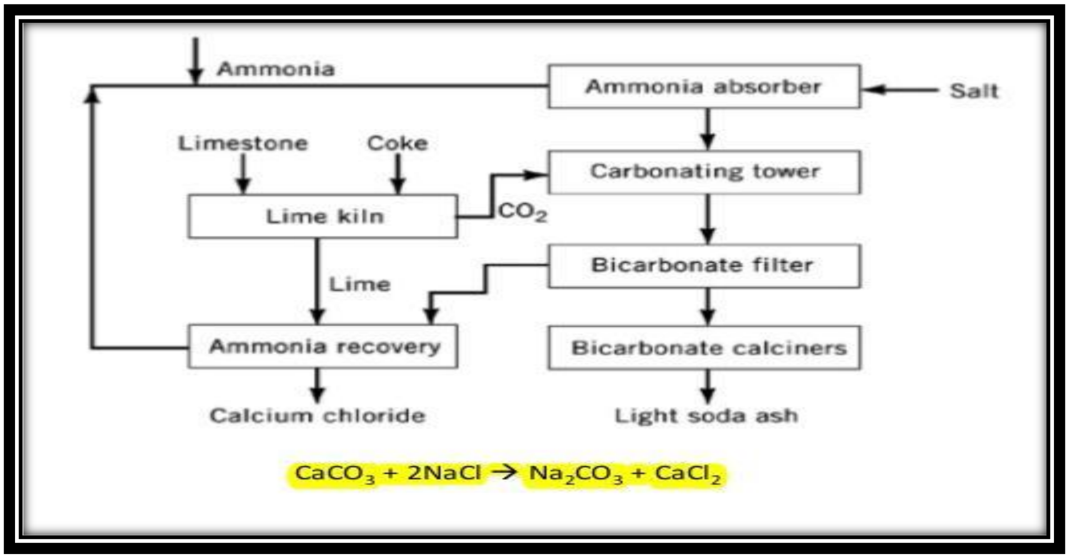
Step # 6

The liquid from the filters contain ammonium salts. Slaked lime is added and all the ammonia is liberated for use again.

$$2NH_4Cl + Ca(OH)_2 \longrightarrow 2NH_3 + CaCl_2 + 2H_2O$$

Or we can directly heat NH_4Cl with CaO

$$2NH_4Cl + CaO \xrightarrow{heat} 2NH_3 + CaCl_2 + 2H_2O$$



USES:

1. It is used to make soft water.
2. It is used to make ordinary glass from which bottles are made.
3. It is used as a cleaning agent.
4. It is used to make soap, detergents, paper.
5. Dehydrated sodium carbonate ($Na_2CO_3.10H_2O$) is called washing soda, which is used for washing clothes.

PREPARATION OF SODIUM Bi CARBONATE (NaHCO3) (BAKING SODA)

1. BY SOLVAY PROCESS:

Sodium bicarbonate is manufactured from common salt by Solvay process.

Step #1:

Lime stone ($CaCO_3$) is heated to produce quick lime (CaO) and carbon dioxide (CO_2) gas.

$$CaCO_3 \longrightarrow CaO + CO_2$$

Step # 2:

The slaked lime $Ca(OH)_2$ is prepared from quick lime CaO

$$CaO + H_2O \longrightarrow Ca(OH)_2$$

Step # 3

Excess carbon dioxide is passed into a solution of ammonia

$$NH_3 + H_2O + CO_2 \longrightarrow NH_4HCO_3$$

Step # 4

Ammonium hydrogen carbonate (NH_4HCO_3) reacts with brine (a solution of NaCl) at 15°C.

$$NH_4HCO_3 + NaCl \longrightarrow NaHCO_3 + NH_4Cl$$

Step # 5

The liquid from the filters contain ammonium salts. Slaked lime is added and all the ammonia is liberated for use again.

$$2NH_4Cl + Ca(OH)_2 \longrightarrow 2NH_3 + CaCl_2 + 2H_2O$$

Or we can directly heat NH_4Cl with CaO

$$2NH_4Cl + CaO \xrightarrow{heat} 2NH_3 + CaCl_2 + 2H_2O$$

2. BY PASSING STEAM OF CO_2:

Sodium bicarbonate is collected in th form of precipitate by passing carbon dioxide through a cold aqeous solution of sodium carbonate.

$$Na_2CO_3 + H_2O + CO_2 \longrightarrow 2NaHCO_3$$

Sodium bicarbonate obtained is then washed with cold water and dried.

USES:

1. It is used in baking powder.
2. It is used in effervescent (producing rapid escape of bubbles of a gas) drink and fruit salts.
3. It is used in antiacid medicines to reduce stomach acidity.
4. It is used in fire extinguishers to put out fires.

PREPARATION OF COPPER SULPHATE / BLUE VITRIOL ($CuSO_4.5H_2O$)

Copper sulphate is an important salt of copper. It is also called blue vitriol. On commercial scale, copper sulphate is prepared by spraying warm dilute sulphuric acid on cupper scrapes in the presence of air.

$$2Cu + 2H_2SO_4 + O_2 \longrightarrow 2CuSO_4 + 2H_2O$$

$$CuSO_4 + 5H_2O \longrightarrow CuSO_4.5H_2O$$

We get blue crystal of copper sulphate. In the laboratory, copper carbonate or copper oxide is dissolved in dilute sulphuric acid to get copper sulphate solution which is concentrated to get copper sulphate crystals.

$$CuCO_3 + H_2SO_4 \longrightarrow CuSO_4 + H_2O$$

$$CuO + H_2SO_4 \longrightarrow CuSO_4 + H_2O$$

USES:

1. It is used in various insecticides, germicides and as a rat killer.
2. It is used in calico printing (cloth printing)
3. It is used in dyes.
4. It is used for the preservation of wood
5. It is used in tanning leather.
6. It is used in the laboratory.
7. It is used in electroplating.

PREPARATION OF COPPER SULPHATE ($MgSO_4.7H_2O$)

Magnesium sulphate ($MgSO_4.7H_2O$) occurs naturally as Epsom salt. Magnesium sulphate is prepared commercially by dissolving kieserite ($MgSO_4.H_2O$) under pressure in cold water.

$$MgSO_4.H_2O + 6H_2O \longrightarrow MgSO_4.7H_2O$$

Crystalline of this cold solution gives crystals of magnesium sulphate. Magnesium sulphate can also be prepared by the reaction of magnaesite ($MgCO_3$) or dolomite ($MgCO_3.CaCO_3$), magnesium oxide (MgO) or magnesium (Mg) by the reaction with dilute sulphuric acid H_2SO_4.

$$MgCO_3 + H_2SO_4 \longrightarrow MgSO_4 + CO_2 + H_2O$$

$$MgCO_3.CaCO_3 + 2H_2SO_4 \longrightarrow MgSO_4 + CaSO_4 + 2CO_2 + 2H_2O$$

$$Mg + H_2SO_4 \longrightarrow MgSO_4 + H_2$$

USES:

1. It is used in medicines as mild purgative.
2. It is used in tanning and dyeing.
3. It is used in making fire proof cloth.
4. It is used as filler in paper industry.
5. It is used in ceramics, glazed tiles and match boxes.
6. It is used in soap formation.