APPLIED CHEMISTRY 1

(CBCGS , DEC 2018)

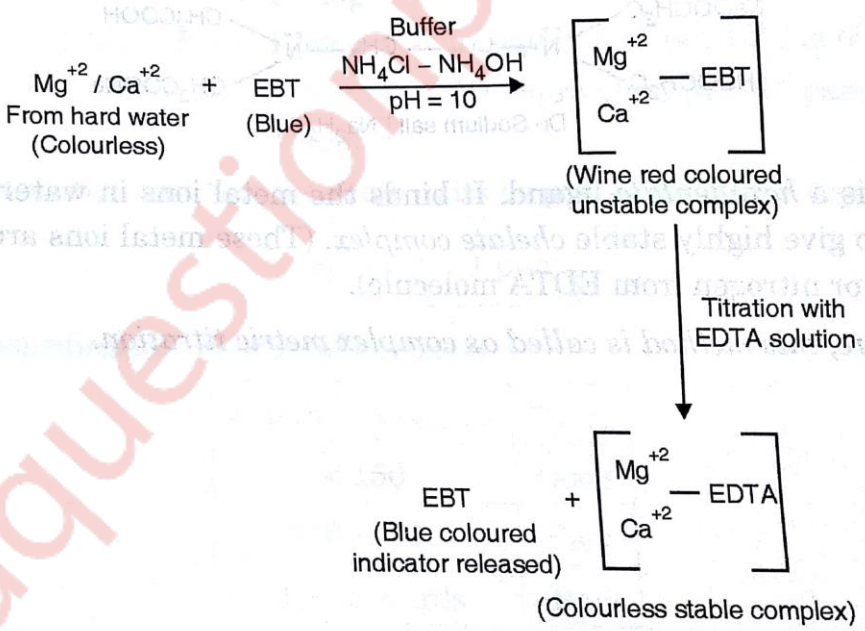
Q1](a) Explain the principle of EDTA method . (3)

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 ,

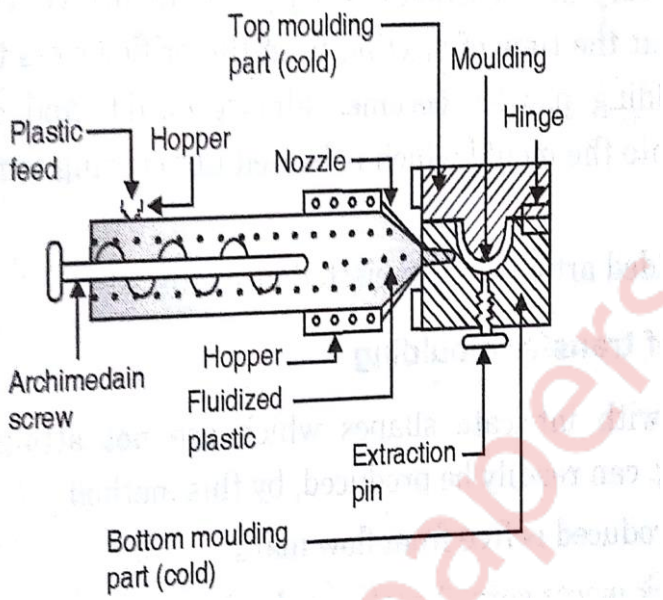
1) *When water is added to cement ,at first hydraton of* C_3A *and* C_4AF *takes place within day .*
2) C_3S *begins to hydrate within 24 hrs and gets completed in 7 days .*
3) *Gel of aluminate begins to crystallise and at the same time* C_2S *begins to hydrate in 7-28 days .*
4) *The development of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

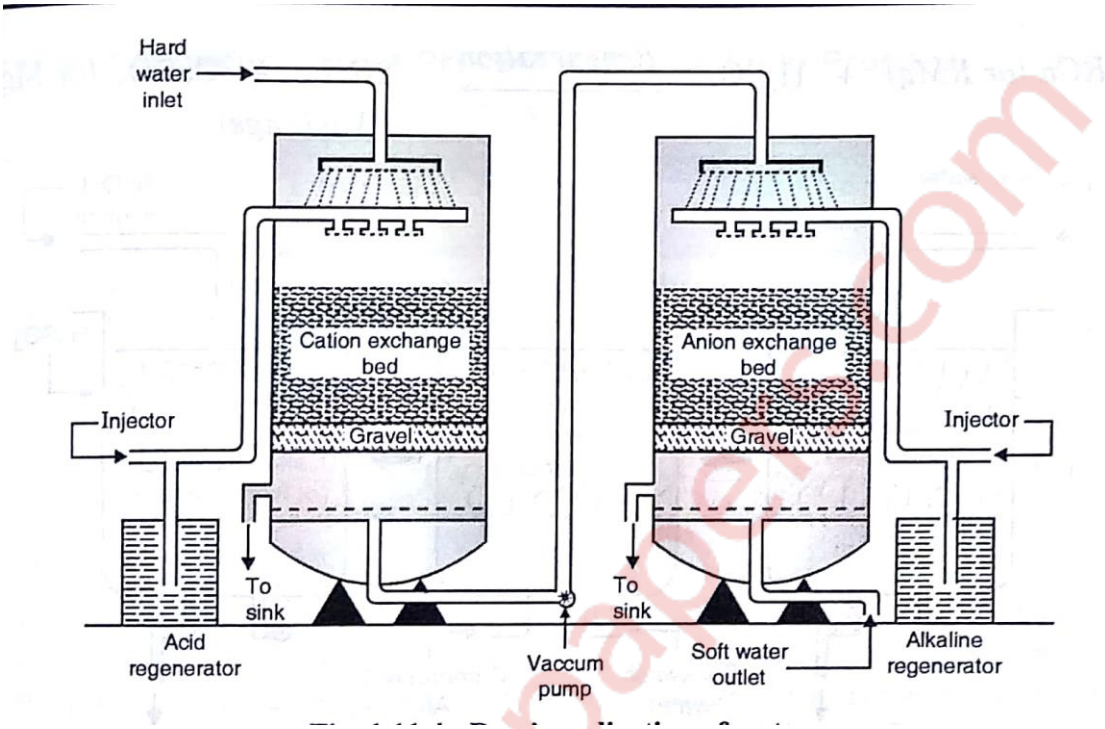
a) *Cation exchange resins* (RH^+) *: Resins which contain acidic functional groups (-COOH ,-*SO_3H *,etc) are capable of exchanging their* H^+ *ions with other cations .These are mainly styrenedivinyl benzene copolymers which on sulphonation/carboxylation become capable of exchanging their* H^+ *ions 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 .*

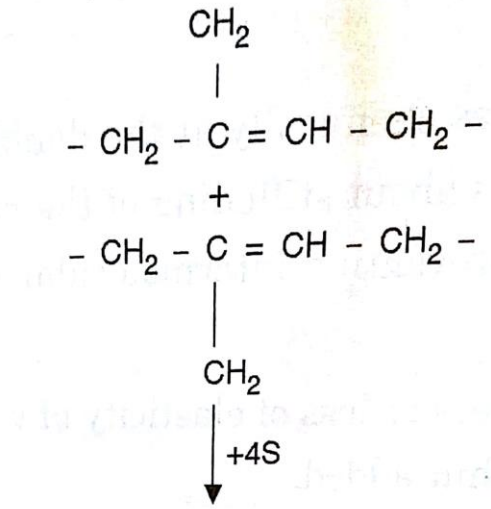
   Thus in order to improve the undesirable properties of natural rubber, it requires vulcanization .

   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

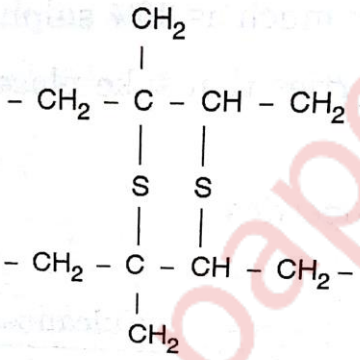
   .During vulcanization double bonds present in rubber structure break and ‘ S’ gets added to it forming cross links .

   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 ..

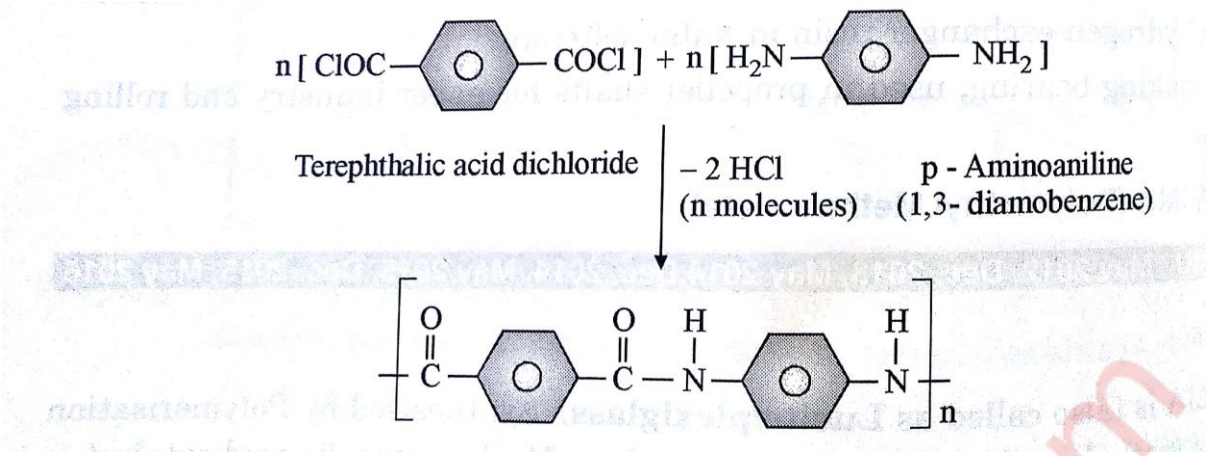
Q5](a) Write preparation ,properties and uses of following polymers : i)Kevlar ii)Silicone rubber iii)Buna S (6)

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 :

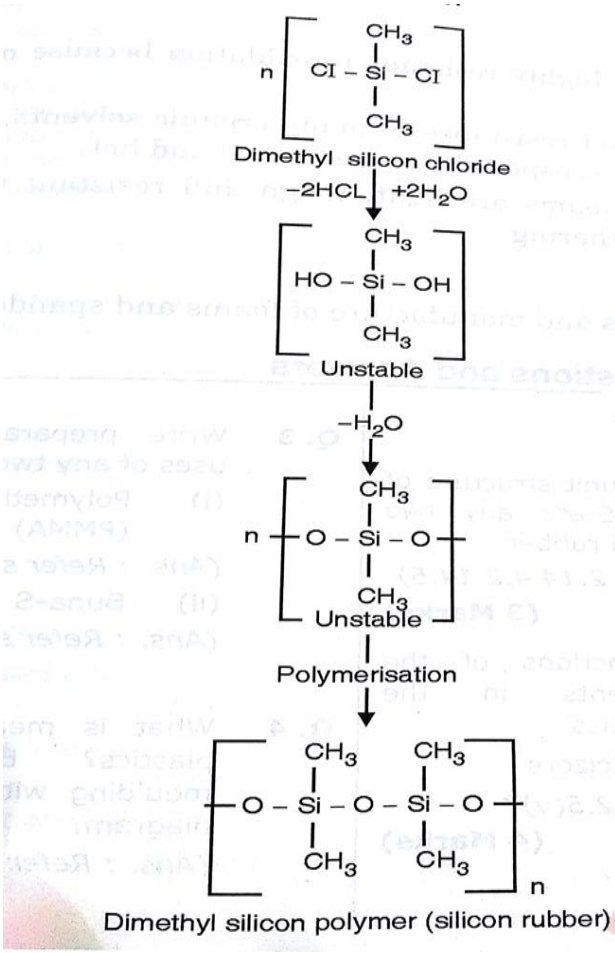
1) *Aerospace and Aircraft industry .*
2) *Making ropes ,cables ,protective clothings ,bullet proof vests,etc*
3) *Making motorcycle helmets .*
4) *Car parts . eg brakes ,tyres ,clutch linings ,etc .*

(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 .*

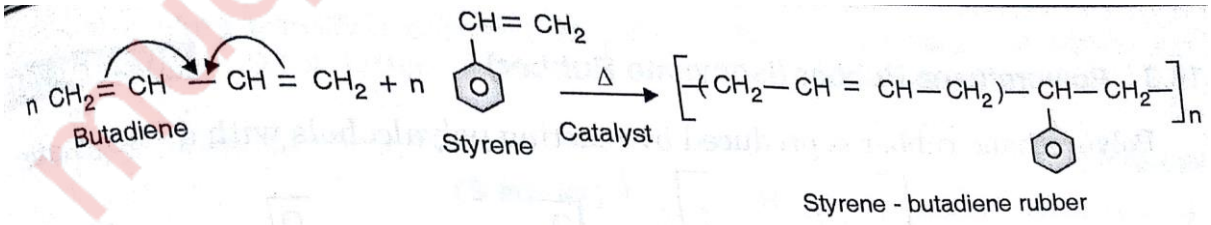


Uses :

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 .*

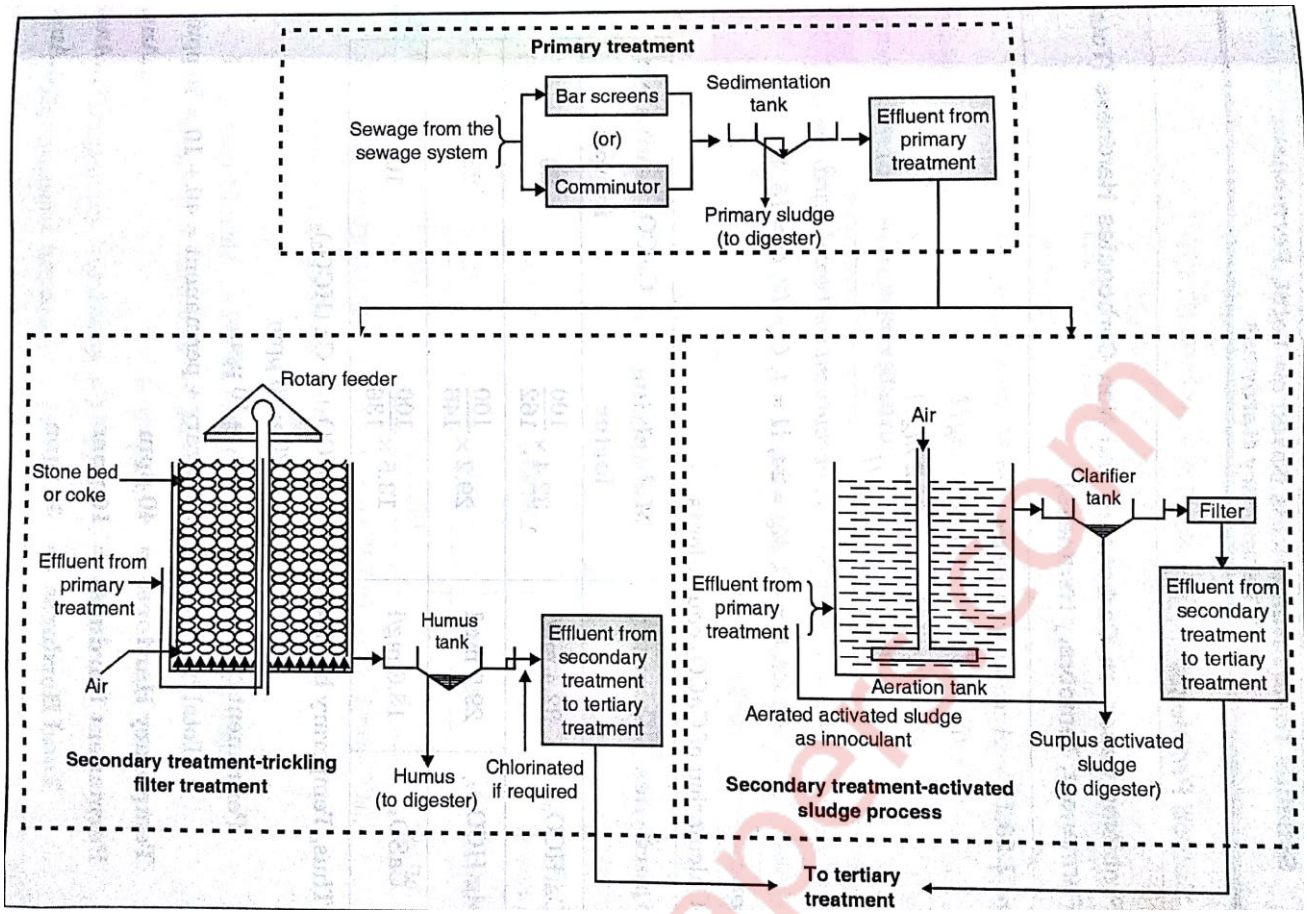
The efficiency of activated sludge is determined by pH ,temperature and redox potential.

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 .

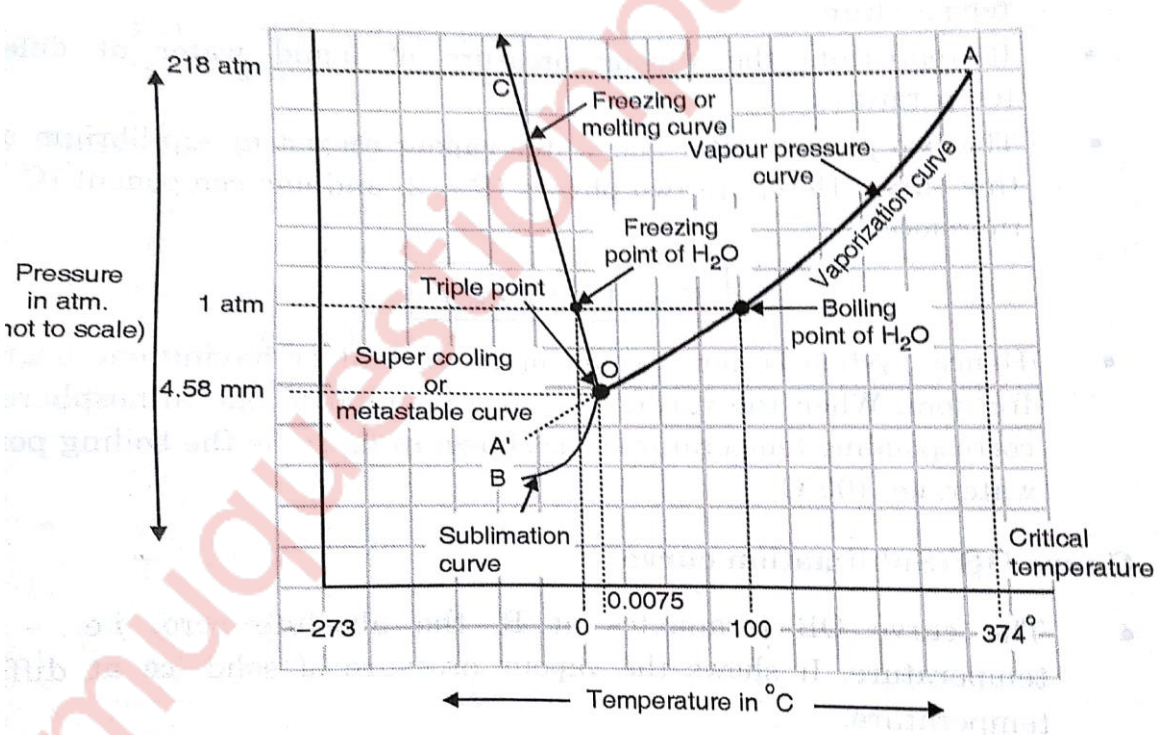
*3)**Curve OC** (Fusion curve)*

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 .

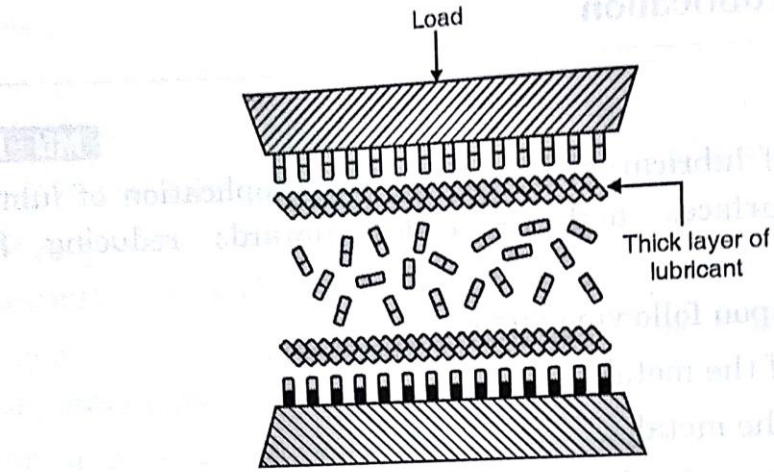
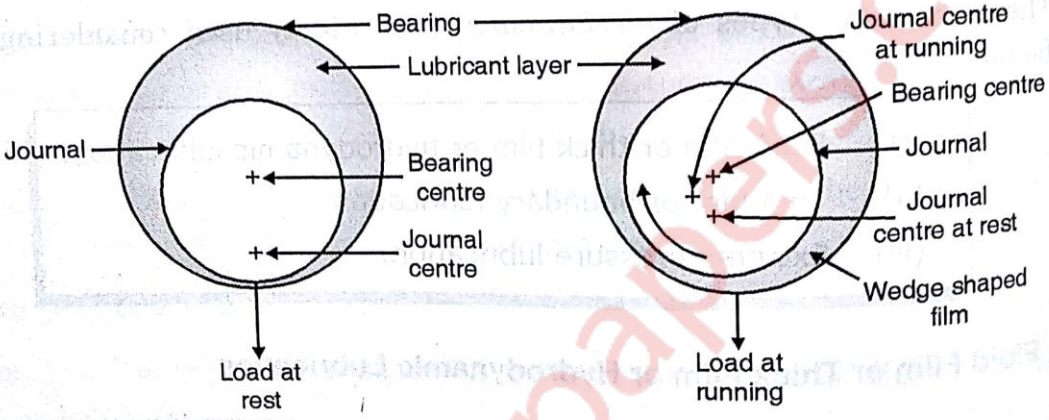


Fig. 3.3.1(a) : Hydrodynamic lubrication or fluid film lubrication



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] .***

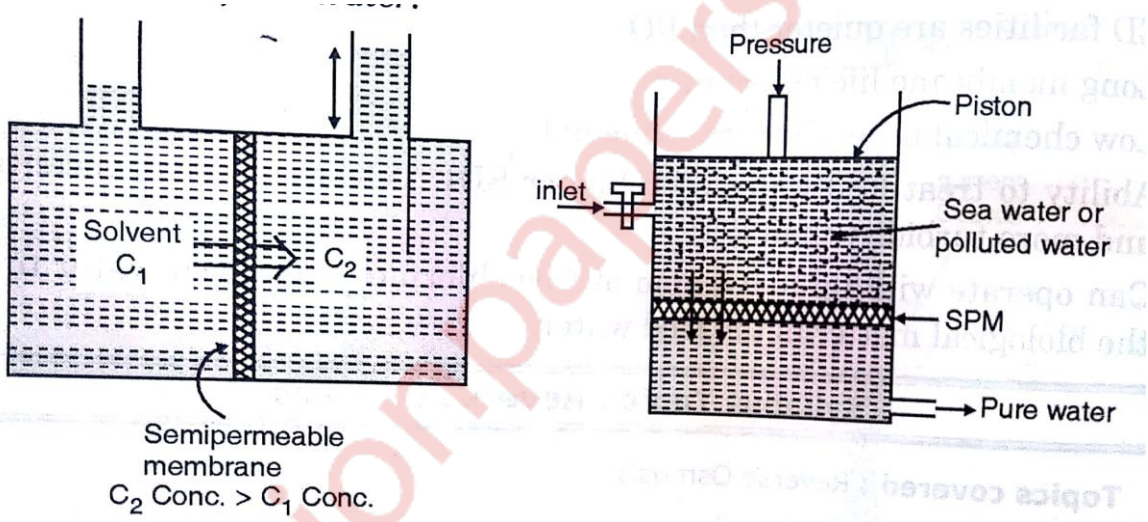
*c****) Degree of freedom*** *or Variance* ***(F****) is the minimum number of independently variable factors such as temperature , pressure and components of a system which have to be arbitrarily specified in order to represent perfectly the conditions of equilibrium .*

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 .*