APPLIED CHEMISTRY 1

(CBCGS,DEC-2016)

Q1](a)What is the role of polymer in medicine and surgery ?Explain with the help of any three examples? (3)

Ans:-Materials which are not causing adverse effect on blood and other tissues can be used in diagnostic, surgical and can be implanted in the body. They can be developed from metals, ceramics and polymers. Uses of polymers in the field of medicine and surgery are increasing day by day. Characteristics of biomedical polymers are:

1.should be bio-compatible, can be fabricated into desire shape or form without being degraded.

2.can be easily sterilized with no alteration in properties, should have optimum physical and chemical properties.

Examples are as follows:

POLYMER	APPLICATION
1. PMMA.	Contact lenses.
2. silicon rubber, polyurethane.	Heart walls, drain tubes.
3. Polyvinyl chloride.	Disposable syringes.
4. polyalkyl sulphone.	Membrane oxygenator.

Q1](b)Distinguish between alkaline and non alkaline hardness? (3)

Ans:-

TEMPORARY OR ALKALINE HARDNESS.	PERMANENET OR NON-ALKALINE HARDNESS
1.Caused by the process of dissolved bicarbonates of calcium , magnesium and other heavy metals and the carbonates of iron. salts responsible for temporary hardness are $Ca(HCO_3)_2$, $Mg(HCO_3)_2$.	**1**.It is due to presence of dissolved chlorides and sulphates of calcium, magnesium, iron and other heavy metals.
2. Temporary Hardness can be removed by boiling water.	**2**.Permanent Hardness cannot be removed by boiling the water.
3.Temporary hardness is called as carbonates or alkaline hardness.	**3**.It is also known as non-carbonates or non-alkaline hardness.
4.Boiling: $Ca(HCO_3)_2 \rightarrow CaCO_3 + CO_2 + H_2O$.	**4**.Can be removed by using chemical and not by boiling e.g. Lime soda method.

$Mg(HCO_3)_2 \rightarrow Mg(OH)_2 + 2CO_2$.	$CaCl_2 + Na_2CO_3 \rightarrow CaCO_3 + 2NaCl$.

Q1](c) State the limitations of phase rule? (3)

Ans:-*The limitations of phase rule are as follows:*

1. *It can be applied to system in equilibrium. It is not of much help when system attain equilibrium very slowly.*
2. *It applies only to single equilibrium state. It does not indicate other possible equilibrium in the system.*
3. *Phase rule consider only the number of phase ,but not their quantities .Even a minute quantity of phases when present accounts towards number of phases.*
4. *All phases must be present under the same condition of the temperature , pressure and gravitational forces.*
5. *Solid and liquid phases must not be in finely-divided state, otherwise deviations occur.*

Q1](d)What are carbon nanotubes? Explain different types of carbon nanotubes? (3)

Ans:-*Carbon nanotubes represents one of the best examples of the novel nanostructures derived by bottom-up chemical synthesis approaches. Nanotubes have the simplest chemical composition and atomic bonding configuration but exhibit perhaps the most extreme diversity and richness among nanomaterial in structure and structure-property relations. The different types of carbon nanotubes are as follows;*

1. *<u>SINGLE WALLED NANOTUBES.</u>*

   SWNTs are an important variety of carbon nanotube. In SWNTs have different chiralities of carbon nanotubes that include Armchair, Zigzag, Chiral. These can be easily twisted. SWNT synthesis requires catalyst.

2. *<u>MULTIWALLED NANOTUBES.</u>*

   Multi-walled nanotubes (MWNTs) consist of multiple rolled layers (concentric tubes) of graphene. This types of CNT's cannot be easily twisted. Purity of MWNT is high also can be easily produced without catalyst.

Q1] (e)When would solid lubricants are used? (3)

Ans:- *Dry lubricants or solid lubricants are material which can reduce the friction without a liquid medium .they are used where,*

1. *Operating conditions are such that a lubricating film cannot be formed or maintained.*

2. *Contaminations of liquid or semi-solid lubricant , with dust or dirt is not desirable ;e.g., open gears.*
3. *Combustible lubricants must be avoided due to the high operating temperature and pressure.*
4. *Heavy machinery working on a crude job at very high loads and slow speed.*
5. *Where the parts to be lubricated are not easily accessible.*

Q1](f) 6ml of waste water was refluxed with 25ml of $K_2Cr_2O_7$ ***solution and after refluxing the excess unreacted dichromate required 20ml of 0.1N FAS solution. A blank of distilled water on refluxing with 25 ml of*** $K_2Cr_2O_7$ ***solution required 35ml of 0.1N FAS solution .Calculate the COD of the waste water sample. (3)***

Ans:-*Given data:-* *Vb=35ml,* *Vt=20ml,*

N=0.1N, *Y=6ml.*

To find:- *COD(Chemical Oxygen Demand).*

Formula:- $COD=\frac{(Vb-Vt)\times N\times 8000}{Y}$ *mg/L*

Solution:- $COD=\frac{(35-20)\times 0.1\times 8000}{6}$ *mg/L*

$COD=2000mg/L.$

Q2] (a)Calculate the quantity of the pure lime and soda required for softening of 40000 litres of water containing the following impurities.

$Ca(hCO_3)_2$ = 16ppm , $Mg(HCO_3)_2$ = 7ppm,$CaSO_4$ = 13ppm ,$Mg(Cl)_2$ = 10ppm, NaCl = 2ppm. *(6)*

Ans:- *Conversion into* $CaCO_3$ *EQUIVALENT AS FOLLOWS:*

impurities(mg/lit)	*Multiplication factor*	$CaCO_3$ *equivalent (mg/lit)*	*Requirement*
$Ca(HCO_3)_2$*=16*	$\frac{100}{162}$	$16\times\frac{100}{162}=9.88$	*L*
$Mg(HCO_3)_2$*=7*	$\frac{100}{146}$	$7\times\frac{100}{146}=4.80$	*2 × L*
$CaSO_4$*=13*	$\frac{100}{136}$	$13\times\frac{100}{136}=9.56$	*S*

$MgCl_2$ *=10*	$\frac{100}{95}$	$10 \times \frac{100}{95} = 10.53$	*L+S*

NaCl does not react with lime and soda.

Calculation of lime,

Lime= $\frac{74}{100} \times \left[CaCO_3 \text{equivalent of } Ca(HCO_3)_2 + 2 \times Mg(HCO_3)_2 + MgCl_2\right] \times \frac{\text{Volume of water}}{1000} \times \frac{100}{\%\text{Purity}}$.

$= \frac{74}{100}[9.88 + (2 \times 4.8) + 10.53] \times \frac{40{,}000}{1000} \times \frac{100}{100}$.

$= \frac{74}{100}[30.01] \times 40 \times 1$.

=888.3gms.

Calculations of Soda,

Soda = $\frac{106}{100}[CaCO_3 \text{equivalent of } CaSO_4 + MgCl_2] \times \frac{\text{Volume of water}}{1000} \times \frac{100}{\%\text{Purity}}$.

$= \frac{106}{100}[9.56 + 10.53] \times \frac{40{,}000}{1000} \times \frac{100}{100}$.

$= \frac{106}{100}[20.09] \times 40 \times 1$.

=851.8gms.

Hence the Lime requirement is 888.3gms and the Soda requirement is 851.8gms.

Q2](b) i) Distinguish between thermoplastic and thermosetting? (3)

Ans:-

THERMOPLASTIC	*THERMOSETTING*
1.Formed by addition polymerization.	*1. Formed by condensation polymerization.*
2.Can be moulded and remoulded.	*2.Remoulding is not possible.*
3.They softens on heating because the linear chains can slip over each other very easily.	*3.They do not become soft on heating, because cross links retain the strength on heating. But prolonged heating causes charring.*
4.Soft , weak and less brittle.	*4. Hard , strong and brittle.*
5.Soluble in some organic solvents.	*5.Insoluble in almost all organic solvents.*
6.Relatively low molecular weight.	*6.Relatively high molecular weight.*
7.Example: PVC, PE, Teflon.	*7.Example: UF, PF, Nylon 6-6, etc.*

Q2] (b) ii) Define flash and fire points. (2)

Ans:-*Flash point:- Flash point is defined as the lowest temperature at which the lubricant gives off enough vapours to cause a momentary flash when a standard test flame is brought near it.*

Fire point:- Fire point is the lowest temperature at which the oil vapours catch fires for at least 5 seconds , on being lighted by a test flame.

Fire point is usually 5-40°C above the flash point. A good lubricant should have flash point at least above the working temperature . This ensures safety against the risk hazards. Thus flash point acts as a guide for the safe storage, transportation and use in machine.

Good lubricant oil should have high flash and fire point.

Q2] (c) Write the CVD method for preparation of carbon nanotubes. (4)

Ans:- *This is very good method from large scale production of carbon nanofiber SWNT, MWNT. Hydrocarbons (e.g., methane, ethane) are allowed to decompose over metal catalyst (e.g., Co, Fe) to produce CNT. Typical yield for CVD are approximately 30% . This process includes production of large amount of CNT's by CVD of acetylene over cobalt and iron. Ethylene can be used with reaction temperatures of 545°C for nickel catalyst CVD and 900°C for an uncatalyzed process that produces carbon nanostructure with open ends. Methane can also be used as carbon source for synthesization . catalytic decomposition of* H_2/CH_4 *mixture over cobalt , nickel, and iron is used to obtain yields of SWNTs at 1000°C. The usage of* H_2/CH_4 *atmosphere between a non-reducible oxide such as* Al_2O_3 *or* $MgAl_2O_4$ *and*

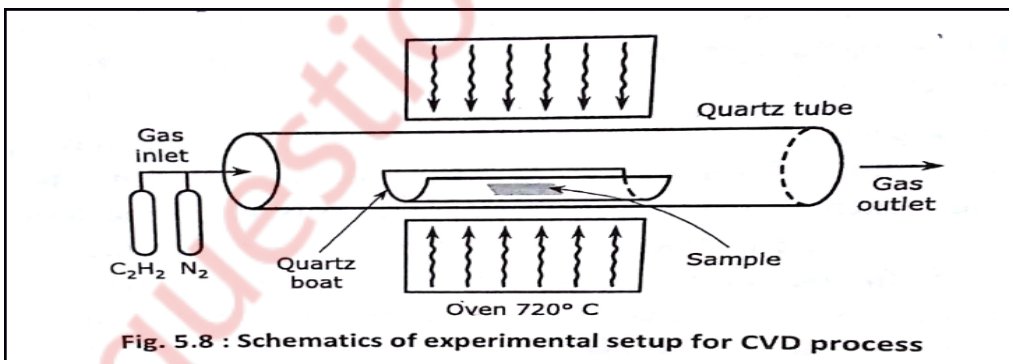


Fig. 5.8 : Schematics of experimental setup for CVD process

one or more transition metal oxides can produce the composite powders containing well dispersed CNTs. Thus , higher proportion of SWNTs and lower proportion of MWNTs can be achieved using the decomposition of CH_4 *over the nanoparticles. Thermal catalytic decomposition of hydrocarbon has become an active area of research and can be a promising route for the bulk production of CNTs. The removal of the catalyst support via an acid treatment which sometimes could destroy the original structure of the carbon nanotube is an issue in this synthesis route. However , alternative catalyst supports that are soluble in water have proven effective for nanotube growth.*

Q3] (a) What is meant by Fabrication of plastics? Explain injection (6)

moulding with the help of neat diagram .

Ans:-*Fabrication of plastic is the technique of giving any desired shape to the plastics by the use of mould. Because of the properties of polymers it is possible to mould them and change their shape using a number of different repetitions manufacturing processes. A proper method is to be selected depending upon the shape and type of resin being used. The most important of these are compression moulding, transfer moulding, extrusion and injection moulding.*

INJECTION MOULDING:

This method is only applicable to Thermoplastic resin. The moulding plastic powder is fed into a heated cylinder . From there it is injected into the tightly locked mould at a controlled rate by means of a screw arrangement or by a piston plunger. The mould is kept cold to allow the hot plastic to cure and become rigid. When the material have been cured sufficiently , half of the mould is opened to allow the injection of the finished article without any deformation . heating is done by oil or electricity.

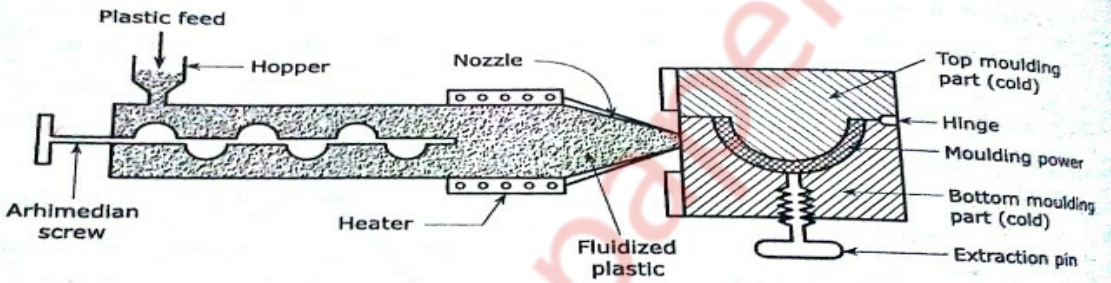


Fig. 2.10 : Injection moulding of plastics.

1.ADVANTAGE:-This method has high speed production, low mould cost , very low cost of material and low finishing cost. Hence it is the most widely used method for moulding of thermoplastics.

2:-DISADVANTAGE:-Since a large amount of cavities cannot be filled simultaneously , there is limitation of design of articles to be moulded.

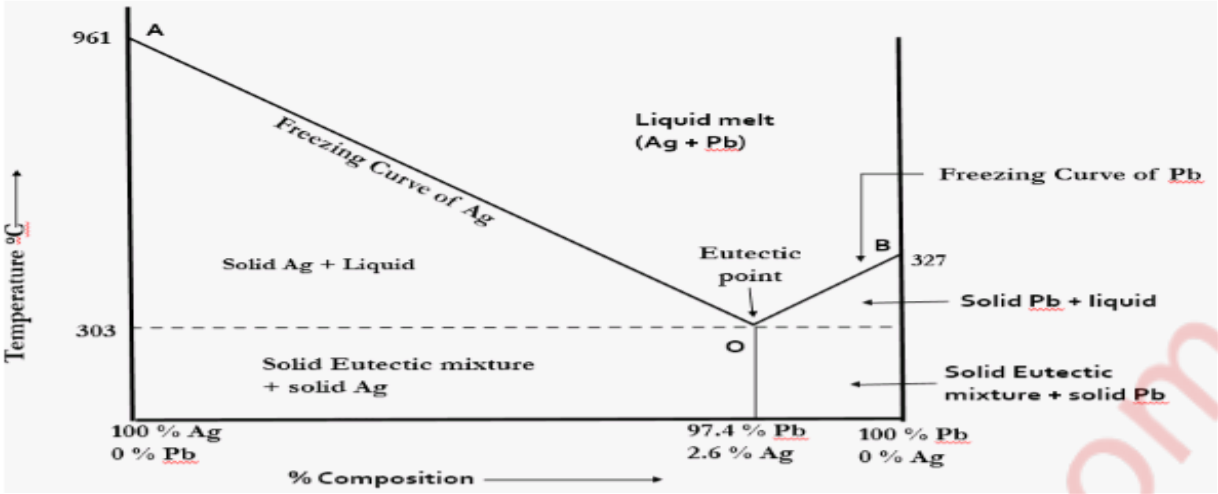
Q3](b) i) State the condensed phase rule. (3)

Ans:- *In some systems , an equilibrium exists between solid – liquid phases and gaseous phase is practically absent . Hence the effect of pressure on such system can be neglected . Then it is*

Necessary to take into account only two variables viz. temperature and concentration.

Such system showing solid – liquid equilibrium is called condensed system and phase rule applied to such system is as follows:-

F = C – P + 1 … known as condensed phase rule.



Q3](b) ii) How is gypsum useful in setting and hardening of cement? (2)

Ans:- C_3A *readily combines with water and liberates a large amount of heat. The added gypsum retards the dissolution of* C_3A *by forming insoluble calcium sulpho-aluminate* $3CaO.Al_2O_3.xCaSO_4.7H_2O$. *This reaction prevents high concentration of alumina in the cement solution which retards the early initial set of the cement.*

Q3](c) The hardness of 85000 litres of water sample was removed by passing it through a zeolite softener. The zeolite required 2000 litres of NaCl solution containing 190 mg/lit of NaCl for regeneration . calculate the hardness of sample. (4)

Ans:- *1 litres of NaCl solution = 190 mg of NaCl*

∴2000 litres of NaCl = 2000 × 190 gm of NaCl

= 3,80,000 gm of NaCl.

Quantity of NaCl in terms of $CaCO_3$ *equivalent hardness.*

$$= 3{,}80{,}000 \times \frac{50}{58.5} \text{ gm of } CaCO_3 \text{ equivalent}$$

$$= 3{,}24{,}786.3 \text{ gm of } CaCO_3 \text{ equivalent}$$

$$= 324.79 \times 10^3 \text{ gm of } CaCO_3 \text{ equivalent}$$

$$= 324.79 \times 10^6 \text{ gm of } CaCO_3 \text{ equivalent}$$

Hardness of 85000 litres of water = 324.79 $\times 10^6$ *gm*

$$\therefore \text{Hardness of 1 litre} = \frac{324.79 \times 10^6}{85000} = 3821 \text{ mg/litre}$$

∴ Hardness of water = 3821 mg/lit

= 3821 ppm.

Q4] (a) How is activated sludge process carried out for the treatment of waste water? Explain with flow sheet diagram.
(6)

Ans:-*Sewage is the liquid which includes human and household waste water, industrial waste , ground waste and street and storm water. Hence due to the toxicity the sewage have to be treated because of the reasons like:*

1. *To prevent pollution of water into which the sewage is left off.*
2. *To prevent offensive odour in the water, and the destruction of fish and other aquatic life.*

SEWAGE TREATMENT BY ACTIVATED SLUDGE PROCESS.

1. *Preliminary Treatment.*

The principal objective of preliminary treatment is the removal of gross solids i.e., large floating and suspended solid matter , grit, oil, and greases if present in considerable quantities . For removing inorganic matter , sewage is allowed to pass through bar screen and mesh screen.

2.Primary Treatment.

For removing suspended matter efficiently and economically , sedimentation process is carried out .Sewage is treated with certain chemicals (e.g., alum, hydrated lime etc.) which form a floc that absorbs and entraps the suspended and colloidal particles present.

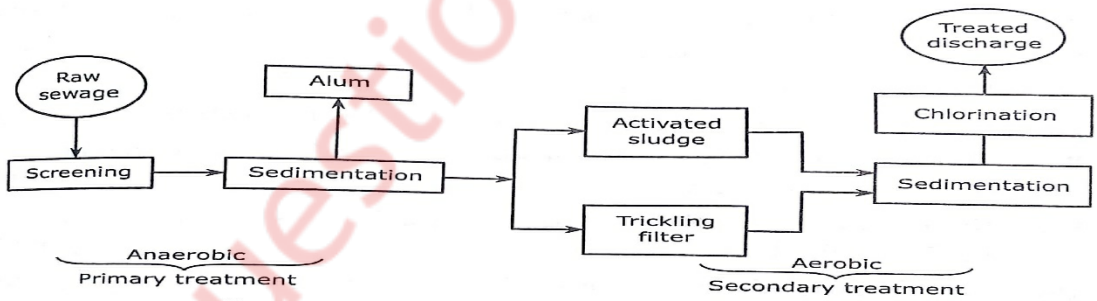


Fig. 1.15 : Flow diagram for sewage treatment.

3.Secondary or Biological Treatment .

It is an essential an aerobic chemical oxidation which includes filtration and activated sludge process. Sewage water is filtered through specially designed sprinkling filters to maintain aerobic conditions. Carbon of the organic matter is converted into CO_2*; and nitrogen into* NH_3 *and finally into nitrates and nitrites. Trickling filters are used for biological oxidation of sewage. Trickled sewage starts percolating downwards an the aerobic bacteria bring about the biological oxidation of organic matter of sewage.*

Hence the sludge formed is known as Activated Sludge. The further process includes mixing of sedimental sewage with proper quantity of activated sludge and mixture is then agitated for 4-5 hrs by blowing air. Suspended and dissolved organic matter is oxidised by aerobic bacteria . after all these process a part of sludge deposited is used for next oxidation batch and the remainder is either spread on land as fertile matter or used for biogas or dumped in

sea.

Q4](b) i)1.4 gm of oil required 1.8 ml of 0.01N KOH for neutralization. Calculate the acid value and mention whether the oil is suitable to be used or not. (3)

Ans:- *Given Data:- Weight of the oil = 1.4 gm .*

Normality of KOH = 0.01.

Volume of KOH = 1.8 ml.

To find:- Acid value of the oil.

Formula:- $\text{Acid value} = \frac{\text{Vol.of KOH} \times \text{Normality of KOH} \times 56}{\text{Weight of oil}}$.

Solution:- $\text{Acid value} = \frac{1.8 \times 0.01 \times 56}{1.4}$.

$= 0.72$ mg

∴Acid Value = 0.72 mg/gm of oil.

As the acid value is much higher than 0.1 , the oil is not suitable to be used.

Q4](b) ii) Write the applications of Fullerenes. (2)

Ans:- *The applications of Fullerene is as follows:*

1.It is used for the preparation of electronic and microelectronic devices.

2.It is used for the preparation of non-linear optical devices.

3. It is used for the preparation of batteries as charge carriers.

4.It is used for the preparation of super conductors.

5.It is used for the preparation of soft ferromagnet with zero remanence.

Q4] (c)What is the functions of fillers and plastisizers in the compounding of plastic?

(4)

Ans:- *1.FILLERS (or EXTENDERS).*

Fillers are added to a base polymer to lower the manufacturing cast of a product made from it. Functions of fillers are as follows:

- *Reducing the cost of plastic.*
- *Increases the tensile strength and hardness.*

- *Reduces the flexiblity.*
- *Decreases the shrinkage during moulding.*
- *Gives opacity to the product.*
- *Examples:-mica, talc, asbestos , saw dust ,chalk etc.*

2.PLASTICIZERS.

The Plasticizer molecule occupies between the polymeric chains and neutralizes the intermolecular forces of attraction and thus allows freedom of movement. The functions of plasticizers are as follows:-

- *Increases the plasticity of the plastics.*
- *Lowers the softening temperature and hence moulding and remoulding can be done at low temperature.*
- *Imparts flames proofness.*
- *Reduces resistance towards chemical , solvents etc.*
- *Examples:- esters of fatty acids, vegetables oils etc.*

Q5](a) Write the preparation , properties and uses of PMMA and Buna-S. (6)

Ans:- *1. POLYMETHYL METHACRYLATE (PMMA).*

- *PREPARATION.*

This is an important thermoplastic resin. It is obtained by polymerisation of methyl methacrylate which is an ester of methyl acrylic acid, $CH_2 = C(CH_3)COOH$ *, in presence of acetyl peroxide or hydrogen peroxide. It is an acrylic polymer.*

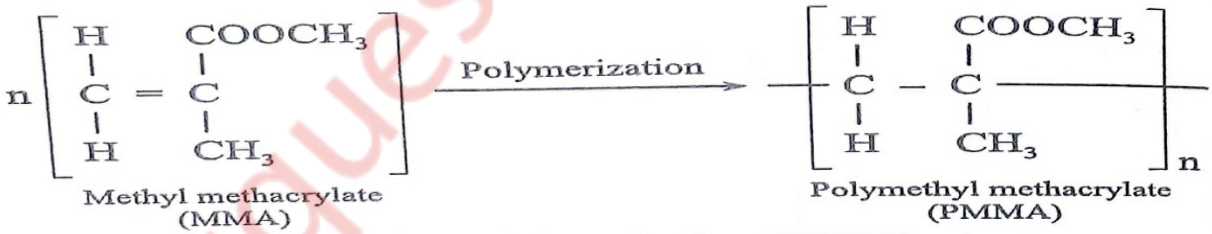


Fig. 2.15 : Polymerization of PMMA

- *PROPERTIES.*

1.It is hard, fairly rigid material with a high softening point of about 130-140°C.

2.It becomes rubber-like at a temperature above 65°C.

3. It has an outstanding shape-forming properties due to wide span of temperature from its rigid state to viscous.

4.It has high optical-transparency.

5.It has high resistance to sunlight and ability of transmission light accurately.

- *USES.*

1. *For making lenses ,optical parts of instruments , air craft , light fixtures, artificial eyes, wind screen , bone splints , decorative articles etc.*
2. *It is found in paint. Acrylic "latex" paints often contain PMMA suspended in water.*
3. *Used in making window glasses.*

2. *BUNA-S (or STYRENE RUBBER)*

- *PREPARATION:*

This is the most important type of synthetic rubber which is produced by copolymerization of butadiene ,$CH_2 = CH - CH = CH_2$(75% by weight) *and styrene ,*$C_6H_5CH = CH_2$(25% by weight).

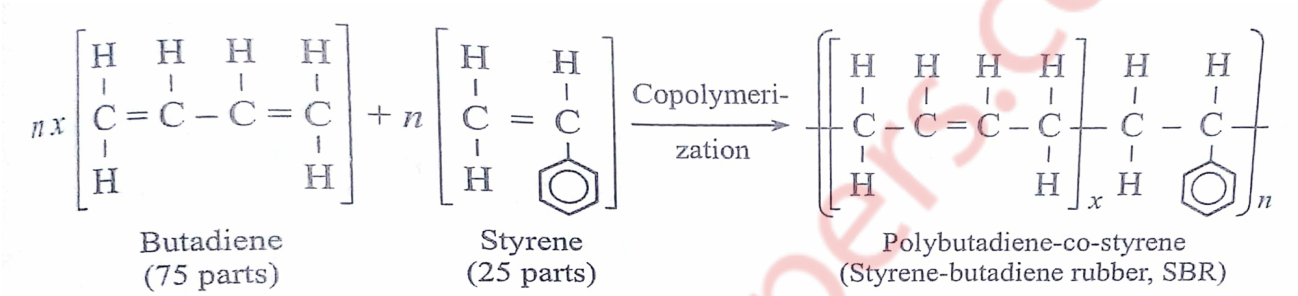


Fig. 2.31 : Preparation of Buna-S

- *PROPERTIES*

1.Styrene rubber resembles natural rubber in processing characteristics as well as quality of finished products.

2.It posses high abrasion-resistance, high load-bearing capacity and resilience

3.It swells in oils and solvents.

- *USES*

1.Mainly used for the manufacture of motor tyres.

2.Other uses of this elastomer are floor tiles , shoe soles, gaskets, foot-wear components, wire and cable insulations, carpet backing , adhesive , tank-lining, etc.

Q5](b) i)What are the advantages of ion exchange process? (3)

Ans:-*The advantages of ion exchange process is as follows:-*

1. *The process cab be used to soften highly acidic or alkaline water.*
2. *It produces water of very low hardness(2 ppm). So it is very good for treating water for use in high-pressure boilers.*
3. *Low maintenance cost.*
4. *Quick separation with efficient technique.*
5. *Re-usable.*

6. *Easily collectable and cost effective.*

Q5](b) ii)What is oiliness? What is its importance in lubrication? (2)

Ans:- *Oiliness of a lubricant is the measure of its capacity to stick on to the surface of machine parts under condition of pressure or load. When a lubricating oil of poor oiliness is applied under high pressure , it gets squeezed out from the surface and the lubrication stops. If the oil has good oiliness it can remain in place and can give lubrication even under pressure. Mineral oil has very poor oiliness whereas vegetable oils possess good oiliness. No direct test are available for measuring oiliness.*

Q5](c) What is the application of phase rule to one component water system? Explain with the help of diagram. (4)

Ans:- *Phase rule helps to study different equilibria and classify them accordingly. It indicates behaviour of the system under a particular set of conditions. Different systems with the same degree of freedom behave in a similar manner. Helps to find out under a set of conditions whether all substances involved in an equilibrium can exist or a particular phases ceases to exist or whether any transformation has taken place.*

<u>One component system with the phase diagram.</u>

In water there is only one component i.e., water and its three phases : ice, water, steam which are solid, liquid, and gaseous respectively. Figure below represents phase diagram or pressure v/s temperature diagram for the water system.

Three curves OA, OB, and OC represents the equilibrium conditions between two phases solid with vapour , vapour with liquid and liquid with solid phase of water.

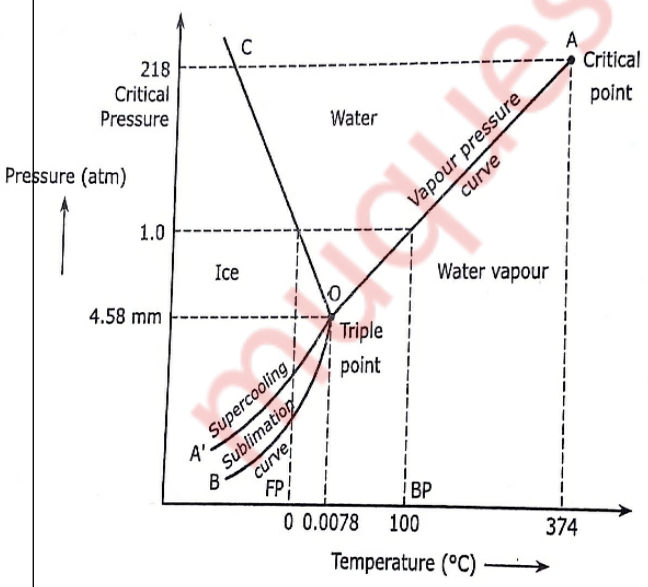


Fig. 4.1 : Phase diagram of water system

Curve OC represents the equilibrium between solid and liquid phase of the water. This curve is known as fusion pressure or melting point curve. Along this curve there are two phases in equilibrium that is ice and water. At atmospheric pressure, ice and water can be in equilibrium only at one temperature i.e., the freezing point of water.

We have C=1, P=2 thus,

F=C-P+2=1.

Curve OB represents the equilibrium between liquid and vapour. It is known as vaporization curve. Here also it is necessary to state either temperature or pressure. E.g., at atmospheric pressure , water and vapour can exist in equilibrium only at 1 temperature i.e., the boiling point of water. Water - vapour system has one degree of freedom F=C-P+2=1.

Q6] (a) Define lubricants and lubrication. Discuss the hydrodynamic lubrication (6)

in detail.

Ans:- *Any substance placed between two moving or sliding surfaces with a view to reduce the frictional resistance between them is known as lubricant.*

Lubricants may be used in solid, liquid or semi solid form. The process of reducing friction between two metallic sliding surfaces by the introduction of lubricants is called as lubrication.

HYDRODYNAMIC OR FLUID-FILM OR THICK -FILM LUBRICATION.

In this type of lubrication , the lubricant is forming a thick film having about 1000 A° thickness between the moving surfaces so that the direct surface to surface contact and welding of junction rarely occurs. The coefficient of friction is very low i.e., 0.001 to 0.03 under hydrodynamic lubrication.

When oil is introduced between the moving surfaces , some of the oil molecules are held up tightly at the surface due to adsorption. The remaining oil molecules are loosely arranged away from metal surfaces. Frictional resistance is only due to the internal resistance between the particles of lubricants moving over each other. Hence lubricant chosen should have the maximum viscosity .

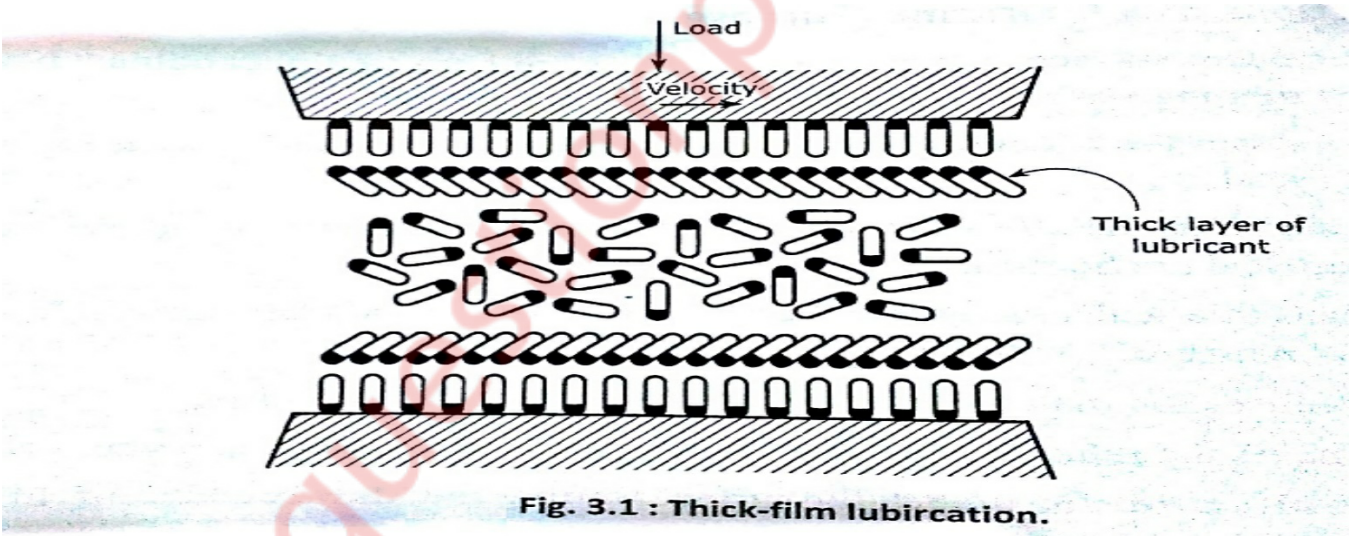


Fig. 3.1 : Thick-film lubircation.

Hydrodynamic lubrication occurs when the surfaces are rigid and retain the shape during operations. For hydrodynamic lubrication to occur ,two essential conditions are to be satisfied : (1)liquid must be viscous and, (2) the shape of the surface should be such that a wedge shaped film should be formed. Journal bearing consist of a shaft or journal that rotates freely in a supporting metal sleeve or shell with lubricating oil in the interface between them. During normal operations the shaft rotates at sufficient speed to force the oil between the conforming curved surfaces of the shaft and the shell thus creating the oil wedge and hydrodynamic film. This film allows these bearing to support extremely heavy loads. Watches , clock, sewing machine , fans, guns etc. requires hydrodynamic lubrication.

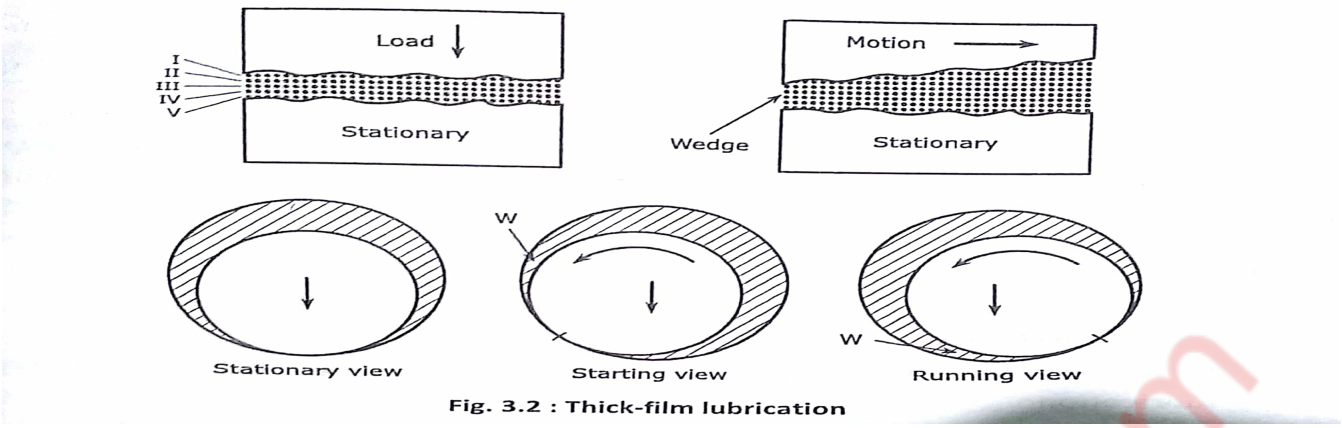


Fig. 3.2 : Thick-film lubrication

Q6](b) i) Define phase , component and degree of freedom. (3)

Ans:- *1. PHASE: A phase is defined as any homogenous , physically distinct and mechanically separable portion of a system , which is separated from other parts of the system by definite surface. Example:-*

- *In a freezing water system ice, water and water vapour are the three phases which are physically distinct and homogenous.*

2.COMPONENT: It is the smallest number of independent variable constituents taking part in the state of equilibrium , by means of which the composition of each phase can be expressed in the form of chemical equation .Example:-

- *In water system the phases present are ice, water and water vapour. The composition of each phase can be expressed by a single component,* H_2O*. Hence it is a one component system.*

3.DEGREE OF FREEDOM: It is defined as the smallest number of independent variables such as pressure , temperature and concentration that must be specified in order to define completely the state of a system. Example:

- *For a system consisting of water in contact with its vapour ,*

$$\text{Water}_l \leftrightarrow \text{Water vapour}_g$$

To define it completely , we have to state either temperature or pressure. Hence , the system is univariant or degree of freedom is one .

Q6] (b)ii) What are the industrial application of ultrafiltration ? (2)

Ans:- *The industrial application of ultrafiltration is as follows:*

1. *Industries such as chemical and pharmaceutical manufacturing , food and beverage processing etc employ ultrafiltration in order to recycle flow or add value to later products.*
2. *Blood dialysis also utilizes ultrafiltration.*

3. *In cheese manufacturing we use ultrafiltration.*
4. *Radiocarbon dating of bone collagen uses ultrafiltration.*
5. *Removal of pathogens from milk.*
6. *Fruit juice concentration and clarification.*

Q6](c) What is RCC? Write the advantages of it. (4)

Ans:-*Plain concrete has good compressive strength , but less ability to withstand tensile stresses. In such cases, to impart tensile strength steel bars or rods and metal meshes are embedded in the concrete. This is called as RCC. Here the concrete bears the compressive strength and the steel rods bears the tensile strength.*

APPLICATION:- Widely used in floor beams, girders, slabs, bridges, etc.

ADVANTAGES:- 1. RCC is easier to make and cast into any desired shapes, which can bear all types of loads.

2.It possesses greater rigidity , moisture , and fire-resistances.

3.Steel reinforcement also tends to distribute the shrinkage cracks, thus preventing the formation of large cracks.

4.Its maintenance cost is practically negligible .

APPLIED CHEMISTRY 1

(CBCGS MAY 2017)

Q1](a) What are cation and anion exchangers? (3)

Ans:- *Ion-exchange resins are insoluble, cross-linked, long chained organic polymer with a microporous structure. The functional group attached to the chains are responsible for the ion-exchange properties. Resins containing acidic functional groups like -COOH, -SO_3H etc. are capable of exchanging their H+ ions with other cations which come into their contact. Those containing basic functional groups like -NH_2, =NH as hydrochloride etc are capable of exchanging their anions with other anions which come into their contact. The ion exchange resins are classified as follows:*

1. *Cation exchange resins*

These are mainly styrene divinyl benzene copolymer which on sulphonation or carboxylation become capable of exchanging their hydrogen ions with the cations in the water.

2. *Anion exchange resins.*

These are styrene divinyl benzene or amine formaldehyde copolymer which contain amino or Quaternary ammonium or quaternary phosphonium or tertiary sulphonium groups as an integral part of the resins matrix. These after treatment with dil. NaOH solution , become capable of exchanging their OH^- anions with anions in water.

Q1](b) Give the preparation, properties and uses of polymethyl methacrylate polymer. (3)

Ans:- *This is the important thermoplastic resin. It is also known as Lucite or plexiglass.*

PREPARATION:

It is obtained by polymerization of methyl methacrylate which is an ester of methyl acrylic acid,$CH_2 = C(CH_3)COOH$, in presence of acetyl peroxide or hydrogen peroxide. It is an acrylic polymer.

PROPERTIES:

- *It is a hard, fairly rigid material with a high softening point of about 130-140* °C.
- *It becomes rubber*-like at a temperature above 65 °C.
- *It has an outstanding shape*-forming properties due to wide span of temperature from its rigid state to viscous state.

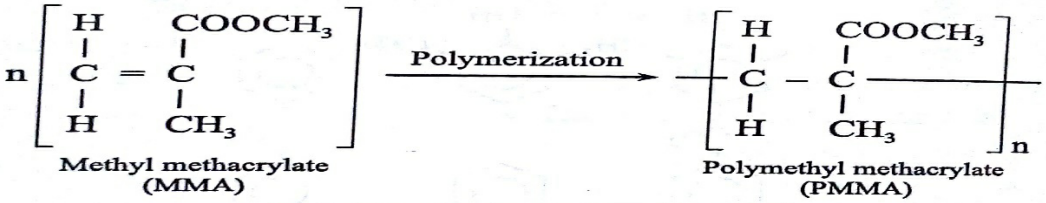


Fig. 2.15 : Polymerization of PMMA

USES:

- *For making lenses, optical parts of instruments, air craft , light fixtures, artificial eyes, wind screen, bone splints, decorative articles etc.*
- *As it is more transparent than glass , it is used for making window glasses.*
- *It is found in paints. It is used as cloud and pour point depressant additives in lubricants.*

Q1](c) A 10ml of sample of waste water was refluxed with 20ml of potassium dichromate solution and after refluxing the excess unreacted dichromate required 36.2ml of 0.1M FAS solution. A blank of 10ml of distilled water on refluxing with 20ml of dichromate solution required 46ml of 0.1M FAS solution. Calculate the COD value of waste water. ***(3)***

Ans:- *Given data :- Vb = 46ml Vt = 36.2ml*

N = 0.1M Ve = 10ml

To find :- COD

Solution :- $COD = \frac{(Vb-Vt)\times Normality \times 8000}{Ve}$

$= \frac{(46-36.2)\times 0.1 \times 8000}{10}$

= 784 ppm

Hence the COD value is 784 ppm.

Q1](d) Define: ***(3)***

i) Flash point.

ii) Oiliness.

iii) Pour point.

Ans:-

i)FLASH POINT.

Flash point is defined as the lowest temperature at which the lubricants gives off enough vapours to cause a momentary flash when a standard test flame is brought near it.

Good lubricant should have high FLASH POINT.

ii) OILINESS.

Oiliness of a lubricant is the measure of its capacity to stick on to the surface of machine parts under conditions of pressure or load. Mineral oils have very poor oiliness whereas vegetable oils posses good oiliness.

iii)POUR POINT.

After cooling oil, the temperature at which it ceases to flow is called its pour point.

Good lubricant should have low POUR POINT.

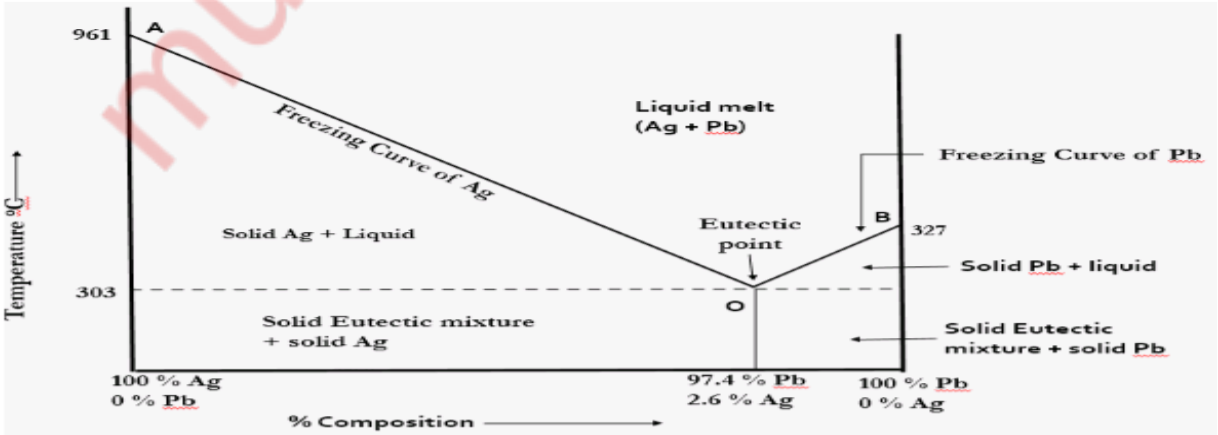
Q1](e)What is reduced phase rule? ***(3)***

Ans:- :- *In some systems , an equilibrium exists between solid – liquid phases and gaseous phase is practically absent . Hence the effect of pressure on such system can be neglected . Then it is*

Necessary to take into account only two variables viz. temperature and concentration.

Such system showing solid – liquid equilibrium is called condensed system and phase rule applied to such system is as follows:-

F = C – P + 1 … known as condensed phase rule.



Q1](f) What are the draw backs of natural rubber? (3)

Ans:- *The drawbacks of natural rubber are as follows:*

- *It swells considerably in organic solvents and gradually disintegrates.*
- *It has little durability.*
- *When stretched to a greater extent , it suffers permanent deformation, because of the 'sliding' or slippage of some molecular chains over each other.*
- *It is weak: its tensile strength is only 200 kg/cm^2.*
- *Natural rubber is brittle below 10 °C and above 50 °C, it becomes soft. Hence it is useful only in limited temperature ranges.*

Q1](g) Explain CVD method for production of CNT's. (3)

Ans:- *This is very good method from large scale production of carbon nanofiber SWNT, MWNT. Hydrocarbons (e.g., methane, ethane) are allowed to decompose over metal catalyst (e.g., Co, Fe) to produce CNT. Typical yield for CVD are approximately 30% . This process includes production of large amount of CNT's by CVD of acetylene over cobalt and iron. . Ethylene can be used with reaction temperatures of 545°C for nickel catalyst CVD and 900°C for an uncatalyzed process that produces carbon nanostructure with open ends. Methane can also be used as carbon source for synthesization . catalytic decomposition of H_2/CH_4 mixture over cobalt , nickel, and iron is used to obtain yields of SWNTs at 1000°C. The usage of H_2/CH_4 atmosphere between a non-reducible oxide such as Al_2O_3 or $MgAl_2O_4$ and one or more transition metal oxides can produce the composite powders containing well dispersed CNTs. Thus , higher proportion of SWNTs and lower proportion of MWNTs can be achieved using the decomposition of CH_4 over the nanoparticles. Thermal catalytic decomposition of hydrocarbon has become an active area of research and can be a promising route for the bulk production of CNTs. The removal of the catalyst support via an acid treatment which sometimes could destroy the original structure of the carbon nanotube is an issue in this synthesis route. However , alternative catalyst supports that are soluble in water have proven effective for nanotube growth.*

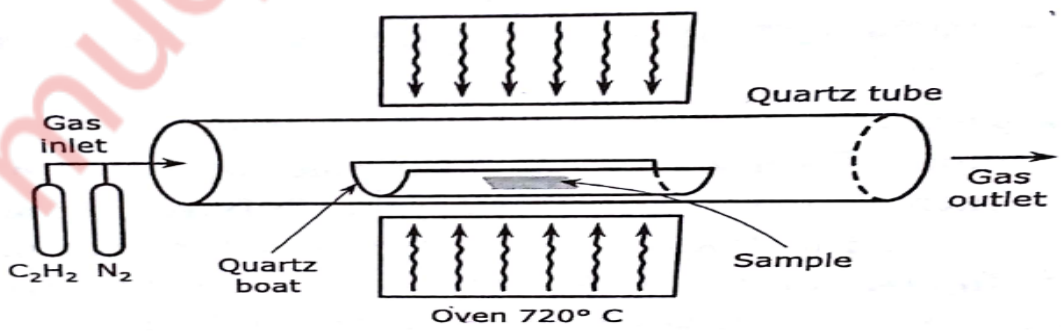


Fig. 5.8 : Schematics of experimental setup for CVD process

Q2](a) Calculate the amount of lime (80 % purity) and soda (90% purity) required for softening of 50,000 of hard water whose chemical analysis results are given below. $Ca(HCO_3)$ ***= 40.5 mg/L ,*** $Mg(HCO_3)_2$ ***= 73.0 mg/L ,*** $MgSO_4$ ***= 60.0 mg/L ,*** $CaSO_4$ ***= 34.0 mg/L ,*** $CaCl_2$ ***= 27.5 mg/L and NaCl = 20.0 mg/L.*** ***(6)***

Ans:-

Impurities(mg/lit)	*Multiplication factor*	$CaCO_3$ *equivalent (mg/lit)*	*Requirement*
$Ca(HCO_3)_2$ *=40.5*	$\frac{100}{162}$	$40.5\times\frac{100}{162} = 25$	*L*
$Mg(HCO_3)_2$ *=73.0*	$\frac{100}{146}$	$73\times\frac{100}{146} = 50$	*2L*
$CaCl_2$ *= 27.5*	$\frac{100}{111}$	$27.5\times\frac{100}{111} = 24.8$	*S*
$CaSO_4$ *= 34*	$\frac{100}{136}$	$34\times\frac{100}{136} = 25$	*S*
$MgSO_4$ *= 60*	$\frac{100}{120}$	$60\times\frac{100}{120} = 50$	*L+S*

NaCl does not react with lime and soda.

LIME = $\frac{74}{100}\left[CaCO_3 \text{ equivalent of } Ca(HCO_3)_2 + 2\times Mg(HCO_3)_2 + MgSO_4\right]\times \frac{\text{Volume of water}}{1000}\times\frac{100}{\%\text{ purity}}$

$= \frac{74}{100}\times[25 + 2\times50 + 50]\times\frac{50000}{1000}\times\frac{100}{80}$

= 8093.75 gms.

SODA = $\frac{106}{100}\left[CaCO_3 \text{ equivalent of } CaCl_2 + MgSO_4 + CaSO_4\right]\times\frac{\text{Volume of water}}{1000}\times\frac{100}{\%\text{purity}}.$

$= \frac{106}{100}[25+50+24.8]\times\frac{100000}{1000}\times\frac{100}{85}.$

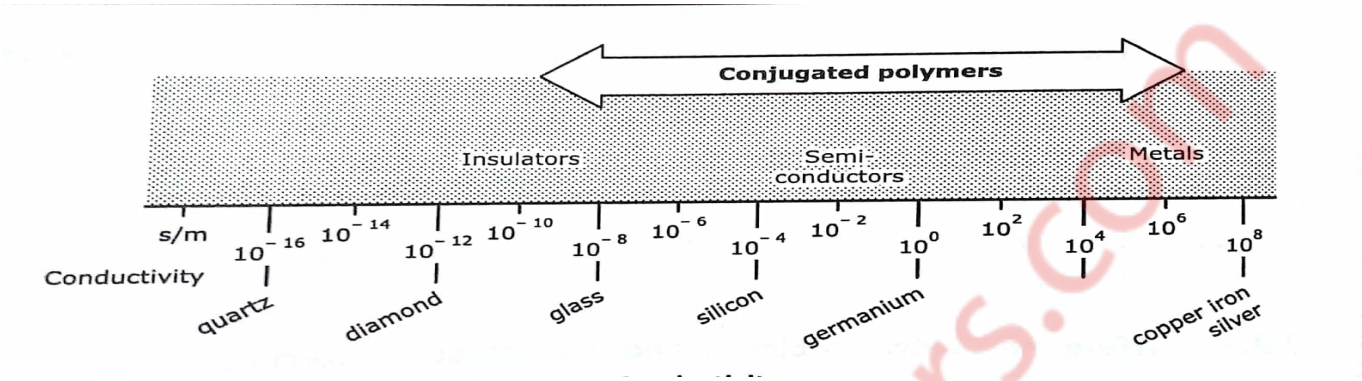
= 5877.1 gms.

The lime requirement is 6541.6 gms and soda requirement is 8203.15 gms.

Q2](b) i) Write a brief note on conducting polymers. ***(3)***

Ans:- *Polymers are insulated because of the absence of free electrons. In becoming electrically*

conductive , a polymer has to imitate metal that is the electron needs to be free to move. Such type of polymer are called Conducting polymer. Polymers with conjugate π-electron backbones display unusual electronic properties such as low energy optical transition , low ionization potentials and high electron affinities. The result is a class of polymers that can be oxidised or reduced more easily and more reversibly than conventional polymers. The effect of this oxidation or reduction on polymer is called doping i.e., convert an insulating polymer to conducting one.



Two conditions for a polymer to become conducting are:-

1. *Polymer possess conjugate double bonds.*
2. *Polymer has to be distributed either by removing or adding electron to the material. This process is called doping.*

Q2](b) ii) Mention the conditions under which semi-solid lubricants can be used (2)

Ans:- *The semi-solid lubricants can be used under following conditions:*

- *In situations where the oil cannot remain in place due to high load, low speed, intermittent operation, sudden jerk etc.*
- *In situation where bearing has to be protected against entry of dirt, dust, moisture etc because greases are less liable to contamination by these.*
- *In situations where dripping or spurting of oil is undesirable because unlike oils, greases if used do not splash or drip over articles being prepared by the machines e.g., machines used in paper, food, textile and dying industry.*
- *When the machine is worked at slow speed and high pressure.*

Q2](c) Explain with the help of chemical reactions 'setting and hardening' process of cement . (4)

Ans:- *When cement is mixed with water, it forms a cement paste. It undergoes several hydration reactions to from gel and crystalline products. The compounds thus formed are responsible for solidification and gradual hardening. The process comprises of i) Setting is the*

initial stiffening of the cement pate due to gel formation. ii) hardening is the gain of strength due to crystallisation.

The process of solidification consists of three steps:-

- *Initial setting is due to the hydration of tricalcium aluminate(*C_3A*) and gel formation of tetra calcium alumino ferrite (*C_4AF*)*

$$3CaCOAl_2O_3 + 6H_2O \rightarrow 3\ CaOAl_2O_36H_2O + 880\ kL/kg$$

$$4CaOAl_2O_3Fe_2O_3 + 7H_2O \rightarrow 3CaOAl_2O_36H_2O + CaOFe_2O_3H_2O + 420 kJ/kg$$

- *Dicalcium silicate (*C_2S*) and Tricalcium silicate (*C_3S*) hydrolyses to from tobermonite gel*

$$3\left[2CaOSiO_2\right] + 4H_2O \rightarrow 3CaO.2SiO_26H_2O + Ca(OH)_2 + 250\ kJ/kg$$

$$2\left[3CaOSiO_2\right] + 6H_2O \rightarrow 3CaO.2SiO_23H_2O + 3Ca(OH)_2 + 500\ kJ/kg$$

- *Final setting and hardening of cement paste is due to the formation of tobermonite gel and crystallisation of calcium hydroxide and hydrated tricalcium aluminate.*

SEQUENCE OF CHEMICAL REACTIONS FOR SETTING AND HARDENING OF CEMENT.

- *At first hydration of tricalcium aluminate (*C_3A*) and tetracalcium aluminoferrite (*C_4AF*) takes place. This leads to the initial setting of the cement.*
- *Next the hydration of tricalcium silicate (*C_3S*) begins within 24 hours and gets completed within 7 days. This provides the initial strength.*
- *Dicalcium silicate (*C_2S*) begins to hydrate after 7 days and gets completed in 28 days. This is responsible for increased strength of cement.*

CEMENT PASTE →HYDRATION OF C_3A AND C_4AF →GELATION OF C_3S→HYDRATION OF C_3S AND C_2S.

Q3](a) Write a short note on :

1) Injection moulding method for plastic.

2) Polymer in medicine and surgery. ***(6)***

Ans:- *1) <u>INJECTION MOULDING</u>.*

This method is only applicable to <u>Thermoplastic resin.</u> The moulding plastic powder is fed into a heated cylinder . From there it is injected into the tightly locked mould at a controlled rate by means of a screw arrangement or by a piston plunger. The mould is kept cold to allow the hot plastic to cure and become rigid. When the material have been cured sufficiently , half of the mould is opened to allow the injection of the finished article without any deformation . heating is done by oil or electricity.

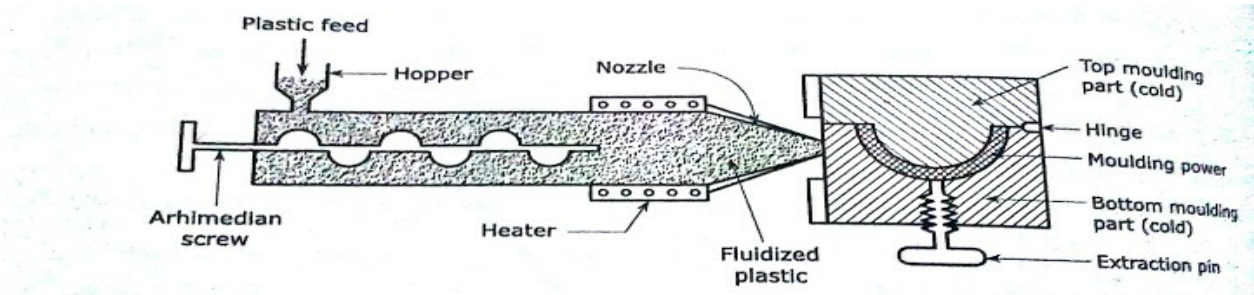


Fig. 2.10 : Injection moulding of plastics.

1.ADVANTAGE:-This method has high speed production, low mould cost , very low cost of material and low finishing cost. Hence it is the most widely used method for moulding of thermoplastics.

2:-DISADVANTAGE:-Since a large amount of cavities cannot be filled simultaneously , there is limitation of design of articles to be moulded.

2)POLYMER IN MEDICINE AND SURGERY.

Materials which are not causing adverse effect on blood and other tissues can be used in diagnostic, surgical and can be implanted in the body. They can be developed from metals, ceramics and polymers. Uses of polymers in the field of medicine and surgery are increasing day by day. Characteristics of biomedical polymers are:

1.should be bio-compatible, can be fabricated into desire shape or form without being degraded.

2.can be easily sterilized with no alteration in properties, should have optimum physical and chemical properties.

3.They should not destroy cellular elements of blood, enzymes or produced toxic or allergic reactions.

4.They should have purity and reproducibility.

Examples are as follows:

POLYMER	***APPLICATION***
1. PMMA.	*Contact lenses.*
2. silicon rubber, polyurethane.	*Heart walls, drain tubes.*
3. Polyvinyl chloride.	*Disposable syringes.*
4. polyalkyl sulphone.	*Membrane oxygenator.*
5.Acrylic hydrogels	*Grafting*

Q3](b) i)Draw and explain important features of phase diagram of water system.

(3)

Ans:- *In water there is only one component i.e., water and its three phases : ice, water, steam which are solid, liquid, and gaseous respectively. Figure below represents phase diagram or pressure v/s temperature diagram for the water system.*

Three curves OA, OB, and OC represents the equilibrium conditions between two phases solid with vapour , vapour with liquid and liquid with solid phase of water.

Curve OC represents the equilibrium between solid and liquid phase of the water. This curve is known as fusion pressure or melting point curve. Along this curve there are two phases in equilibrium that is ice and water. At atmospheric pressure, ice and water can be in equilibrium only at one temperature i.e., the freezing point of water.

We have C=1, P=2 thus,

F=C-P+2=1.

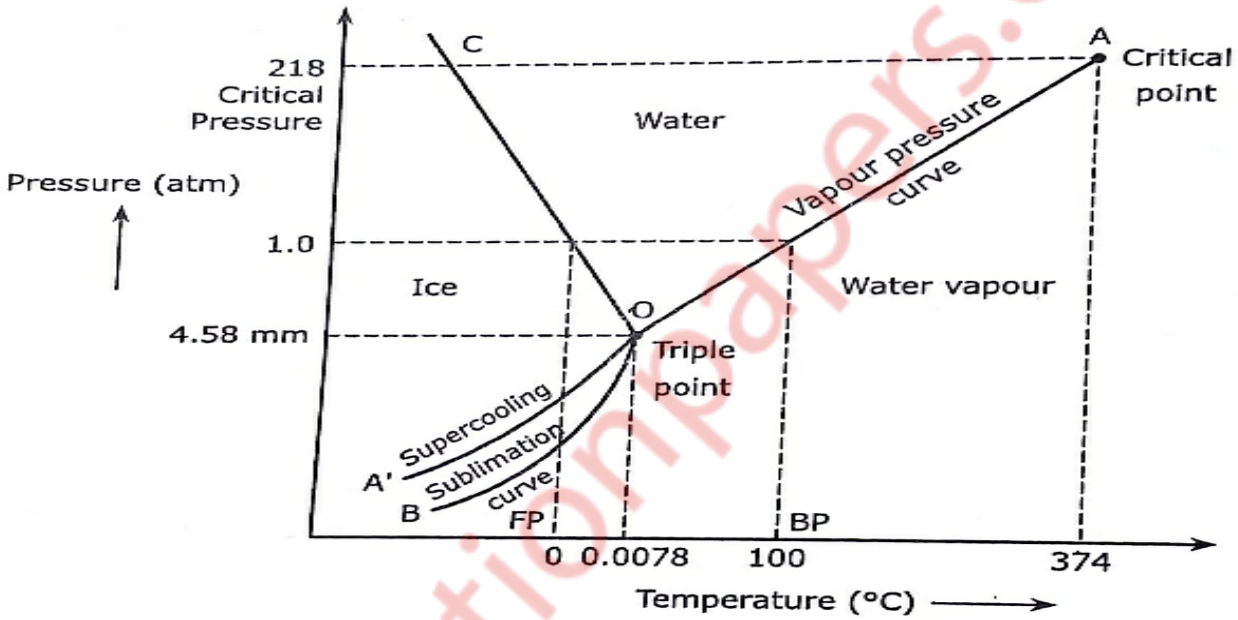


Fig. 4.1 : Phase diagram of water system

Curve OB represents the equilibrium between liquid and vapour. It is known as vaporization curve. Here also it is necessary to state either temperature or pressure. E.g., at atmospheric pressure , water and vapour can exist in equilibrium only at 1 temperature i.e., the boiling point of water. Water -vapour system has one degree of freedom F=C-P+2=1.

Q3](b) ii) Mention the Raw material of Portland cement along with their percentage composition. *(2)*

Ans:-

CONSTITUENTS	*PERCENTAGE(%)*
Lime	*60-68*
Silica	*17-25*
Alumina	*3-8*

Gypsum	*2-3*
Iron oxide	*2-4*
Sulphur trioxide	*1-2*
Alkali oxides	*0.5-1.3*

Q3](c) Ten thousand litres of hard water was made soft with zeolite. The exhausted zeolite required a total amount of 8 lit of NaCl solution containing 150 gm per litre for regeneration. Calculate the hardness of water. (4)

Ans:- *1 litre of NaCl solution = 150 gm of NaCl*

∴ 8 litres of NaCl = 8 × 150 gm of NaCl

= 1200 gm of NaCl

Quantity of NaCl in terms of $CaCO_3$ = $1200 \times \frac{50}{58.5}$ gm of $CaCO_3$ equivalent

equivalent hardness

= *1,025.64 gm of* $CaCO_3$ equivalent

= *1.0256* × 10^3 $CaCO_3$ equivalent

= *1.0256* × 10^6 $CaCO_3$ equivalent.

Hardness of 10,000 litres of water = 1.0256 × 10^6 *mg.*

∴ Hardness of 1 litres = $\frac{1.026 \times 10^6}{10000}$ *= 102.6 mg/lit*

∴ Hardness of water = 102.6 ppm

Q4](a) Explain Ion-exchange process for Softening of hard water. What are its advantages and disadvantages (6)

Ans:- *Ion-exchange resins are insoluble, cross-linked, long chained organic polymer with a microporous structure. The functional groups attached to the chains are responsible for the ion-exchange properties. The ion exchange resins are classified as follows:*

1. *Cation exchange resins*
2. *Anion exchange resins.*

- *<u>CATION EXCHANGE RESINS.</u>*

There are mainly styrene-divinyl benzene copolymers, which on sulphonation or

carboxylation, become capable of exchanging their hydrogen ions with the cations in the water.

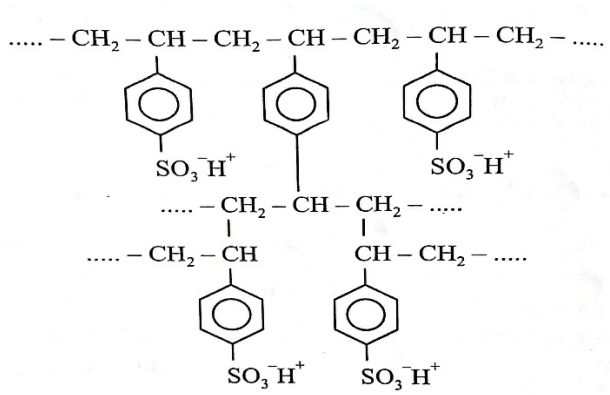


Fig. 1.4 : Acidic or cation exchange resin (sulphonate form)

- *ANION EXCHANGE RESINS.*

There are styrene -divinyl benzene or amine- formaldehyde copolymers, which contain amino or quaternary ammonium or quaternary phosphonium or tertiary sulphonium groups as an integral part of the resins matrix. These are after treatment with dil. NaOH solution, become capable of exchanging their OH^- anions with anions in water .

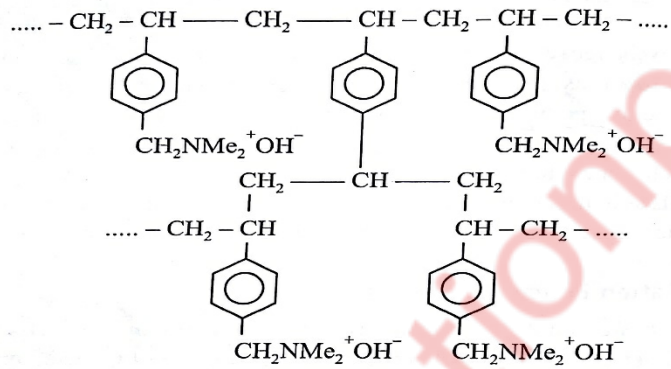


Fig. 1.5 : Basic or anion exchange resin (hydroxide form)

PROCESS:

The hard water is passed first through cation exchange column which removes all the cations like Ca^{2+}, Mg^{2+} etc. from it and equivalent amount of H^+ ions are released form this column to water,

$$2RH^+ + Ca^{2+} \rightarrow R_2Ca^{2+} + 2H^+$$

$$2RH^+ + Mg^{2+} \rightarrow R_2Mg^{2+} + 2H^+$$

After cation exchange column the hard water is passed through anion exchange column, which removes all the anions like SO_4^{2-},Cl^- etc, present in the water and equivalent amounts of OH^- ions are released from this column to water.

$$R'OH^- + Cl^- \rightarrow R'Cl^- + OH^-$$

$$2R'OH^- + SO_4^- \rightarrow R'_2SO_4^{2-} + 2OH^-$$

$$2R'OH^- + CO_3^{2-} \rightarrow R'_2CO_3^- + 2OH^-$$

H^+ and OH^- ions get combined to produce water molecule. Thus the water coming out from the exchanger is free from cations as well as anions. Ion-free water is known as deionized or demineralised water.

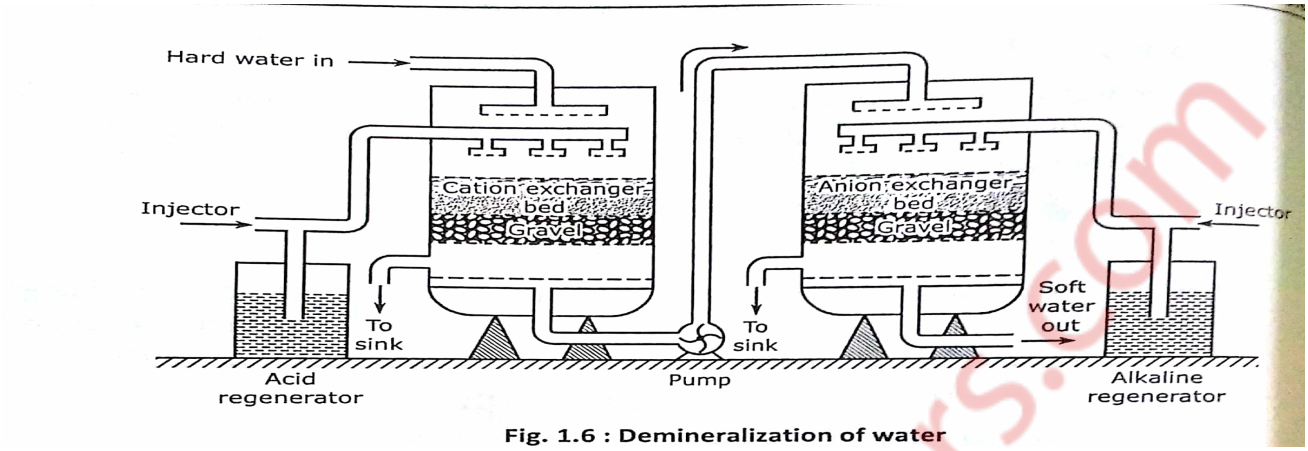


Fig. 1.6 : Demineralization of water

ADVANTAGES:

1. *The process can be used to soften highly acidic or alkaline water.*
2. *It produces water of very low hardness. So it is very good for treating water for use in high pressure boilers.*

DISADVANTAGES:

1. *The equipment is costly and more expensive chemicals are needed.*
2. *If water contains turbidity , then the output of the process is reduced. The turbidity must be below 10 ppm. If it is more , it has to be removed first by coagulation and filtration.*

Q4](b) i) 9ml of oil is taken from machine and it requires 1.5ml of 0.04 N KOH. Find acid value(density = 0.81 g/ml) (3)

Ans:- *Given data: volume of oil = 9ml*

Volume of KOH = 1.5ml

Normality of KOH = 0.04 N

To find: Acid value

Formula: Acid value $= \dfrac{\text{Volume of KOH} \times \text{Normality of KOH} \times 56}{\text{weight of oil}}$ *mg/gm*

Solution: Acid value $= \dfrac{1.5 \times 0.04 \times 56}{9}$ *mg/gm*

$= 0.373$ *mg/gm*

Acid value of the oil is 0.373 mg/gm.

Q4](b) ii) Write a note on Deccay of Concrete. (2)

Ans:- *The cement concrete although mechanically strong , but due to the presence of free lime it become susceptible to the attack of acidic water. Alkaline water do not have marked effect on concrete strength. Also lime is more soluble in soft water than hard water and hence deterioration of concrete in contact with soft water is more. Presence of sulphates cause maximum damage because it reacts with tricalcium aluminate to form sulpho aluminates which occupies more volume and hence undergo expansion making the cement structure weak.*

PROTECTION OF CONCRETE

- *By giving a coating of bituminous material. This prevents direct contact between concrete and water. This is a very inexpensive method.*
- *By coating the surface with silicon fluoride in a soluble form together with oxides of Zn, Mg or Al. the precipitate of calcium fluoride so-formed in the capillaries prevents dissolution of lime.*

Q4](c) What are the additives mixed with plastics for its compounding? Explain their functions. (4)

Ans:- *By using different types of additives the properties of the base polymer may be modified in very many different ways so that the range of use of the polymer is extended.*

The main compounding ingredients are:

1. *RESINS.*
2. *PLASTICIZERS.*
3. *FILLERS or EXTENDERS.*
4. *LUBRICANTS.*
5. *PIGMENTS.*
6. *CATALYSTS.*
7. *STABILIZERS.*

There functions are as follows:

- *RESINS.*

1. *It is the binder which holds the various constituents together.*
2. *It determines which method of moulding is to be used. Resin part of the finished product may be 30-100 %.*

- *PLASTICIZERS.*

1. *Increases the flexibility of the plastics.*
2. *Imparts flame proofness.*
3. *Reduces resistance towards chemicals, solvents etc.*
4. *Examples:- vegetables oils, esters of fatty acids.*

- *FILLERS or EXTENDERS.*

1. *Reducing the cost of plastics.*
2. *Increases the tensile strength and hardness.*
3. *Reduces the flexibility.*
4. *Examples:- mica, saw dust, chalk etc.*

- *LUBRICANTS.*

1. *Imparts glossy finish.*
2. *Prevent sticking to plastic to the mould.*
3. *Example:- waxes, soaps.*

- *PIGMENT.*

1. *They provide colour to the final plastic material.*
2. *Dyes give transparent colours and pigment gives opaque ones.*
3. *Examples :- organic and inorganic dyes stuffs.*

- *CATALYST.*

1. *They are added to only thermosetting plastic. They accelerates the rate of polymerisation.*
2. *Examples:-* H_2O_2*, Zn, ammonia and its salts.*

- *STABILIZERS.*

1. *In order to prevent the decomposition and discolouration of the plastic at the moulding temperature , stabilizers can be used.*
2. *Examples:- stearates of Pb, Ca , Ba, Pb silicates etc,* $PbCrO_4$.

Q5](a) i) Distinguish between Thermoplastic and Thermosetting plastic. (3)

Ans:-

THERMOPLASTIC	*THERMOSETTING*
1.Formed by addition polymerization.	*1. Formed by condensation polymerization.*
2.Can be moulded and remoulded.	*2.Remoulding is not possible.*
3.They softens on heating because the linear chains can slip over each other very easily.	*3.They do not become soft on heating, because cross links retain the strength on heating. But prolonged heating causes charring.*
4.Soft , weak and less brittle.	*4. Hard , strong and brittle.*
5.Soluble in some organic solvents.	*5.Insoluble in almost all organic solvents.*
6.Relatively low molecular weight.	*6.Relatively high molecular weight.*
7.Example: PVC, PE, Teflon.	*7.Example: UF, PF, Nylon 6-6, etc.*

Q5](a) ii) Write a note on Visco-elastic state. (3)

Ans:- *Viscoelasticity is the property of materials that exhibit both viscous and elastic characteristics when undergoing deformation. Viscous materials, like honey, resist shear flow and strain linearly with time when a stress is applied. Viscoelasticity is a molecular rearrangement. When a stress is applied to a viscoelastic material such as a polymer, parts of a long polymer chain change positionals. Synthetic polymers, woods and human tissues, as well as metals at high temperature , show significant viscoelasticity.*

PROPERTIES:

- *They behave like an elastic material as well as viscous material when stress is applied.*
- *They dissipate energy in form of heat when a load is applied and then removed.*

USES:

- *They are used for isolation vibration.*
- *They are used for dampening noise.*

Q5](b) i) Write a note on Ultrafiltration method for purification of water. (3)

Ans:- ***Ultrafiltration*** *is a variety of membrane filtration in which forces like pressure or concentration gradients lead to a separation through a semipermeable membrane. Suspended solids and solutes of high molecular weight are retained in the so-called retentate, while water and low molecular weight solutes pass through the membrane in the permeate(filtrate). This separation process is used in industry and research for purifying and concentrating macromolecular solutions, especially protein solutions. Ultrafiltration is not fundamentally*

different from microfiltration. Both of these separate based on size exclusion or particle capture. It is fundamentally different from membrane gas separation, which separate based on different amounts of absorption and different rates of diffusion. Ultrafiltration membranes are defined by the molecular weight cut off of the membrane used. Ultrafiltration is applied in cross-flow or dead-end mode.

Applications:

1. *Filtration of effluent from paper pulp mill*
2. *Cheese manufacture, see ultra filtered milk.*
3. *Removal of pathogens from milk*
4. *Process and waste water treatment*
5. *Enzyme recovery.*

Q5](b) ii) Give the important functions of lubricant. (2)

Ans:- *1. It reduces surface deformation , wear and tear because direct contact between the rubbing surface is avoided.*

1. *It reduces the frictional heat, or it acts as a coolant . This reduces the expansion of metal.*
2. *It increases the maintenance cost and running costs of machine.*
3. *It makes the relative motion of sliding parts smooth and noise free.*
4. *It increases the efficiency of machine by minimizing the loss of mechanical , electrical or chemical energy.*

Q5] (c)What is the mathematical form of the Gibbs phase rule equation? Explain the meaning of each one of the term involved in it. (4)

Ans:-*GIBB'S PHASE RULE: Gibb's phase rule states that, in every heterogenous system in equilibrium ,the sum of the number of phases and degree of freedom is greater than the number of component by two provided the equilibrium between any number of phases is not influenced by gravity, electrical or magnetic forces or by surface action, and is only influenced by temperature, pressure and concentration. It is expressed in the form,*

$$P+F = C+2$$

$$Or \quad F = C-P+2$$

Where , P = Number of phases, C= Number of components and F = Degree of freedom.

1) *PHASES:*

A phases is defined as any homogenous ,physically distinct and mechanically separable portion of a system, which is separated from other parts of the system by definite bounding surfaces.

Example: 1. A gaseous mixture, which is thoroughly miscible in all proportion, consists of a single phase.

2) <u>COMPONENT:</u>

It is the smallest number of independent variable constituents taking part in the state of equilibrium, by means of which the composition of each phase can be expressed in the form of chemical equation. The components do not represent the number of constituents or chemical individual present in the system.

Examples: 1. In water system the phases present are ice, water and water vapour. The composition of each phase can be expressed by a single component, H_2O. Hence it is a component system.

3) <u>DEGREE OF FREEDOM:</u>

It is defined as the smallest number of independent variables such as pressure, temperature and concentration that must be specified in order to define completely the state of a system.

Example: 1. For a system consisting of water vapour phase only, to describe the system completely , the values of both, the temperature and pressure, must be stated. Hence , the system is bivariant or degree of freedom is two.

Q6](a) What is lubrication? Explain the mechanism of fluid film lubrication. (6)

Ans:- *Any substance placed between two moving or sliding surfaces with a view to reduce the frictional resistance between them is known as <u>lubricant.</u> The lubricant when interposed between the moving parts makes the surface slippery and eliminates cohesion. Lubricants may be used in solid, liquid or semi solid form. The process of reducing friction between two metallic sliding surfaces by the introduction of lubricants is called as <u>lubrication.</u>*

<u>HYDRODYNAMIC OR FLUID-FILM OR THICK -FILM LUBRICATION.</u>

In this type of lubrication , the lubricant is forming a thick film having about 1000 A° thickness between the moving surfaces so that the direct surface to surface contact and welding of junction rarely occurs. The coefficient of friction is very low i.e., 0.001 to 0.03 under hydrodynamic lubrication.

When oil is introduced between the moving surfaces , some of the oil molecules are held up tightly at the surface due to adsorption. The remaining oil molecules are loosely arranged away from metal surfaces. Frictional resistance is only due to the internal resistance between the particles of lubricants moving over each other. Hence lubricant chosen should have the maximum viscosity .

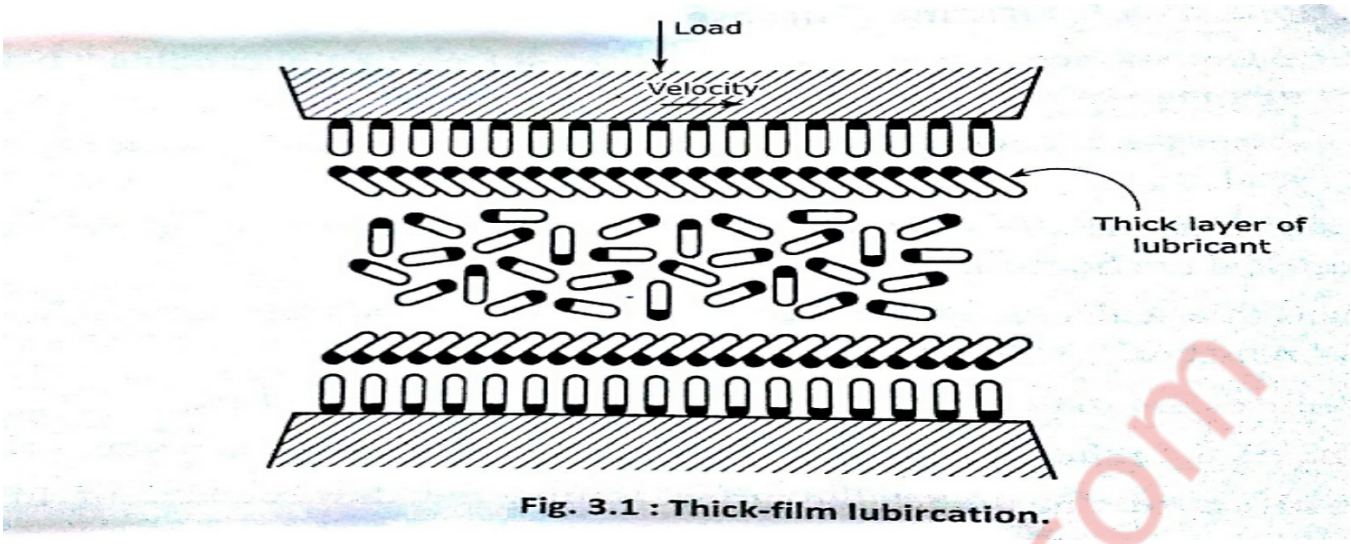


Fig. 3.1 : Thick-film lubircation.

Hydrodynamic lubrication occurs when the surfaces are rigid and retain the shape during operations. For hydrodynamic lubrication to occur ,two essential conditions are to be satisfied : (1)liquid must be viscous and, (2) the shape of the surface should be such that a wedge shaped film should be formed. Journal bearing consist of a shaft or journal that rotates freely in a supporting metal sleeve or shell with lubricating oil in the interface between them. During normal operations the shaft rotates at sufficient speed to force the oil between the conforming curved surfaces of the shaft and the shell thus creating the oil wedge and hydrodynamic film. This film allows these bearing to support extremely heavy loads. Watches , clock, sewing machine , fans, guns etc. requires hydrodynamic lubrication.

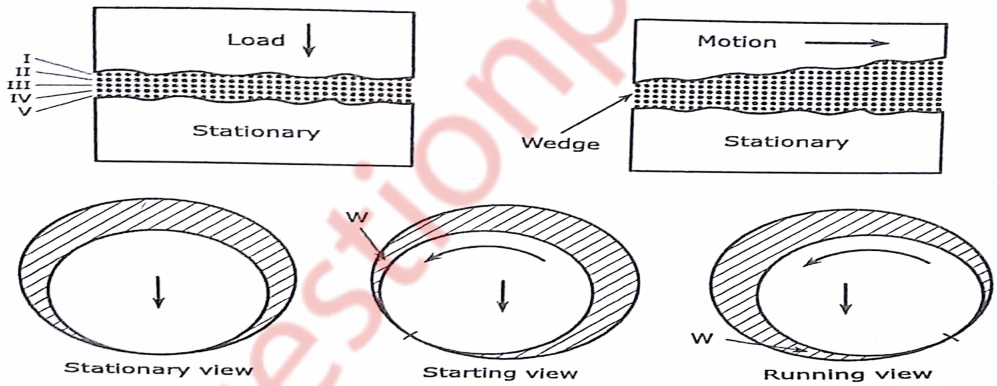


Fig. 3.2 : Thick-film lubrication

Q6](b) i)What is meant by Triple point? Apply phase rule and find degree of freedom for triple point. *(3)*

Ans:- :- *TRIPLE POINT:- The three curves OA, OB, and OC meet at O at which solid, liquid and vapour co-exist in equilibrium. This point at 273.16K (0.0075°C) and 4.58 mm of Hg pressure is called Triple point. The system is invariant. F=C-P+2 ∴ F=3-P=3-3=0 ∴ F=0. This means the degree of freedom is zero therefore neither pressure nor temperature can be changed without causing the disappearance of one of the phases. If either temperature or pressure is changed even slightly , one of the three phases disappears and the system changes from non-varient to univariant*

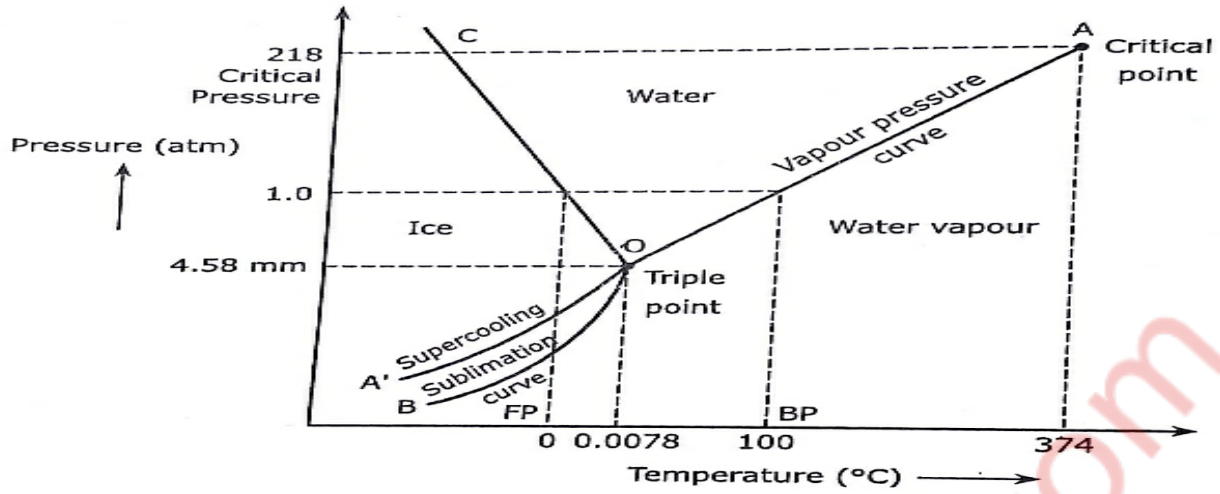


Fig. 4.1 : Phase diagram of water system

Q6](b) ii) Distinguish between temporary and permanent hardness of water. (2)

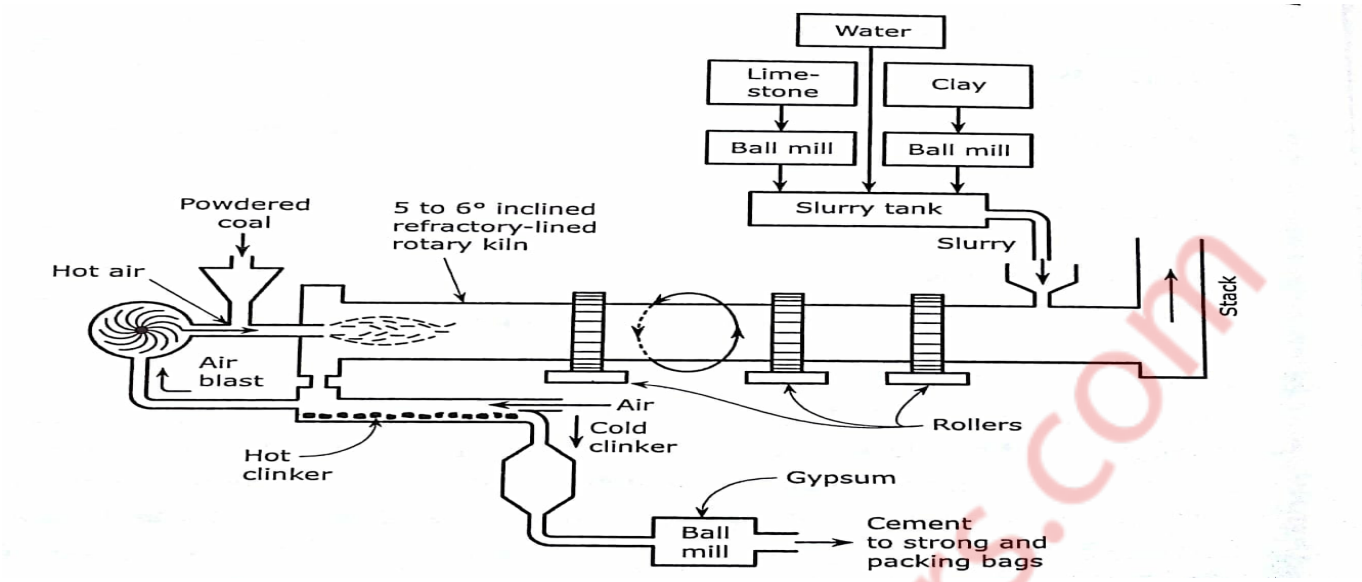
Ans:-

TEMPORARY OR ALKALINE HARDNESS.	***PERMANENET OR NON-ALKALINE HARDNESS***
1*.Caused by the process of dissolved bicarbonates of calcium , magnesium and other heavy metals and the carbonates of iron. salts responsible for temporary hardness are* $Ca(HCO_3)_2$, $Mg(HCO_3)_2$.	***1****.It is due to presence of dissolved chlorides and sulphates of calcium, magnesium, iron and other heavy metals.*
2*. Temporary Hardness can be removed by boiling water.*	***2****.Permanent Hardness cannot be removed by boiling the water.*
3*.Temporary hardness is called as carbonates or alkaline hardness.*	***3****.It is also known as non-carbonates or non-alkaline hardness.*
4*.Boiling:* $Ca(HCO_3)_2 \rightarrow CaCO_3 + CO_2 + H_2O$. $Mg(HCO_3)_2 \rightarrow Mg(OH)_2 + 2CO_2$.	***4****.Can be removed by using chemical and not by boiling e.g. Lime soda method.* $CaCl_2 + Na_2CO_3 \rightarrow CaCO_3 + 2NaCl$.

Q6](c) Describe the wet process for manufacture of Portland cement. (4)

Ans:- *The calcareous raw material are crushed, powdered and stored in silos. The argillaceous materials are thoroughly mixed with water in wash mills to remove the adhering organic matter. The basin washed clay is stored. Powdered lime from silos and washed wet clay from basins are allowed to flow in a channel in right proportions. From the channel, the raw material are led to grinding mills where they are mixed intimately to form a paste called slurry. The slurry is led to a correcting basin where its chemical composition may be adjusted if necessary. This slurry*

containing 38-40 % water is finally stored in storage tanks and are kept to be fed into rotatory kiln.



APPLIED CHEMISTRY 1

(CBCGS , DEC-2017)

Q1] (a) Distinguish between BOD and COD. (3)

Ans:-

BOD	COD
1.It means the oxygen demand of bio-degradable pollutants only.	**1.**It measures the oxygen demand for bio-degradable pollutants along with non-biodegradable pollutants.
2.Less stable measurement method as it uses micro-organism which are susceptible to pH , temperature and other variable in the water.	**2.**More stable measurement method as it uses potassium dichromate which oxidises regardless of water condition.
3.Slow process. It takes 5 days.	**3.**Fast process. It takes 2-3 hours.
4.BOD values are generally less than COD values.	**4.**COD values are generally greater than BOD values.
5. $\text{BOD} = (DO_b - DO_i) \times \frac{\text{Volume of undiluted sample}}{\text{Volume of diluted sample.}}$	**5.** $\text{COD} = \frac{(V_1 - V_2) \times N \times 8000}{Y}$

Q1] (b) Give the preparation ,properties, and uses of Kevlar. (3)

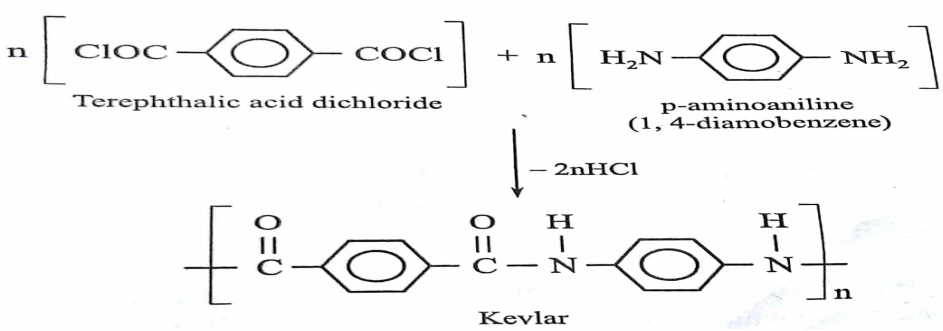
Ans:-It is an aromatic polyamide with benzene rings linked to the amide group, -CONH- group.

1.<u>PREPARATION.</u>

It is prepared by polycondensation between aromatic dichloride like terephthalic acid dichloride (terephthaloyl chloride) and aromatic diamines like 1,4-phenylene diamine (1,4-diamine benzene).

<u>2.PROPERTIES.</u>

- It is exceptionally strong, 5 times stronger than steel and 10 times stronger than aluminium.
- It has high heat stability and flexibility.
- It has resistance against almost all the solvents except some powerful acids.
- It does not lose its strength at -196°C .



3.USES.

- *It is used in aerospace and aircraft industries.*
- *It is used for the preparation pf car parts such as tyres, brakes, clutch, lining etc.*
- *Used for the preparation of ropes ,cables, helmets etc.*

Q1] (c)Calculate total hardness , in ppm, in given water sample. (3)

i)50ml standard hard water , containing 1mg pure $CaCO_3$ per ml , consumed 20ml EDTA solution.

ii)50ml water sample consumed 30ml EDTA solution using EBT indicator.

Ans:-

	1 ml SHW	≡	*1 mg of* $CaCO_3$ *eq.*
∴	*50 ml SHW*	≡	*50 mg of* $CaCO_3$ *eq.*
	50 ml of SHW	≡	*20 ml of EDTA solution.*
	20 ml of EDTA	≡	*50 mg of* $CaCO_3$ *eq.*
∴	*1 ml of EDTA*	≡	$\frac{50}{20}$ *mg of* $CaCO_3$ *eq.*
		=	*2.5 mg of* $CaCO_3$ *eq.*
	50 ml of water sample	≡	*30 ml of EDTA solution.*
∴	*1000 ml of water sample*	≡	$\frac{1000 \times 30}{50}$
		=	*600 ml of EDTA solution*
	1 ml of EDTA	≡	*2.5 mg of* $CaCO_3$ *eq.*
∴	*600 ml of EDTA*	≡	*2.5 × 600*
		=	*1500 mg of* $CaCO_3$ *eq*
∴	*Total hardness of*	=	*1500 mg/L*
	water sample	=	*1500 ppm.*

Q1] (d)Define flash point and fire point? Give its significance. (3)

Ans:- :-Flash point:- Flash point is defined as the lowest temperature at which the lubricant gives off enough vapours to cause a momentary flash when a standard test flame is brought near it.

Fire point:- Fire point is the lowest temperature at which the oil vapours catch fires for at least 5 seconds , on being lighted by a test flame.

Fire point is usually 5-40°C above the flash point. A good lubricant should have flash point at least above the working temperature . This ensures safety against the risk hazards. Thus flash point acts as a guide for the safe storage, transportation and use in machine. **Good lubricant oil should have high flash and fire point.**

Q1] (e) State the number of phases , component, for the following equilibrium

i) $H_2O_{(s)} \leftrightarrow H_2O_{(l)} \leftrightarrow H_2O_{(g)}$

ii)Mixture of Rhombic and monoclinic sulphur. (3)

Ans:- i) No. of. Phases = 3 (solid, liquid and gas)

No. of . components = 1 (H_2O).

ii) No. of. Phases = 2 (rhombic and monoclinic)

No. of . components = 1 (sulphur).

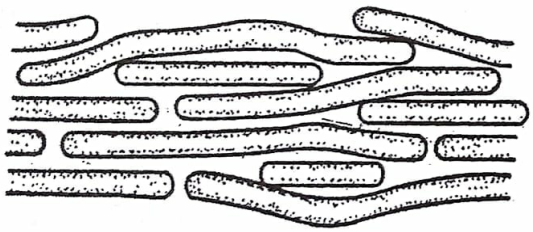
Q1] (f) What are plasticizers ? Give its uses and examples. (3)

Ans:-Plasticizers are added to increase the plasticity and flexibility of the polymers.

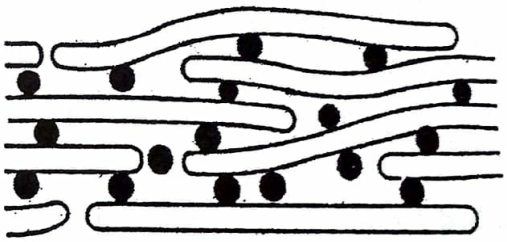
The Plasticizer molecule occupies between the polymeric chains and neutralizes the intermolecular forces of attraction and thus allows freedom of movement. The functions of plasticizers are as follows:-

- Increases the plasticity of the plastics.
- Lowers the softening temperature and hence moulding and remoulding can be done at low temperature.
- Imparts flames proofness.
- Reduces resistance towards chemical , solvents etc.
- Examples:- esters of fatty acids, vegetables oils etc.

The presence of small molecules of plasticizers reduces the attraction of the large polymer molecules for one another and thus permit more flexibility and easier slip.



(a) No plasticizer



(b) Plasticizer present

Q1] (g)Write a brief note on CNT's. ***(3)***

Ans:- :-*Carbon nanotubes represents one of the best examples of the novel nanostructures derived by bottom-up chemical synthesis approaches. Nanotubes have the simplest chemical composition and atomic bonding configuration but exhibit perhaps the most extreme diversity and richness among nanomaterial in structure and structure-property relations. The different types of carbon nanotubes are as follows;*

1. *SINGLE WALLED NANOTUBES.*

SWNTs are an important variety of carbon nanotube. In SWNTs have different chiralities of carbon nanotubes that include Armchair, Zigzag, Chiral. These can be easily twisted. SWNT synthesis requires catalyst.

2. *MULTIWALLED NANOTUBES.*

Multi-walled nanotubes (MWNTs) consist of multiple rolled layers (concentric tubes) of graphene. This types of CNT's cannot be easily twisted. Purity of MWNT is high also can be easily produced without catalyst.

Q2] (a)Calculate the quantity of lime and soda required for softening of 1,00,000 litres of water containing the following impurities in ppm. The purity of lime is 70% and soda is 85% $Ca(HCO_3)$ ***= 30.2 ,*** $Mg(HCO_3)$ ***= 20.8 ,*** $CaCl_2$ ***= 28.1 ,*** $MgCl_2$ ***= 8.78 ,*** $CaSO_4$ ***= 35 ,*** $MgSO_4$ ***= 6.7.*** ***(6)***

Ans:-

Impurities(mg/lit)	*Multiplication factor*	$CaCO_3$ *equivalent (mg/lit)*	*Requirement*
$Ca(HCO_3)$*=30.2*	$\frac{100}{162}$	$30.2\times\frac{100}{162} = 18.64$	*L*
$Mg(HCO_3)_2$*=20.8*	$\frac{100}{146}$	$20.8\times\frac{100}{146} = 14.24$	*2L*
$CaCl_2$ *= 28.1*	$\frac{100}{111}$	$28.1\times\frac{100}{111} = 25.32$	*S*

$CaSO_4$ = 35	$\frac{100}{136}$	$35\times\frac{100}{136} = 25.74$	S
$MgSO_4$ = 6.7	$\frac{100}{120}$	$6.7\times\frac{100}{120} = 5.58$	L+S
$MgCl_2$ = 8.7	$\frac{100}{95}$	$8.7\times\frac{100}{95} = 9.16$	L+S

LIME = $\frac{74}{100}\left[CaCO_3 \text{ equivalent of } Ca(HCO_3)+2\times Mg(HCO_3)_2+MgCl_2+MgSO_4\right]\times \frac{\text{Volume of water}}{1000}\times\frac{100}{\%\text{ purity}}$

$= \frac{74}{100}\times[18.64 + 2\times14.25 + 9.16 + 5.58]\times\frac{100000}{1000}\times\frac{100}{70}$

= *6541.6 gms.*

SODA = $\frac{106}{100}\left[CaCO_3 \text{ equivalent of } CaCl_2+MgCl_2+MgSO_4+CaSO_4\right]\times\frac{\text{Volume of water}}{1000}\times\frac{100}{\%\text{purity}}.$

$= \frac{106}{100}[25.31+9.16+25.73+5.58]\times\frac{100000}{1000}\times\frac{100}{85}.$

= *8203.15 gms.*

The lime requirement is 6541.6 gms and soda requirement is 8203.15 gms.

Q2] (b) i) Distinguish between thermoplastic and thermosetting resins. (3)

Ans:- Ans:-

THERMOPLASTIC	*THERMOSETTING*
1.Formed by addition polymerization.	*1. Formed by condensation polymerization.*
2.Can be moulded and remoulded.	*2.Remoulding is not possible.*
3.They softens on heating because the linear chains can slip over each other very easily.	*3.They do not become soft on heating, because cross links retain the strength on heating. But prolonged heating causes charring.*
4.Soft , weak and less brittle.	*4. Hard , strong and brittle.*
5.Soluble in some organic solvents.	*5.Insoluble in almost all organic solvents.*
6.Relatively low molecular weight.	*6.Relatively high molecular weight.*
7.Example: PVC, PE, Teflon.	*7.Example: UF, PF, Nylon 6-6, etc.*

Q2] (b) ii)What are the functions of lubricants. (2)

Ans:- *1. It reduces surface deformation , wear and tear because direct contact between the rubbing surface is avoided.*

2. *It reduces the frictional heat, or it acts as a coolant . This reduces the expansion of metal.*
3. *It increases the maintenance cost and running costs of machine.*
4. *It makes the relative motion of sliding parts smooth and noise free.*
5. *It increases the efficiency of machine by minimizing the loss of mechanical , electrical or chemical energy.*

Q2](c)What is Decay of concrete? Discuss its prevention. (4)

Ans:- *The cement concrete although mechanically strong , but due to the presence of free lime it become susceptible to the attack of acidic water. Alkaline water do not have marked effect on concrete strength. Also lime is more soluble in soft water than hard water and hence deterioration of concrete in contact with soft water is more. Presence of sulphates cause maximum damage because it reacts with tricalcium aluminate to form sulpho aluminates which occupies more volume and hence undergo expansion making the cement structure weak.*

PROTECTION OF CONCRETE

- *By giving a coating of bituminous material. This prevents direct contact between concrete and water. This is a very inexpensive method.*
- *By coating the surface with silicon fluoride in a soluble form together with oxides of Zn, Mg or Al. the precipitate of calcium fluoride so-formed in the capillaries prevents dissolution of lime.*

Q3] (a)Define Fabrication. List the methods used. Discuss extrusion moulding in detail. (6)

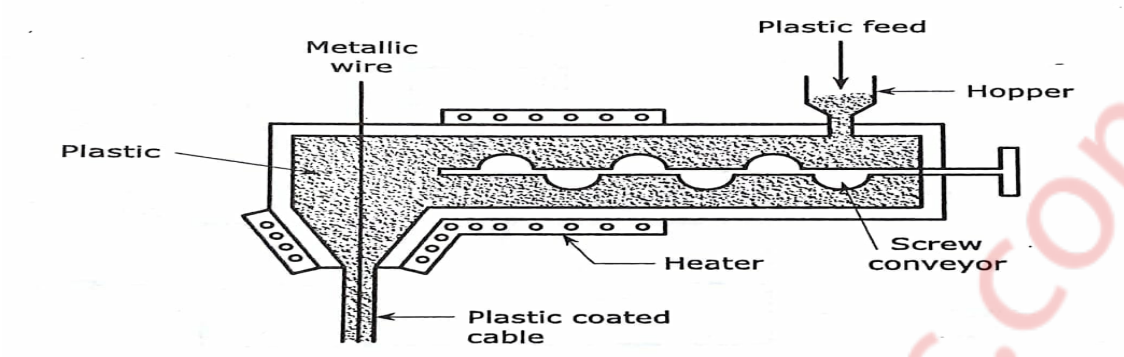
Ans:- *Fabrication of plastic is the technique of giving any desired shape to the plastics by the use of mould. Because of the properties of polymers it is possible to mould them and change their shape using a number of different repetitions manufacturing processes. A proper method is to be selected depending upon the shape and type of resin being used. Before moulding ,it is essential to dry the resin in order to achieve optimum performance of finished products.*

The methods used are:

1. *compression moulding.*
2. *transfer moulding.*
3. *extrusion moulding.*
4. *injection moulding.*

EXTRUSION MOULDING.

The thermoplastic materials are moulded by this method. They undergo continuous moulding to from articles of uniform cross-section. These articles include tubes, rods, strips, insulated electrical cables , etc. In this method , thermoplastic materials are heated to plastic condition and then pushed by means of a screw conveyor into a die having the required shape of the article to be manufactured. Here the plastic mass gets cooled due to the atmosphere exposure. A long conveyor carriers away the cooled product continuously .



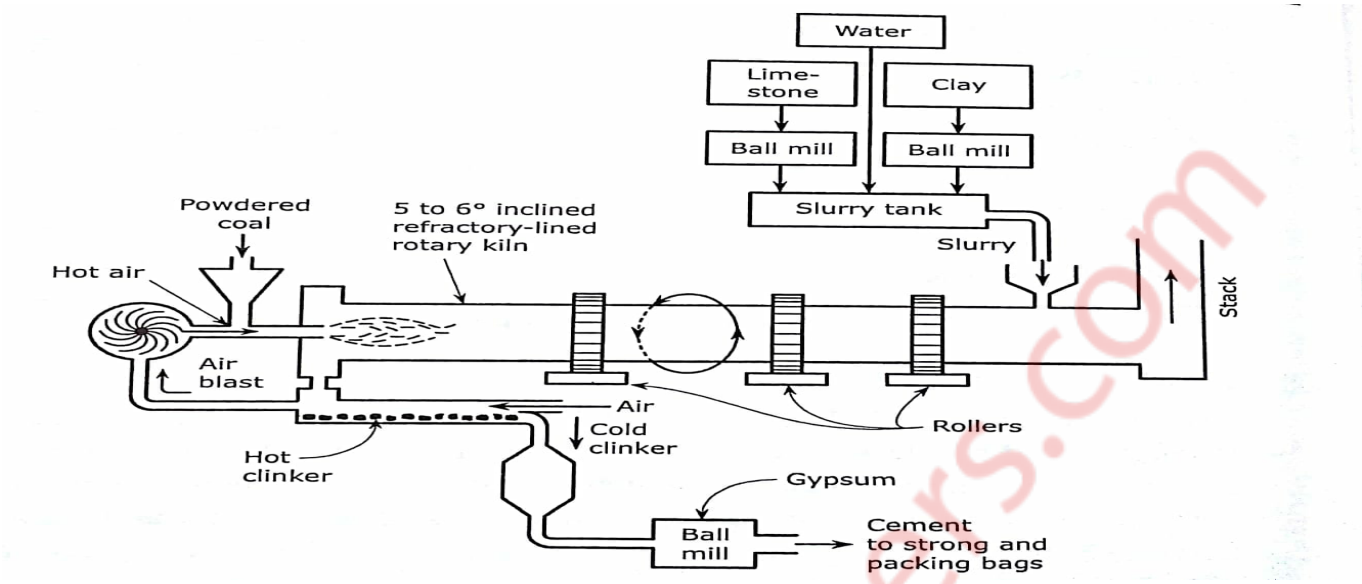
Q3] (b)i) What are the limitations of Phase rule? *(3)*

Ans:- :-*The limitations of phase rule are as follows:*

1. *It can be applied to system in equilibrium. It is not of much help when system attain equilibrium very slowly.*
2. *It applies only to single equilibrium state. It does not indicate other possible equilibrium in the system.*
3. *Phase rule consider only the number of phase ,but not their quantities .Even a minute quantity of phases when present accounts towards number of phases.*
4. *All phases must be present under the same condition of the temperature , pressure and gravitational forces.*
5. *Solid and liquid phases must not be in finely-divided state, otherwise deviations occur.*

Q3](b) ii)Draw a neat , labelled diagram of the rotatory kiln. (2)

Ans:-



Q3](c)15000 litres of hard water was passed through a zeolite softener. The exhausted zeolite required 120 litres of NaCl having stream of 30g/l of NaCl. Calculate the hardness of water.
(4)

Ans:- *1 litre of NaCl solution = 30 gm of NaCl.*

∴ 120 litre of NaCl = 120 ×30×10^3 mg of NaCl.

∴ 3600 ×10^3 mg of NaCl. = 3600 ×10^3×$\frac{50}{58.5}$

= 30.7692 ×10^5mg of $CaCO_3$ equivalent.

15000 litres of water = 30.7692 ×10^5mg of $CaCO_3$ equivalent.

∴ 1 litres of water = $\frac{30.7692\times10^5}{15000}$ = 205.1 ppm

∴ Hardness of water sample = 205.1 ppm

Q4](a) What is activated sludge? How is the process carried out for treatment of waste water? Explain with a flow sheet diagram. (6)

Ans:- *Sewage is the liquid which includes human and household waste water, industrial waste , ground waste and street and storm water. Hence due to the toxicity the sewage have to be treated because of the reasons like:*

1. *To prevent pollution of water into which the sewage is left off.*
2. *To prevent offensive odour in the water, and the destruction of fish and other aquatic life.*

SEWAGE TREATMENT BY ACTIVATED SLUDGE PROCESS.

1. *Preliminary Treatment.*

The principal objective of preliminary treatment is the removal of gross solids i.e., large floating and suspended solid matter , grit, oil, and greases if present in considerable quantities . For removing inorganic matter , sewage is allowed to pass through bar screen and mesh screen.

2.Primary Treatment.

For removing suspended matter efficiently and economically , sedimentation process is carried out .Sewage is treated with certain chemicals (e.g., alum, hydrated lime etc.) which form a floc that absorbs and entraps the suspended and colloidal particles present.

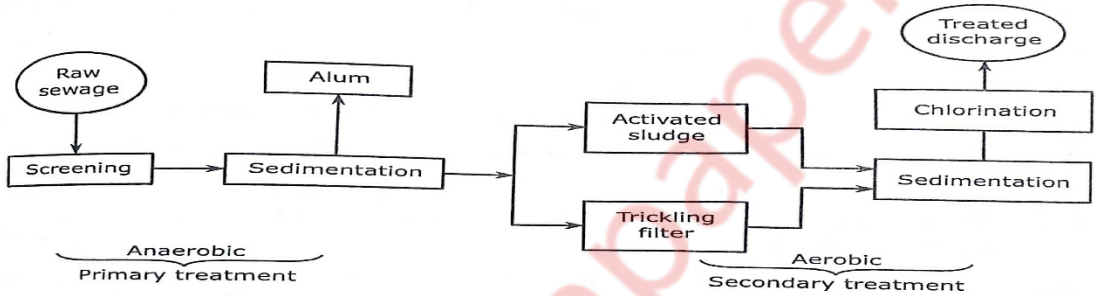


Fig. 1.15 : Flow diagram for sewage treatment.

3.Secondary or Biological Treatment .

It is an essential an aerobic chemical oxidation which includes filtration and activated sludge process. Sewage water is filtered through specially designed sprinkling filters to maintain aerobic conditions. Carbon of the organic matter is converted into CO_2; and nitrogen into NH_3 and finally into nitrates and nitrites. Trickling filters are used for biological oxidation of sewage. Trickled sewage starts percolating downwards an the aerobic bacteria bring about the biological oxidation of organic matter of sewage.

Hence the sludge formed is known as Activated Sludge. The further process includes mixing of sedimental sewage with proper quantity of activated sludge and mixture is then agitated for 4-5 hrs by blowing air. Suspended and dissolved organic matter is oxidised by aerobic bacteria . after all these process a part of sludge deposited is used for next oxidation batch and the remainder is either spread on land as fertile matter or used for biogas or dumped in sea.

Q4](b) i) 20ml of lubricating oil was dissolved in alcohol. The solution was titrated against 0.1N KOH solution. At the end point the burette reading was found to be 2.5ml. calculate the acid value of the oil.(density of oil = 0.86 g/ml) (3)

Ans:- *Given data :- Normality of KOH = 0.1N*

Volume of KOH = 2.5 ml

Density of oil = 0.86 g/ml

Volume of oil = 20ml.

To find :- *Acid value of oil*

Formula :- $\text{Acid value} = \frac{\text{Vol. of KOH} \times \text{Normality of KOH} \times 56}{\text{Weight of oil}}$

Solution :- *weight of oil = Density × Volume*

$= 0.86 \times 20$

= 17.2 gms.

$\text{Acid value} = \frac{\text{Vol of KOH} \times \text{Normality} \times 56}{\text{Weight of oil}}$

$= \frac{2.5 \times 0.1 \times 56}{17.2}$

= 0.814 mg

∴ *Acid value = 0.814 mg/ gm of the oil.*

Q4](b) ii) Distinguish between the dry and wet process for manufacturing of Portland cement. (2)

Ans:-

DRY PROCESS	*WET PROCESS*
1. *This is used when the raw material are hard.*	***1.*** *This is used for any type of raw material.*
2.*Fuel consumed is less.*	***2.****Fuel consumed is more.*
3.*Process is slow.*	***3.****Process is faster.*
4.*Cement produced is of inferior quality.*	***4.****Cement produced is of superior quality.*
5.*Costly process.*	***5.****Cheaper process.*

Q4](c) List the uses of polymer in medicine and surgery. (4)

Ans:- *Materials which are not causing adverse effect on blood and other tissues can be used in diagnostic, surgical and can be implanted in the body. They can be developed from metals, ceramics and polymers. Uses of polymers in the field of medicine and surgery are increasing day by day. Characteristics of biomedical polymers are:*

1.should be bio-compatible, can be fabricated into desire shape or form without being

degraded.

2.can be easily sterilized with no alteration in properties, should have optimum physical and chemical properties.

3.They should not destroy cellular elements of blood, enzymes or produced toxic or allergic reactions.

4.They should have purity and reproducibility.

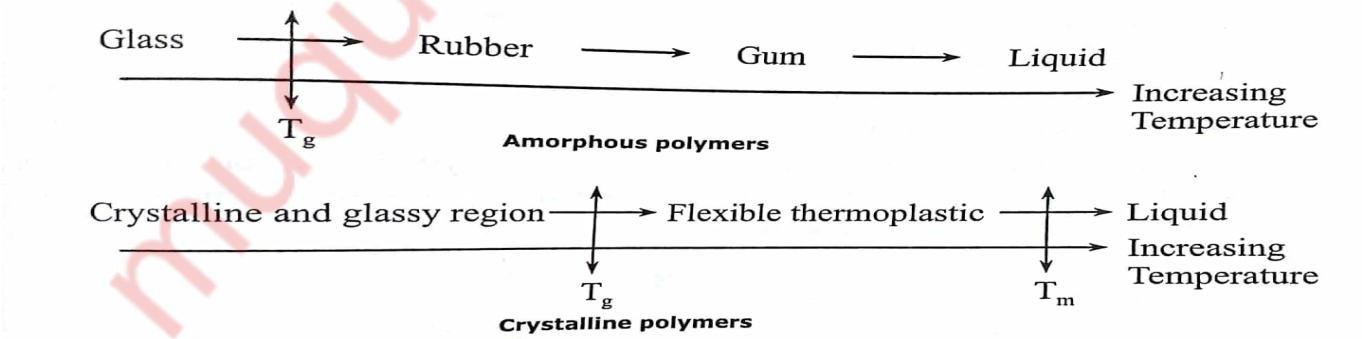
Examples are as follows:

POLYMER	***APPLICATION***
1. PMMA.	*Contact lenses.*
2. silicon rubber, polyurethane.	*Heart walls, drain tubes.*
3. Polyvinyl chloride.	*Disposable syringes.*
4. polyalkyl sulphone.	*Membrane oxygenator.*
5.Acrylic hydrogels	*Grafting*

Q5] (a) Write notes on (any two) *(6)*

i)Glass transition temperature *(3)*

Ans:- *The temperature at which polymer experience the transition from rubbery to rigid state is termed as the 'Glass transition temperature'(T_g).The behaviour of a polymer is temperature sensitive. Glass transition temperature is also defined as the lowest temperature below which the polymer becomes hard and brittle and above which it becomes soft and flexible. The polymer becomes too soft, that it behaves like a fluid called as the visco fluid state. The temperature at which the soft, flexible polymer goes to the visco fluid state is called the melting temperature T_m.*



Factors Influencing T_g.

1.Cross linking increases the T_g value.

2.Presence of bulky groups increases the T_g value.

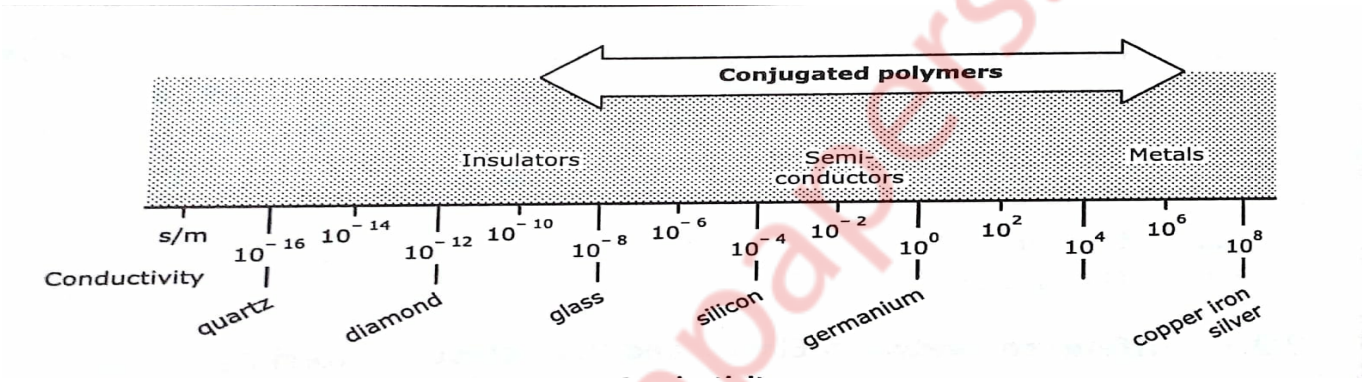
3.Addition of plasticizer decreases the T_g value.

4.Polymers having strong intermolecular forces of attraction increases T_g value.

5.Polar side atoms or groups of atoms increases the T_g value.

Q5](a) ii)Conducting polymers *(3)*

Ans:-*Polymers are insulated because of the absence of free electrons. In becoming electrically conductive , a polymer has to imitate metal that is the electron needs to be free to move. Such type of polymer are called Conducting polymer. Polymers with conjugate π-electron backbones display unusual electronic properties such as low energy optical transition , low ionization potentials and high electron affinities. The result is a class of polymers that can be oxidised or reduced more easily and more reversibly than conventional polymers. The effect of this oxidation or reduction on polymer is called doping i.e., convert an insulating polymer to conducting one.*



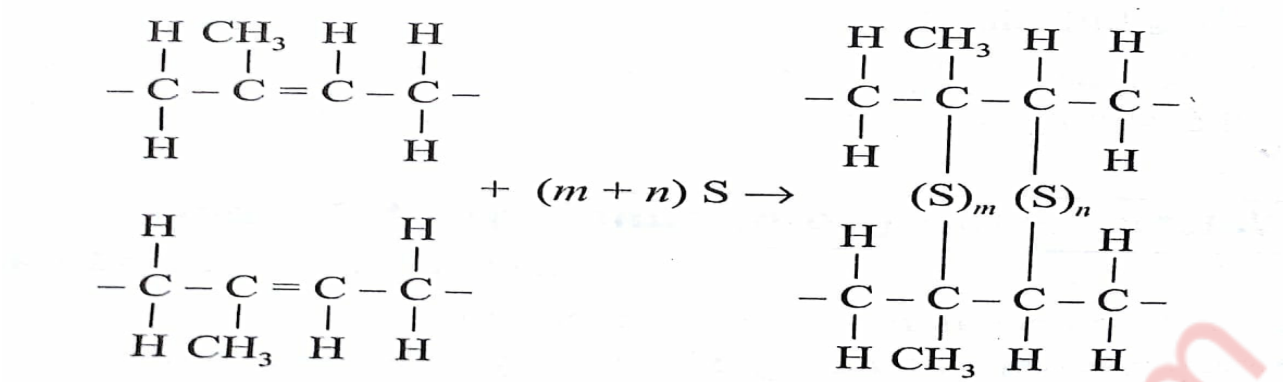
<u>Two conditions for a polymer to become conducting are:-</u>

1. *Polymer possess conjugate double bonds.*
2. *Polymer has to be distributed either by removing or adding electron to the material. This process is called doping.*

Q5](a) iii)Vulcanization. *(3)*

Ans:-*When rubber is heated with sulphur, its tensile strength , elasticity and resistance to swelling are increased tremendously. This process is named as <u>Vulcanization.</u> Vulcanization brings about a stiffness of the rubber by anchoring and restricting the intermolecular movement of the rubber springs. The vulcanization can be carried out in several ways:-*

1. *The article to be vulcanised is heated with a steam under pressure.*
2. *The article is immersed in hot water under pressure.*
3. *By heating the article in air or in carbon dioxide.*
4. *By vulcanizing the article in the mould in which it is shaped.*



PROPERTIES OF VULCANIZED RUBBER.

- *High tensile strength.*
- *Elastic to lesser extent.*
- *Water absorption is small.*
- *Do not swell much in organic solvents.*
- *Better abrasion resistance.*

Q5](b) i)Discuss the treatment of water using bleaching powder (3)

Ans:- *In small water-works, about 1 kg of bleaching powder per 1,000 kilolitres of water is mixed and water is allowed to stand undisturbed for several hours the chemical action produces hypochlorous acid*

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

$$Cl_2 + H_2O \rightarrow HCl + HOCl$$

$$\text{germs} + HOCl \rightarrow \text{germs are killed}$$

The disinfecting action of bleaching powder is due to the chlorine made available by it.

Drawbacks:

1. *Bleaching powder introduces calcium in water , thereby making it more hard.*
2. *Bleaching powder deteriorates, due to its continuous decomposition during storage. So whenever it is added , it has to be analysed for its effective chlorine content.*
3. *Only a calculated quantity of bleaching powder should be used , since an excess of it gives a bad taste and smell to treated-water.*

Q5](b) ii)Explain the mechanism of Extreme pressure lubrication. (2)

Ans:-*Under heavy load and high speed operating conditions, large amount of frictional heat is generated. Under these conditions a liquid lubricant fails to stick and may decompose. To withstand such extreme conditions, special additives are added to the lubricating oil. Additives*

are generally organic compounds having active radicals or group such as chlorine, sulphur , phosphorous etc. They react with the metal surfaces at high temperature and form durable films of metallic chlorides, sulphides and phosphides. These compounds posses high melting point and good thermal stability and hence , serve as good lubricant. However , they are not effective on chemically inert metal surfaces of Ag, Ti , and Cu. This type of lubrication is used for cutting tools, in wire drawing, rocket crushing machines etc.

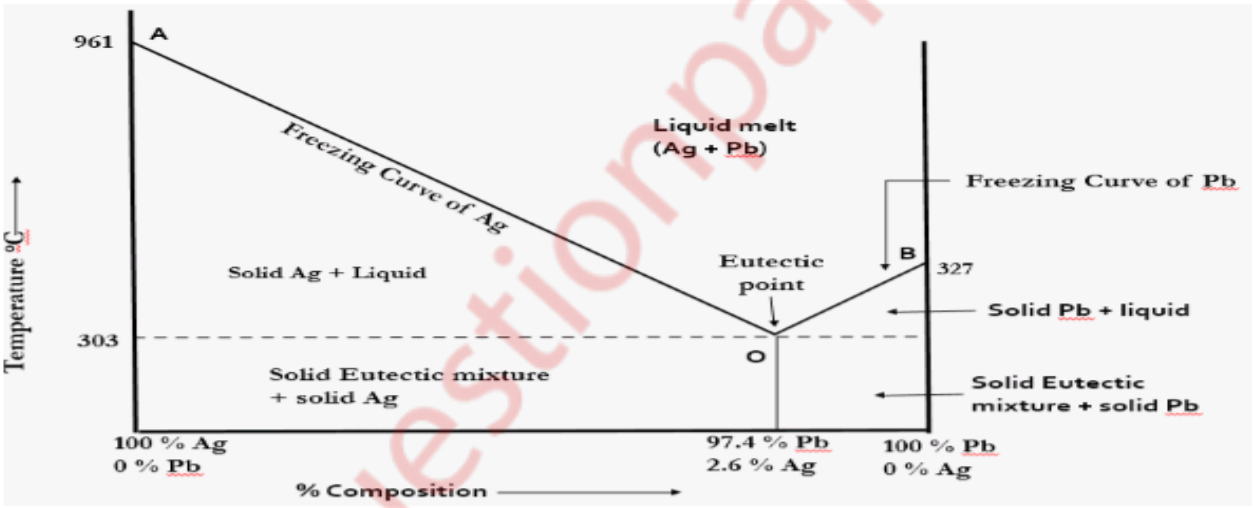
Q5](c) What is reduced phase rule? Draw the phase diagram of the Ag-Pb system with proper labelling. *(4)*

Ans:- *In some systems, an equilibrium exists between solid - liquid phases and gaseous phase is practically absent. Hence the effect of pressure on such system can be neglected. Then it is necessary to take into account only two variables viz. temperature and concentration.*

Such system showing solid-liquid equilibrium is called condensed system and phase rule applied to such systems is as follows:

F = C – P + 1 … known as condensed phase rule.

Phase diagram of Ag-Pb system



In two component systems there are four possible phases solid Ag, solid Pb, solution of Ag, + Pb and vapour. Since the pressure has no effect on equilibrium so the system can be represented by temperature concentration diagram at constant atmospheric pressure. As pressure is neglected the phase rule is called condensed phase rule.

1) Curve Ao. *It is a freezing point curve of Ag. Ag Co exists as solid and liquid. Melting point of Ag falls gradually on adding Pb till the lowest point is reached. The solution gets saturated with respective to lead.*

2) Curve Bo. *It is a freezing point curve of Pb. At this curve the melting point gradually falls on the addition of Ag till lowest point it reach.*

3) Point O. *It is eutectic point. Here 3 phases co-exists and point O represents a fixed composition and system is in variant.*

Below the temperature line of eutectic temperature, we have two regions.

a) The region marked eutectic plus solid Ag in which crystalline silver and solid eutectic are stable.

b) The region marked eutectic plus solid Pb in which crystalline lead and solid eutectic are stable.

***4) Area AOB.** It represents solution of Pb Ag. On lowering temperature the lead begins to separate out till the point O is reached.*

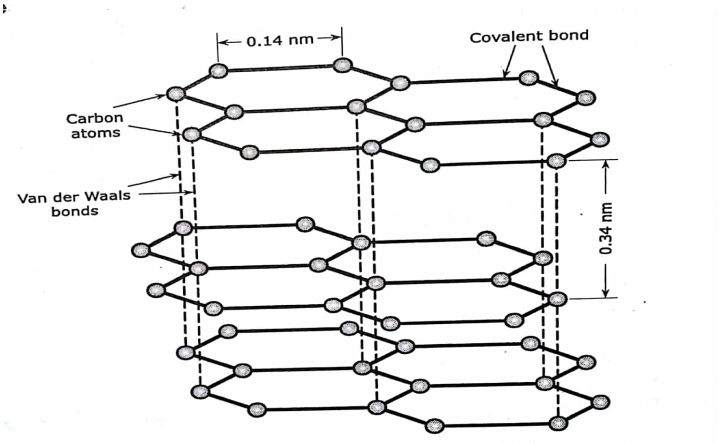
Q6](a)What are the conditions for use of solid lubricants? Discuss the structure and uses of Graphite. *(6)*

***Ans:-** Dry lubricants or solid lubricants are material which can reduce the friction without a liquid medium .they are used where,*

1. *Operating conditions are such that a lubricating film cannot be formed or maintained.*
2. *Contaminations of liquid or semi-solid lubricant , with dust or dirt is not desirable ;e.g., open gears.*
3. *Combustible lubricants must be avoided due to the high operating temperature and pressure.*
4. *Heavy machinery working on a crude job at very high loads and slow speed.*
5. *Where the parts to be lubricated are not easily accessible.*

GRAPHITE:

Graphite is the most widely used of all solid lubricants. It consists of a layered lattice structure. A layer of hexagonally arranged sp^2 hybridized carbon atom in the planar graphite molecule bonded covalently. The two neighbouring parallel layers are 3.7A° apart and are held together by weak vander waals forces. Therefore the forces required to shear layers is very low and the molecules can slip over each other easily by mechanical forces. Hence , graphite powder is very soapy to touch or vey soft and can act as lubricant. It is not inflammable and not oxidised in air below 375℃. In the absence of air , It can be used up to very high temperature. Usually some organic substances are mixed with solid lubricants so that they may stick firmly to the metal(called "Aqua dag") or oil(called "Oil dag"). Oil dag is used in IC engines. Aqua dag is useful in air compressors , general machine shop work, lathes and for machinery used in food industry. Graphite is also mixed with greases to form graphite greases , which are used at higher temperature.



Q6](b) i)Discuss triple point in one component system (3)

Ans:- *TRIPLE POINT:- The three curves OA, OB, and OC meet at O at which solid, liquid and vapour co-exist in equilibrium. This point at 273.16K (0.0075°C) and 4.58 mm of Hg pressure is called Triple point. The system is invariant.*

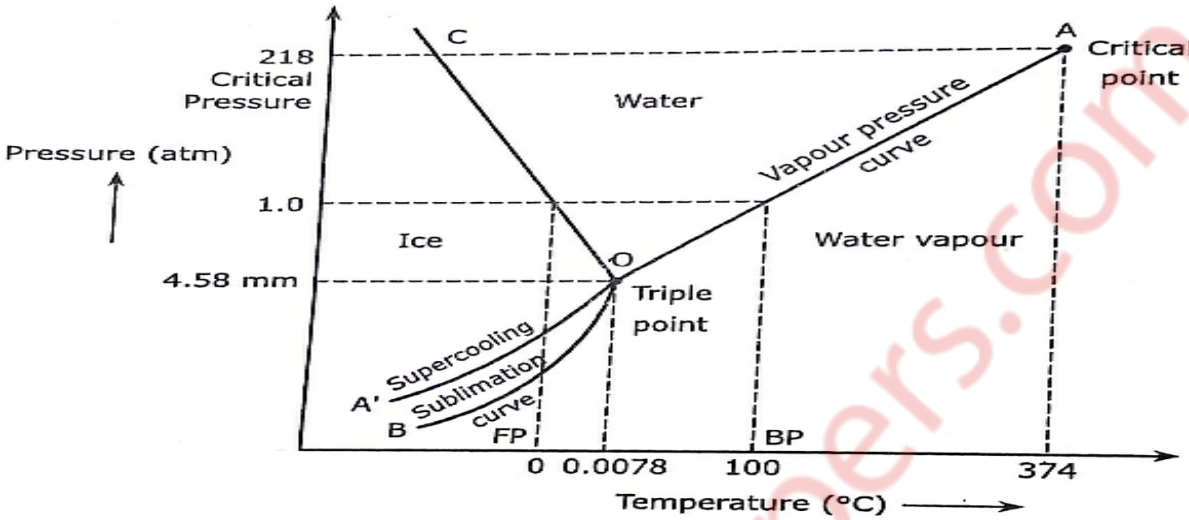


Fig. 4.1 : Phase diagram of water system

F=C-P+2 ∴ F=3-P=3-3=0 ∴ F=0

This means the degree of freedom is zero therefore neither pressure nor temperature can be changed without causing the disappearance of one of the phases. If either temperature or pressure is changed even slightly , one of the three phases disappears and the system changes from non-varient to univariant.

Q6](b) ii)Explain reverse osmosis. (2)

Ans:- *When two solutions of unequal concentrations are separated by a semipermeable membrane which selectively does not permit the passage of dissolved solute particles, i.e., molecules , ions etc flow of solvent takes place from dilute to concentrated sides due to osmosis. If a hydrostatic pressure in excess of osmotic pressure is applied on the concentrated side to dilute side across the membrane.*

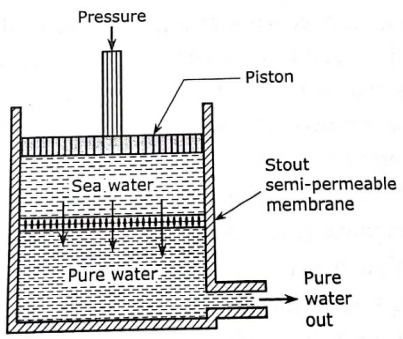


Fig. 1.14 : Reverse osmosis cell

This process is called as reverse osmosis. Thus in reverse osmosis methods pure solvent is separated from its contaminates, rather than removing contaminants from the water.

Q6](c)Write a note on fullerene. (4)

Ans:- *One of the nano-forms of the carbon is Buckminster fullerene (C_{60}). A fullerene is a molecule of carbon in the form of a hollow sphere, ellipsoid, tube and many other shapes. Spherical fullerene are also called as bucky balls and resembles football. Fullerene have 12 pentagons and 20 hexagons. A common method used to produce fullerene is to send a large current between two nearby graphite electrodes in an inert atmosphere of Argon. The resulting carbon plasma arc between the electrodes cools into sooty residues from which many fullerenes can be isolated.*

PROPERTIES OF FULLERENE:

- *It is mustard coloured solid, which appears brown to black with increasing thickness of its film.*
- *On sublimation , it forms translucent magenta face-centered cubic crystals.*
- *It is moderately soluble in aromatic hydrocarbons giving magenta solution.*
- *As a pure solid , it is electrically insulating. With proper impurity addition , it can be made highly conductive and super conductive.*

USES OF FULLERENE:

- *It is used for the preparation of electronic and microelectronic devices.*
- *It is used for the preparation of non-linear optical devices.*
- *It is used for the preparation of batteries as charge carriers.*
- *It is used for the preparation of super conductors.*
- *It is used for the preparation of soft ferromagnet with zero remanence.*

APPLIED CHEMISTRY 1

(CBCGS MAY 2018)

Q1](a) Discuss the drawback of natural rubber. (3)

Ans:- *The drawbacks of natural rubber are as follows:*

- *It swells considerably in organic solvents and gradually disintegrates.*
- *It has little durability.*
- *When stretched to a greater extent , it suffers permanent deformation, because of the 'sliding' or slippage of some molecular chains over each other.*
- *It is weak: its tensile strength is only 200 kg/cm^2.*
- *Natural rubber is brittle below 10 °C and above 50 °C, it becomes soft. Hence it is useful only in limited temperature ranges.*

Q1](b) Explain the disinfection of water by addition of bleaching powder. (3)

Ans:- *In small water-works, about 1 kg of bleaching powder per 1,000 kilolitres of water is mixed and water is allowed to stand undisturbed for several hours the chemical action produces hypochlorous acid*

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

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3. *Only a calculated quantity of bleaching powder should be used , since an excess of it gives a bad taste and smell to treated-water.*

Q1](c) What are the limitations of Phase rule ? (3)

Ans:- *The limitations of phase rule are as follows:*

1. *It can be applied to system in equilibrium. It is not of much help when system attain equilibrium very slowly.*

2. *It applies only to single equilibrium state. It does not indicate other possible equilibrium in the system.*
3. *Phase rule consider only the number of phase ,but not their quantities .Even a minute quantity of phases when present accounts towards number of phases.*
4. *All phases must be present under the same condition of the temperature , pressure and gravitational forces.*

Solid and liquid phases must not be in finely-divided state, otherwise deviations occur

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Q1](d) Discuss fullerenes. Give its applications. (3)

Ans:- :- *One of the nano-forms of the carbon is Buckminster fullerene (C_{60}). A fullerene is a molecule of carbon in the form of a hollow sphere, ellipsoid, tube and many other shapes. Spherical fullerene are also called as bucky balls and resembles football. Fullerene have 12 pentagons and 20 hexagons. A common method used to produce fullerene is to send a large current between two nearby graphite electrodes in an inert atmosphere of Argon. The resulting carbon plasma arc between the electrodes cools into sooty residues from which many fullerenes can be isolated.*

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- *It is used for the preparation of super conductors.*
- *It is used for the preparation of soft ferromagnet with zero remanence.*

Q1](e) Write a note on Greases. (3)

Ans:- *lubricating grease is a semisolid consisting of thickening agent such as metallic soaps, dispersed throughout liquid lubricating oil. The liquid lubricant may be petroleum oil or even synthetic oil and it may contain any of the additives for specific requirement.*

GREASES ARE USED UNDER FOLLOWING CONDITION:-

- *In situations where the oil cannot remain in place due to high load, low speed, intermittent operations , sudden jerks etc.*
- *When the machine is worked at slow speed and high pressure.*
- *In situations where bearing has to be protected against entry of dirt , dust, moisture etc because greases are less liable to contamination by these.*
- *In situations where dripping or spurting of oil is undesirable because unlike oils , greases if used do not splash or drip over articles being prepared by the machines e.g., machines used in paper, food, textile and dying industry.*

Q1](f) A 10ml of sample of water was refluxed with 20ml potassium dichromate solution and after refluxing the excess unreacted dichromate required 26.2ml of 0.1M FAS solution. A blank 10ml of distilled water on refluxing with 20ml of dichromate solution required 36ml of 0.1M FAS solution. Calculate the COD of waste water. ***(3)***

Ans:- *Given data :- Vb = 36ml Vt = 26.2ml*

N = 0.1M Ve = 10ml

To find :- COD

Solution :- $COD = \frac{(Vb-Vt)\times Normality \times 8000}{Ve}$

$= \frac{(36-26.2)\times 0.1 \times 8000}{10}$

= 784 ppm

Hence the COD value is 784 ppm.

Q1](g) Discuss the role of polymer in medicine and surgery . ***(3)***

Ans:- *Materials which are not causing adverse effect on blood and other tissues can be used in diagnostic, surgical and can be implanted in the body. They can be developed from metals, ceramics and polymers. Uses of polymers in the field of medicine and surgery are increasing day by day. Characteristics of biomedical polymers are:*

1.should be bio-compatible, can be fabricated into desire shape or form without being degraded.

2.can be easily sterilized with no alteration in properties, should have optimum physical and chemical properties.

Examples are as follows:

POLYMER	***APPLICATION***

1. PMMA.	*Contact lenses.*
2. silicon rubber, polyurethane.	*Heart walls, drain tubes.*
3. Polyvinyl chloride.	*Disposable syringes.*
4. polyalkyl sulphone.	*Membrane oxygenator.*

Q2](a) Calculate the amount of lime (85% pure) and soda (95% pure) required to soften one million litre of water which contains $CaCO_3$ ***= 12.5ppm,*** $MgCO_3$ ***= 8.4ppm,*** $CaCl_2$ ***= 22.2ppm,*** $MgCl_2$ ***= 9.5ppm,*** CO_2 ***= 33ppm, HCl = 7.3ppm, organic matter= 16.8ppm*** ***(6)***

Ans:-

Impurities(mg/lit)	*Multiplication factor*	$CaCO_3$ *equivalent (mg/lit)*	*Requirement*
$CaCO_3$*=12.5*	$\frac{100}{100}$	$12.5\times\frac{100}{100} = 12.5$	*L*
$MgCO_3$*=8.4*	$\frac{100}{84}$	$8.4\times\frac{100}{84} = 10$	*2L*
$CaCl_2$ *= 22.2*	$\frac{100}{111}$	$22.2\times\frac{100}{111} = 20$	*S*
$MgCl_2$ *= 9.5*	$\frac{100}{95}$	$9.5\times\frac{100}{95} = 10$	*L+ S*
CO_2 *= 33*	$\frac{100}{44}$	$33\times\frac{100}{44} = 75$	*L*
HCl = 7.3	$\frac{100}{73}$	$7.3\times\frac{100}{73} = 10$	*L+S*

NaCl does not react with lime and soda.

LIME = $\frac{74}{100}\left[CaCO_3 \text{ equivalent of } 2\times MgC0_3+CaCO_3+MgCl_2+HCl+CO_2\right]\times \frac{\text{Volume of water}}{1000}\times\frac{100}{\%\text{ purity}}$

$= \frac{74}{100}\times[2\times10 + 12.5 + 10 + 10 + 75]\times\frac{10^6}{1000}\times\frac{100}{85}$

= 111000 gms.

SODA = $\frac{106}{100}\left[CaCO_3 \text{ equivalent of } CaCl_2+MgCl_2\right]\times\frac{\text{Volume of water}}{1000}\times\frac{100}{\%\text{purity}}.$

$= \frac{106}{100}[20+10] \times \frac{10^6}{1000} \times \frac{100}{95}.$

= 33473.68 gms.

The lime requirement is 111000 gms and soda requirement is 33473.68 gms.

Q2](b) (i) Give the preparations, properties and uses of Kevlar. (3)

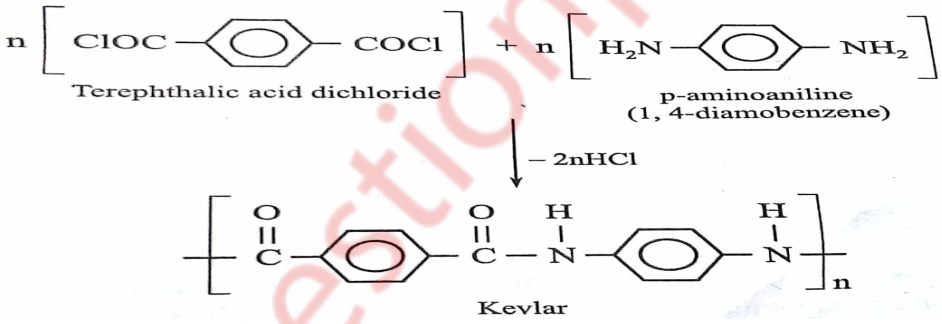
Ans:- :-*It is an aromatic polyamide with benzene rings linked to the amide group, -CONH- group.*

1.PREPARATION.

It is prepared by polycondensation between aromatic dichloride like terephthalic acid dichloride (terephthaloyl chloride) and aromatic diamines like 1,4-phenylene diamine (1,4-diamine benzene).

2.PROPERTIES.

- *It is exceptionally strong, 5 times stronger than steel and 10 times stronger than aluminium.*
- *It has high heat stability and flexibility.*
- *It has resistance against almost all the solvents except some powerful acids.*
- *It does not lose its strength at -196°C .*



3.USES.

- *It is used in aerospace and aircraft industries.*
- *It is used for the preparation pf car parts such as tyres, brakes, clutch, lining etc.*
- *Used for the preparation of ropes ,cables, helmets etc.*

Q2](b)(ii) Define Cloud point and Pour point of a lubricant. (2)

Ans:- *i) CLOUD POINT.*

When oil is cooled slowly , the temperature at which it become cloudy or hazy in appearance is called its cloud point.

ii)POUR POINT.

After cooling oil, the temperature at which it ceases to flow is called its pour point.

Good lubricant should have low POUR POINT.

Cloud and pour point indicates the suitability of the lubricating oil in cold conditions. Lubricant used in a machine working at low temperature should possess low pour point. Otherwise solidification of the lubricant will cause the jamming of the machine.it has been found that presence of waxes in the oil raises the pour point.

Good lubricating oil should have low cloud and pour point.

Q2](c) Write a note on decay of concrete. (4)

Ans:- *The cement concrete although mechanically strong , but due to the presence of free lime it become susceptible to the attack of acidic water. Alkaline water do not have marked effect on concrete strength. Also lime is more soluble in soft water than hard water and hence deterioration of concrete in contact with soft water is more. Presence of sulphates cause maximum damage because it reacts with tricalcium aluminate to form sulpho aluminates which occupies more volume and hence undergo expansion making the cement structure weak.*

PROTECTION OF CONCRETE

- *By giving a coating of bituminous material. This prevents direct contact between concrete and water. This is a very inexpensive method.*
- *By coating the surface with silicon fluoride in a soluble form together with oxides of Zn, Mg or Al. the precipitate of calcium fluoride so-formed in the capillaries prevents dissolution of lime.*

Q3](a) Define Moulding. List the different techniques of moulding. Explain injection moulding with the help of neat diagram. (6)

Ans:- *Fabrication of plastic is the technique of giving any desired shape to the plastics by the use of mould. Because of the properties of polymers it is possible to mould them and change their shape using a number of different repetitions manufacturing processes. A proper method is to be selected depending upon the shape and type of resin being used. The most important of these are compression moulding, transfer moulding, extrusion and injection moulding.*

INJECTION MOULDING:

This method is only applicable to Thermoplastic resin. The moulding plastic powder is fed into a heated cylinder . From there it is injected into the tightly locked mould at a controlled rate by means of a screw arrangement or by a piston plunger. The mould is kept cold to allow the hot plastic to cure and become rigid. When the material have been cured sufficiently , half of the mould is opened to allow the injection of the finished article without any deformation . heating is done by oil or electricity.

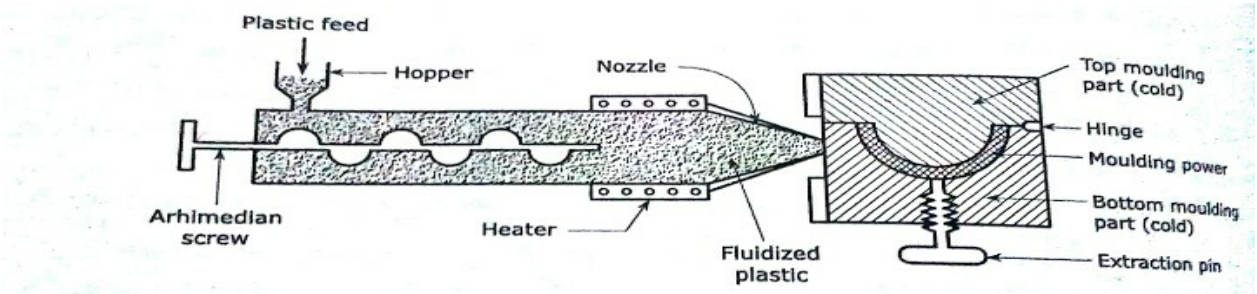


Fig. 2.10 : Injection moulding of plastics.

1.ADVANTAGE:-This method has high speed production, low mould cost , very low cost of material and low finishing cost. Hence it is the most widely used method for moulding of thermoplastics.

2:-DISADVANTAGE:-Since a large amount of cavities cannot be filled simultaneously , there is limitation of design of articles to be moulded.

Q3](b)(i) Explain the term 'phase' with appropriate examples. (3)

Ans:- *1. PHASE: A phase is defined as any homogenous , physically distinct and mechanically separable portion of a system , which is separated from other parts of the system by definite surface. Example:-*

- *In a freezing water system ice, water and water vapour are the three phases which are physically distinct and homogenous.*
- *A gaseous mixture which is thoroughly miscible in all proportion consists of a single phase.*
- *If two liquids are miscible they will form one liquid phase only.*
- *Thermal decomposition of* $CaCO_3$ *consists of three phases namely, two solids and one gaseous.*
- *A mixture of* CaO *and* $CaCO_3$ *consists of two phases.*
- *Two immiscible liquids like water and oil will form two separate phases.*

Q3](b)(ii) Discuss the role of gypsum during the manufacturing of Portland cement . (2)

Ans:- C_3A *readily combines with water and liberates a large amount of heat. The added gypsum retards the dissolution of* C_3A *by forming insoluble calcium sulpho-aluminate* $3CaO.Al_2O_3.xCaSO_4.7H_2O$. *This reaction prevents high concentration of alumina in the cement solution which retards the early initial set of the cement.*

Q3](c) Calculate the total hardness in ppm in given water sample.

: 50ml of standard hard water ,containing 1mg pure $CaCO_3$ ***per ml consumed 20ml EDTA solution.***

: 50ml of water sample consumed 30ml EDTA solution using EBT indicator. ***(4)***

Ans:- *1 ml SHW* ≡ *1 mg of* $CaCO_3$ *eq.*

∴ *50 ml SHW* ≡ *50 mg of* $CaCO_3$ *eq.*

50 ml of SHW ≡ *20 ml of EDTA solution.*

20 ml of EDTA ≡ *50 mg of* $CaCO_3$ *eq.*

∴ *1 ml of EDTA* ≡ $\frac{50}{20}$ *mg of* $CaCO_3$ *eq.*

= *2.5 mg of* $CaCO_3$ *eq.*

50 ml of water sample ≡ *30 ml of EDTA solution.*

∴ *1000 ml of water sample* ≡ $\frac{1000 \times 30}{50}$

= *600 ml of EDTA solution*

1 ml of EDTA ≡ *2.5 mg of* $CaCO_3$ *eq.*

∴ *600 ml of EDTA* ≡ *2.5 × 600*

= *1500 mg of* $CaCO_3$ *eq.*

∴ *Total hardness of water sample = 1500 mg/L*

= 1500 ppm.

Q4](a) Explain the zeolite method for softening of water giving suitable diagram and reactions. What are the limitations of this method. ***(6)***

Ans:- *Zeolite is chemically hydrated sodium alumino silicate* $Na_2O.Al_2O_3.xSiO_2.yH_2O$ *where x= 2 to 10 and y= 2 to 6 . there are two types of zeolite (1) Natural zeolite (2) Synthetic zeolite.*

PROCESS:-

Zeolite softener is made up of a cylinder in which there is a bed of zeolite. Hard water is percolated through the bed of zeolite at a specific rate. The hardness producing ions like Ca^{2+}, Mg^{2+} *etc are retained by the zeolite forming* $CaZe$ and $MgZe$. *The outgoing water contains sodium salts.*

The reactions taking place during the softening process are:-

$$Na_2Ze + Ca(HCO_3)_2 \rightarrow CaZe + 2NaHCO_3$$

$$Na_2Ze + Mg(HCO_3)_2 \rightarrow MgZe + 2NaHCO_3$$

$$Na_2Ze + CaCl_2(\text{or } CaSO_4) \rightarrow CaZe + 2NaCl \text{ (or } Na_2SO_4)$$

$$Na_2Ze + MgCl_2(\text{or } MgSO_4) \rightarrow MgZe + 2NaCl \text{ (or } Na_2SO_4)$$

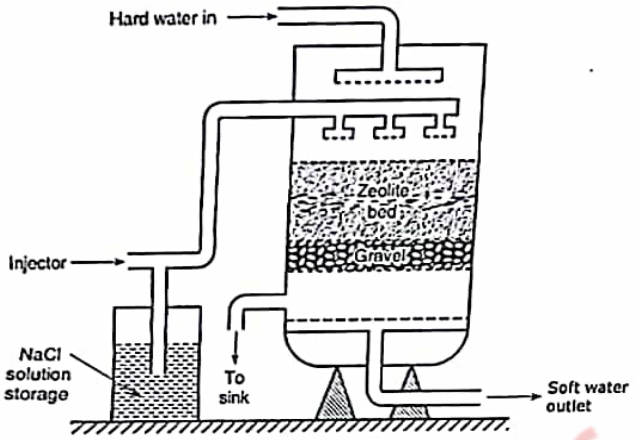


Fig. 1.3 : Zeolite softener.

REGENERATION OF ZEOLITE:-

During softening of water Ca^{2+} and Mg^{2+} *ions are retained by zeolite forming CaZe and MgZe i.e., calcium zeolite and magnesium zeolite. Once all the zeolite gets completely converted to CaZe and MgZe it is said to be exhausted. At this stage zeolite is unable to soften more of the hard water. The supply of hard water is then stopped. They exhausted zeolite which is CaZe and MgZe is treated with concentrated brine solution i.e., NaCl solution.*

$$CaZe + 2NaCl \rightarrow Na_2Ze + CaCl_2$$

$$MgZe + 2NaCl \rightarrow Na_2Ze + MgCl_2$$

The washing containing $CaCl_2$ *and* $MgCl_2$ *are discarded and the regenerated zeolite is used again for softening of water.*

LIMITATIONS OF ZEOLITE :-

1. *If the supply of water is turbid , the suspended matter must be removed before the water is admitted to the zeolite bed. Otherwise the turbidity will clog the pores of zeolite bed thereby making it inactive.*
2. *If water contain large quantities of coloured ions such as* Mn^{2+} and Fe^{2+}*, they must be removed first because these ions produce manganese and iron zeolites, which cannot be easily regenerated.*
3. *Mineral acids, if present in water destroy the zeolite bed and therefore they must be neutralised with soda before admitting the water to the zeolite softening plant.*

Q4](b)(i) 6gms of oil was saponified with 50ml of 0.5N alcoholic KOH solution. After refluxing for 2 hours the mixture was titrated with 25ml 0.5N HCl. Find the saponification value of Oil. (3)

Ans:- *Given Data :- Weight of oil = 6 mgs Blank titration reading = 50ml = V2*

Back titration reading = 25ml = V1

Solution :- Volume of 0.5N KOH required for saponification in terms of 0.5N HCl

= V2 – V1 = 50 – 25 = 25 ml

$$\text{Saponification value of oil} = \frac{\text{Volume of KOH} \times \text{Normality of KOH} \times 56}{\text{weight of oil}}$$

$$= \frac{25 \times 0.5 \times 56}{6} = 116.66 \text{ mg of KOH}$$

Therefore the Saponification value of the oil is 116.66 mg of oil.

Q4](b)(ii) Distinguish between the wet and dry process for manufacturing of Portland cement. (2)

Ans:-

DRY PROCESS	***WET PROCESS***
1. *This is used when the raw material are hard.*	***1.*** *This is used for any type of raw material.*
2.*Fuel consumed is less.*	***2.****Fuel consumed is more.*
3.*Process is slow.*	***3.****Process is faster.*
4.*Cement produced is of inferior quality.*	***4.****Cement produced is of superior quality.*
5.*Costly process.*	***5.****Cheaper process.*

Q4](c) Discuss the following additives in compounding of plastics

(a)Fillers (b) Plasticizers. (4)

Ans:- :- *1.FILLERS (or EXTENDERS).*

Fillers are added to a base polymer to lower the manufacturing cast of a product made from it. Functions of fillers are as follows:

- *Reducing the cost of plastic.*
- *Increases the tensile strength and hardness.*
- *Reduces the flexiblity.*
- *Decreases the shrinkage during moulding.*
- *Gives opacity to the product.*
- *Examples:-mica, talc, asbestos , saw dust ,chalk etc.*

2.PLASTICIZERS.

The Plasticizer molecule occupies between the polymeric chains and neutralizes the intermolecular forces of attraction and thus allows freedom of movement. The functions of plasticizers are as follows:-

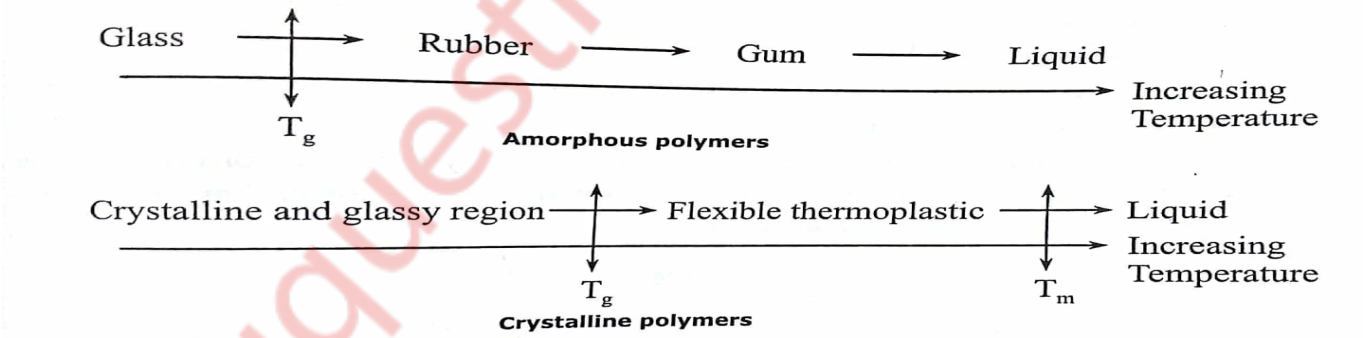
- *Increases the plasticity of the plastics.*
- *Lowers the softening temperature and hence moulding and remoulding can be done at low temperature.*
- *Imparts flames proofness.*
- *Reduces resistance towards chemical , solvents etc.*
- *Examples:- esters of fatty acids, vegetables oils etc.*

Q5](a)Write note on (any two):-

(a)Glass transition temperature (b) Buna-S (c) Vulcanisation (6)

Ans:- *1.GLASS TRANSITION TEMPERATURE :-*

The temperature at which polymer experience the transition from rubbery to rigid state is termed as the 'Glass transition temperature'(T_g).The behaviour of a polymer is temperature sensitive. Glass transition temperature is also defined as the lowest temperature below which the polymer becomes hard and brittle and above which it becomes soft and flexible. The polymer becomes too soft, that it behaves like a fluid called as the visco fluid state. The temperature at which the soft, flexible polymer goes to the visco fluid state is called the melting temperature T_m.



Factors Influencing T_g:

1.Cross linking increases the T_g value.

2.Presence of bulky groups increases the T_g value.

3.Addition of plasticizer decreases the T_g value.

4.Polymers having strong intermolecular forces of attraction increases T_g value.

5.Polar side atoms or groups of atoms increases the T_g value.

2. <u>BUNA-S (or STYRENE RUBBER)</u>

- *<u>PREPARATION:</u>*

This is the most important type of synthetic rubber which is produced by copolymerization of butadiene , $CH_2 = CH - CH = CH_2 (75\%$ by weight$)$ *and styrene ,* $C_6H_5CH = CH_2 (25\%$ by weight$)$.

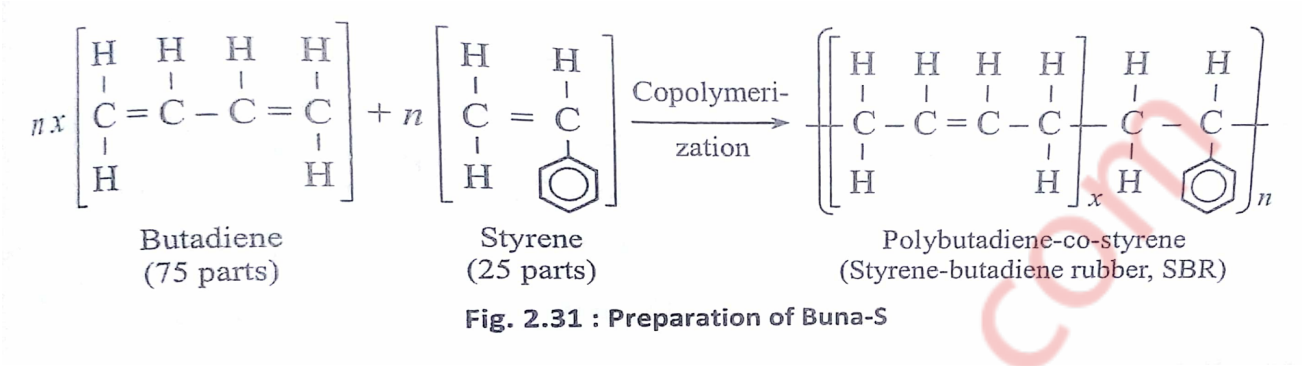


Fig. 2.31 : Preparation of Buna-S

- *<u>PROPERTIES</u>*

1.Styrene rubber resembles natural rubber in processing characteristics as well as quality of finished products.

2.It posses high abrasion-resistance, high load-bearing capacity and resilience

3.It swells in oils and solvents.

- *<u>USES</u>*

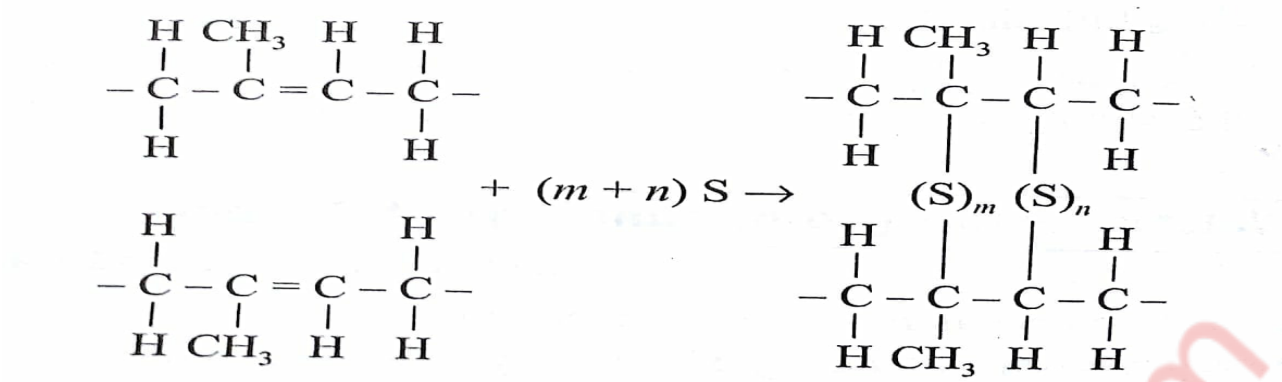
1.Mainly used for the manufacture of motor tyres.

2.Other uses of this elastomer are floor tiles , shoe soles, gaskets, foot-wear components, wire and cable insulations, carpet backing , adhesive , tank-lining, etc.

3. <u>VULCANIZATION:-</u>

When rubber is heated with sulphur, its tensile strength , elasticity and resistance to swelling are increased tremendously. This process is named as <u>Vulcanization.</u> Vulcanization brings about a stiffness of the rubber by anchoring and restricting the intermolecular movement of the rubber springs. The vulcanization can be carried out in several ways:-

1. *The article to be vulcanised is heated with a steam under pressure.*
2. *The article is immersed in hot water under pressure.*
3. *By heating the article in air or in carbon dioxide.*
4. *By vulcanizing the article in the mould in which it is shaped.*



PROPERTIES OF VULCANIZED RUBBER.

- *High tensile strength.*
- *Elastic to lesser extent.*
- *Water absorption is small.*
- *Do not swell much in organic solvents.*
- *Better abrasion resistance.*

Q5](b)(i) Distinguish between BOD and COD . *(3)*

Ans:-

BOD	***COD***
1.*It means the oxygen demand of bio-degradable pollutants only.*	***1.****It measures the oxygen demand for bio-degradable pollutants along with non-biodegradable pollutants.*
2.*Less stable measurement method as it uses micro-organism which are susceptible to pH , temperature and other variable in the water.*	***2.****More stable measurement method as it uses potassium dichromate which oxidises regardless of water condition.*
3.*Slow process. It takes 5 days.*	***3.****Fast process. It takes 2-3 hours.*
4.*BOD values are generally less than COD values.*	***4.****COD values are generally greater than BOD values.*
5. $\text{BOD} = (\text{DO}_b - \text{DO}_i) \times \frac{\text{Volume of undiluted sample}}{\text{Volume of diluted sample.}}$	***5.***$\text{COD} = \frac{(V_1 - V_2) \times N \times 8000}{Y}$

Q5](b)(ii) Define Oiliness. What is its significance *(2)*

Ans:- *Oiliness of a lubricant is the measure of its capacity to stick on to the surface of machine parts under condition of pressure or load. When a lubricating oil of poor oiliness is applied under*

high pressure , it gets squeezed out from the surface and the lubrication stops. If the oil has good oiliness it can remain in place and can give lubrication even under pressure. Mineral oil has very poor oiliness whereas vegetable oils possess good oiliness. No direct test are available for measuring oiliness.

Q5](c) Discuss the application of Phase rule to the one component system based on:Diagram, triple point. *(4)*

Ans:- *Phase rule helps to study different equilibria and classify them accordingly. It indicates behaviour of the system under a particular set of conditions. Different systems with the same degree of freedom behave in a similar manner. Helps to find out under a set of conditions whether all substances involved in an equilibrium can exist or a particular phases ceases to exist or whether any transformation has taken place.*

<u>One component system with the phase diagram.</u>

In water there is only one component i.e., water and its three phases : ice, water, steam which are solid, liquid, and gaseous respectively. Figure below represents phase diagram or pressure v/s temperature diagram for the water system.

Three curves OA, OB, and OC represents the equilibrium conditions between two phases solid

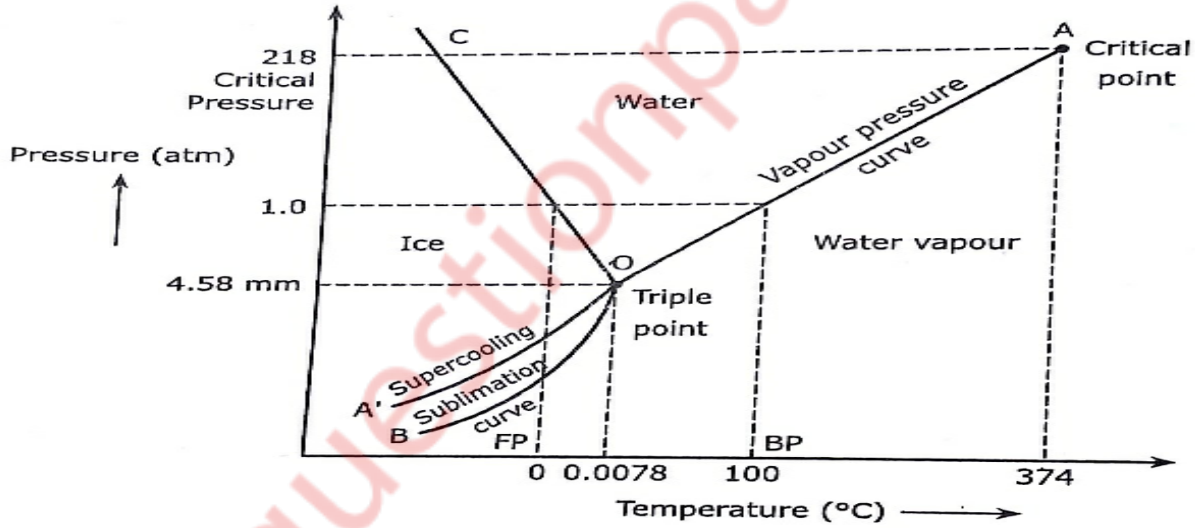


Fig. 4.1 : Phase diagram of water system

with vapour , vapour with liquid and liquid with solid phase of water.

Curve OB represents the equilibrium between liquid and vapour. It is known as vaporization curve. Here also it is necessary to state either temperature or pressure. E.g., at atmospheric pressure , water and vapour can exist in equilibrium only at 1 temperature i.e., the boiling point of water. Water -vapour system has one degree of freedom F=C-P+2=1.

Curve OC represents the equilibrium between solid and liquid phase of the water. This curve is known as fusion pressure or melting point curve. Along this curve there are two phases in equilibrium that is ice and water. At atmospheric pressure, ice and water can be in equilibrium only at one temperature i.e., the freezing point of water.

We have C=1, P=2 thus,

F=C-P+2=1.

TRIPLE POINT:- The three curves OA, OB, and OC meet at O at which solid, liquid and vapour co-exist in equilibrium. This point at 273.16K (0.0075°C) and 4.58 mm of Hg pressure is called Triple point. The system is invariant.

F=C-P+2 ∴ F=3-P=3-3=0 ∴ F=0

This means the degree of freedom is zero therefore neither pressure nor temperature can be changed without causing the disappearance of one of the phases. If either temperature or pressure is changed even slightly , one of the three phases disappears and the system changes from non-varient to univariant.

Q6](a) Define lubricants and lubrication. Mention the various mechanisms involved in lubrication of machine. Discuss boundary lubrication. (6)

Ans:- *Any substance placed between two moving or sliding surfaces with a view to reduce the frictional resistance between them is known as lubricant.*

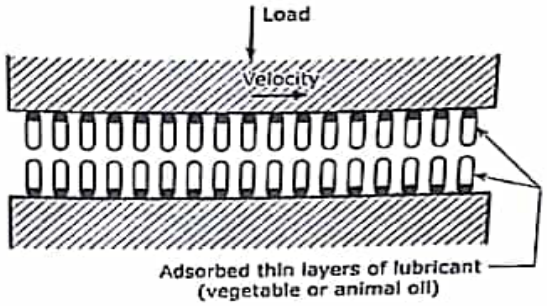
Lubricants may be used in solid, liquid or semi solid form. The process of reducing friction between two metallic sliding surfaces by the introduction of lubricants is called as lubrication.

BOUNDARY or THIN- FILM LUBRICATION.

Boundary lubrication occurs when the film thickness between two surfaces in relative motion is so thin so that the formation hydrodynamic oil film is not possible and result in direct metal-metal contact. Such a situation may arise when.

1. *The load is very high.*
2. *A shaft starts from rest.*
3. *Low speed resulting in insufficient supply of oil.*
4. *Viscosity of the oil is too low.*

In boundary lubrication the space between the metal surface is lubricated with oil lubricants a thin layer of which is absorbed chemically or physically and avoid direct metal to metal contact. The thin film will have thickness around 10 A° and consists of one or two molecular layers. The coefficient of friction is about 0.05 to 0.15. the load is carried by the layer of the absorbed lubricant or both metal surfaces. The extent with which the lubricant gets adhered to the metal surface depends on oiliness of lubricant.



Mineral oils blended with vegetables and animal oils, graphite molybdenum disulphide etc are useful for boundary lubrication.

Gears , railways track joints , tractors, rollers etc are provided with this type of lubrication.

For boundary lubrication to be effective molecules should have:-

1. *Long hydrocarbon chains.*
2. *Polar groups to promote spreading and orientation over the metallic surfaces at high pressure.*
3. *Lateral attraction between the chains.*
4. *Active groups or atoms that can form chemical linkages with the metals or other sufaces.*

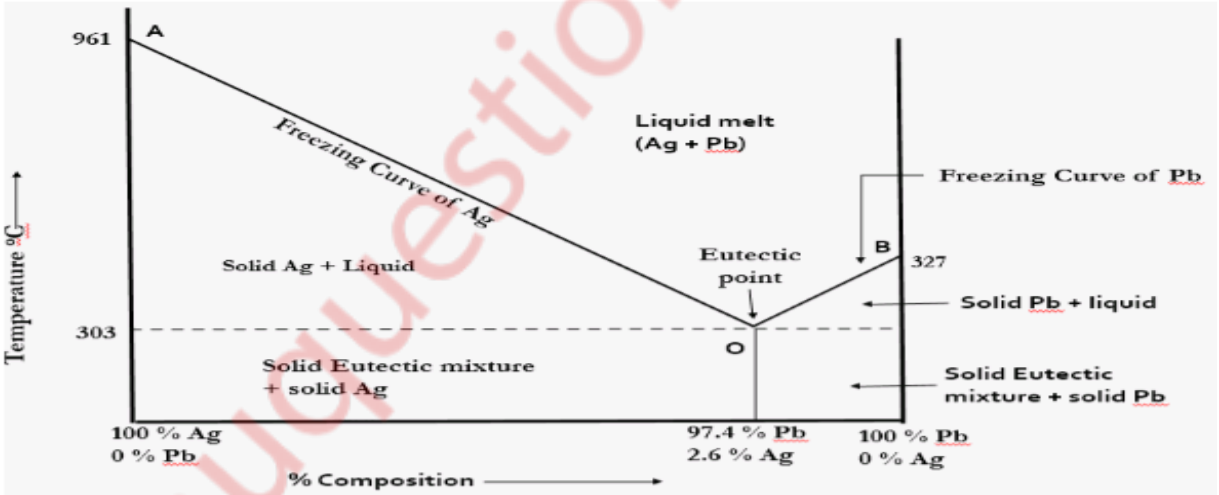
Q6](b)(i) What is reduced or condensed phase rule. *(3)*

Ans:- *In some systems , an equilibrium exists between solid – liquid phases and gaseous phase is practically absent . Hence the effect of pressure on such system can be neglected . Then it is*

Necessary to take into account only two variables viz. temperature and concentration.

Such system showing solid – liquid equilibrium is called condensed system and phase rule applied to such system is as follows:-

F = C – P + 1 … known as condensed phase rule.



Q6](b)(ii) Discuss Reverse Osmosis. *(2)*

Ans:- *When two solutions of unequal concentrations are separated by a semipermeable membrane which selectively does not permit the passage of dissolved solute particles, i.e., molecules , ions etc flow of solvent takes place from dilute to concentrated sides due to osmosis. If a hydrostatic pressure in excess of osmotic pressure is applied on the concentrated side to dilute side across the membrane.*

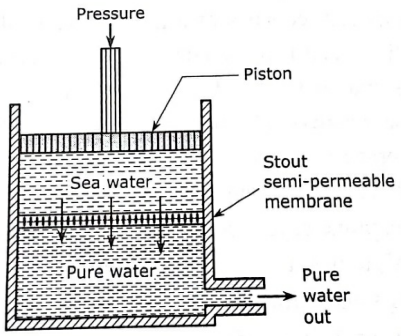


Fig. 1.14 : Reverse osmosis cell

This process is called as reverse osmosis. Thus in reverse osmosis methods pure solvent is separated from its contaminates, rather than removing contaminants from the water.

Q6](c) What are carbon nanotubes . what are its types. Discuss the laser method for its production. *(4)*

Ans:- *Carbon nanotubes represents one of the best examples of the novel nanostructures derived by bottom-up chemical synthesis approaches. Nanotubes have the simplest chemical composition and atomic bonding configuration but exhibit perhaps the most extreme diversity and richness among nanomaterial in structure and structure-property relations. The different types of carbon nanotubes are as follows;*

1. *SINGLE WALLED NANOTUBES.*
2. *MULTIWALLED NANOTUBES.*

LASER VAPORIZATION METHOD.

This method is used to produce CNT's with 70% purity. In this process , a graphite rod with 50:50 catalyst mixtures of cobalt and nickel at 1200 °C in flowing argon is used to prepare sample. The uniform vaporization of the target can be achieved by using the initial laser vaporization pulse followed by a second pulse. The amount of deposition of carbon soot is primarily minimized by the usage of these two successive laser pulses. The large particles are broken by applying the second laser pulse. The CNT's produced through this process are 10-20nm in dia and 100μm or more in length. The average nanotube diameter and size distribution can vary for different growth temperature, catalyst composition , and other process parameters.

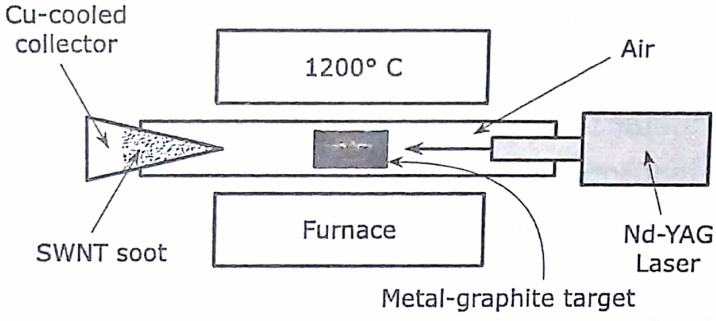


Fig. 5.7 : Schematics of experimental setup for laser ablation process

DRAWBACKS.

1. *This method involves evaporation of carbon source, so it is unclear to scale up the production to industrial level.*
2. *Vaporisation methods grow CNT's in highly tangled form, mixed with unwanted forms of C and metal species.*
3. *CNT's produced are difficult to purify.*

APPLIED CHEMISTRY 1

(CBCGS , DEC 2018)

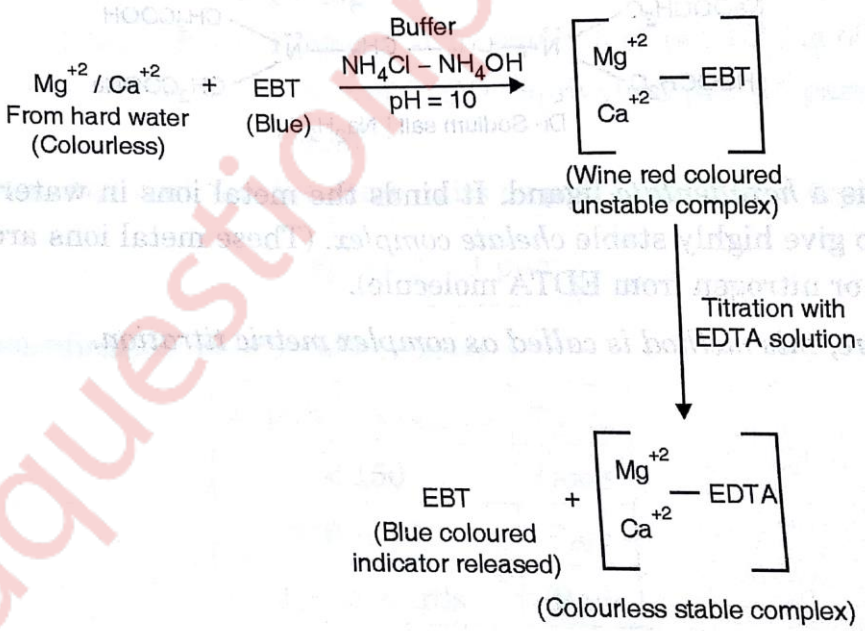
Q1](a) Explain the principle of EDTA method . (3)

Ans : *1) EDTA or its sodium salt forms stable complex ion with Ca^{2+} or Mg^{2+} (hardness producing ions) in water .The titration is carried out in presence of indicator such as Eriochrome Black T (EBT) .*

2) In a hard water sample ,the total hardness can be determined by titrating Ca^{2+} and Mg^{2+} present in an aliquot of the sample with Na EDTA solution ,using NH_4Cl , NH_4OH buffer solution of pH =10 and the metal indicator EBT .

3) At pH 10 ,EBT indicator forms wine red coloured unstable complex with Ca^{2+} or Mg^{2+} ions in hard water .

4) When EDTA is added from burette to this wine red complex ,there is formation of more stable Ca-EDTA but colourless complex . Near the end point , when all Ca^{2+} ions get complexed with EDTA ,indicator EBT ions set free giving blue colour to the solution .



Q1](b) What is glass transition temperature ?Write its significance. (3)

Ans : *1)There is a temperature boundary for almost all amorphous polymers and many crystalline polymers,only above which the substance remains soft,flexible,rubbery and below which it becomes hard,brittle and glassy.*

*Eg. An ordinary rubber ball if cooled below -70*C becomes so hard and brittle that it will break into pieces like a glass ball falling on a hard surface.*

2)The temperature below which a polymer is hard,brittle and glassy and above which it is soft and flexible is called as 'Glass Transition Temperature'(Tg).

3)A polymer is not preferred to be used at temperatures below its glass transition temperature since it becomes hard,stiff and brittle.

4)A polymer material should have much lower T_g than the operating temperature.

Eg polymers to be used for refrigerators, air conditioners or used in cold countries should have lower Tg,so that they donot break during use.

5)At glass transition temperature,the internal energy of the polymer increases to that extent where chain segments of a polymer molecule just start leaving their lattice sites.

Q1](c) Write the significance of the following properties of lubricants.

i) Emulsification ii) Cloud point iii) Fire point (3)

Ans : ***i) Significance of Emulsification:***

(1) A good oil lubricant generally has a low steam emulsion number , so that even if water comes in contact with the oil in the lubricated parts , it will not form emulsion which has tendency to collect dirt , dust, etc.

(2) Petroleum oils have very low Stream Emulsion Number (S.E.N) but vegetable oils have higher S.E.N as the vegetable oil and water molecules have affection.

(3) Whenever a stable oil in water or water in oil emulsion is required for lubricants (eg cutting , drilling operations , large IC engines , pneumatic compressors , etc) , then they are prepared by use of emulsifiers like soap , fatty acids , etc .

ii) Significance of Cloud point :

(1) Coloud point is significant as it helps us in knowing the lowest temperature upto which the oil can be suitable as a liquid lubricant .

(2) Knowledge of cloud point can help the machines to be prevented from getting jammed in places in cold region in some areas of India.

(3) The lubricating oils should have much lower cloud point than the working temperature.

iii) Significance of Fire point :

(1) Fire point is significant as it helps in knowing the highest temperature upto which an oil can be used as a lubricant .

(2) A lubricating oil selected for a job should have a fire point which is reasonably above its working temperature .

(3) It helps in the storage , transport and use of the lubricating oil.

(4) It is also useful for identification and detection of contaminants in the oil .

Q1] (d) What is RCC ? What are the advantages of RCC over concrete?
Ans : ***(3)***

1) *RCC is the combination of steel and concrete structure which has high load-bearing capacity. It is the ordinary concrete reinforced with steel rods or heavy wire mesh.*
2) *Plain concrete has a great compressive strength but little ability to withstand tension. Hence when steel and concrete are together used , embedded steel takes up tension and strength is given by concrete.*

Advantages of RCC over concrete :

a) *RCC is easier to make and cast into desired shape , which can bear any type of load.*
b) *It posseses greater rigidity , moisture and fire resistances .*
c) *Steel reinforcement tends to distribute shrinkage cracks , thus preventing formation of large cracks .*
d) *The concrete on setting gets bonded very strongly with the reinforcements giving high compressive and tensile strengths .*
e) *Its maintainance cost is practically negligible .*

Q1](e) Explain the reduced phase rule . ***(3)***

Ans : *i) In two component system , when P=2 and C=2*

$$F=C-P+2=3.$$

ii)Since the maximum number of degrees of freedom in a two-component system is three , the phase behaviour of a binary system may be represented by a three dimensional diagram of pressure , temperature and composition or space models , which cannot be conveniently shown on paper .

iii) A solid-liquid equilibrium of an alloy has practically no gas phase and the effect of pressure is small on this type of equilibrium ,since the experiments are conducted under atmospheric pressure.

iii) Keeping the pressure constant of a system , in which vapour phase is not considered , is known as <u>Condensed System</u>.

iv) It will reduce the degree of freedom by one and for such a system , phase rule becomes

$$F=C-P+1$$

This is known as the reduced/condensed phase rule having two variables ,namely temperature and concentration of constituents .

Q1](f) Distinguish between thermoplastic and thermosetting polymer.

Ans : ***(3)***

Thermoplastic Polymer	***Thermosetting Polymer***
1)These are formed by addition polymerisation .	*1)These are formed by condensation polymerisation .*
2)They have low molecular weight .	*2)They have high molecular weight .*
3)They are usually soft ,weak and less brittle .	*3)They are usually hard ,strong and more brittle .*
4)They are long chain linear polymer with negligible cross links	*4)They have three-dimensional network structure with number of crosslinks .*
5)They are usually soluble in some organic solvents .	*5)Due to strong bonds and crosslinks ,they are insoluble in almost all organic solvents .*
6)They get softened on reheating readily because secondary forces between the individual chain can break easily by heat or pressure .	*6)They donot soften on reheating because the crosslinks and bonds retain their strength on heating .*
7) Example : Polyethylene ,Polystyrene ,PVC ,PVA .	*7) Example : Phenolformaldehyde,ureaformaldehyde , Nylon 6,6 .*

Q1](g) 20 ml sample of waste water was refluxed with 30 ml of potassium dichromate solution and after refluxing the excess unreacted dichromate required 11 ml of 0.1 N FAS solution . Blank of 20 ml of distilled water on refluxing with 30 ml of dichromate solution required 14 ml of 0.1 N FAS solution . Calculate the COD value of waste water . ***(3)***

Ans :

Given data : Volume of FAS required for the blank solution =V_B =14 ml

Volume of FAS required for estimation of sewage =V_E =11 ml

V_B – V_E =14-11 =3 ml

Normality of FAS =N =0.1 , Volume of sewage =20 ml

To find : COD

Solution :

COD = 8 x N x (V_B – V_E) x 1000/ Volume of sewage mg/lit

COD = 8x 0.1 x 3 x 1000 / 20 = 120 mg/lit .

The COD value of waste water is 120 mg/lit .

Q2](a) A sample of water contains following impurities :

$Mg(HCO_3)_2$ =73 mg/lit , $MgSO_4$ = 120 mg/lit , $CaCl_2$ = 222 mg/lit and $Ca(NO_3)_2$ = 164 mg/lit . The purity of lime is 74% and soda is 90% . Calculate the quantity of lime and soda needed for softening of 50,000 litres of water . (6)

Ans :

Impurities (mg/lit)	***Multiplication Factor***	***$CaCO_3$ equivalents (mg/lit)***	***Requirement***
$Mg(HCO_3)_2$	*100/146*	*73 x 100/146 =50*	*2L*
$MgSO_4$	*100/120*	*120 x 100/120 =100*	*L + S*
$CaCl_2$	*100/111*	*222 x 100/111 =200*	*S*
$Ca(NO_3)_2$	*100/164*	*164 x 100/164 =100*	*S*

Lime Requirement = 74/100 x [$CaCO_3$ equivalent of 2x $Mg(HCO_3)_2$ + $MgSO_4$]

= 74/100 x [100 + 100]

=148 ppm .

Lime Required for 50,000 litres of water with 74% purity

= 148 x 50,000 x 100/74

= 10,000 gm .

Soda Requirement = 106/100 x [$CaCO_3$ equivalent of $MgSO_4$ + $CaCl_2$ + $Ca(NO_3)_2$]

= 106/100 x [100 + 200 + 100]

= 424 ppm .

Soda Requirement for 50,000 litres of water with 90% purity

=424 x 50,000 x 100/90

= 23,556 gm .

The Lime Requirement is 10,000 gm and Soda Requirement is 23,556 gm .

Q2](b)(i) Write a brief note on polymers used in medical field . (3)

Ans : *1) Biomaterials are the substances that can be implanted in the bodies of human beings to provide special prosthetic function or used in surgical ,diagnostic and therapeutic applications without causing any adverse effect on the blood and other tissues of human body .*

3) *Biomaterials are versatile and can be modified to suit specific body functions .*
4) *The following are the characteristics of biomaterials :*
   a) *Purity and reproducibility*
   b) *Easy sterilization and should not be toxic or allergic .*
   c) *Optimum physical and chemical properties .*
   d) *Should be fabricated into desired shape or form .*
   e) *Should be chemically inert and not affect body fluids .*
   f) *Should be flexible .*
5) *The applications of polymeric biomaterials are as follows :*

Polymer	***Applications***
1) *Silicone polymer rubber*	*Heart valves ,artificial heart ,blood filters ,vascular tubing.*
2) *Polymethyl methacrylate*	*Contact lenses ,dental restoratives*
3) *Polyvinyl chloride*	*Disposable syringes*
4) *Polylactic acid*	*Dialysis media ,drug delievery ,organ regeneration ,plastic surgery ,etc.*
5) *Polyglycollic acid*	*Surgical applications ,medical devices such as anastomosis rings ,plates ,rods ,pins ,screws ,etc .*
6) *Polyurethane rubber*	*Reconstructive surgery*

Q2](b)(ii) Name two additives added in blended oils .Give one example of each . ***(2)***

Ans : *(i)No single oil serves as the most ideal lubricant for many of the modern machineries . Therefore specific additives can be incorporated into petroleum oils to improve their characteristics .*

(ii) Blending improves the properties of lubricants such as good oiliness ,lower pour point ,increase in resistance power for oxidation and corrosion ,etc .

Sr No.	Name of the additive	Chemical used	Functions
1	Dispersants	Polymers such as nitrogen containing polymethacrylates ,alkyl succinimides and high molecular weight amines and amides .	Prevent or retard sludge formation and deposition under low temperature operating conditions .
2	Antioxidants	Phenols ,amines ,organic sulphides ,organic sulphides , etc .	Retard the oxidation of oil .Minimize the formation of resins,varnish,acids,sludges and polymers

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Q2](c) Explain with the help of chemical reactions " Setting and Hardening " of cement . ***(4)***

Ans : *When cement is mixed with water to a plastic mass ,called "cement paste " ,hydration reaction begins ,resulting in the formation of gel and crystalline products.The interlocking of the crystals ,finally bind the inert particles of the aggregates into a compact rock-line material .The process of solidification comprises of :*

(i)setting and then , (ii) hardening

" Setting "is defined as stiffening of the original plastic mass ,due to initial gel formation . "Hardening "is development of strength ,due to crystallization .

After setting ,hardening starts ,due to the gradual process of crystallization in the interior of the mass .The strength developed by cement paste at any time ,depends upon the amount of gel formed and the extend of crystallization .

Initial setting of cement-paste is mainly due to the hydration of tricalcium aluminate (C_3A) and gel formation of tetracalcium

$$3CaO . Al_2O_3 + 6H_2O \rightarrow 3CaO . Al_2O_3 . 6H_2O + 880\ KJ/Kg$$

Or $C_3A + 6H_2O \rightarrow C_3A \cdot 6H_2O + 880\ KJ/Kg$

Tricalcium aluminate Hydrated tricalcium aluminate

$4CaO \cdot Al_2O_3 \cdot Fe_2O_3 + 7H_2O \rightarrow 3CaO \cdot Al_2O_3 \cdot 6H_2O + CaO \cdot Fe_2O_3 \cdot H_2O + 420\ KJ/Kg$

Or $C_4AF + 7H_2O \rightarrow C_3A \cdot 6H_2O$ *(crystalline)* $+ CF \cdot H_2O$ *(gel)* $+ 420\ KJ/Kg$

Dicalcium silicate starts hydrolysing to tabermonite gel (which possesses a very high surface area and thus ,very high adhesive property) ,which also contributes to initial setting .

$2[2CaO \cdot SiO_2] + 4H_2O \rightarrow 3CaO \cdot 2SiO_2 \cdot 6H_2O + Ca(OH)_2 + 250\ KJ/Kg$

Or $2C_2S + 4H_2O \rightarrow C_3S_2 \cdot 6H_2O + Ca(OH)_2 + 250\ KJ/Kg$

Dicalcium silicate Tabermonite gel Crystalled calcium hydroxide

Final setting and hardening of Portland cement-paste is due to the formation of tabermonite gel (formed above) plus crystallization of calcium hydroxide and hydrated tricalcium aluminate .

$2[2CaO \cdot SiO_2] + 6H_2O \rightarrow 3CaO \cdot 2SiO_2 \cdot 3H_2O + Ca(OH)_2 + 500\ KJ/Kg$

Tricalcium silicate Tabermonite gel Calcium hydroxide

Or $2C_3S + 6H_2O \rightarrow C_3S_2 \cdot 3H2O + 3Ca(OH)2 + 500\ KJ/Kg$

In short ,

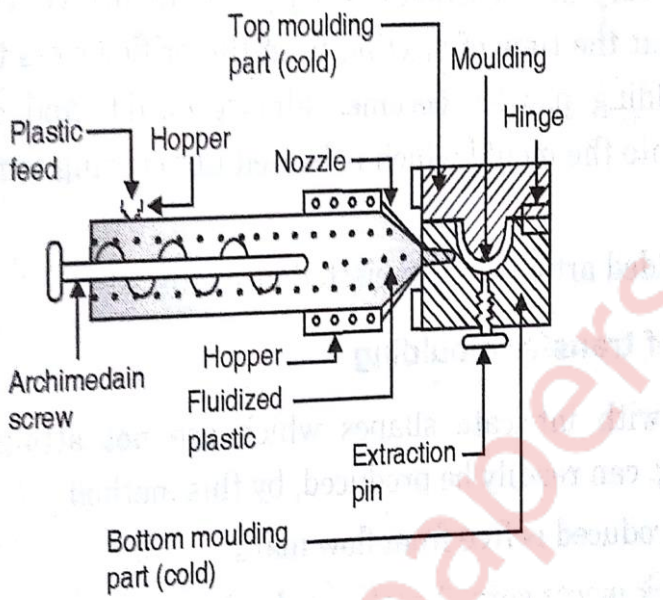
1) *When water is added to cement ,at first hydraton of* C_3A *and* C_4AF *takes place within day .*
2) C_3S *begins to hydrate within 24 hrs and gets completed in 7 days .*
3) *Gel of aluminate begins to crystallise and at the same time* C_2S *begins to hydrate in 7-28 days .*
4) *The development of early strength between 1-7 days is due to the hydration of* C_3S *and further hydration of aluminate*
5) *The increase of strength between 7-28 days ,is due to hydration of* C_2S *and continued hydration of* C_3s *.*

Q3](a) What is fabrication of plastic ? Explain injection moulding process with a neat diagram . *(6)*

Ans : ***Fabrication*** *is the process in which the prepared resins in the form of granules or powder are converted into desired shape by using various machines or moulds . It transforms the compound materials into finished articles .A proper method has to be selected depending on the shape and size of the resin being used .*

Injection Moulding *:*

1) *It is used for thermoplastic resins only .*
2) *Here ,a predetermined amount of the granular or powdered resin is fed into a heated cylinder .*
3) *From the cylinder ,the powdered resin is injected at a controlled rate through a nozzle into the tightly locked mould by means of a screw arrangement or by piston plunger .*



4) *The mould is kept cold to allow the hot plastic to cure and become rigid .After sufficient curing ,the mould is half opened and finished particle is ejected without any deformation .*
5) *Automation of the entire cyclic process is possible .*
6) *The method is widely used because of high speed production ,low mould cost ,very low loss of material and low finishing cost .*
7) *The limitation of this method is large number of cavities cannot be filled simultaneously .*
8) *Articles prepared by injection moulding are ball pens ,telephones ,buckets ,dustbins ,flower pots ,etc .*

Q3](b)(i) Discuss the advantage and limitations of the phase rule . (3)

Ans : Advantages of phase rule :

1) *It is applicable to both physical and chemical equilibria .*
2) *It requires no information regarding molecular /micro-structure ,since it is applicable to macroscopic systems .*
3) *It is a convenient method of classifying equilibrium states in terms of phases ,components and degrees of freedom .*
4) *It helps us to predict the behaviour of a system under different conditions of the governing variable .*

5) *It indicates that different systems with same degree of freedom behave similarly .*
6) *It does not take any cognizance of either the nature or quantities of components present in the system .*
7) *It helps in deciding whether under the given set of conditions :*
   a) *Various substances would exist together in equilibrium or*
   b) *Some of the substances present would be interconverted or*
   c) *Some of the substances present would be eliminated .*

Limitations of phase rule :

1) *It can be applied to systems in equilibrium only .*
2) *It is of little value in case of systems which attain the equilibrium state very slowly*
3) *It applies only to a single equilibrium system and provides no information regarding any other possible equilibria in the system .*
4) *It requires utmost care in deciding the number of phases existing in an equilibrium state ,since it considers only the number of phases rather than their amounts .Thus ,even if a trace of the phase is present ,it accounts towards the total number of phases .*
5) *It conditions that all phases of the system must be present simultaneously ,under the same conditions of temperature and pressure .*
6) *The solid ,liquid phases should not be so finely sub-divided as to bring about deviation from their normal values of vapour pressure .*

Q3](b)(ii) Differentiate between SWNT and MWNT . (2)

Ans :

SWNT	***MWNT***
1)It consists of single layer of graphene	*1)It consists of multiple layer of graphene*
2)Catalyst is required for synthesis of SWNT .	*2) MWNT can be produced without the help of catalyst*
3)Bulk synthesis is difficult as it requires proper control over growth and atmospheric condition .	*3)Bulk synthesis is easy .*
4) A chance of defect is more during functionalization .	*4) A chance of defect is less but once occurred it is difficult to improve .*
5)It can be twisted easily and are more pliable .	*5)It cannot be easily twisted .*
6)I t causes less accumulation in body .	*6)It causes more accumulation in body .*

Q3](c) A zeolite softener was completely exhausted and was generated by passing 1000 litres of NaCl .How many litres of a sample of hardness 500 ppm can be softened by this softener ? (4)

Ans : *The total amount of NaCl required for the softening process is*

1000 litres x 100 mg/lit =100000 mg .

$CaCl_2 + Na_2Ze \rightarrow 2NaCl + CaZe$

$1CaCl_2 \rightarrow 2NaCl$

$1CaCl_2 \rightarrow 1CaCO_3$

Hence $1CaCO_3 \rightarrow 2NaCl$

100 mg of $CaCO_3$ *= 2 x 58.5 mg of NaCl*

2 x 58.5 mg of NaCl = 100 mg of $CaCO_3$

100000 mg of NaCl = 100000 x 100/2 x 58.5 mg of $CaCO_3$

The hardness of the water sample is 500 ppm , i.e. 500 mg of $CaCO_3$ *is required for 1 litre of water .*

Volume of water required for 100000 x 100 /2 x 58.5 mg of $CaCO_3$ *is*

= 100000 x 100 /2 x 58.5 x 500 Litres

= 170.94 Litres

170.94 Litres of a sample of water can be softened by this softener .

Q4](a) Draw the diagram for demineralization process and write suitable reactions involved in the process .What are the advantages and disadvantages of the method . ***(6)***

Ans : *Demineralization is also called as Ion exchange or de-ionization process .This softening process is carried out with help of organic substances called as ion-exchange resins .*

Principle : *Ion-exchange resins are insoluble , crosslinked organic polymers with a microporous structure and the functional groups attached to chains are responsible for exchanging ions .Ion exchange resins are of two types :*

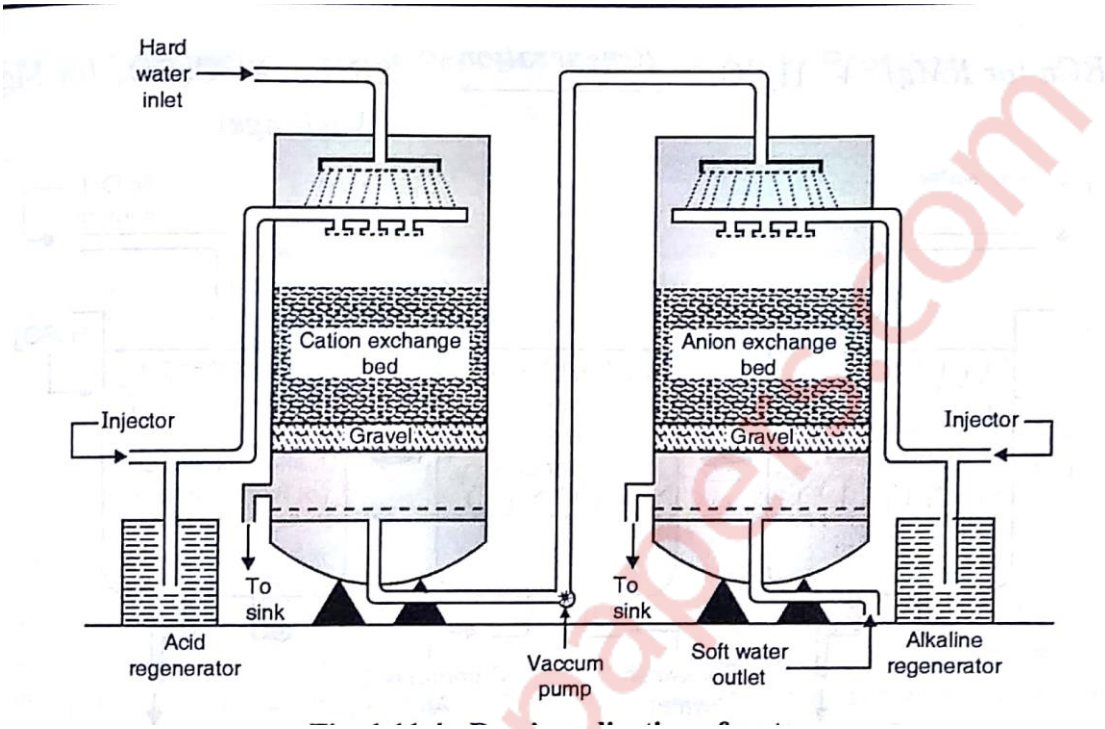
a) *Cation exchange resins* (RH^+) *: Resins which contain acidic functional groups (-COOH ,-*SO_3H *,etc) are capable of exchanging their* H^+ *ions with other cations .These are mainly styrenedivinyl benzene copolymers which on sulphonation/carboxylation become capable of exchanging their* H^+ *ions with other cations in water .*
   Eg . Amberlite IR-120 ,Dowex-50 .
   $2RH^+ + Ca^{2+} \rightarrow R_2Ca^{2+} + 2H^+$
b) *Anion exchanger resin* (ROH^- *):Those resins containing basic functional group (-*NH_2 *,= NH as hydrochloride) are capable of exchanging their anions with other anions in contact .The styrene-divinyl benzene or amine formaldehyde copolymers ,which contain amino/quaternary ammonium/quaternary sulphonium*

groups ,on treatment with dil NaOH becomes capcble of exchanging their OH^- ions with any other anion .

Eg .Amberlite 400 ,Dowex-3 .

$$ROH^- + Cl^- \rightarrow R^+Cl^- + OH^-$$

Diagram : The schematic diagram of the unit used for this purpose is as shown in the figure .



Process : *The hard water first passes through the cation exchange column when all the cations like Ca^{2+}, Mg^{2+} ,etc are removed (taken up by the resin) and an equivalent amount of H^+ is released from resin to water .Subsequently this water is passed through the anion exchange column when all the anions like Cl^- ,SO_4^{2-} ,etc. The H^+ and OH^- released respectively from cation exchanger and anion exchanger combine to give water .*

$$H^+ + OH^- \rightarrow H_2O$$

Thus water flowing out of the anion exchange column is free from all the cations and anions and becomes ion-free or deionized or demineralized .

When capacities of cation and anion exchangers to exchange H^+ and OH^- ions respectively are lost ,they are said to be exhausted .

These columns are regenerated by respective acid and alkali solutions as stated before .

The cation exchanger is regenerated by diluted H_2SO_4 and then washed with deionised water and washing (containing Ca^{2+} ,Mg^{2+} and Cl^- , SO_4^{2-} ions) is passed to the sink .

$$R_2Ca^{2+} + 2H^+ \rightarrow 2RH^+ + Ca^{2+}$$

The anion exchanger is regenerated by diluted NaOH and then washed with

deionised water and washing (containing Na^+ , Cl^- , SO_4^{2-} ions) is passed to the sink .The regenerated column is used again .

$$R'_2SO_4^{2-} + 2OH^- \rightarrow 2R'OH^- + SO_4^{2-}$$

***Advantages** of the method :*

1) *The process can be used to soften highly acidic or alkaline waters .*
2) *It produces water of very low hardness (upto 2 ppm) .*
3) *The water softened by this process is good for high pressure boilers .*

***Disadvantages** of the method :*

1) *The equipment is costly and more expensive chemicals are needed .*
2) *If water contains turbidity then the output of the process is reduced .*

Q4](b)(i) Find the acid value of the given oil whose 20 ml required 2.8 ml of N/10 KOH during titration .(Density of oil =0.86 g/ml) (3)

Ans :

Given : V_{KOH} = 2.8 ml , V_{Oil} = 20 ml , N = 1/10 , D_{Oil} = 0.86 g/ml

To Find : Acid Value

Formula : Acid Value = 56 x V_{KOH} x N /W_{Oil}

Solution : $W_{Oil} = D_{Oil} \times V_{Oil} = 0.86 \times 20 = 17.2$ g

Acid Value = 56 x 2.8 x 0.1 /17.2 mg of KOH

= 0.912 mg of KOH

The Acid Value of the given oil is 0.912 mg of KOH .

Q4](b)(ii) Write a short note on decay of concrete . (2)

Ans : *1) As concrete contains free lime (CaO) ,it is susceptible to chemical attack.*

2) In acidic water (pH<7) ,lime dissolves thus making concrete weak .Higher is the acidity ,more is the deterioration of concrete.

3) Lime is more soluble in soft water than in hard water .Hence deterioration of concrete is more in soft water than in hard water .

4) Lime of concrete is removed by sulphates and chlorides ,present in water .If concrete is soaked in mineral oil for sometime ,its resistance to abrasion decreases .If old sugar bags are used to carry sand or cover fresh concrete during curing ,the setting time of concrete is delayed and strength is greatly affected during first four weeks .

5) The most serious type of damage to concrete takes place in the presence of sulphates .The sulphates combine with tricalcium aluminate to form sulpho-aluminates ,which occupies more volume .This causes expansion ,thereby the life of concrete is greatly reduced .Such a danger can be avoided by eliminating tricalcium aluminate from the cement composition and manufacturing cement containing tetracalcium aluminoferrite ,instead of aluminate .

Q4](c) Natural rubber requires vulcanization .Give reasons .With appropriate reactions explain how the drawbacks are overcome. (4)

Ans : *The natural rubber has the following properties :*

1) *Its plasticity is greater than elasticity. It cannot sustain stress .Thus when stretched to a great extent ,it undergoes deformation permanently .*
2) *It has large water absorption tendency ,which makes it weak .*
3) *It has very low tensile strength .*
4) *Due to large percentage of unsaturation in its structure , it is easily attacked by various reagents such as HNO_3 ,conc . H_2SO_4 ,organic matter ,air ,oxygen ,ozone ,etc . and as a result gets gradually disintegrated .*
5) *It possesses high percentage of tackiness (property of developing stickiness on surface) which makes difficult to store the rubber stocks .*
6) *Durability and abrasion resistance of natural rubber is very low .*

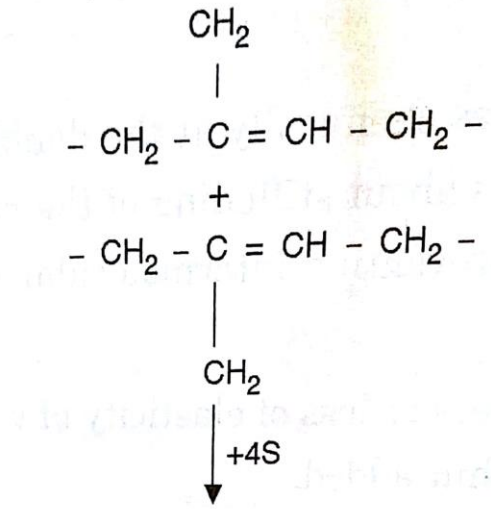
   Thus in order to improve the undesirable properties of natural rubber, it requires vulcanization .

   In vulcanization of rubber,crude rubber is mixed with vulcanizing agent like sulphur . Mixture is heated toabout 110-140◌C ,where sulphur chemically combines with rubber

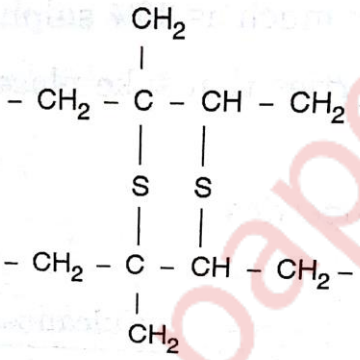
   .During vulcanization double bonds present in rubber structure break and ‘ S’ gets added to it forming cross links .

   Formation of cross links between C-atoms restrict intermolecular movement ,which gives stiffness (hardness) to rubber and decreases elasticity .The extent of hardness in vulcanised rubber depends on the amount of sulphur chemically added to rubber .

Straight Unsaturated Chains



Saturated Crosslinked Structure



The properties of rubber are changed considerably by vulcanization ,vulcanized rubber are of high molecular weights and less unsaturated than the raw rubber . The quantity of sulphur used varies upto 45 % ,soft rubber contains 0.5-5 % of sulphur ,hard rubber contains more than 30 % ,tyre rubber contains 3-5 % and battery case rubber contains 30 % of sulphur ..

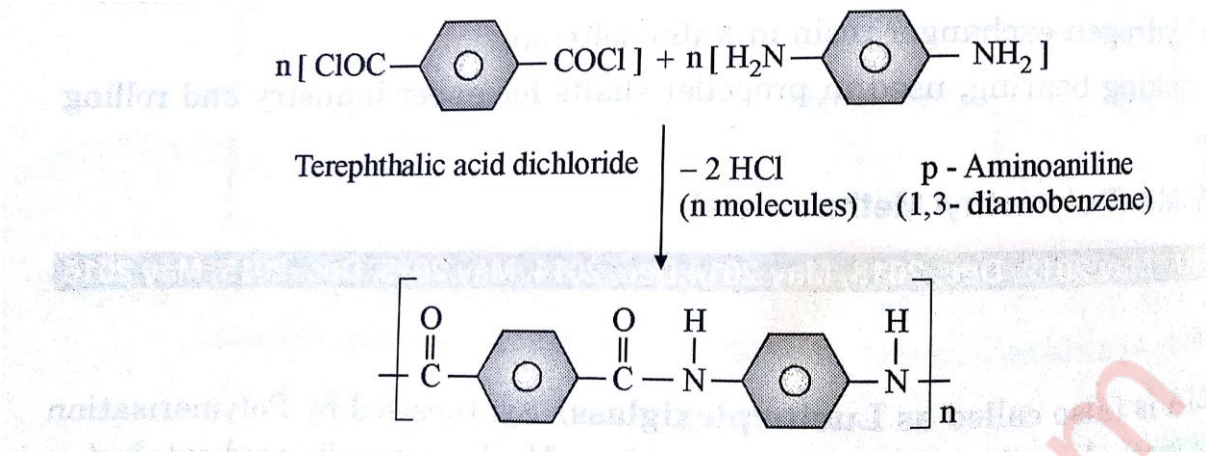
Q5](a) Write preparation ,properties and uses of following polymers : i)Kevlar ii)Silicone rubber iii)Buna S (6)

Ans :

(i)Kevlar

Preparation :

It is aromatic polyamide or polyaramide resin .It is prepared by polycondensation reaction between aromatic dichloride and aromatic diamines .



Properties :

1) *Exceptionally strong (5 times stronger than steel) .*
2) *High heat stability and flexibility .*
3) *Very high rigidity (due to delocalized bonding which causes benzene rings to be inflexible) .*
4) *High electron density in chains of Kevlar .*

Uses :

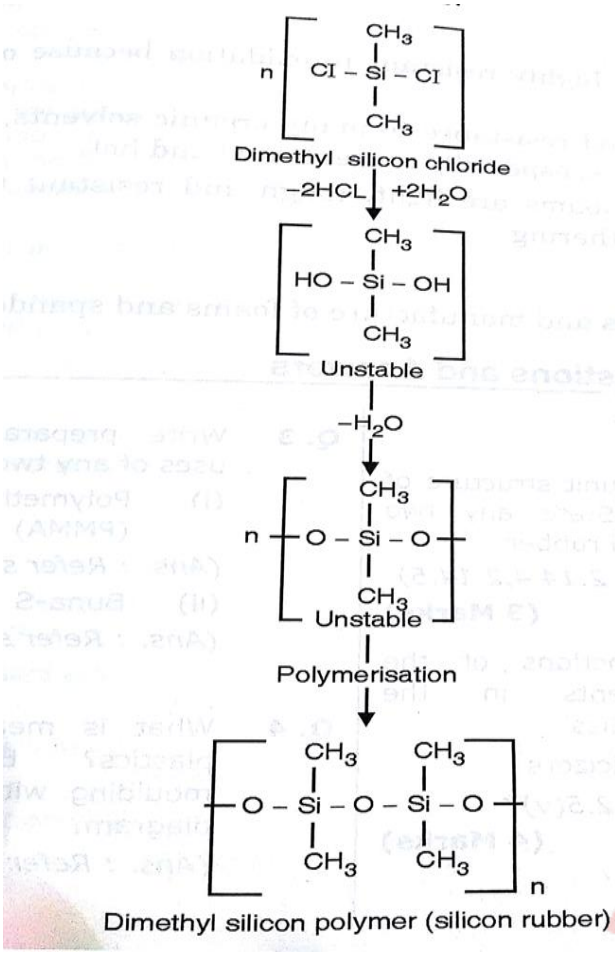
1) *Aerospace and Aircraft industry .*
2) *Making ropes ,cables ,protective clothings ,bullet proof vests,etc*
3) *Making motorcycle helmets .*
4) *Car parts . eg brakes ,tyres ,clutch linings ,etc .*

(ii)Silicone rubber

Preparation : It is a type of inorganic polymer where backbone contains atoms other than carbon ,linked together by covalent bonds (-Si-O-Si-). Silicon rubbers are produced by polymerization of dimethylsilicon hydroxide .

Properties :

1) *Exceptional resistance to prolonged exposure to sunlight ,weathering ,moist oils ,dilute acids and alkalis .*
2) *It shows flexibility in temperature from 90-250℃*
3) *When silicone rubber is kept at very high temperatures , it decomposes leaving behind non-conducting silica (SiO2) .*
4) *Non-toxic in nature .*
5) *Water repellent .*
6) *Shows good electrical insulating properties .*

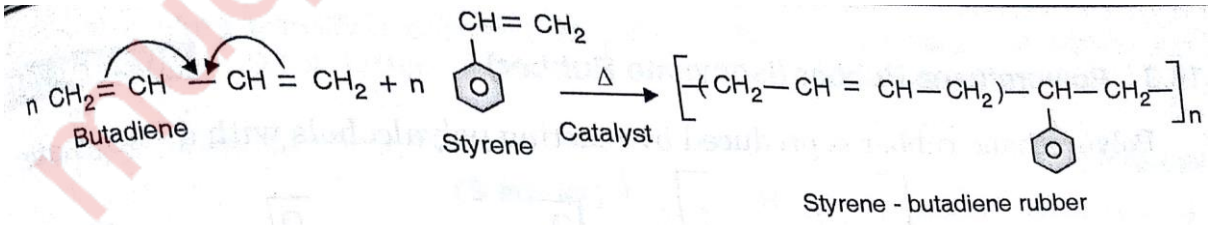


Uses :

1) *In fighter aircrafts .*
2) *For manufacture of tyres .*
3) *As adhesives in electronic industry .*
4) *For making artificial heart valves , padding in plastic surgery .*
5) *High voltage insulators .*

<u>(iii)Buna S :</u>

Preparation :Buna S / Styrene Butadiene rubber is synthesized from two monomers , namely i)Styrene (25% by weight) ii)Butadiene (75% by weight) .It is obtained by co-polymerization reaction in presence of Na as catalyst .



Properties :

1) *High abrasion resistance .*
2) *High load bearing capacity and resilience .*
3) *Readily it gets oxidized in presence of ozone .*
4) *It swells in oils and solvents .*
5) *It needs more accelerators for vulcanization .*

6) *It can be vulcanized by sulphur but the quantity required is less .*

Uses :

1) *It is used in motorcycle tyres .*
2) *It is used in shoe soles , foot wear components , floor tiles .*
3) *Wire and cable insulations , adhesives .*

Q5](b)(i) Explain Activated sludge method with the help of diagram (3)

Ans : ***Principle*** *-Here ,the adequate amount of O_2 or air is passed through sewage ,containing aerobes ,complete aerobic oxidation takes place .If this aeration is carried out with sludge from previous oxidation process ,the oxidation is faster .This sludge is known as activated sludge .*

Process : *The process involves the mixing of sedimented sewage with activated sludge and then it is sent to aeration tank. Microorganisms should be provided with nutrients such as N and P which are supplied in form of urea .The other nutrients such as K,Mg,Ca are generally present in waste .*

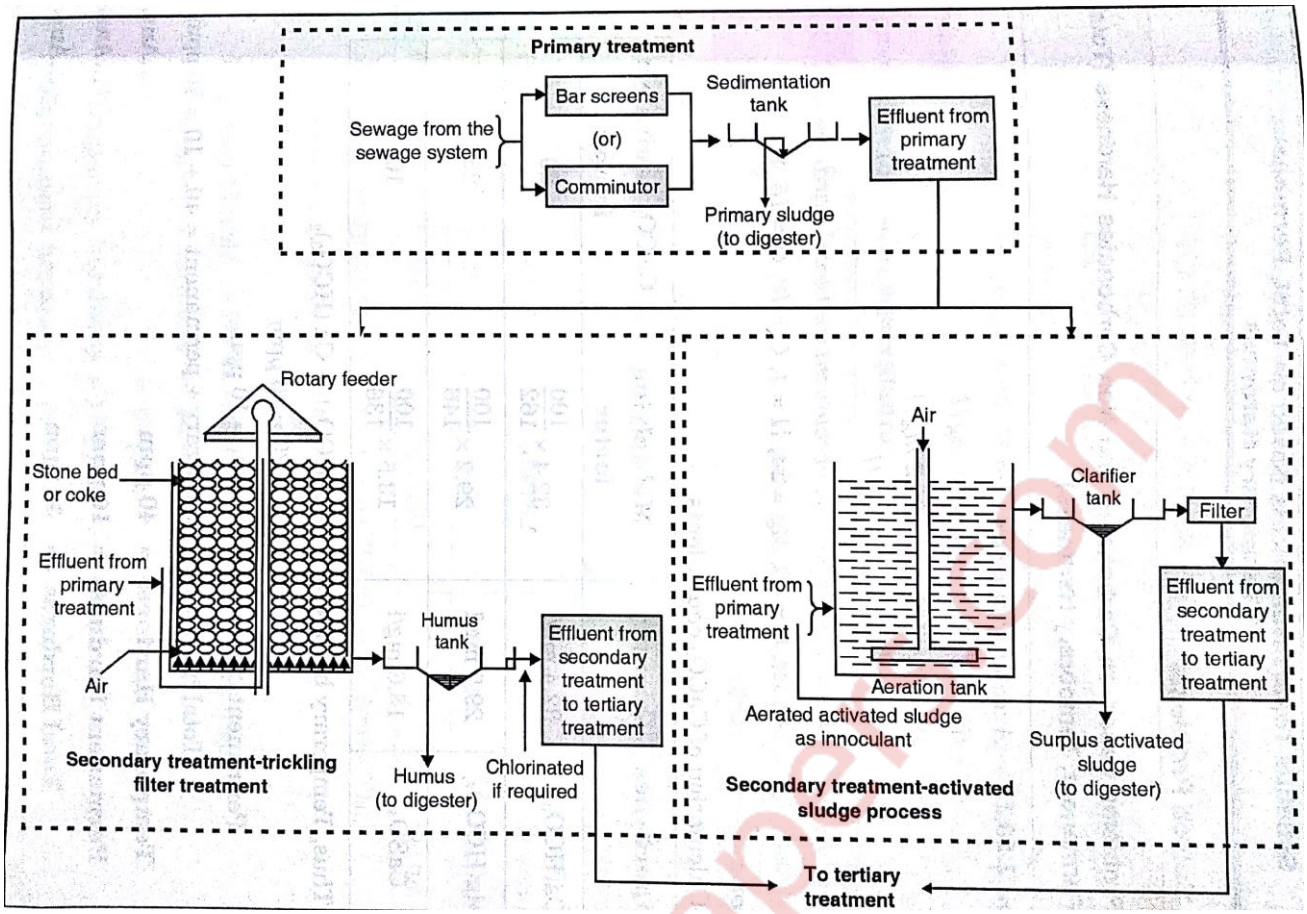
The efficiency of activated sludge is determined by pH ,temperature and redox potential.

It is kept for 5-6 hrs in order to have complete oxidation ,whereby C gets converted to CO2 ,N to NH3 and then to nitrites , nitrates .At least 0.5 ppm O2 must be present and pH is maintained between 6.5-9 .

After aeration ,the effluent is settled in settling tank ,where the sludge is settled and clean ,liuid is drawn off .A part of settled sludge can be used further for fresh batch of sewage and the process continues .

The remaining sludge is used for i)Land spreading ii)Dumping in sea iii)Digestion process : where sludge is kept in closed tank in absence of air for almost a month ,it gives methane which can be used as a fuel (400-600 Litres of fuel is generated per Kg of sludge) .

It is the most versatile method and BOD removal is upto 90-95 % .



Q5](b)(ii) What is grease ? What are the conditions in which greases are used ? ***(2)***

Ans : *Greases are semisolid substances consisting of an emulsion of soap with mineral/vegetable oil dispersed throughout the liquid .*

Greases/Semisolid lubricants are used in the following cases :

Where oil does not remain in position because of high load ,low speed ,intermittent operations ,sudden jerks ,etc .

In bearing and gears that work at high temperatures .

In situations where dripping or spurting of oil is undesirable eg.in machines preparing paper , textiles , etc .

Where bearing needs to be sealed against entry of dust , dirt , grit or moisture .

Q5](c) Draw the phase diagram of one component system and find out the number of degree of freedom along the curves and areas . ***(4)***

Ans : *1)**Curve OA** (Vapour Pressure curve)*

Along this curve , the two phases water and water vapour coexist in equillibrium .

Water system is one component system .

Hence there are two phases ,P=2 and one component ,C=1

$$F = C-P+2 = 1-2+2 = 1$$

The system is univariant .

*2)**Curve OB** (Sublimation curve)*

Along this curve , the two phases solid-ice and water-vapour coexist in equillibrium .

Hence , P = 2 and C =1

$$F = C-P+2 = 1-2+2 = 1$$

The system is univariant .

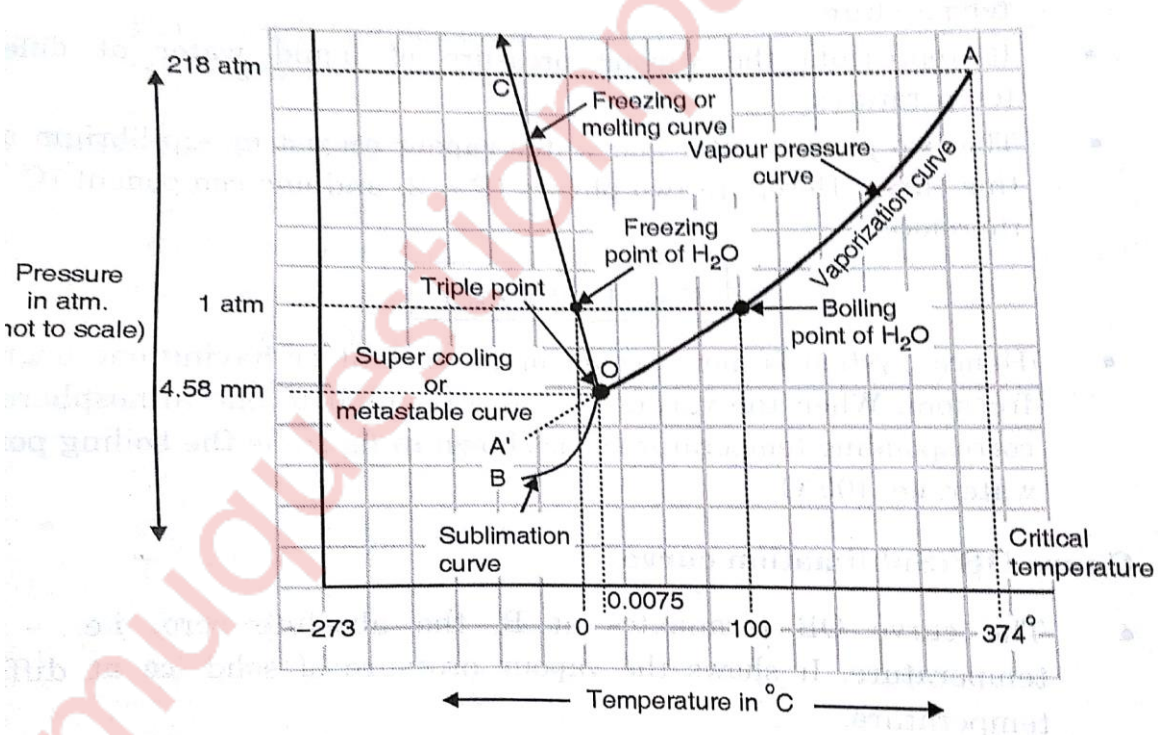
*3)**Curve OC** (Fusion curve)*

Along this curve ,the two phases solid-ice and water coexist in equillibrium . Hence ,

P =2 and C =1

$$F = C-P+2 = 1-2+2 = 1$$

The system is univariant .



4) Areas AOC , AOB and BOC

These areas between the curves show the conditions of temperature and pressure under which a single phase exists .

Area AOC represents conditions for liquid water ,i.e. water .

Area AOB represents conditions for gaseous phase ,i.e. water vapour .

Area BOC represents conditions for solid phase ,i.e. ice .

In all th three areas ,thereis one phase and one component ,

$$F = C-P+2 = 1-1+2 = 2$$

Hence , the system along the areas is bivariant .

Q6](a) What are lubricants ? Define lubrication .Explain Hydrodynamic lubrication mechanism with neat diagram . (6)

Ans : *The lubricants are defined as the chemical substances which reduce friction between two sliding/moving metal surfaces and thereby reduce wear and tear of machines .The lubricant keeps the two surfaces apart ,thus the frictional resistance reduces .*

The process of reducing frictional resistance between moving/sliding surface ,by introduction of lubricants in between them is called lubrication .

Hydrodynamic Lubrication :

Fluid film lubrication is done by introducing sufficiently thick layer of liquid lubricant at least 1000˚a thick in between the moving or sliding surfaces .Lubricant film first of all covers the irregularities of the sliding surfaces and then forms a thick layer between them .This thick layer of lubricant avoids metal to metal contact and reduces frictional resistance and hence wear and tear .The coefficient of friction is as low as 0.001-0.03 .

In this case lubricant film acquires the motion of machine and hence the resistance to movement of moving parts is only due to the internal resistance between the particles of the lubricant moving over each other .

Thus in fluid film lubrication ,lubricant used is liquid lubricant with optimum viscosity ,because if viscosity is more ,it will resist smooth movement of machine decreasing the efficiency of machine .If viscosity is less ,it may squeeze out from machine parts leaving no lubrication in between the machine part which will make metallic surfaces to come in direct contact resulting in the generation of heat and wear and tear .

Hydrodynamic lubrication occurs in the case of a shaft running at a fair speed in a well lubricated bearing with not too high road .If the centre line of shaft is displaced from the journal axis ,a wedge shaped lubricant film can be drawn in .

According to hydrodynamic theory , development of sufficient pressure is generated to keep shaft and journal (bearing) apart and the shaft floats in the lubricant .

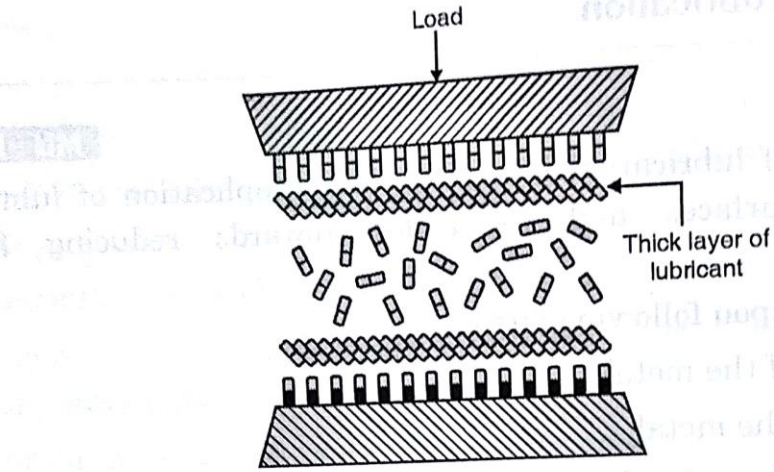
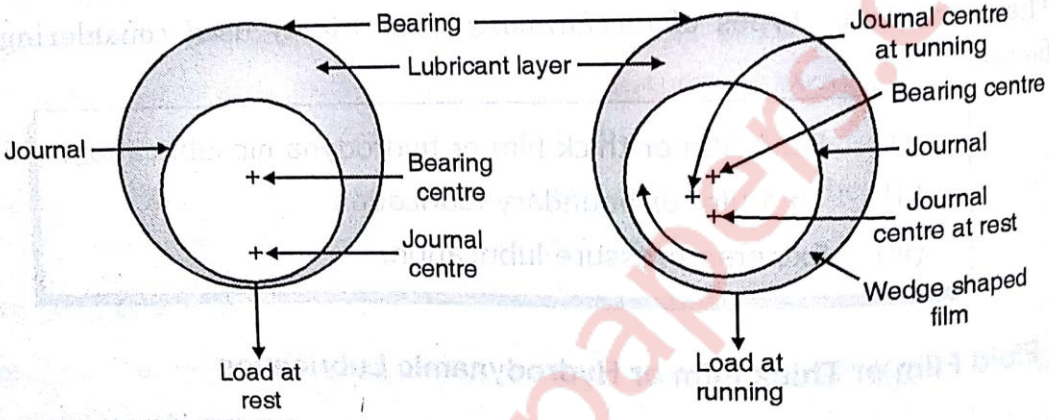


Fig. 3.3.1(a) : Hydrodynamic lubrication or fluid film lubrication



Such lubrication is preferred for machines moving with light load and high speed .Therefore fluid film lubricants are used in case of delicate instruments and light machines like watches ,clocks ,guns ,sewing machines ,scientific instruments ,etc .

Q6](b)(i) Define ***(3)***

a) Phase b) Component c) Degree of freedom

Ans : *a) The homogeneous ,physically distinct and mechanically separable portion of a system ,which is separated from other such parts of the system by definite boundary surfaces is called as* ***Phase[P] .***

b) The smallest number of independently variable constituents taking part in the state of equillibrum by means of which the composition of each phase can be expressed directly or in the form of chemical equation are called as ***Components*** *of a system* ***[C] .***

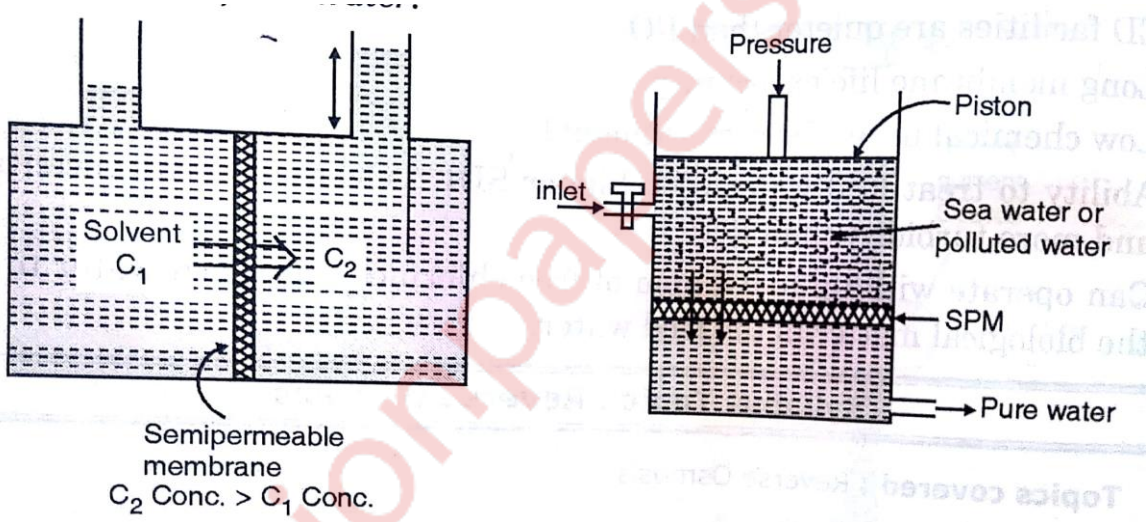
*c****) Degree of freedom*** *or Variance* ***(F****) is the minimum number of independently variable factors such as temperature , pressure and components of a system which have to be arbitrarily specified in order to represent perfectly the conditions of equilibrium .*

Q6](b)(ii) Write a short note on Reverse Osmosis . *(2)*

Ans : *When two solution of unequal concentration are separated by semipermeable membrane ,flow of solvent takes place from dilute to concentrated section due to osmosis .If hydrostatic pressure which is slightly higher than the osmotic pressure is applied on concentrated section of solution ,the flow of solvent reverses i.e solvent moves from high concentration to low concentration across the membrane .This is known as Reverse Osmosis (RO) .*

In RO ,pure solvent (water) is separated from its contaminants .

In reverse osmosis ,a pressure of 200-800 psi is applied to seawater/impure water so that pure water is forced through semipermeable membrane ,leaving behind dissolved solids . Membranes used in this process are thin films of cellulose acetate fixed to either side of perforated tube and polymethyl methacrylate PA fibre .



The use of this process is getting water for high pressure boilers and for many industrial applications like car wash water reclamation ,wastewater treatment ,etc .

Q6](c) Explain laser ablation method for production of CNT's. *(4)*

Ans : *1) CNT's are prepared by dual pulse laser .*

2) Quartz tube containing Argon and graphite mixed with (Co + Ni) in 1: 1 ratio is vapourised to 1200˚C , followed by heat treatment in a vacuum at 1000˚C to get C60 and other fullerenes .

3) The use of two successive laser pulses minimizes the amount of carbon deposited as soot .

4) The second laser pulse breaks up the larger particles ablated by the first one , and feeds them into the growing nanotube structure .

5) The material produced by this method appears as a mat of "ropes ", 10-20 nm in diameter and upto 100 µm or more in length .

6) Each rope is found to consist primariy of a bundle of single walled nanotubes ,aligned along a common axis .

7) By varying the temperature ,the catalyst composition ,and other process parameters ,the average nanotube diameter and size distribution can be varied .

8) Argon then sweeps C-atoms from high temperature zone to colder copper collector on which they condense into nanotubes .

The limitations of laser ablation method are :

1) *Both methods involve evaporating he carbon source ,hence to increase production to the industrial level using these approaches is difficult .*
2) *Both methods produce CNT's in highly tangled forms ,mixed with unwanted forms of carbon or metal species .*
3) *Hence ,CNT's produced are difficult to purify ,manipulate and assemble for building nanotube device architectures for practical applications .*

MUMBAI UNIVERSITY PAPER SOLUTION

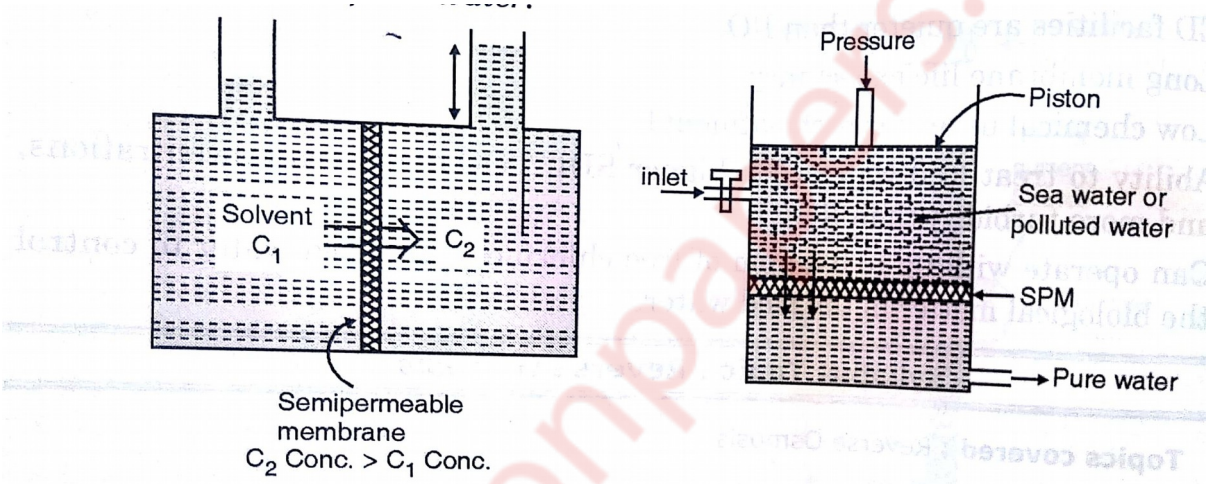
APPLIED CHEMISTRY I MAY 2019

Q1)(a) Write a brief note on Reverse Osmosis . (3M)

Ans : 1. When two solution of unequal concentration are separated by semipermeable membrane, flow of solvent takes place from dilute to concentrated section due to osmosis.

2. If hydrostatic pressure, which is slightly higher than the osmotic pressure is applied on the concentrated section of solution, the flow of solvent reverses, i.e. solvent moves from high concentration to low concentration across the membrane. This is known as Reverse Osmosis (RO).

3. In RO, pure solvent (water) is separated from its contaminants.



4. In one section, pressure of 15-40 kg is applied to seawater/impure water so that pure water is forced through semi permeable membrane, leaving behind dissolved solids.

5. This process is used for getting water for high pressure boilers.

6. The advantage of reverse osmosis process is that it removes ionic, non-ionic, colloidal, high molecular weight organic matter. It also removes colloidal silica which is not removed by filtration.

Q1)(b) Write methods of preparation, properties and uses of polyurethane rubber . (3M)

Ans: Preparation:

Properties :

1. Polyurethane rubber has high resistance to oxidation because of saturated character.

2. Good resistance to many organic solvents.

3. It gets attacked by acids and alkalies (hot and concentrated).

4. Polyurethane is light, tough, resistant to heat, abrasion chemicals, weather, etc.

Uses :

1. For manufacture of foams, spandex fibres.

2. For surface coatings.

3. For shoe soles.

Q1)(c) Define and discuss giving significance of the following (3M)

(i) Viscosity (ii) Cloud Point

Ans : i) Viscosity

Viscosity is defined as the property by virtue of which a liquid or fluid (oil) offers resistance to its own flow.

Significance of Viscosity :

1. A lubricating oil selected for a job should have viscosity as high as possible.

2. It helps in achieving desired results to control wear and tear of machine parts.

3. It also helps to decide about the addition of blending agents to improve the property of lubricating oil.

ii) Cloud Point :

Cloud point is defined as the temperature at which the oil becomes cloudy or hazy in appearance.

Significance of cloud point :

1. It helps us to know the lowest temperature upto which the oil can be suitable as a liquid lubricant.

2. The lubricating oils used in machines working at low temperatures should have lower cloud point than the working temperature.

3. Knowledge of this can help the machines to be prevented from getting jammed in places from cold region or during winter season in some areas in India.

Q1)(d) Write advantages and drawbacks of Phase Rule . (3M)

Ans : Advantages of phase rule :

1. It applies to physical as well as chemical phase reaction.

2. It provides a convenient basis for classification of equilibrium states of systems with the help of phases, components and degree of freedom.

3. It applies to microscopic systems.

4. It indicates that different systems having the same degrees of freedom behave in a similar fashion.

5. It helps in predicting the behaviour of a system under different conditions of the governing variables.

6. It helps in deciding whether the given number of substances together would exist in equilibrium under a given set of conditions or whether some of them will have to be inter converted or eliminated.

7. Phase rule does not take any cognizance of the nature of the amounts of substances present in the system.

Disadvantages of phase rule :

1. Phase rule can be applied for systems in equilibrium only.

2. It is not of much help in case of systems which attain the equilibrium state very slowly.

3. It applies to a single equilibrium state. It does not indicate the other possible equilibria in the system.

4. Phase rule considers only the number of phases but not their quantities.

5. All the phases of the system must be present under the same conditions of temperature, pressure and gravitational forces.

6. The solid, liquid phases should not be so finely sub-divided as to bring about deviation from their normal values of vapour pressure.

Q1)(e) A hard water sample contains following impurities (in mg/L) (3M)

$Mg(HCO_3)_2$ = 150 ; NaCl = 77 ; $CaCl_2$ = 150 ; $MgSO_4$ = 85 .

Calculate temporary, permanent and total hardness of the given sample of water.

Ans :

Salt	Concentration	Multiplication Factor	$CaCO_3$ Equivalents	Hardness
$Mg(HCO_3)_2$	150	150 X $\frac{100}{146}$ = 102.73	102.73	Temporary
NaCl	77	-	-	Doesn't impart hardness
$CaCl_2$	150	-	-	Doesn't impart hardness
$MgSO_4$	85	85 X $\frac{100}{120}$ = 70.83	70.83	Permanent

Temporary Hardness = 102.73 ppm.

Permanent Hardness = 70.83 ppm.

Total Hardness = 173.56 ppm.

Q1)(f) Discuss the effect of temperature on polymers . (3M)

Ans :

1. The hard and brittle state is the glassy state and soft-flexible state is the viscoelastic state. If the viscoelastic state of polymer is heated further, the polymer becomes a viscous liquid and can flow. This state is known as viscofluid state.
2. Below T_g the molecules in polymer do not move apart and do not have movements within the molecular chains. Therefore stress transfer property is lost and polymer below T_g is brittle.
3. Above the T_g , the chain segments within the long molecules move locally like a person moving his hands, legs, leaning forward-backward but standing at one place, during exercise. Thus the polymers in the viscoelastic state have flexibility or stress transfer property.
4. Above the temperature T_m ; the kinetic energy of the polymer molecules is high enough to cause movement within the chain segments as well to move from one position to another. Therefore this state has flow character like liquids .
5. Some polymers have thermal degradation at and above T_m .

Polymer	T_g ℃	T_M ℃
Polyethylene	-125	115
Polypropylene	-18	175
Polystyrene	100	240
Polyvinyl chloride	80	212
Polyacrylonitrile	97	241

Q1)(g) Why gypsum is added during manufacturing of the cement? (3M)

Ans : 1) When water is added to cement, tricalcium aluminate (C_3A) starts setting first.

2) C_3A combines with water very rapidly with evolution of large amount of heat.

$$C_3A + 6H_2O \rightarrow C_3A.\ 6H_2O + \Delta\ .$$

3) If gypsum is added to cement, it doesn't set very quickly by forming insoluble tricalcium sulphoaluminate ($3CaO.Al_2O_3.xCaSO_4.7H_2O$).

4) Thus it acts as retarding agent for early setting of cement.

$$3CaO.Al_2O_3 + xCaSO_4.7H_2O \rightarrow 3CaO.Al_2O_3.xCaSO_4.7H_2O$$

C_3A Gypsum Tricalcium Sulphoaluminate (Insoluble)

This reaction prevents high concentration of alumina and is retarding initial set of cement.

Q2)(a) A hard water sample has following composition **(6M)**

CaSO4 = 170 mg/L ; Ca(HCO3)2 = 130 mg/L ; Mg(HCO3)2 = 95 mg/L ; HCl = 58 mg/L ; KNO3 =75 mg/ L

Calculate lime (90% pure) and soda (95% pure) required for complete softening of one million litres of above hard water sample .

Ans :

Salt / Impurity	Quantity	Multiplication Factor	$CaCO_3$ Equivalents	Requirement of Lime or Soda
$CaSO_4$	170	$\frac{100}{136}$	125	S (Permanent)
$Ca(HCO_3)_2$	130	$\frac{100}{162}$	80.24	L (Temporary)
$Mg(HCO_3)_2$	95	$\frac{100}{146}$	65.07	2L (Temporary)
HCl	58	$\frac{100}{136}$	42.64	L+S
KNO_3	-	-	-	-

Lime Requirement = $\frac{74}{100}$ [Temporary Ca^{2+} + 2 X Temporary Mg^{2+} + H^+] X $\frac{Volume\ of\ water}{1000000}$ X 100/%purity

$$= \frac{74}{100} [80.24+2X65.07+42.64] X \frac{1000000}{1000000} X \frac{100}{90}$$

= 208.04 kg .

Soda Requirement = $\frac{106}{100}$ [Permanent Ca^{2+}+H^+] X $\frac{Volume\ of\ water}{1000000}$ X $\frac{100}{\%\ of\ purity}$ kg

Soda Requirement = $\frac{106}{100}$ [125+42.64] x $\frac{1000000}{1000000}$ x $\frac{100}{95}$ kg .

Soda Requirement = 187.05 kg .

Ans : Soda requirement of the water sample is 208.04 kg and lime requirement is 187.05 kg.

Q2)(b)(i) What is glass transition temperature ? **(3M)**

Ans:

1)There is a temperature boundary for almost all amorphous polymers and many crystalline polymers, only above which the substance remains soft, flexible, rubbery and below which it becomes hard, brittle and glassy.

Eg. An ordinary rubber ball if cooled below -70°C becomes so hard and brittle that it will break into pieces like a glass ball falling on a hard surface.

2)The temperature below which a polymer is hard, brittle and glassy and above which it is soft and flexible is called as 'Glass Transition Temperature'(Tg).

3)A polymer is not preferred to be used at temperatures below its glass transition temperature since it becomes hard, stiff and brittle.

4)A polymer material should have much lower Tg than the operating temperature.

Eg. polymers to be used for refrigerators, air conditioners or used in cold countries should have lower Tg, so that they do not break during use.

5)At glass transition temperature, the internal energy of the polymer increases to that extent where chain segments of a polymer molecule just start leaving their lattice sites.

(ii) What are semi solid lubricants? Under which conditions they are used? (2M)

Ans :

1) Semisolid lubricant consists of an emulsion of soap with mineral/vegetable oil , with or without addition .It consists of soap dispersed throughout liquid lubricating oil .
2) The semisolid lubricants are used under working conditions such as ,
   i) Low speed and high pressure, and high temperature (upto 80 ℃) .
   ii) Machineries used in textile mills, paper and food product manufacturing, etc. where spilling and spurting of lubricant is harmful to the product .
   iii) Machines where liquid lubricant cannot be maintained in position due to intermittent operations of machine parts such as shaft , etc .
   iv) In places where the bearing has to be sealed against entry of dirt, water , dust and grit .

Q2)(c)Explain briefly Carbon nanotubes by CVD method . (4M)

Ans :

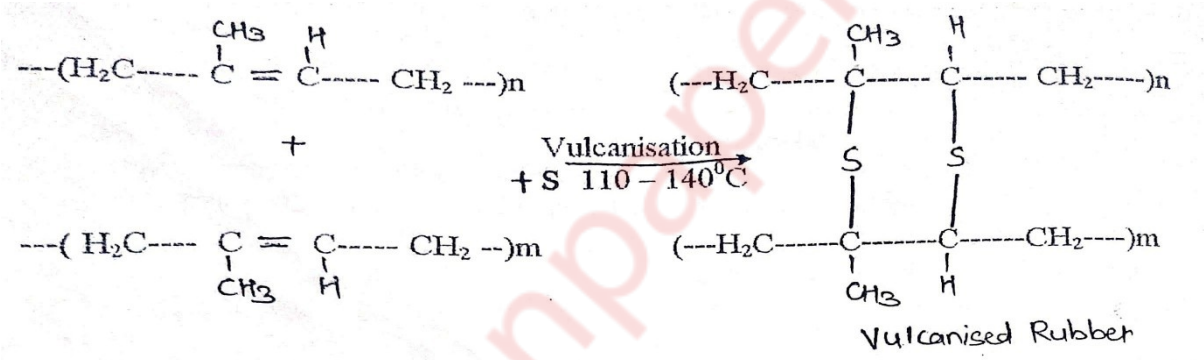
1. It is a method of preparation of mostly single walled nanotube .
2. It is obtained by chemical vapour of hydrocarbon over metal catalyst (such as Co, Fe) supported on silica or zeolite.
3. The carbon deposition activity depends upon
   i) Co content of the catalyst
   ii) pH in catalyst preparation
4. Ethylene/methane is used in reaction with temperature of 545 ° C .For nickel-catalysed CVD and 900 ℃ for an uncatalyzed process to give single walled nanotube. Resultant carbon tubes have open ends. It is used to obtain nanotube chips containing isolated single walled nanotubes at controlled locations .
5. High yields of single walled nano tubes have been obtained by catalytic decomposition of H_2/ CH_4 mixture over well dispersed metal particles such as Co, Ni or Fe on MgO at 1000 ℃ .
6. Fullerenes and bundles of single walled nanotubes are obtained on carbonyl zeolite catalysts.

7. Method is established for last 20 years and has been in use for producing various carbon materials such as carbon fibres, filaments, etc .

Q3)(a) What is natural rubber? What is vulcanization of rubber? Compare the properties of vulcanized rubber over natural rubber . (6M)

Ans :

1) Natural rubber is a high polymer which has elastic properties and can be stretched to 4-10 times of its original length and as soon as stretching force is removed, it returns to its original length.
2) Natural rubber is obtained from soaps of range of rubber plants like Havea Brasillians. The rubber latex is obtained by making in cis ions in the bark of rubber trees and allowing the soaps to flow into small vessels. Tapping is done at intervals of 6 months.
3) Latex is diluted to contain between 15-20% of rubber and filtered to remove any dirt present in it.Then it is treated with acetic/formic acid where rubber is coagulated .



Vulcanization of rubber :To improve properties of rubber, it is compounded with substances like sulphur,H_2S, benzoyl chloride, etc .Generally, vulcanization is done by heating low rubber with sulphur to 110-140 ℃ .The added sulphur combines chemically at double bonds forming cross-linked structure which gives stiffness to rubber molecule .

Properties of vulcanized rubber over natural rubber :

1) It has good tensile strength and extensibility when tensile force is applied.
2) It possesses low water absorption tendency .
3) It has higher resistance to oxidation and to abrasion.
4) It has much higher resistance to wear and tear.
5) It is a better electrical insulator.
6) It is resistant to organic solvent, fats and oils.
7) It is easy to manipulate the vulcanized rubber to produce the desired shapes.
8) It's useful temperature range is 40-150 ℃.
9) It's tackiness is only slight.

Q3)(b)(i) What is 'Triple Point'? Write the condition for which triple point exists for water system. (3M)

Ans:

1) The point where all the three curves ,i.e. Vapour Pressure Curve, Sublimation Curve and Fusion Curve meet is called as the 'Triple Point' .At triple point 'O' , all the three phases solid, liquid and vapour are simultaneously in equilibrium .
2) This triple point occurs at 0.0075 ℃ and 4.58 mm Hg pressure. Since there are three phases and one component, therefore
   F = C - P + 2
   F = 1 - 3 + 2
   F = 0 .
3) The system at triple point is zero variant or nonvariant. Thus, neither pressure nor temperature can be altered .

(ii) What are Fullerenes? Write important properties and uses of Fullerene. (2M)

Ans :

1. Fullerenes are hollow, pure carbon molecules in which carbon atoms lie at the vertices of a polyhedron with 12 pentagonal faces and any number of hexagonal faces .
2. Each carbon is bound to other three carbons in a pseudo-spherical arrangement consisting of alternating pentagonal and hexagonal rings, in the manner of a soccer ball .

Properties of Fullerenes :

i) All atoms lie on surface of sphere symmetrically as seen in truncated icosahedrons .
ii) With changes in temperature, fullerene shows variation in behaviour and structure .
iii) Fullerene 60 resembles to an electrophile in chemical reactions.
iv) Fullerene exhibits ferromagnetism and can be methylated, hydrogenated, ammoniated and fluorinated .

Uses of Fullerenes :

a) Fullerenes are used in synthetic, pharmaceuticals and industrial applications, as inhibitor of HIV protease .
b) They can be useful in light emitting diodes (LED), molecular electronics and computing, as lubricants, rocket fuel, etc .

Q3)(c) In the process of determination of hardness, a standard hard water sample was prepared by dissolving 2.5g $CaCO_3$ and making solution upto one litre.

50 ml of above hard water required 45 ml of EDTA. 50 ml of unknown hard water sample was titrated it required 30 ml of same EDTA. The unknown hard water sample was boiled and filtered. 50 ml of this boiled sample required 20 ml of EDTA. Calculate hardness of all types of unknown hard water sample. (4M)

Solution:

Given data: Concentration of SHW = 1g/lit

Quantity of SHW (1 g/lit) = 50 ml

Quantity of EDTA consumed by 50 ml SHW = 45 ml

Quantity of hard water sample = 50 ml

Quantity of EDTA consumed = 30 ml

Quantity of EDTA consumed after boiling = 20 ml

Hardness = ?

Standardization of EDTA:

Standard hardwater has 1g I.e. 1 X 1000 = 1000 mg of $CaCO_3$ equivalent hardness per litre

= 1000 mg/lit

= 1000/1000 = 1 mg/ml $CaCO_3$ equivalent hardness

50 ml SHW = 50 X 1 mg $CaCO_3$ = 50 mg $CaCO_3$

45 ∴ ml SHW = 50 ml SHW = 50 mg $CaCO_3$

1 ml EDTA = 50/45 = 1.11 mg of $CaCO_3$ equivalent hardness

Calculation of total hardness:

50 ml Hard water sample = 30 ml EDTA = 30 X 1.11 mgs of $CaCO_3$ per 50 ml

= 33.3 mgs of $CaCO_3$

∴Total Hardness per litre = 666 mgs of $CaCO_3$

Calculation of permanent hardness:

50 ml boiled water = 20 ml of EDTA = 20 X 1.11 mgs of $CaCO_3$ in 100 ml

= 22.2 mgs of $CaCO_3$

∴ per litre = 444 mgs of $CaCO_3$

$H_{Temporary} = H_{Total} – H_{permanant}$ =666 – 444 = 222 mgs of $CaCO_3$

Total Hardness = 666 ppm

Permanent Hardness = 222 ppm

Temporary Hardness = 444 ppm

Q4)(a) Draw a neat labelled diagram and explain zeolite process of softening of hard water. Discuss its merits and demerits. (6M)

Ans :

1) The zeolite, i.e. the boiling stone, is a group of naturally occurring minerals which release their water of hydration in the form of steam. Eg Na-zeolite $Na_2O.Al_2O_3.xSiO_2.yH_2O$
   X = 2-10 , Y = 2-6
2) Thus zeolite is hydrated sodium aluminosilicate, capable of exchanging their sodium ions for the hardness producing ions in water.
3) Zeolites are of two types :
   i) Natural Zeolites : These are non-porous. These are derived from green sands by washing, heating and treating with caustic soda. Eg Natrolite .
   ii) Synthetic Zeolites : These are porous and gel structures .It is prepared by heating together china clay ,feldspar and soda ash, following by cooling and granulating the resultant mass or prepared by heating solutions of Na-silicate, $Al_2(SO_4)_3$ and $NaAlO_2$.These have higher exchange capacity but less durable.
4) If water containing Ca^{2+}, Mg^{2+} ions are passed over zeolite bed, Ca^{2+}, Mg^{2+} are exchanged for sodium as
   a) $CaCl_2 + Na_2Ze \rightarrow CaZe + 2NaCl$
   b) $MgSO_4 + Na_2Ze \rightarrow MgZe + Na_2SO_4$

   Here Na – Zeolite is converted into Ca^{2+} and Mg^{2+} Zeolites whereas water becomes free from $Ca^{2+}$and Mg^{2+} but richer in sodium salts.

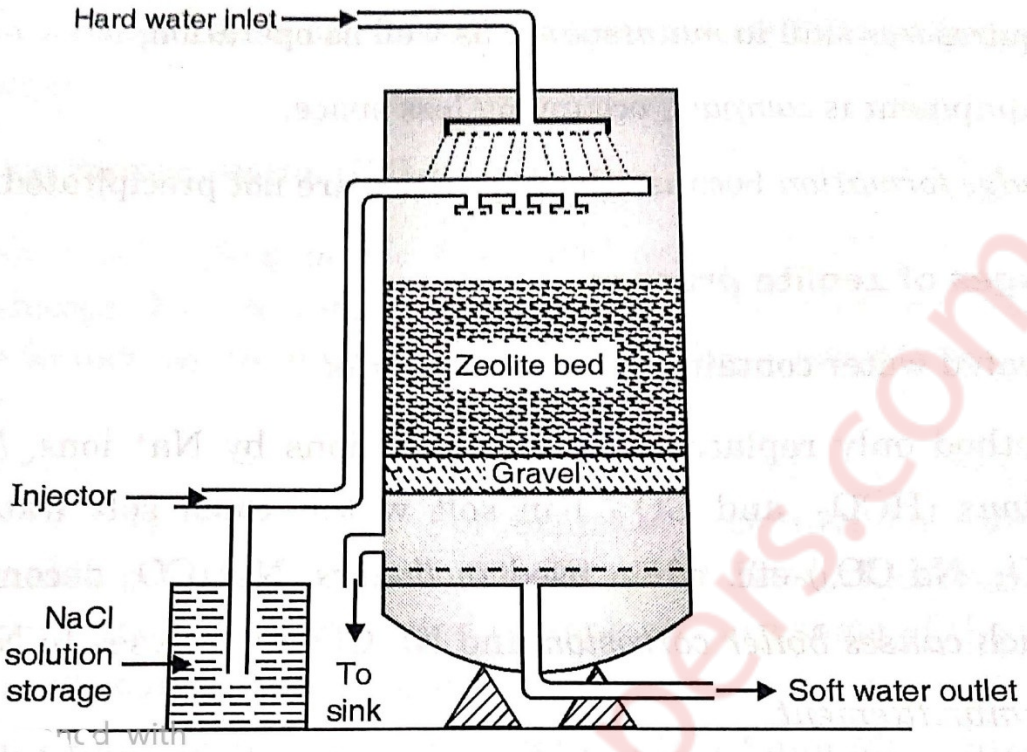


Fig. 1.11.3 : Zeolite Softner

5) Regeneration: When zeolite is exhausted, it is regenerated by washing bed with concentrated brine solution (NaCl) .

   $CaZe/MgZe + 2NaCl \rightarrow Na_2Ze + CaCl_2/MgCl_2$

6) Process: For softening of water, hard water is percolated at a specific rate through zeolite bed kept in a cylinder. The calcium and zeolite ions are retained by zeolite bed and water becomes rich in sodium salts.
   $Na_2Ze + Ca(HCO_3)_2 \rightarrow CaZe + 2NaHCO_3$
   $Na_2Ze + MgCl_2 \rightarrow MgZe + 2NaCl$

Merits of using zeolite:

1) It removes hardness almost upto 10 ppm.

2) The equipment is compact.

3)No sludge formation takes place. Hence it is clean operation.

4)It requires less time for softening.

5)It removes Fe and Mg from water.

Demerits of using zeolite :

1) The treated water contains more sodium salts.

2) The method only replaces calcium and magnesium ions by sodium ions, but leaves all acidic ions in soft water.

3) Such soft water containing carbonates and bicarbonates is used in boilers, sodium bicarbonate decomposes to give carbon dioxide which causes boiler corrosion and sodium carbonate hydrolyses to sodium hydroxide, causing caustic embrittlement.

Q4)(b)(i) 10g of lubricating oil was heated with 25 ml of 50% alcohol, the resultant mixture required 25 ml of N/10 KOH. The blank reading was obtained to be 8 ml of same KOH. Calculate acid value of the lubricating oil . (3M)

Solution:

Given : Weight of oil = 10 g , Normality of KOH = 1/10=0.1 N , Volume of KOH = 25 ml

To Find : Acid Value

$$\text{Acid Value} = \frac{Volume\ of\ KOH\ X\ Normality\ of\ KOH\ X\ 56}{Weight\ of\ oil \in grams} .$$

$$\text{Acid Value} = \frac{25\ X\ 0.1\ X\ 56}{10} .$$

Acid Value = 14 mgs of KOH .

Ans : The Acid Value of the oil is 14 mgs of KOH .

Q4)(b)(ii) Explain the terms : (a) Concrete (b) RCC (2M)

Ans : Concrete

1) Concrete is a building and structural material obtained by mixing a binding material (cement/lime), inert mineral aggregates (such as sand, crushed stone, gravel, bricks) and water in suitable proportion and which can be readily worked or moulded into almost any desired shape which is compact, rigid, strong and durable .
2) Concrete is of two types , lime concrete and cement concrete .
3) More amount of cement in concrete gives water proofness to concrete. Next to steel, it is important in construction works .

RCC

1) RCC (Reinforced Concrete Construction) is the combination of steel and concrete structure which has high load-bearing capacity .
2) Plain concrete has a great compressive strength but little ability to withstand tension. Hence when steel and concrete are together used, embedded steel takes up tension and strength is given by concrete .
3) RCC is easy to make and cast into desired shape which can bear any type of load .

Q4)(c) Explain the importance of polymers in the field of surgery and medicine . (4M)

Ans :

1) Biomaterials are materials that can be implanted in the body to provide special prosthetic functions or used in diagnostic, surgical, therapeutic applications, without causing adverse effect on blood and other tissues.
2) These materials are versatile and can be modified to suit specific body functions.
3) Biomaterials should possess following characteristics:
   i) Purity and reproducibility
   ii) Easy sterilization and should not be toxic or allergic.
   iii) Optimum physical and chemical properties.
   iv) Should be fabricated into desired shape or form.
   v) Should be chemically inert and not affect body fluids.
   vi) Should be flexible.
4) Applications of polymeric biomaterials:
   i) To construct artificial replacement for human organs:
   Some man made polymers are used for complete replacement of organs like artificial heart, heart lung machines, artificial kidneys, legs, artificial faces, in plastic surgery, etc.
   ii) To repair, sustain and augment function of organs:
   Polymers find application in clothing, glasses for sight, dentures, vascular prostheses, heart valves, pace makers, meshes and forms for reconstructive surgery, cannulae for haemodialysis, etc.
   iii) To provide biochemical function:
   Some polymers have specific and definite chemical interaction with the biochemistry of body.
   Eg. Synthetic ion exchange resins for absorbing metaboiles from blood, synthetic polyelectrolytes capable of absorbing specific viruses, polymers for production of interferon (antiviral agent), synthetic polypeptides, enzymes having higher biological activity.
   Silicone Rubber is used in heart valves, plastic surgery.
   Polyurethane rubber: artificial rubber, reconstructive surgery.
   PMMA: contact lenses, dental restoratives.
   PVC: disposable syringes.
   Polylactic acid: dialysis media, drug delivery, plastic surgery.

Q5)(a) What is compounding of plastic? Explain the role played by various constituents used during manufacturing of plastic . (6M)

Ans :

1) Compounding of plastic consists of preparing plastic formulations by mixing or blending polymers and additives in a molten state, these blends are automatically dosed with fixed setpoints usually through feeders/hoppers.
2) The moulding constituents of plastic are :
   i) Binders e.g. resins
   Binders hold other constituents together during manufacture and influence the properties of plastic. Usually natural or synthetic resins or cellulosic derivatives are used as binders. Resins can be either thermoplastic or thermosetting.
   ii) Fillers or extenders

Fillers are those substances which reduce the cost per kg of polymers and introduce some specific property in resin like better tensile strength, hardness, finish, workability, opacity etc to the plastic material.
Eg quartz, mica improve hardness.
Ba salts, when introduced, make the sheet impervious to X-rays.

iii) Pigments or dyes or colouring agents
These impart desired colour to plastic. Organic dyestuffs and inorganic pigments are used for this in small proportion.

iv) Catalysts or accelerators
These are added only to thermosetting resins. These substances accelerate the process of cross linking of polymer to form infusible cross linked form during moulding operations.
Eg. hydrogen peroxide, benzoyl peroxide, metallic oxides.

v) Plasticizers
These are substances that are added to resins to increase plasticity and flexibility. These substances reduce intermolecular force of attraction between macromolecules of resin.
Eg. oils (non-drying type), camphor, esters of stearic/phthalic acid .

vi) Lubricants
These when added make moulding of plastic easier and impart glossy, flawless finish to the products. Even it presents plastic material from sticking to moulding equipment .

vii) Stabilizers
It is to improve thermal stability during processing. These are required especially in the processing stage for plastics, which have tendency to decompose or change their colours at moulding temperatures.
Opaque moulding compound- Salts of lead- Red lead, White lead.
Transparent moulding compound- Stearates of lead, Cadmium, Barium .

Q5)(b)(i) Define and briefly explain (3M)

Biological Oxygen Demand (BOD)

Chemical Oxygen Demand (COD)

Ans : BOD

1. The Biochemical Oxygen Demand (BOD) of water is a measure of amount of oxygen required for the biological oxidation of organic matter under aerobic conditions, at 20 and for a period of five days.

2. BOD is directly related to the extent of pollution in waste water and industrial effluent.

3. The higher the BOD of a sample, higher will be the pollution caused by it. Drinking water should have BOD preferably less than 1 ppm.

4. BOD = $[(DO)_1-(DO)_2]/x$ ppm where $(DO)_1$=DO in blank titration, $(DO)_2$=DO of the sample water

x = Volume of sample/Total Volume to which it was diluted.

COD

1.The amount of oxygen required by organic matter in a sample water for its oxidation by strong oxidizing agent is known as Chemical Oxygen Demand or COD of the sample.

2. It helps in designing the water treatment plant and deciding the disposal of domestic effluents in various types of water streams.

3.COD = $(V_2-V_1)X\ NX\ 8X\ 1000/V$ where V_1 = Volume of FAS for sample titration,

V_2=Volume of FAS for blank titration, V= Volume of sample taken for the test, N=Normality of FAS

Q5)(b)(ii) Write important functions of lubricant. (2M)

Ans : The functions of lubricants are :

1) Lubricants act as coolants, thereby avoiding loss of energy. They reduce the frictional heat, thereby controlling expansion of metals. It helps to maintain shape, size and dimensions of metal parts of machines.
2) Lubricants reduce the wastage of power, eg in internal combustible engines, the lubricant applied between the piston and the cylinder acts as a coolant.
3) Lubricant acts as a sealant, as it does not allow the escape of gases from engine under high pressure.
4) Lubricant prevents the attack of moisture on machine surface. This helps to control corrosion of the metal parts.
5) Lubricant act as cleansing agents, because they have the tendency to wash off solid particles produced due to combustion or wear.
6) Lubricants help to reduce maintenance cost of machines, because a thin film of a lubricant reduces friction and thus controls wear.

Q5)(c) Draw and explain phase diagram of Pb-Ag system . (4M)

Ans : Lead Silver system has two components and four phases. The phases are:

1) Solid Silver
2) Solid Lead
3) Solution of molten silver and lead
4) Vapour

Since pressure has nearly no effect on equilibrium, so gaseous phase is practically absent, the condensed phase rule F = C-P+1 will be applicable.

In the phase diagram of Pb-Ag System, following salient features are observed.

1) Curve AO (Freezing curve of Ag)
2) Curve BO (Freezing curve of Pb)
3) Eutectic Point ‘O’
4) Area AOB

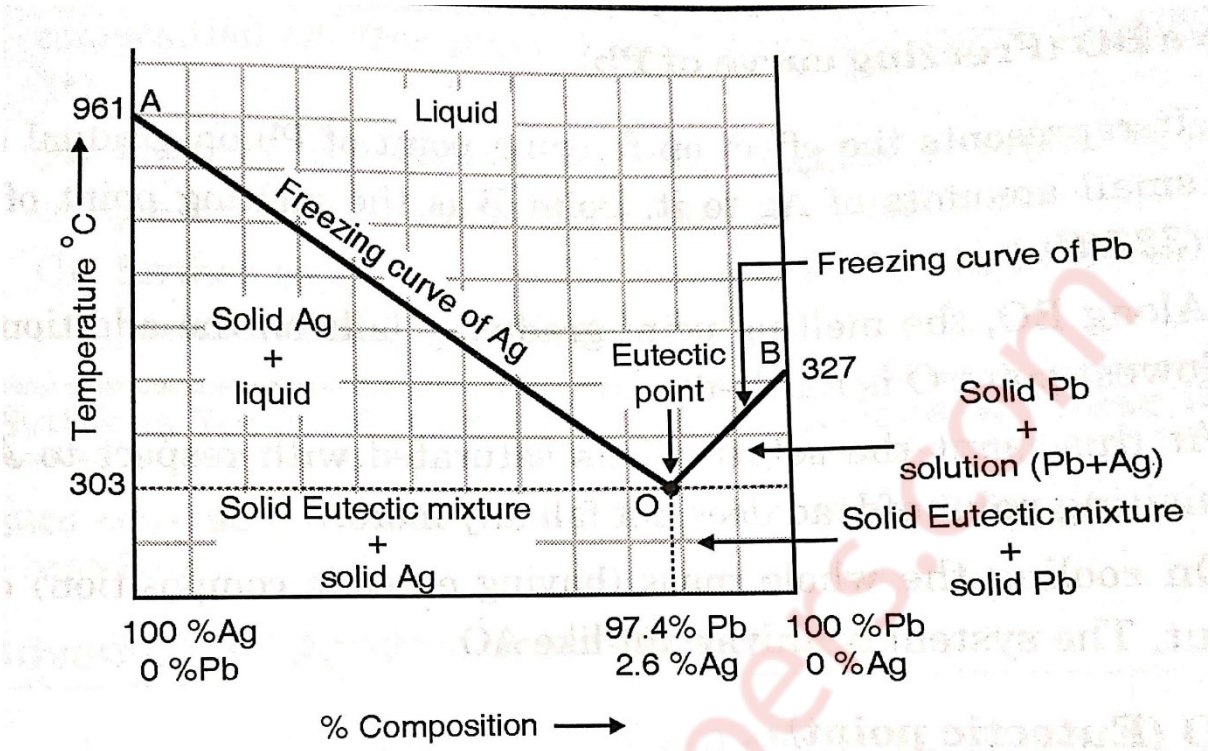


Fig. 4.6.1 : The phase diagram of Pb- Ag system

Curve AO :

i) When Pb is added to Ag, freezing point of Ag decreases till the lowest point (303 ˚C) is reached, where solution gets saturated with Pb.

ii) At point O, no more lead can go in solution and on further addition of Pb, it separates as the solid phase.

iii) Along the curve OA, solid Ag and solution co-exist. Hence F=C-P+1=2-2+1=1 i.e. System is Univariant .

Curve BO :

i) When Ag is added to Pb, freezing point of Pb (327 ˚C) decreases till the lowest point (303 ˚C) is reached , where solution gets saturated with Ag.

ii) On cooling further, the whole mass (eutectic composition) crystallizes out .

iii) Number of phases = 2 (solid Pb + solution) .
F = C - P + 1 = 1 .

Point O :

i) The curve AO and BO meet at point O (303 ˚C) where all three phases (that is solid Pb, solid Ag and then solution) coexist.

ii) Therefore F=0, this represents zero variant system at point O because it is fixed composition (Ag=2.6% and Pb=97.4%).

iii) No mixture of lead and silver has melting point lower than eutectic temperature.

iv) Below this temperature, we have two regions :
1) eutectic + solid Ag in which crystalline silver and solid eutectic are stable.
2) eutectic + solid Pb in which crystalline lead and solid eutectic are stable.

Area AOB :

i) It represents solution of Ag and Pb .

ii) If a sample of lead containing less than 2.6% Ag is taken, at an arbitrary point on the curve. On allowing the mass to cool, the temperature gradually falls without any change in composition till this point is reached on the curve BO .

iii) Since Number of Phases (P) = 1, F = 2-1+1 = 2 .
Therefore, the system is bivariant.

Q6)(a) Draw a neat diagram and explain the mechanism of thick film lubrication . (6M)

Ans :

1) In this type of mechanisms, a liquid lubricant with high viscosity is applied in the form of thick film between two moving surfaces. The film is at least 1000 $^{\circ}$A thick .
2) Such film helps to avoid surface to surface contact of moving surfaces. The hydrodynamic lubrication helps to reduce the coefficient of friction μ to about 0.001 to 0.003, which is much lower as compared to that of unlubricated surfaces .
3) The mechanism of hydrodynamic lubrication can be better understood by considering the operation of a journal bearing.
4) The bearing consists of a shaft rotating at a fair speed, with moderate load. The lubricant is applied in annular space.
5) When journal bearing is stationary, the two surfaces remain in contact, but as the shaft (journal) begins to rotate, the film of lubricant also rotates between the two metallic surfaces.
6) Due to the presence of thick oily layer, all the asperities of the metal surfaces are filled up and a pressure is developed which practically keeps the two surfaces away from each other, thereby reducing wear.
7) The motion is smooth as the resistance to the motion is restricted amongst the particles of lubricant. Essential characteristics of lubricants required are :
   i) Adequate viscosity, oiliness and higher viscosity index .
   ii) Lubricant should be resistant to seasonal impact.
8) The blending oils used in hydrodynamic or thick film lubrication are vegetable oils or mineral oils blended with antioxidants or organometallic compounds .The machines in which this mechanism is used are sewing machines, clocks, watches, scientific instruments .

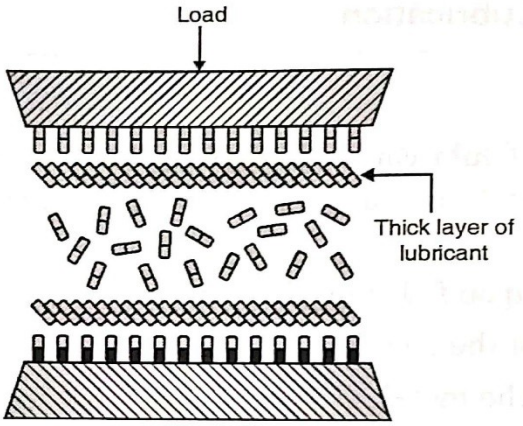
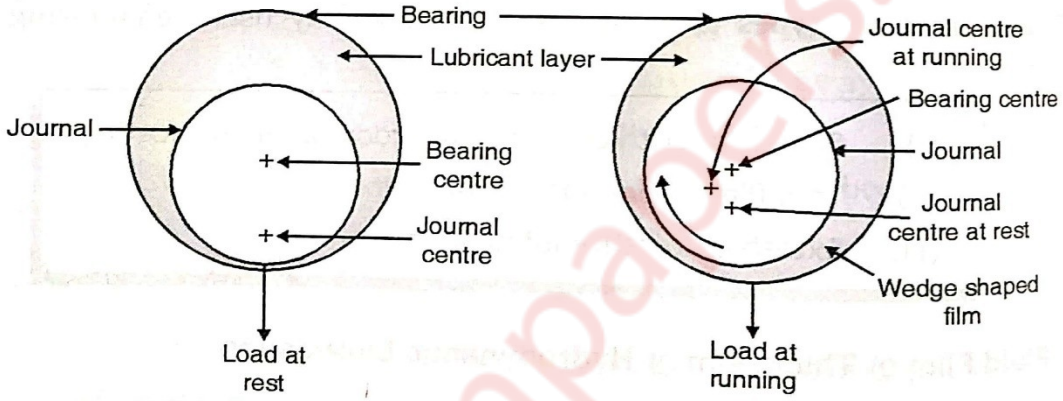


Fig. 3.3.1(a) : Hydrodynamic lubrication or fluid film lubrication



(i) Rest position **(ii) Running**

Fig. 3.3.1(b) : Fluid film lubrication

Q6)(b)(i) Write Gibb's mathematical equation of phase rule and define the terms involved in it.

(3M)

Ans : 1) Gibb's mathematical equation for phase rule may be stated as, The number of degrees of freedom (F) of the system is related to the number of components (C) and phases (P) by the phase rule equation provided equilibrium between any number of phases is not influenced by gravitational, electric or magnetic forces or by surface action, but only by temperature, pressure and concentration for any system at equilibrium at definite temperature and pressure.

$F = C - P + 2$

2) A Phase is defined as any homogeneous, physically distinct and mechanically separable portion of a system, which is separated from other such parts of the system by definite boundary surfaces.

3) Component is defined as the smallest number of independently variable constituents taking part in the state of equilibrium by means of which the composition of each phase can be expressed directly or in the form of chemical equation.

4) Degree of freedom is defined as the minimum number of independently variable factors such as temperature, pressure and composition of the phases which must be arbitrarily specified in order to represent perfectly the condition of a system.

Q6)(b)(ii) With chemical equation, explain role played by bleaching powder in water treatment.

(2M)

Ans: 1) Bleaching powder reacts with water as

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

$Cl_2 + H_2O \rightarrow HCl + HOCl$

Hypochlorous Acid

$HOCl \rightarrow HCl + [O]$

Nascent Oxygen

2)In these reactions above, the HOCl deactivates the enzymes present in the cells of micro-organism.

3)Thus the metabolic activity of micro-organism gets affected, thereby making the micro organism inactive and finally the organism dies.

Q6)(c) Explain manufacturing of the cement by wet process materials . (4M)

Ans : Wet process manufacturing of cement involves the following operations:

1) Mixing of Raw Material:
   i) The calcareous raw materials are crushed, powdered and stored in big silos. The argillaceous materials are thoroughly mixed with water and then both are passed to 'Grinding Mills' to get fine paste of slurry of raw materials. The slurry contains about 38-40% of water. It is stored in storage tanks and kept ready for feeding to a rotary kiln.
2) Burning of Raw Material:
   i) The collected slurry is injected into rotary kiln at its upper end. Due to slope and slow rotation of kiln, the materials move towards higher and higher temperature sections of kiln, to get clinkers of cement.

   Rotary Kiln:

   1) A rotary kiln is a steel tube about 2.5-3 m in diameter and 90-120 m in length, lined inside with refractory bricks. It rests on roller bearings, which are supported on concrete structure. It is inclined around 4-5 ° and rotating at 1 rpm. Burning fuel and air are injected at lower end, which heats interior of kiln upto 1750 ℃ .
      a) Drying Zone: It is upper part of kiln, where water is completely removed from slurry.
      b) Calcining Zone (upto 1000 ℃) :

i) In this zone, lime stone of slurry undergo decomposition to form quick lime and carbon dioxide, which is latter space out.

ii) The material forms small lumps. The following reaction takes place in this zone

$CaCO_3 \leftrightarrow CaO + CO_2$

c) Clinkering Zone (upto 1700 ℃):

i) Here lime and clay undergo chemical reactions to give clinkers of cement:

$2CaO + SiO_2 \rightarrow Ca_2SiO_4(C_2S)$

Dicalcium silicate

$3CaO + SiO_2 \rightarrow Ca_3SiO_5(C_3S)$

Tricalcium silicate

$3CaO + Al_2O_3 \rightarrow Ca_2Al_2O_6(C_3A)$

Tricalcium Aluminate

$4CaO + Al_2O_3 + Fe_2O_3 \rightarrow Ca4Al2Fe_2O_{10}(C_3A)$

Tetracalcium Alumino Ferrite

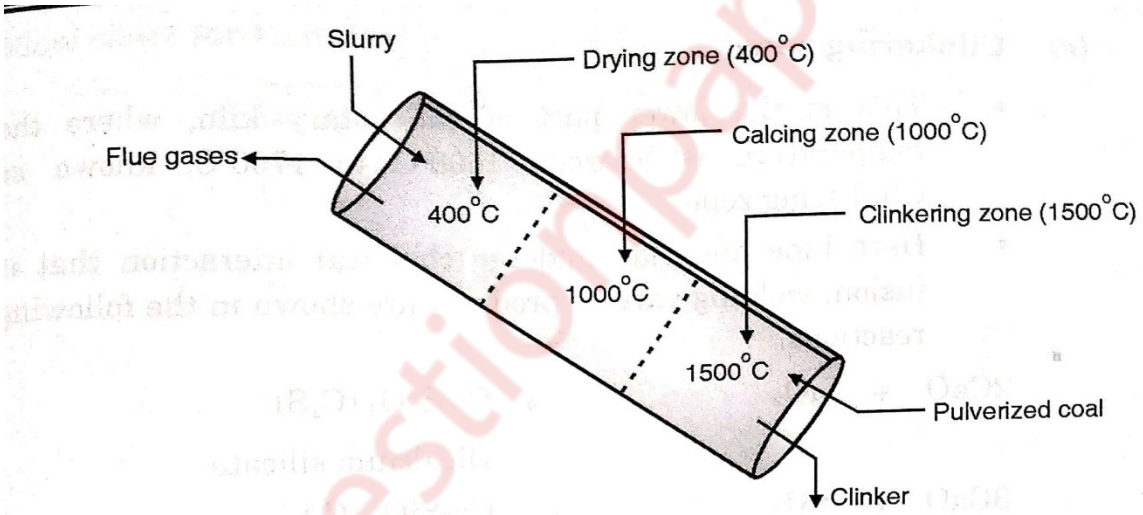


Fig. 5.2.1 : Schematic diagram of rotary kiln

ii) The aluminates and silicates of calcium then fuse together to form small, hard greyish stones called clinkers. These clinkers are very hot and hence they are cooled with air-counter-blast. This hot air so produced is used for burning powdered coal/oil. The cooked clinkers are collected in trolleys.

3) Grinding and Packaging:

i) The cooled clinkers are ground to a fine, powder in ball mills/ tube mills.

ii) During final grinding 2-3% gypsum is added, to enhance setting time of cement.

iii) This ground cement is stored in silos through automatic machines.