INORGANIC CHEMISTRY

Chapter -1 : Metallurgy

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METALLURGY

MINERAL:

"The natural material found in the earth crust which contains metals or their compound are known as minerals".

In other words the combined state occurrences of metals are called minerals.

For example: NaCl, $NaNO_3$, Na_2SO_4, etc. are the minerals of 'Na'.

Similarly $Al_2O_3.2H_2O$(Bauxite), $Al_2O_3.2SiO_2.2H_2O$ (Kaolin) are the minerals of 'Al'.

ORE

"Ores are the minerals from which the concerned metals can be extracted conveniently and economically."

For example: Both Bauxite ($Al_2O_3.2H_2O$) and Kaolin ($Al_2O_3.2SiO_2.2H_2O$) are the minerals of Al. However, 'Al' can be extracted easily and profitably from 'Bauxite'. Thus Bauxite is an ore of Al.

On the other hand it is difficult and non-profitable to extract 'Al' from Kaolin, hence Kaolin is simply a mineral of Aluminum. All ores are minerals, however all minerals are not ores.

Properties of Minerals :

1. The combined state of occurrence of metals is called mineral

2. Extraction of metals from minerals is difficult and non-profitable

3. Minerals contain low percentage of metals but high percentage of impurities

4. All minerals are not ores

5. Example: Kaolin ($Al_2O_3.2SiO_2.2H_2O$) is a mineral of Aluminium

Properties of Ores:

1. Ores are the minerals from which the concerned metals can be extracted conveniently and economically.

2. Extraction of metals from ores is

convenient and profitable.

3. Ores contain high percentage of metals but

low percentage of impurities.

4. All ores are minerals.

5. Example: Bauxite ($Al_2O_3. 2H_2O$) is an ore

of Aluminium.

Flux : The substance which combines with gangue to form light and easily fusible material is called as flux.

Slag : The easily fusible material which is not soluble in the molten metal is called slag.

METALLURGICAL OPERATION:

The art of extraction of metals from ores conveniently and economically is called metallurgy or metallurgical operation.

The following steps are followed during the process of metallurgical operation:

1. **Crushing and grinding of ore**
2. **Concentration of ore**
3. **Extraction of metal**
4. **Refining of the crude metal**

1. *CRUSHING AND GRINDING OF ORE:*

The ores obtained from mines are in the form of huge lumps. These are first crushed into small pieces with the help of jaw crusher and then grinded in to their powder form with the help of stamp mill.

2. CONCENTRATION OF ORE:

The process of removal of maximum impurities from the ore is called concentration or ore dressing. The method of concentration to be followed depends upon the nature of the impurities present.

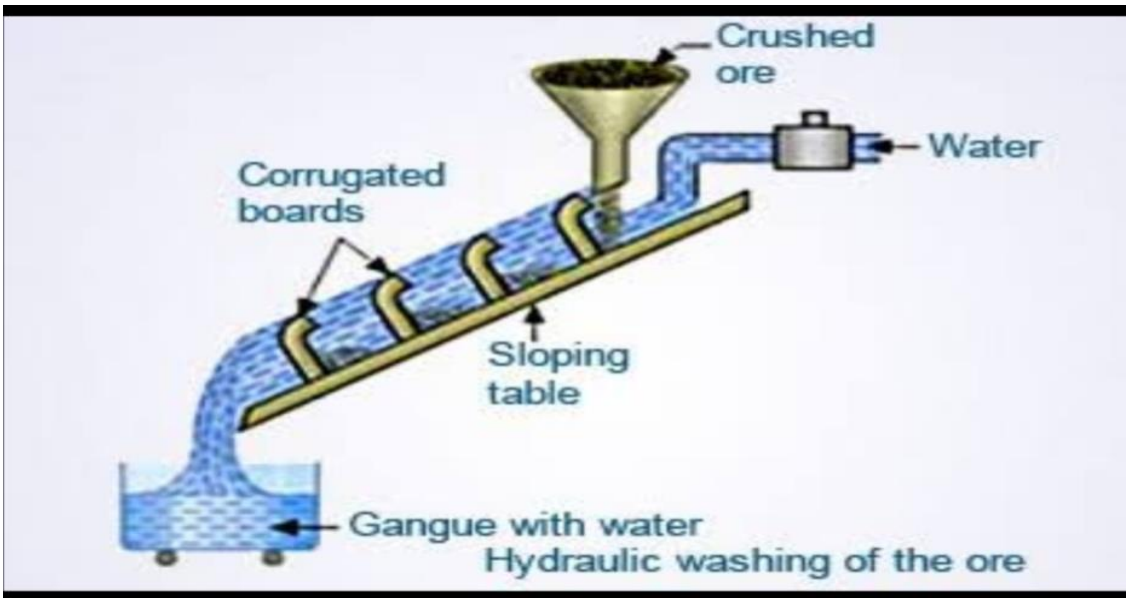
METHODS OF CONCENTRATION:

(A) GRAVITY SEPARATION METHOD:

This method of concentration is adopted only when there is a gravity difference between the ore and impurities. Normally carbonate and oxide ores are heavier than the impurities associated with them and hence they are concentrated by this method.

In this method the powdered or pulverized ores are kept in some containers over a specially

designed table called wilfley table. The table contains a number of transverse grooves. The table is kept slightly inclined position and is provided with a rocking motion. When water is spread over the ore, lighter impurities are washed away while heavier ore particles get deposited in the grooves, which are finally carried out in to the main canal.



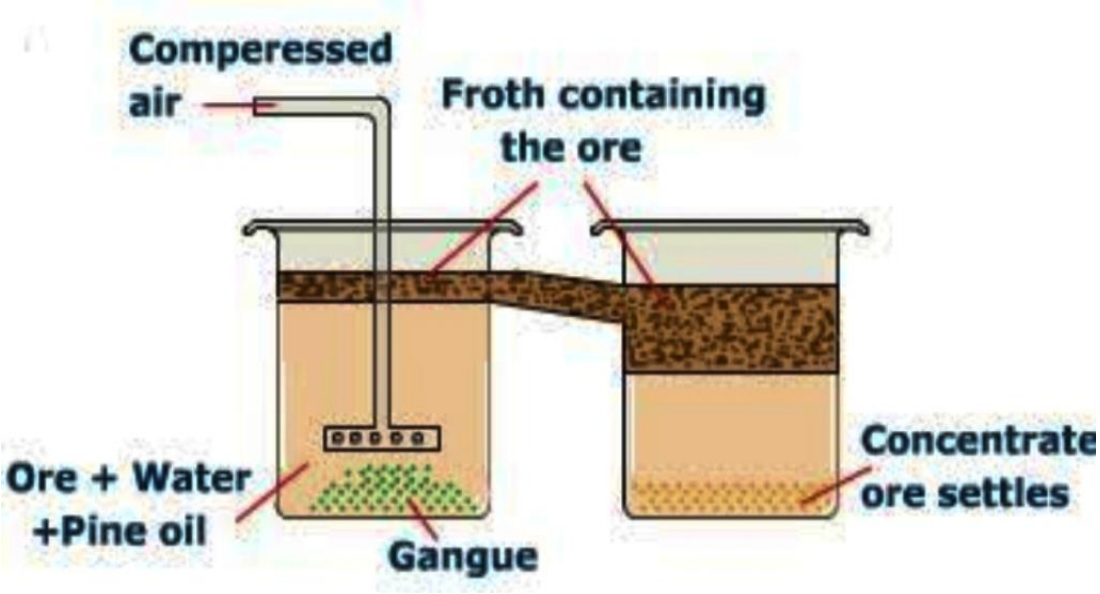
(B) FROTH FLOATATION METHOD:

This method is suitable for the concentration of sulphide ores only such as ZnS, PbS etc.

In this method of concentration , two interconnected tanks are used. In one of the tanks, a mixture of finely crushed ore, oil (preferably pine / eucalyptus oil), and water. The suspension is agitated strongly with the help of a

rotating peddle which draws in air causing frothing.

These sulphide ores particles stick to the froth and rise to the surface with the froth. The gangue particles are left behind in tank (1). The froth containing sulphide particles are carried out in to the second container along with the foam formed due to agitation. After sometime the froth settles down and the concentrated sulphide ore is obtained.

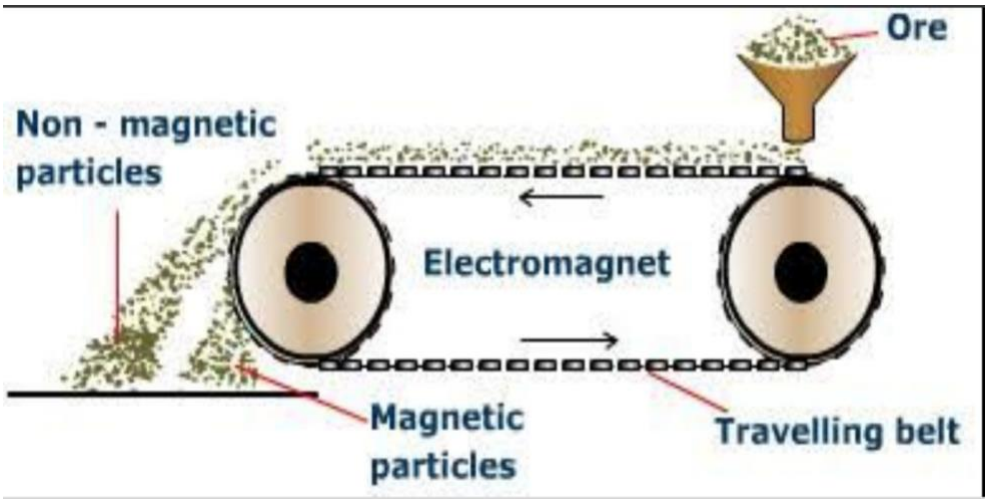


(3) MAGNETIC SEPARATION METHOD :

This method of concentration is suitable only when there is a difference in magnetic behaviour between the ores and the impurities.
Normally magnetic ores containing non-magnetic impurities are concentrated by this method.

In this method a belt is tied over two rollers of which one is made up of magnet. Powdered ore is added over the belt through a hopper. The pulverized ore move towards the magnetic pulley along with the rotating belt. The non-magnetic impurities fall directly below the magnetic pulley while the magnetic ore form a separate heap due to the influence of the magnetic field.

Ex. Separation of tin stone (SnO_2) from Ferrous tongstate ($FeWO_4$).



(4) LEACHING :

This is a chemical method for concentration of the ore.

In this method the impure ore is treated with a suitable solvent which dissolves the ore leaving behind the impurities. The solution is filtered, impurities are discarded and the mother liquor is

treated with another suitable chemical reagent to get the pure ore.

For example : Impure bauxite ore is treated with dil. NaOH solution which dissolves Bauxite to form soluble Sodium Meta-aluminate.

$$Al_2O_3.2H_2O + 2NaOH \rightarrow 2NaAlO_2 + 3H_2O$$

(soluble Sodium Meta-aluminate)

The solution is filtered to remove the impurities. The solution obtained is diluted with a plenty of distilled water when a precipitate of Al(OH)3 is formed.

$$2NaAlO_2 + 2H_2O \rightarrow Al(OH)_3\downarrow + 2NaOH$$

The precipitate obtained is dried and ignited (heated) strongly to get pure Alumina.

$$2Al(OH)_3 \rightarrow Al_2O_3 + 3H_2O$$

Pure alumina

3 . EXTRACTION OF METAL FROM CONCENTRATED ORE :

The extraction of metals from the concentrated ore involves the following steps.

(a) Conversion of concentrated ore into metal oxides.

(b) Conversions of metal oxides in to metals by reduction process.

A. CONVERSION OF CONCENTRATED ORE INTO METAL OXIDES.

The concentrated ores are converted into the respective metal oxides by the following two methods:-

1. CALCINATION

The process of heating an ore strongly below its melting point in absence of or in a limited supply of air is called calcination. The various functions of calcination are:-

i) It removes moisture.

$Al_2O_3.2H_2O \rightarrow Al_2O_3 + 2H_2O$

ii) It removes volatile impurities like S, P, As, Sb, etc.

$S + O_2 \rightarrow SO_2\uparrow$

$2P + 5O_2 \rightarrow 2P_2O_5\uparrow$

iii) It oxidizes oxidizable substances ('ous' to 'ic')

$4FeO + O_2 \rightarrow 2Fe_2O_3$

iv) It decomposes carbonates of alkali and alkaline earth metals into oxides.

$CaCO_3 \rightarrow CaO + CO_2\uparrow$

2. ROASTING

The process of heating an ore strongly below its melting point in a free but controlled supply

of air is called roasting. The various functions of roasting are:-

i) It removes moisture.

$Al_2O_3.2H_2O \rightarrow Al_2O_3 + 2H_2O \uparrow$

ii) It removes volatile impurities like S, P, As, Sb, etc.

$S + O_2 \rightarrow SO_2 \uparrow$

iii) It oxidizes oxidizable substances ('ous' to 'ic')

$4FeO + O_2 \rightarrow Fe_2O_3$

iv) It decomposes carbonates into oxides.

$CaCO_3 \rightarrow CaO + CO_2 \uparrow$

v) It makes the ore porous.

The process of roasting is carried out in a reverberator furnace.

B. REDUCTION (Conversion of metal oxides into metals)

In this step of metallurgical operation the roasted ores are reduced to convert the metal oxides into the respective metals. The various methods of reduction are:-

1. SMELTING

The process of heating a roasted ore strongly above its melting point with a suitable quantity of coke or

charcoal is called smelting. During the process of smelting, metal oxides are reduced into their respective metals. For the reduction of the oxides of less electro positive metals such as Zn, Fe, Cu, Cr, W etc. and the reducing agents like H2O, CO, Na, K etc are used.

$PbO + C \rightarrow Pb + CO$

$CuO + CO \rightarrow Cu + CO2 \uparrow$

During the process of smelting, an additional substance called flux is added which combines with the impurities to form fusible slag.

Impurity + flux → slag

Thus, "a substance added during the process of smelting to convert the gangue or matrix into fusible mass (slag) is called flux.

"Slag is the fusible mass obtained during the process of smelting when flux combines with impurities".

The nature of the flux to be added depends upon the nature of the impurity present. For acidic impurities basic flux while for basic impurities acidic flux are used.

$SiO2 + CaO \rightarrow CaSiO3$

(Acidic impurity) (Basic flux) (fusible slag)

Smelting is carried out in a blast furnace which is a tall cylindrical furnace made up of steel plates lined inside with fire bricks. Since the density of slag is lower it floats over the molten metal. The molten metal is tapped out at the bottom of the furnace.

4.REFINING :

The metals obtained after reduction still contain some impurities. The process of removal of impurities from crude metal is called refining. The method of refining to be followed depends upon the nature of the metal and the impurity contaminated with it.

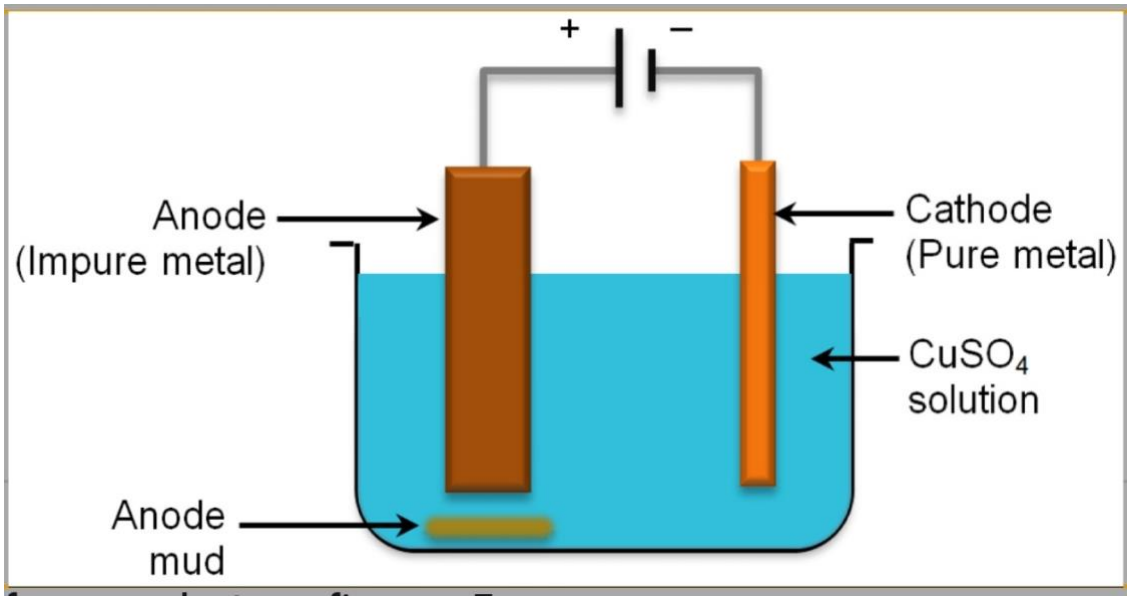
1. DISTILLATION METHOD:

This method of refining is suitable for volatile metals like Hg, Zn, Pb etc. contaminated with non-volatile impurities. The impure metal is heated in a distillation flask attached with a water condenser. During heating the volatile metal get evaporated and condensed which is collected in a separate container while the non-volatile impurities left at the bottom of the distillation flask.

2. ELECTRO REFINING:

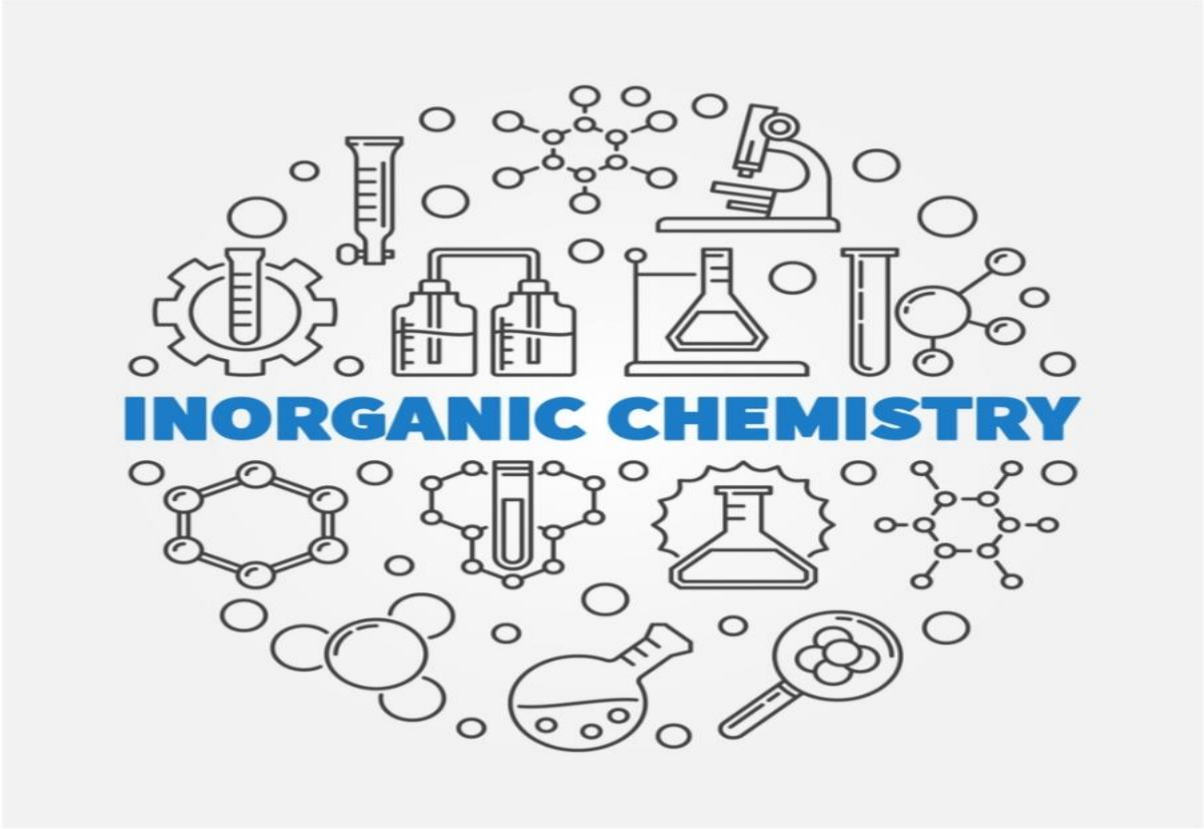
This method is employed to refine the less electro positive metals such as Zn, Pb, Al, Cu etc.

The impure metal bar is used as anode while a pure metal (same metal) bar is taken as cathode. Both the electrodes are dipped in a suitable aqueous salt solution of the concerned metal. During the process of electrolysis, the impure metal dissolves in its aqueous salt solution providing metal ions which get discharge deposited over the cathode.



INORGANIC CHEMISTRY

Chapter-2 : Alloys



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ALLOYS

Definition: The material obtained by melting two or more metals or metals with non-metals is called an alloy. Or in other words, "an alloy is a mixture of two or more different elements, at least one of which is a metal."

Features of Alloy

1. Alloys are homogeneous in molten state .

2. Alloys containing mercury as one of the constituent are called amalgams.

3. An alloy must contain a metal.

4. In alloys, chemical properties of the component elements are retained, but certain physical properties are improved.

Classification of Alloys: Alloys can broadly be classified into two categories:-

A. Ferro alloys B. Non-Ferro alloys

A. Ferro alloys: The alloy containing iron as the main constituent is called a ferro alloy.

For example: Stainless steel, Manganese steel etc.

B. Non-ferro alloys: The alloy which does not contain iron as the main constituent is called non-ferro alloys. For example: Brass, Bronze, Solder, Gun metal, Bell metal, Duralumin etc.

COMPOSITIONS AND USES OF BRASS, BRONZE, ANILCO, AND DURALUMIN.

Alloys	Composition.	Uses
1. **Brass**.	Cu:60% – 90%. Zn: 40 10%	It is used in making: utensils, hard wares, screws, jewellery musical instrument, battery caps, tubes, name plates
2. **Bronze**.	Cu: 80% – 95% Sn: 20% – 5%	Making imitation jewellery water fittings, statues, medals, heavy load bearings, turbine blades, pump valves, coins.
3.**Alnico**	Steel: 50%. Ni: 21% Al: 20% Co: 9%	For making permanent magnets.
4. **Duralumin**	Al: 95%. Cu: 4% Mn: 0.5% Mg: 0.5%	It is used in making air ships

Amalgam: Alloys containing mercury as one of the constituent are called amalgams.

Example:

1. Copper amalgam: used for filling dental cavities.
2. Tin amalgam : used for silvering cheap mirrors.
3. Sodium amalgam : it is made to decrease the reactivity of sodium. More ever it is also used as a good reducing agent.

ORGANIC CHEMISTRY

Aromatic Hydrocarbon

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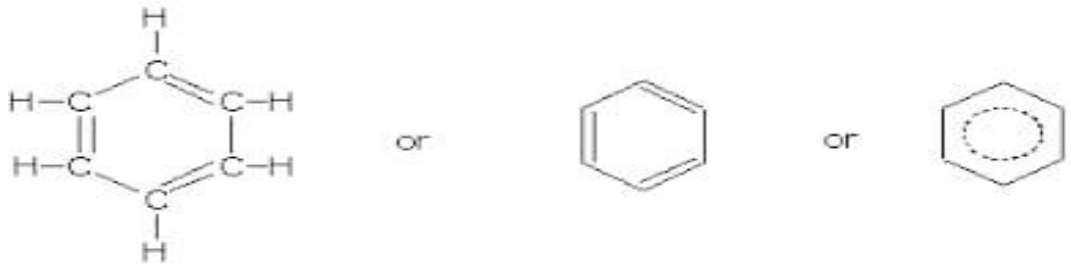
USES OF SOME COMMON AROMATIC HYDROCARBON

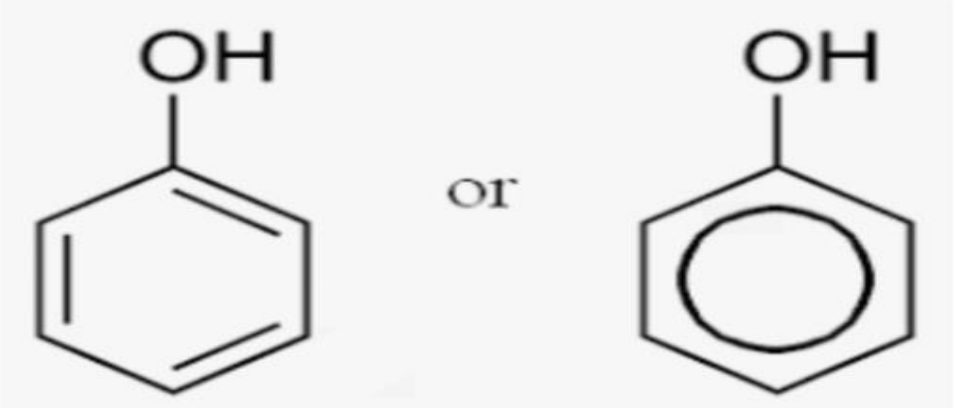
BENZENE:



1. **It is used in production of tyres and rubbers.**

2. **It is used in painting industry for cleaning the painting equipments.**
3. **It is used to manufacture chemical and plastic products.**
4. **It is used to manufacture different dyes.**
5. **It is used to manufacture insecticides, drugs and detergents.**
6. **It is used in dry cleaning.**
7. **It is used as motor fuel when mixed with petrol.**

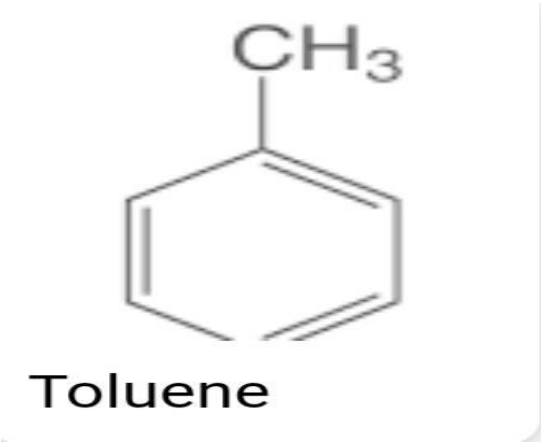
PHENOL:



1. **It is used widely as a house hold product and as an intermediate for industrial synthesis.**

2. **It is used as a disinfectant . Ex. Used in the preparation of Dettol and savlon.**
3. **It is used as a preservative for ink.**
4. **It is used in the preparation of fungicides and bacterisides.**
5. **It is used to avoid the entry of snakes through drains.**

TOLUENE:

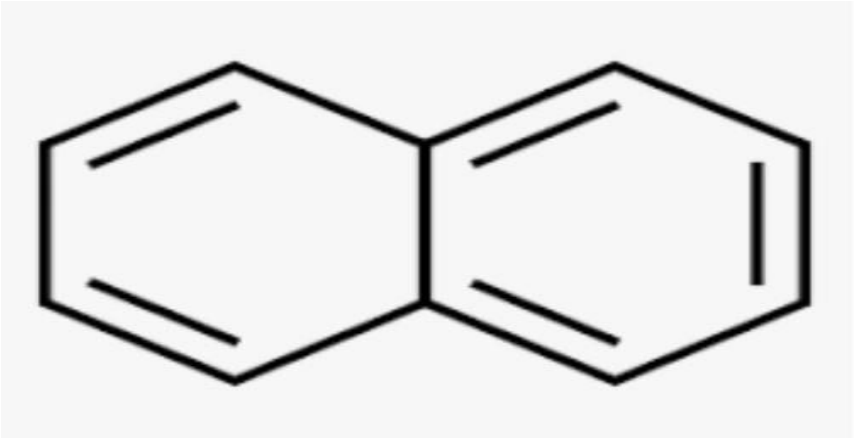


Toluene

1. **It is used as a solvent in paints and thinners in glues, correction fluid and nail polish remover.**
2. **It is used in printing and lather industry.**
3. **It is used as a substitute for petrol.**

4. **It is used for the manufacture of benzene and other organic chemicals.**
5. **It is used as a ingredient in pharmaceutical, dyes and cosmetic industry.**
6. **It is used in agricultural sector against round worm and hook worm.**

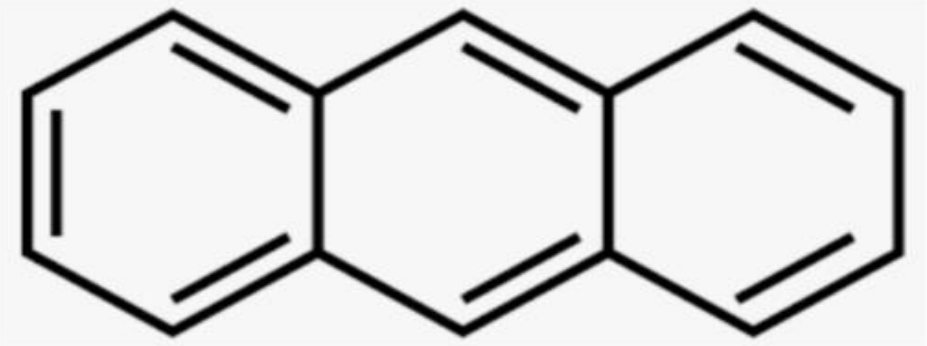
NAPHTHALENE :



1. **It is used as an insecticide and pest repellent.**
2. **It is used in pharmaceutical industries.**

3. **It is used to make dyes, phthalic anhydride, alpha naphthol and beta naphthol.**
4. **It is used as a toilet deodorant.**

ANTHRACENE:



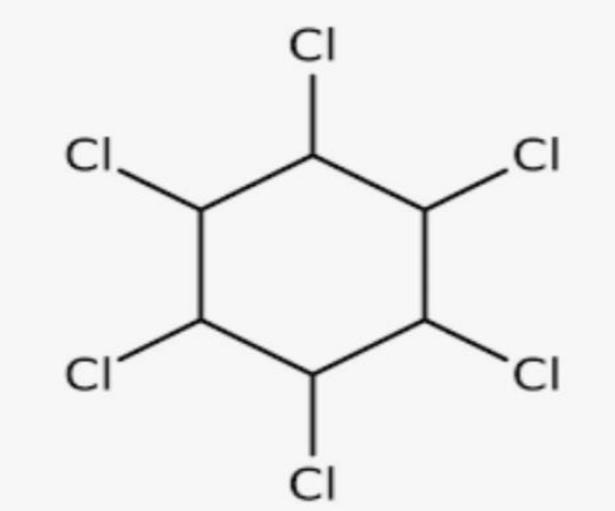
1 . It is used for the prevention of wood.

2. It is used as an insecticide.

3. It is used as a coating material.

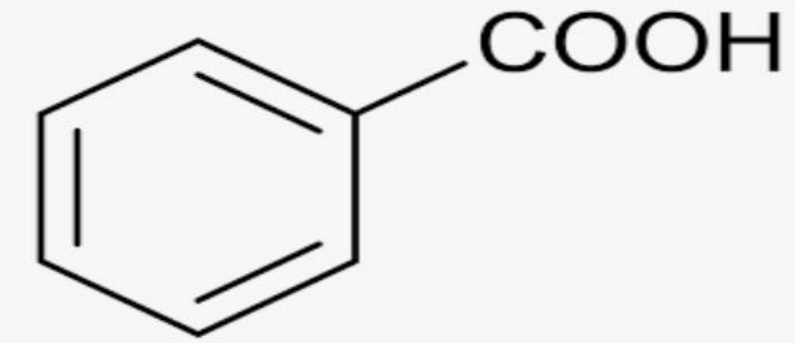
4. It is used in the artificial production of a red dye called alizarin.

BHC (BENZENE HEXA CHLORIDE):



1. **Specially it kills ants and cockroaches.**
2. **It is used as an agricultural insecticide.**
3. **It is used for pharmaceutical treatment of lice and scabies.**

BENZOIC ACID:



1. **It is used as a good preservative for preserving fruit juice, pickles, tomato ketchup etc.**
2. **It is used as an intermediate for preparation of other chemicals.**
3. **It is used as a medicine , specially as an urinary antiseptic in the form of its salt.**
4. **Benzoic acid and salicylic acid is a combination medicine used to treat skin irritation and inflammation caused by burns, insect bite, fungal infections or eczema.**

INDUSTRIAL CHEMISTRY

Chapter 1- Water

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WATER

Water is one of the most important compounds of hydrogen and oxygen. It is a colourless liquid and possesses a high dielectric constant (80) and therefore, salts are highly ionised when dissolved in water, but not so in other solvents. It is the most convenient universal solvent. In general, water is a good solvent for ionic compounds but a poor one for co-valent compound.

CLASSIFICATION OF WATER

i. Soft water: Water which produces enough foam or lathers with soap solution is called soft

water.

ii. Hard water: Water which does not produce much foam or which does not lathers with

soap solution is called hard water.

Hardness of water: The characteristic of water by virtue of which it prevents the formation of foam with soap solution is called hardness. The hardness of water is due to the presence of certain dissolved minerals like bicarbonate, chloride and sulphates of calcium and magnesium i.e $Ca(HCO_3)_2$, $Mg(HCO_3)_2$, $CaCl_2$, $MgCl_2$, $CaSO_4$,$Mg\ SO_4$ etc in

water.

The unit of Hardness: Parts per million (PPM).

TYPES OF HARDNESS

Hardness of water is of two types:

A. Temporary or Carbonate hardness

B. Permanent or Non-carbonate hardness

A. Temporary hardness: The temporary hardness of water arises due to the presence of

bicarbonates of Ca and Mg, [$Ca(HCO_3)_2$, $Mg(HCO_3)_2$].

Temporary hardness is also called carbonate hardness.

B. Permanent of hardness: The permanent hardness of water arises due to the presence of

chlorides And sulphates of Ca, Mg ($CaCl_2$, $MgCl_2$, $CaSO_4$, $MgSO_4$).

REMOVAL OF HARDNESS OR SOFTENING OF WATER

The process of decreasing the hardness of water is called softening. It involves decreasing the concentration of calcium and magnesium salts in water.

REMOVAL OF HARDNESS

A. Removal of Temporary Hardness:

1. By boiling : The temporary hardness of water can easily be removed just by boiling the water. When hard

water is boiled, the soluble Ca(HCO3)2 and Mg(HCO3)2 are decomposed in to insoluble carbonates, which are removed by filtration.

$Ca(HCO_3)_2 \rightarrow CaCO_3 \downarrow + H_2O + CO_2 \uparrow$

Hard Water (precipitate)

(insoluble)

$Mg(HCO_3)_2 \rightarrow MgCO_3 \downarrow + H_2O + CO_2 \uparrow$

Hard Water (Precipitate)

(insoluble)

2. By adding slaked lime : When temporary hard water is treated with calculated quantity of lime, bicarbonates present in water changes to insoluble water which settles down.

$Ca(HCO_3)_2 + CA(OH)_2 \rightarrow CaCO_3 + H_2O$

Hard water lime precipitate

ADDITION OF EXCESS LIME TO WATER : Excess of lime in water convert soft water into hard water agayby absorbing CO2 from air.

$CA(OH)_2 + CO_2 \rightarrow CA(HCO_3)_2$.

Lime From air Hard water

B. Removal of Permanent Hardness:

Removal of permanent hardness requires chemical treatment. Various methods used for the

removal of permanent hardness are described below.

1. **Ion exchange method**
2. **Lime soda method**

ION EXCHANGE METHOD

This is the most modern method of softening hard water.

In this method the ions responsible for the hardness of water are exchanged with other ions which don't make water hard.

Removal of cation from hard water:

First of all the hard water is passed through a column of cation exchange resin, called ZERO

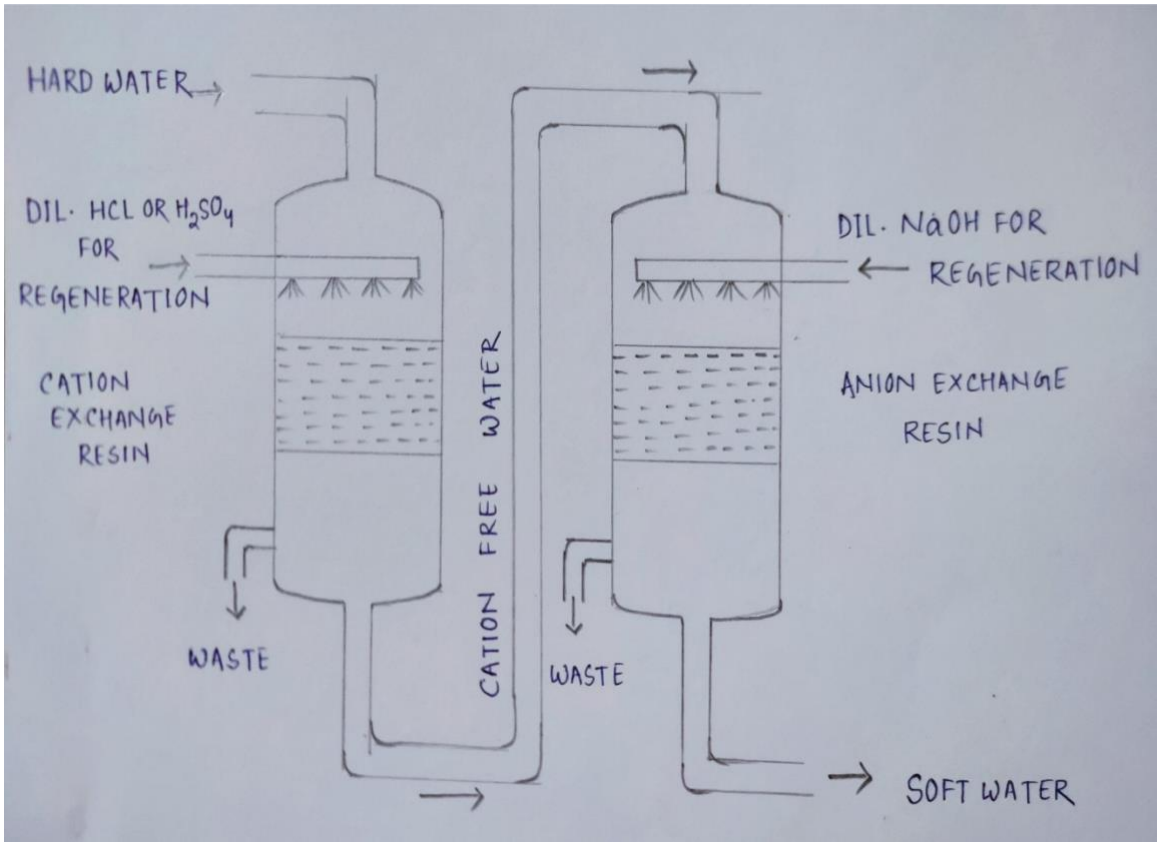
CARB. All the captions present in hard water get exchanged with H+ ion.

$CaCl_2$ + (H+ - resin) ⟶ (Resin)2 CA + H+

+ 2 Cl-

The water is allowed to flow down the column. Calcium and Magnesium ion are retained by the resin.

The cation free water is allowed to pass through the second tank.



Removal of anion from cation free water:

The cation free water is now allowed to pass through a column of anion exchange resin, called DE-ACIDITE.

A the anions get exchanged with OH- ion of the resin.

$H^+ + Cl^- + (OH^-\ resin) \longrightarrow (Cl^-\ resin) + H^+ + OH^-$

Regeneration of Resin:

The exhausted or used cation resin is regenerated by treatment with Dil. HCl or H_2SO_4.

$Ca - (resin)_2 + HCl \longrightarrow (H^+ - resin) + CaCl_2$

Similarly used anion resin is regenerated with Dil. NaOH solution.

$Cl^-\ resin + NaOH \longrightarrow (OH^-\ resin) + NaCl.$

2. *Lime soda process :* Principle:

In this process hard water is treated with a calculated quantity of lime and soda. Lime and soda convert the soluble hardness causing chemicals present in hard water in to insoluble substances.

$$CaCl_2 + Na_2CO_3 \rightarrow CaCO_3\downarrow + 2NaCl$$

(soluble) soda (insoluble)

$$MgCl_2 + Ca(OH)_2 \rightarrow Mg(OH)_2\downarrow + CaCl_2$$

(soluble) (Insoluble)

The precipitate or sludge formed is then removed by filtration to get soft water.

Lime-Soda process is of two types.

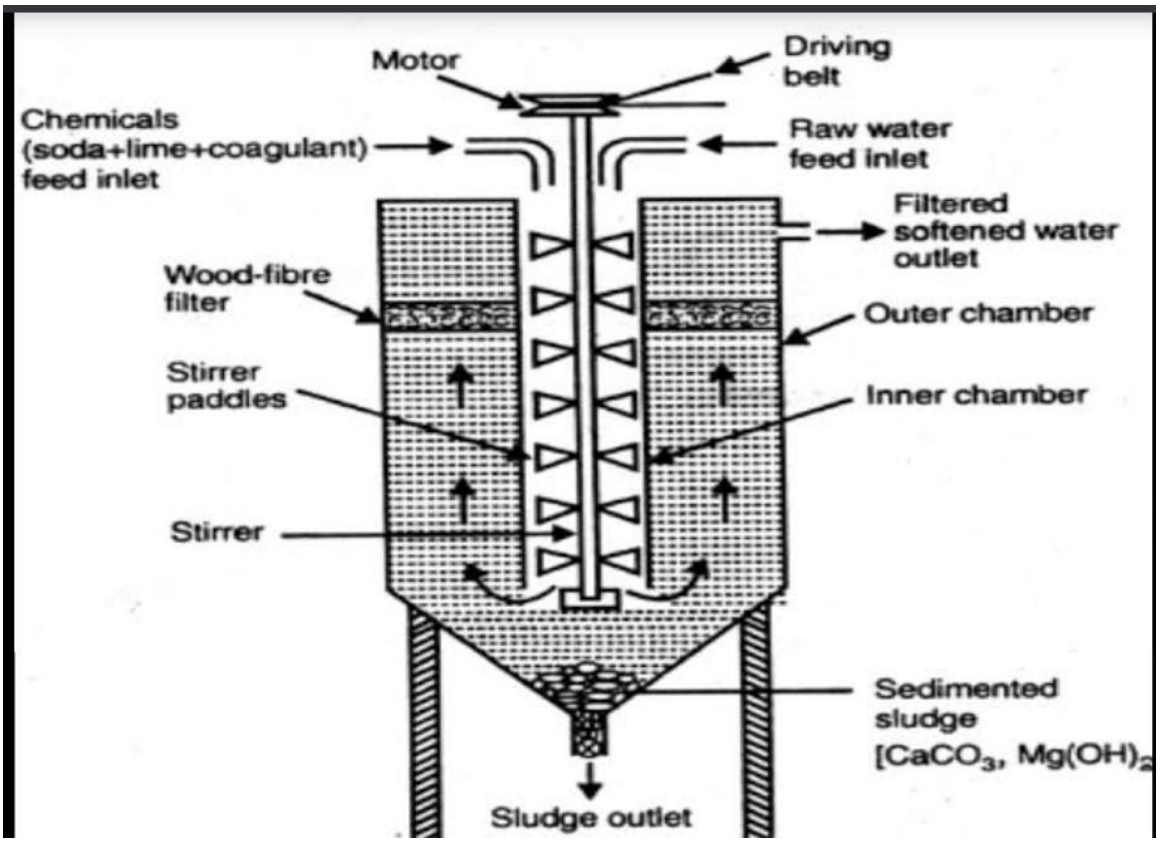
a. COLD Lime– Soda PROCESS:

Principle:

In this method calculated quantity of chemicals along with accelerator (rotater) and coagulant are added to a tank that is connected with a stirrer.

It was stirred continuously. After softening, the soft water rises upward and the heavy sludge settles down. The softened water passes

through a filtering media ensuring complete removal of sludge. Finally the filtered water flows out by the outlet.



- **Cold lime soda method is used for softening of municipal water.**
- **The process takes 24 hours to complete**
- **After softening the hardness left in the water is 60 ppm.**

Hot lime soda process :

Priniciple: This process involves treatment of hard water with a calculated quantity of lime

and soda in presence of super-heated steam (at 80 ^{o}C to 150 ^{o}C).

Apparatus: The apparatus consists of three main parts:

1. Reaction tank: Here the reaction of lime and soda with the hard water takes places.

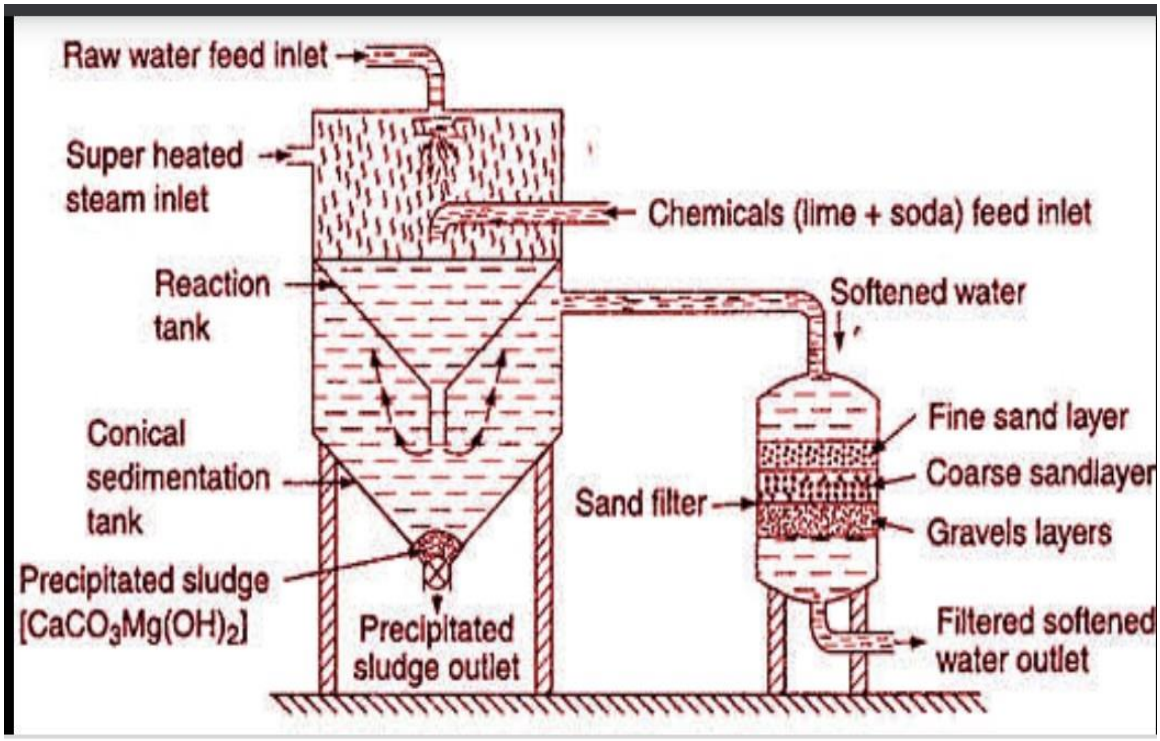
2. Conical sedimentation tank: Here the precipitates (sludge) are formed and deposited.

3. Filtering unit: It consists of a number of layers of gravels which is used to filter water.

Working Process:

Hard water along with a calculated quantity of lime and soda are introduced into the reaction tank. Also super-heated steam at 80 ^{o}C to 150 ^{o}C is passed in to it. The soluble hardness causing chemicals present in the hard water react with lime and soda to form insoluble sludge which settles down in the conical sedimentation tank. The sludge formed is removed periodically through its

outlet. Water is then allowed to pass thorough the filtering unit to get soft water. The residual hardness left in this process is only about 15 – 30 ppm.



Advantages of hot L-S process over Cold L-S Process

i. It is much economical.

ii. The reaction is completed within a short period.

iii. The reaction proceeds faster. Hence the softening capacity in increased.

iv. No coagulant is required, as the sludge settles down easily.

v. Dissolved gasses like CO_2, air etc. are removed.

vi. Under hot condition viscosity of water is lowered. Thus filtration becomes easier.

vii. Pathogenic bacteria are destroyed.

viii. The residual hardness left in this process is much lower (15-30 ppm) as compared to that in the cold L-S process (50-60 ppm).

INDUSTRIAL CHEMISTRY

Chapter 2: Lubricant

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LUBRICANT

The substance applied in between two moving or sliding surfaces to reduce the frictional resistance between them is called 'lubricant'.

Functions of lubricants

i. It reduces the frictional resistance between the sliding surfaces.

ii. It reduces wearing and tearing of machinery parts

iii. It reduces lose in energy

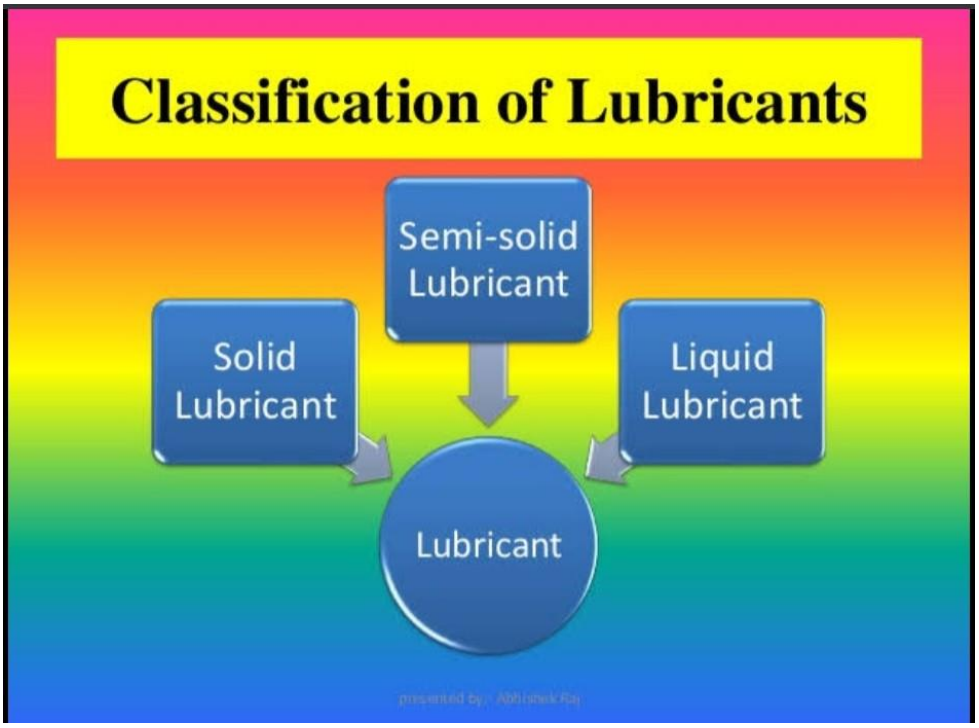
iv. It increases the efficiency of engines.

v. It enhances the durability of machinery parts.

vi. It reduces expansion of metals

vii. It acts as a cooling medium.

Type of lubricants



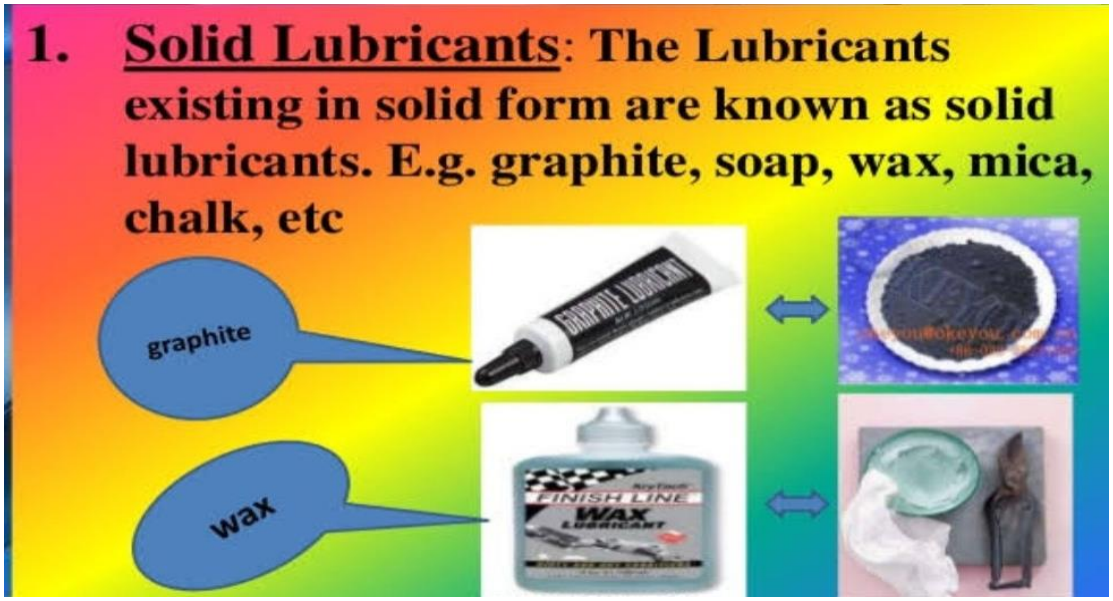
Lubricants can be classified into three categories based upon their physical states. They are:

1. Solid lubricants: For example: Graphite, mica, molybdenum disulphide, boron trinitride,

etc.

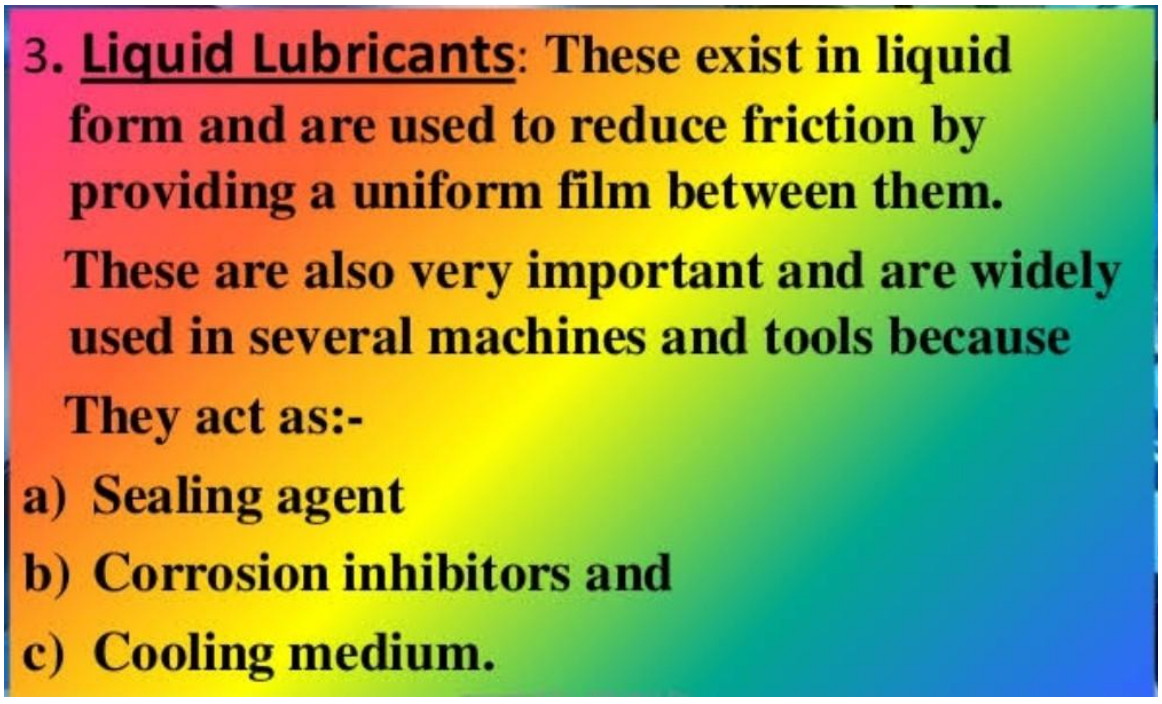
☐ It is used where the working temperature is very high

☐ It is used where there is a chance of contamination of the products with the lubricants.



2. Liquid lubricants: For example: Oils, Mobiles, petroleum oil, blended oil, animal oil,

vegetable oil etc.



Functions of Liquid Lubricants:

i. It acts as a cooling medium

ii. It reduces the chance of rusting of metals.

iii. It prevents corrosion of machinery parts.

Liquid lubricants are used when:

- **The operating temperature is very high**
- **The speed of the roller is very high**
- **The sealing arrangement is perfect to prevent the loss of oil.**

3. Semi solid lubricants: For example: Grease

Some major components of greases are:

i. Oil component: mineral oil, waxes, petroleum oils.

ii. Thickening component: Na, K, Ca, Al soaps.

iii. Modifiers: antioxidant, antirust agent, antiwear agents, etc.

Semi solid lubricants are used where there is a chance of heavy jerk. Semi-solid lubricants stick to the rolling surfaces in spite of heavy jerk.

Purpose of Lubrication or functions of Lubrication

Lubrication is highly important in industrial fields. The purposes of lubrications are:

i. Lubrication helps to reduce frictional resistance between the moving, rolling or sliding surfaces.

ii. It reduces wearing and tearing of machinery parts.

iii. It reduces noise pollution

iv. It reduces lose in energy

v. It increases the efficiency of engines.

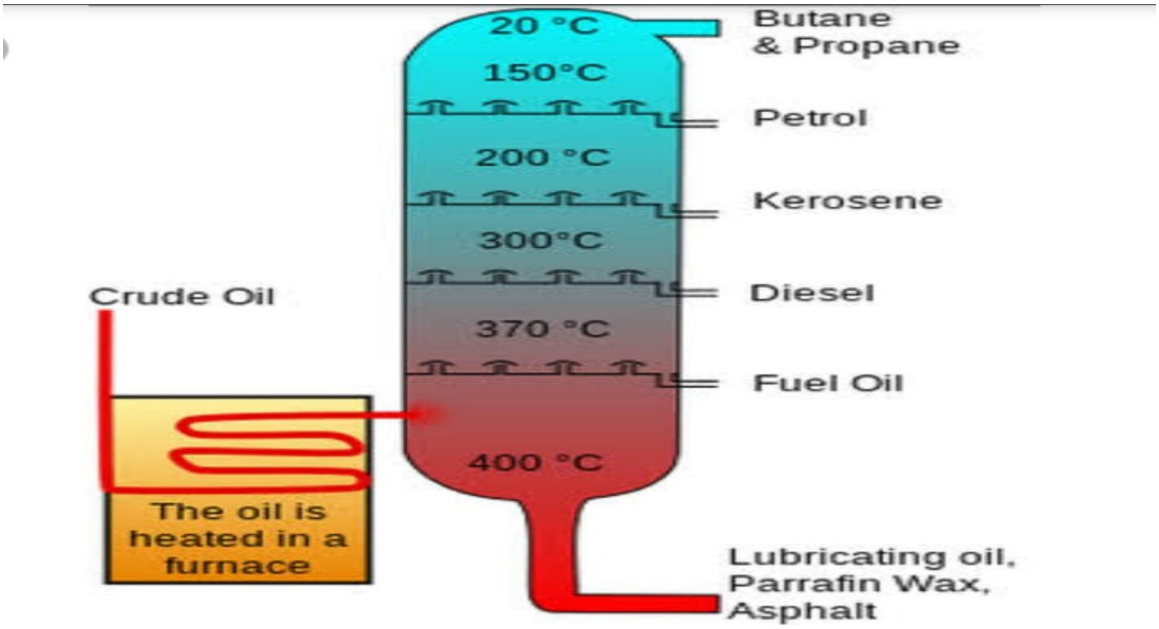
vi. It enhances the durability of machinery parts.

vii. It reduces expansion of metals

viii. It acts as a cooling medium.

INDUSTRIAL CHEMISTRY

Chapter 3: Fuel



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FUEL

Fuel is a combustible matter which on burning with air produces a huge quantity of heat energy along with a low quantity of other by products.

Fuel + O2 → Product(s) + Heat

In other words, fuel is defined as any combustible substance which maybe burnt to supply heat for practical applications.

Characteristics of good fuel

1. Its calorific value should be high.

2. It should be cheap and readily available.

3. It should be stored for a longer period i.e. it should be non-volatile and stable.

4. It should not produce much ash.

5. Transportation should be easy.

6. It should not produce any poisonous gas.

7. It should not produce much smoke.

8. It should have low ignition temperature.

9. It should not be explosive in nature.

10. It should not contain high percentage of moisture.

11. It should contain low percentage of volatile matter.

Calorific value

Calorific value may be defined as "the net amount of heat energy produced by the complete combustion of a unit mass or unit volume of fuel in air.

" Units of Calorific value are: Cal/gm,

Kcal/Kg, KJ/Kg, British Thermal Unit (BTU), etc.

Classification of Fuel

Depending upon the physical state fuels may be classified in to three categories:-

1. Solid fuel: (Coal, wood, saw dust, rice bran, straw)

2. Liquid fuel: (Kerosene, Petrol, Diesel, Spirit, alcohol, LPG, CNG, etc.)

3. Gaseous fuel: (Methane, butane, water gas, producer gas, bio-gas, coal gas, acetylene,

hydrogen etc.

SOLID FUEL

1. Wood

i. A freshly cut wood contains about 50% moisture.

ii. On air drying the moisture content reduces to about 15%.

iii. The average composition of a dry wood is, C = 50%, H = 6%, O = 43%, Ash = 1%

iv. The calorific value = 3500 to 4500 Kcal / kg

v. It is largely used as a domestic fuel and seldom used for industrial purpose.

2.COAL

Coal is nothing but a combustible solid. It is usually stratified. That means, formed by the burial of partially decomposed vegetation in post geological ages.

During natural calamities big trees are uprooted from the ground and get buried under the surface of earth.

After thousands and thousands of years under high temperature and pressure and in absence

of oxygen, by the action of bacteria wood is decomposed into coal.

The progressive conversion of wood into coal is called coalification.

Wood → Peat → Lignite → Bituminous → Anthracite

A.Peat

i. It is either brown or black in colour.

ii. It is a jelly like substance and assumed as the first stage in the coalification of wood.

iii. It contains about 80% to 90% moisture.

iv. Average composition: C = 57%, H=6%, O=35%, Ash =2.5 to 6%.

v. Calorific Value is very lo i.e 5400 Kcal/ Kg.

vi. It is neither wood nor coal in the proper sense, but something intermediate between the

two.

Uses: It is used for domestic purpose.

B.Lignite

i. It is brown in colour and soft in nature. Considered as second stage in conversion of vegetable matter in to coal

ii. It contains about 20 to 60% moisture.

iii. Average composition

C = 67%

O=27.8%

H and N = 5.2%

iv. Calorific value = 5500 to 7000 Kcal/kg.

Uses: It is used as fuel in small scale industries and for domestic purpose.

It is also used in producer gas generation plant.

C. Bituminous

i. It contains about 10% to 40% moisture.

It is widely used fuel. It has higher carbon content than peat & lignite.

ii. Average composition: C = 95%, O=5% , H= 5%.

iii. Caloric value = 8000 to 8500 Kcal/kg.

iv. It contains about 45% volatile matter.

Uses: It is used as fuel in small scale industries and in domestic purpose.

It is also used in metallurgical industries and for coke & coal gas preparation.

D. Anthracite

i. It has dark brown or black surface. It is very hard and it is the purest form of coal.

ii. It has higher density than other form of coal.

iii. It is lustrous in appearance.

iv. It contains very low percentage of moisture and volatile matter.

v. Average Composition C = 94%, H = 3.5%, O= 2.5%

vi. Calorific Value = 8500 to 8700 Kcal/kg

vii. It contains a very low %age of ash (about 3%)

Uses: It is used in metallurgical operation as a reducing agent and as a fuel.

PETROLEUM

The word petroleum is coined from two Greek words, 'Petra' - means 'rock' and 'Oleum' -means 'Oil'. It is also known as rock oil and mineral oil.

Origin of petroleum: It is obtained deep in the earth crust and at the bottom of sea.

Petroleum is formed by the partial decomposition of aquatic creatures deep in the sea. The decomposition occurs as a result of high pressure and in the absence of air. Petroleum oil contains various constituents such as petrol, diesel, kerosene, fuel oil, paraffin, petroleum gas, etc. Also it contains water and sulphur as impurities.

Purification of crude petroleum oil

Removal of water (Cottrell's process)

The crude petroleum oil is passed through two highly charged electrodes, when water gets separated as emulsion.

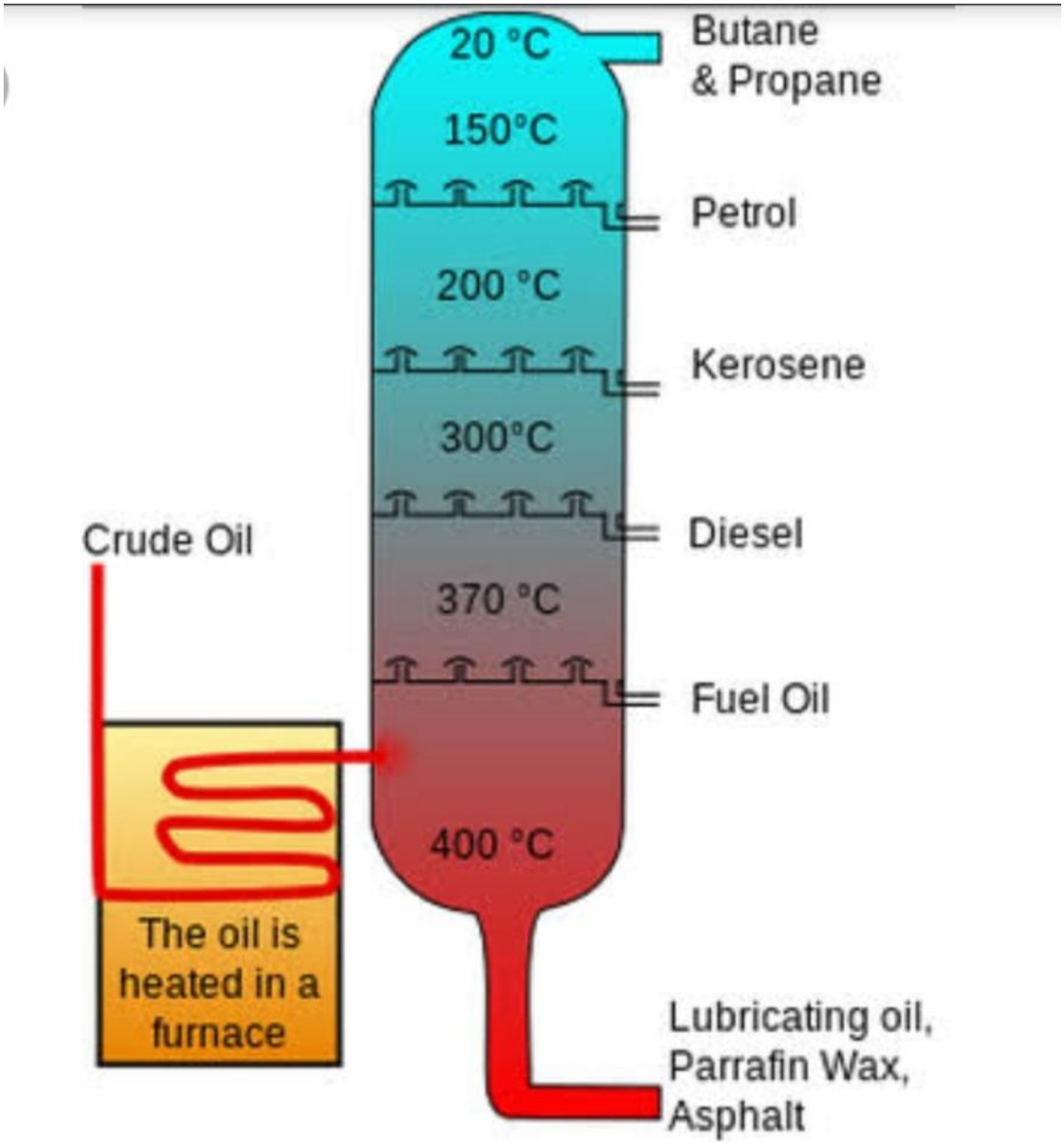
Removal of sulphur

The crude petroleum oil free from water is then passed through copper oxide (CuO) solution, so that sulphur present in the petroleum reacts with the solution giving insoluble CuS, which can be filtered off.

Separation of different constituents from petroleum (Fractional Distillation Method)

Different constituents of crude petroleum oil are separated by fractional distillation method. The crude petroleum oil is passed through a furnace where it is heated to about 4000 C, so that all the fractions are converted into their gaseous form. The vapours are then passed through a fractional distillation unit. When the vapours move in upward direction, the temperature gradually falls and fractional condensation occurs at different heights of the distillation unit. Different fractions

are collected from their respective outlets. The fraction with highest boiling point is collected at the bottom, while that with lowest boiling point is collected at the top.



Petrol or Gasoline

i. The fraction obtained between 40º - 120 ºC, chiefly contains petrol.

ii. It consist of hydrocarbons between pentane to octane (C5H12 to C8H18)

iii. It is volatile and inflammable.

iv. Average Composition

C = 84%,

H=15%,

O+S+N =1%

v. Calorific Value = 11,250 Kcal / Kg.

Uses:

- **It is used as a fuel in the petrol engine.**
- **It is used as a dry cleaning agent.**

Kerosene

i. It is obtained between 180º – 250 ºC

ii. It consists of hydrocarbons between decane to hexadecane (C10H22 to C16 H34).

iii. Average Composition, C = 84 % , H = 16%, S < 0.1%

iv. Calorific value = 11, 100 Kcal/ Kg

Uses:

- **It is used as a domestic fuel in stoves.**
- **It is used as a fuel in jet planes.**
- **It is used in making oil gas.**

Diesel

i. It is obtained between 250º – 320ºC

ii. It contains a mixture of hydrocarbons between pentadecane to octadecane (C15H32 to C18

H38).
iii. Average composition: C = 85%, H = 12%, Rest = 3%
iv. Calorific Value = 11000Kcal/kg
Uses: It is used as a fuel in diesel engine.

Water Gas

It is a mixture of combustible gases CO and H2 with a little quantity of non-combustible gases
CO2 and N2.
The average composition of water gas is
H2= 51 %, CO = 41 %, CO2 = 4%, N2 = 4%,
Its calorific value is 2800 Kcal / m3
Uses: It is used as:
i. an illuminating gas.
ii. a fuel
iii. a source of H2
iv. Used for welding purposes

Producer Gas:

It is a mixture of combustible gases, CO and H2 with large quantities of non-combustible
gases CO2 and N2
The average composition of producer gas is
CO = 22- 30%, H2 = 8 - 12 %,
CO2 = 3%, N2 = 52 55 %
Its calorific value is 1300 Kcal /m3
Uses: It is used:
i. In heating furnace in metallurgical operations.

ii. As a reducing agent.
iii. in coke and coal gas manufacture.
iv. Used for heating open hearth furnace.

CNG : Compressed Natural Gas:

It is a natural colourless and odourless mixture of gases which is obtained from the upper part of petroleum deposition.

Properties:

1. **It is very cheap**
2. **It burns with a pale blue(light blue) flame liberating large amount of heat.**

Composition:

It contains
methane (CH_4) = 70- 90%
Ethane (C_2H_6)= 4-9%
And a traces of propane (C_3H_8) & butane (C_4H_{10}).

Uses

1. **It is used as a fuel for vehicle.**
2. **It is used as domestic and industrial fuel.**
3. **It is used as a source of carbon in tyre industries.**
4. **Specially CNG is used in low emissive vehicle.**

LPG : Liquified Petroleum

It is obtained as a bi- product during cracking of heavy oil or from natural gas.

Properties:

1. **It is highly volatile**
2. **It burns with a blue flame in the burner of the cooking stove.**
3. **It burns with smokeless flame.**

Composition:

n- butane (C_4H_{10}) = 27%

Iso- butane (C_4H_{10})= 25%

Butene (C_4H_8) = 43%

Propane(C_3H_8)= 2.5%

Propene (C_3H_6)= 2.5%

Uses:

1. **Used as a domestic fuel and industrial fuel.**
2. **It is used as a motor fuel.**

INDUSTRIAL CHEMISTRY

POLYMER

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POLYMER

Polymers are one of the important products of chemical industry which have a great impact on our modern life. Plastics, synthetic fibres, synthetic rubber, etc are common examples of polymers. These polymers have multifarious uses ranging from household articles, automobiles, clothes, furniture, etc. to space aircraft, biomedical and surgical operations.

Polymerisation: The chemical process in which a large number of smaller molecular units are united or joint together to form a bigger molecule of high molecular weight is called polymerization.

Polymers: Compounds of very high molecular masses formed by the combination of a large number of simple molecules are called polymers.
For example: Polythene, PVC (polyvinyl chloride), Bakelite, Buna-S, Buna –N, Teflon, etc.
In Greek,
'poly' means many and
'meros' means units or parts.

The simple molecules which combine to give polymers are called monomers.

Monomer: Monomer is the single repeating unit which on polymerization gives a polymer.
For example: Ethene is the monomer of polyethene.

Classification of Polymers

Polymers may basically be classified in to two types, they are:
i. Homo-polymer
ii. Co-polymer

Homo-polymer

The polymer containing monomer units of identical chemical composition is called a homo-polymer.

In other words the polymer formed from one type of monomer is called a homo-polymer.

Example: polythene, PVC, Polystyrene etc.

--------M – M – M – M – M – -------- where, "M" is the monomer unit.

Copolymer

A polymer containing monomer units of different chemical composition is called co-polymer or mixed polymer.

For example: terylene is a polymer of two monomers ethylene glycol and terephthalic acid.

Other examples of co-polymer are Bakelite, Nylon-6,6, Nylon-6,10, Buna-S, Buna-N etc.

--------M1 – M2 – M1 – M2 – M1 –M2 -------
(Copolymer)

Types of plastics:

1. **Thermoplastic**
2. **Thermosetting plastic.**

Thermoplastic	Thermosetting
1.These are formed by addition polymerization.	1. These are formed by condensation polymerization.
2. These have usually Linear structure.	2. They show 3- D structure.
3.These can be remolded, recast and reshaped.	3. These can't be reminded, recast or reshaped.
4. These are less brittle.	4. These are more brittle.
5. These are soluble in organic solvents.	5. These are insoluble in organic solvents.
6. These are hard at room temperature and melts on heating.	6. These don't melt rather goes harder on prolonged heating.
7. Example : Polythene, PVC etc.	7. Example : Bakelite

PVC (Poly Vinyl Chloride)

When Vinyl-Chloride undergo polymerization in presence of a small quantity of benzoyl Peroxide or hydrogen peroxide in a autoclave (under high pressure), Poly Vinyl Chloride is formed.

$$n(CH_2 = CHCl) \longrightarrow (CH_2 - CHCl)_n$$

(Vinyl Chloride) (monomer) → (PVC) (polymer)

There are two types of PVC.

1. **Plasticised**
2. **Un- Plasticise.**

Plasticised PVC: These are flexible, durable and cheap.

Uses: It is used for making:

1. Rain coats & packing

2.Table cloths & curtains.

3. Electrical insulators , covering of electric cable.

4.Chemical containers, disposable syringes etc

Un- Plasticised PVC : These are rigid, durable, fire resistance and recyclable.

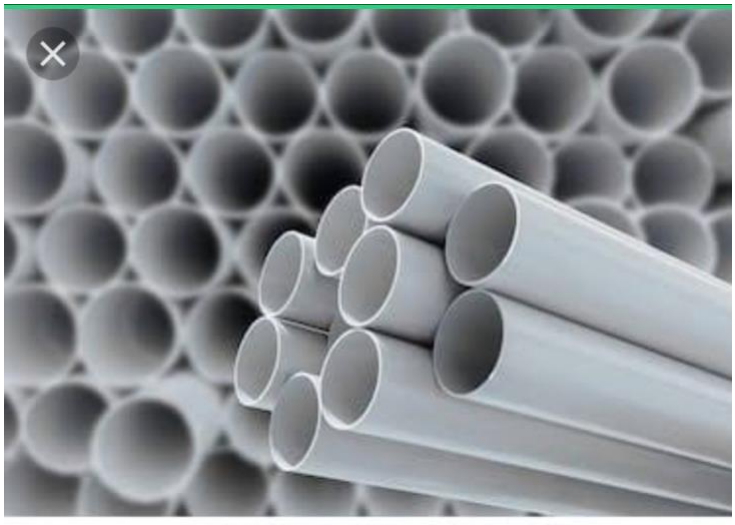
Uses: These are used for making

1. Sheets for tank lining

2.Safely helmets

3.Refrigerator components

4. Tyres, cycle and motor cycle mudguards



BAKELITE:

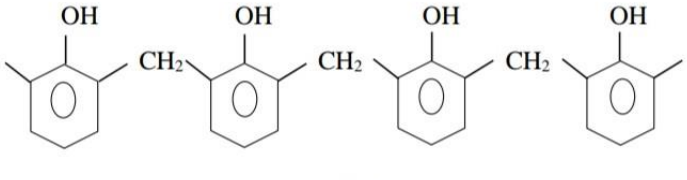
In the production of Bakelite, two types of monomers are used.

1. **Phonol**
2. **Formaldehyde**

It is a co-polymer of phenol and formaldehyde. When phenol and formaldehyde are reacted together two isomeric compounds O-hydroxy methylphenol and P-hydroxy methylphenol are obtained.

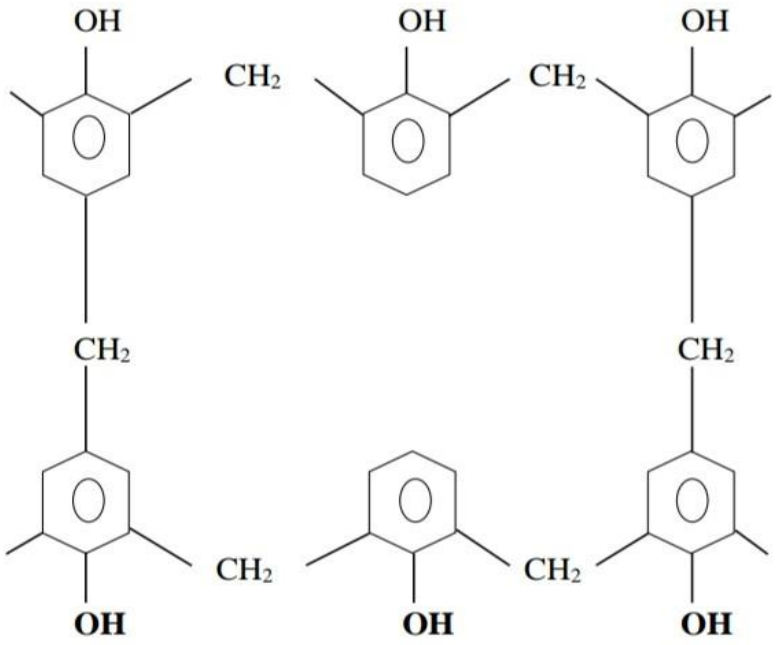
Phenol Formaldehyde (o-Hydroxymethyl (p-

The orthohydroxy methylphenol thus formed undergoes polymerisation to form a linear polymer compound called "NOVOLAC".



(NOVOLAC)

During the process of polymerization, a little quantity of hexamethylene tetramine [(CH2)6N4] is added which converts novolac into a hard resinous mass called Bakelite.



BAKELITE

NATURAL RUBBER :

It is a polymer of isoprene or 2- methyl buta-1,3-diene.

Natural rubber is cis- isomer.

It is made from the sap of a plant (Havea Brasillians). Rubber latex obtained from the tree are dilutes (15-20)% with water. It is then filtered to remove the suspended impurities. Now acetic acid is added for co- agulation. The white sticky mass is obtained, which is called co- agulum.

Types of rubber:

1. **Crape rubber : co- agulum is pressed in a creeping machine. Here rubber sheets with alternate rough & smooth surfaces are obtained, it is called crepe rubber.**
2. **Smoker rubber : The crape rubber sheets are hung on a smoke house at 40-50°C for 4 days. Here colored rubber sheets are obtained, called smoker rubber.**
3. **Gutta purcha : Rubber tree leaves are dried and then Powdered. It is then heated with water at 70°C for one hour. Now the solution is poured in cold water. The yellow sticky mass obtained is dried and the product obtained is gutta purcha.**
   It is trans- polyisoprene.

Vulcanised rubber:

It is the process of heating raw rubber with varying amount of sulfur (3.5%) at 140°C for sometime. After vulcanisation the rubber gains high tensile strength and become resistance to oxidation.

Advantages of vulcanisation :

1. **It has high resistance to oxidation, absorption, wear & tear.**
2. **It has high chemical resistance to organic solvents.**

3. **It has much better electrical insulation power.**
4. **It has good tensile strength and load bearing capacity**
5. **It has useful temperature range of 40- 100°C.**

INORGANIC CHEMISTRY

Chemicals in Agriculture

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CHEMICALS IN AGRICULTURE

Many chemicals are used in agricultural sector for better production of crops. They includes

1. ***Pesticides***
2. ***Fertilizers***

PESTICIDES :

Pesticides are chemical substances that are meant to kill pests.

In general a pesticide is a chemical or biological agent such as virus, bacteria, antimicrobes or disinfectant that are used to kill pest.

Pesticides – also known as agricultural chemicals – are substances that are used to protect plants against pests. They include herbicides to kill weeds, fungicides to get rid of diseases and insecticides to kill bugs.

- **protect plants against pests and diseases;**
- **influence how much the plants grow;**
- **preserve plant products;**
- **kill or prevent the growth of undesired plants;**

It is further decided in to three types.

1. **Fungicide**
2. ***Insecticide***
3. ***Herbicide***

FUNGICIDES :_ Fungicides are chemical compounds or biological compounds that are used to kill parasitic fungi and their spores.

Fungicides reduces the growth of fungus.

Example- Captain, Mancozeb,mane, nabam, zineb

Uses:

1. **They are used to control fungus that damages the plant**
2. **They are used to improve the storage life and quality of plants.**

INSECTICIDES :

- **These are the substance used to kill insects.**
- **They includes ovicides & larvicides, used against insect eggs and larvaes respectively.**
- **Example : Nicotine & nim extracts (natural insecticides)**
- **DDT, BHC, lindane, cyclodiene**

Uses :

1. **They are used to kill insects like flies, house flies, mosquitoes , ants, cockroaches, and other insects including spiders.**
2. **These are also used to kill termites or white ants.**

HERBICIDES :

- **The herbicide is a pesticide that is used to kill unwanted plants.**
- **It is of two types.**
  1. **Selective**
  2. **Non selective**

Selective herbicides: It kills certain targets while leaving the desired crops relatively unharmed.

Ex: Decamba – It is used on corn field.

Non selective herbicides : These are used to clear the waste ground, industrial construction sites, railways and railway embankment as they kill all plants.

Ex. Glufofocinate ammonium

BIO FERTILIZER

Bio fertilizer are the substance that contains microorganisms living or latent cells.

These increase the nutrients of the host plant when applied to the seeds, plant surface or soil by colonizing the rhizosphere of the plant.

These are more cost effective as compared to chemical fertilizers.

Ex.

Azobactor : soil when treated with this, specially non legume crops & dry crops control some disease and also increase the yield 10-15%.

Azospirithin : it is used in non legume plants like maize, barley, oats, sugarcane, rice etc. And increase the yield uplo 10- 20%.