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.

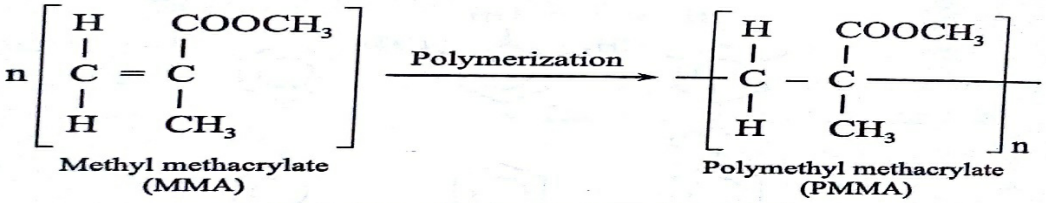


Fig. 2.15 : Polymerization of PMMA

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.

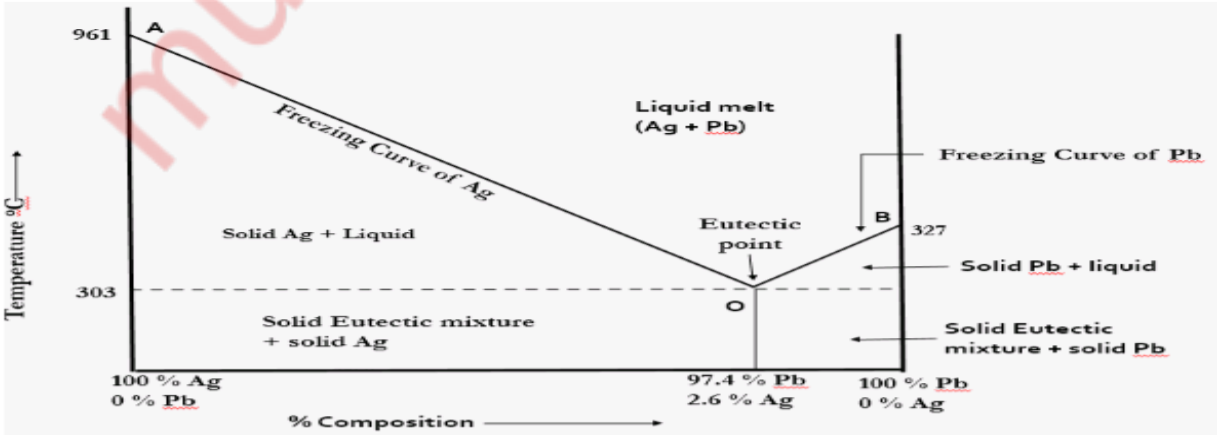
Q1](e)What is reduced phase rule? ***(3)***

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.*

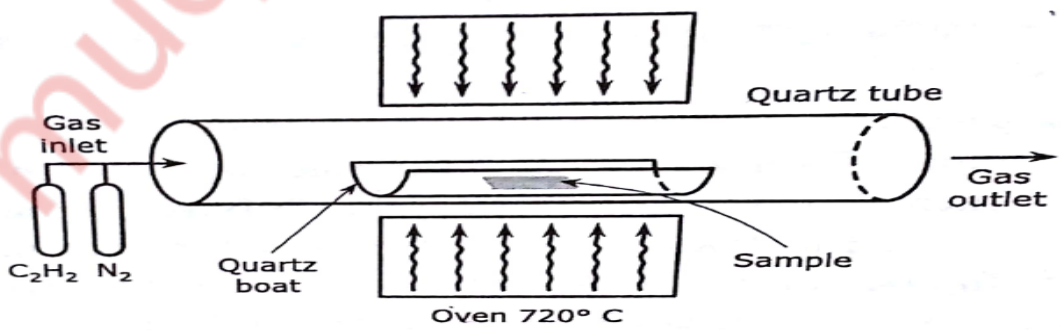


Fig. 5.8 : Schematics of experimental setup for CVD process

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

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

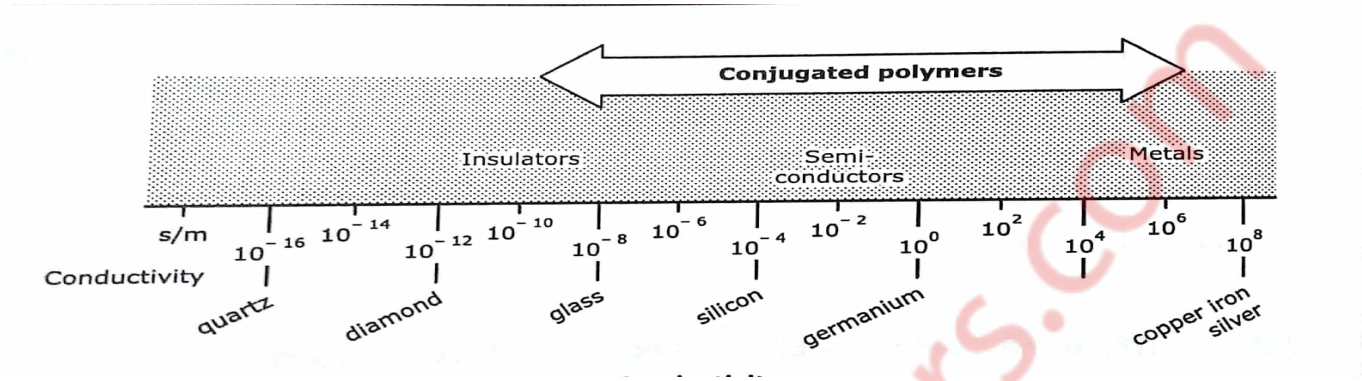
= 5877.1 gms.

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.

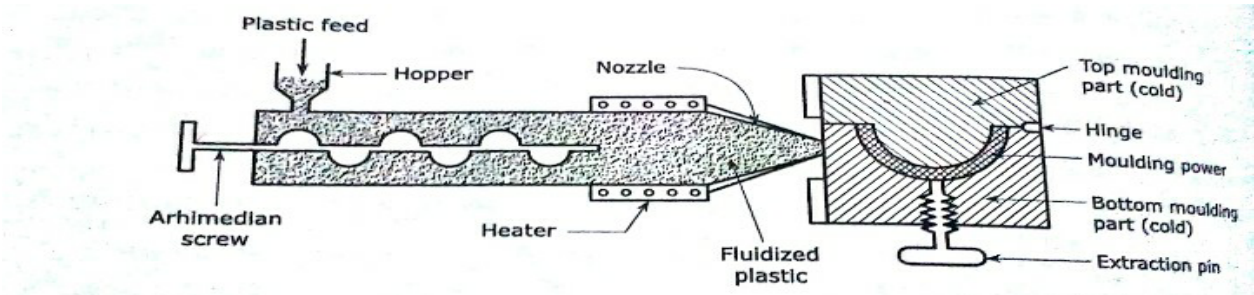


Fig. 2.10 : Injection moulding of plastics.

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.

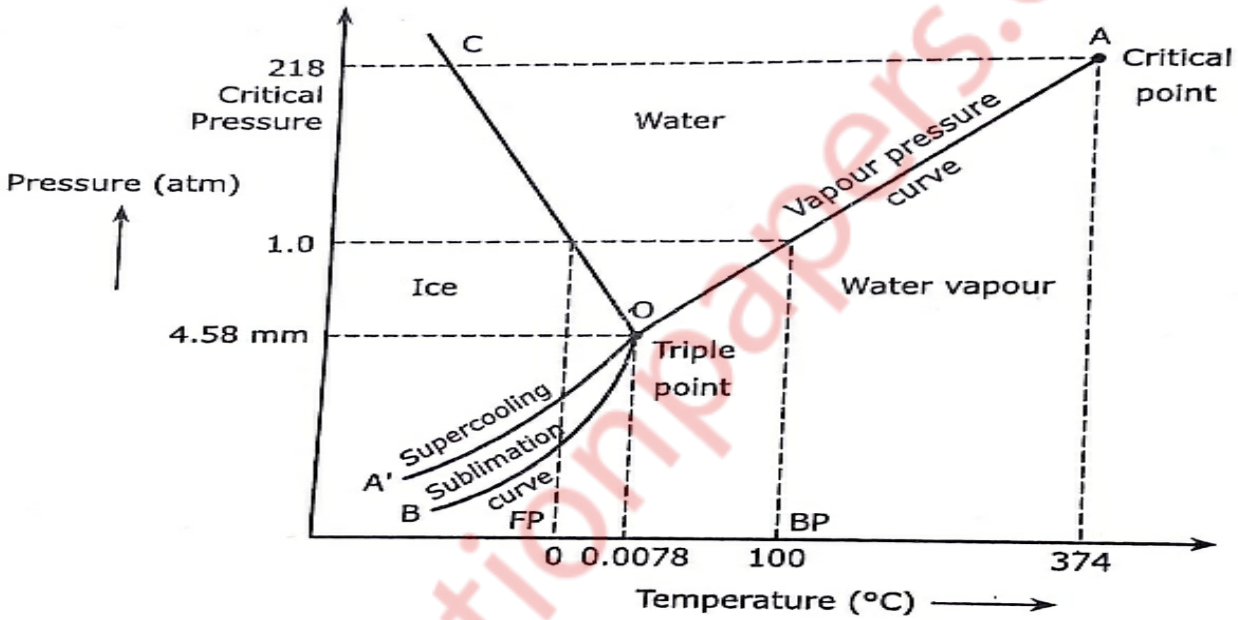


Fig. 4.1 : Phase diagram of water system

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.

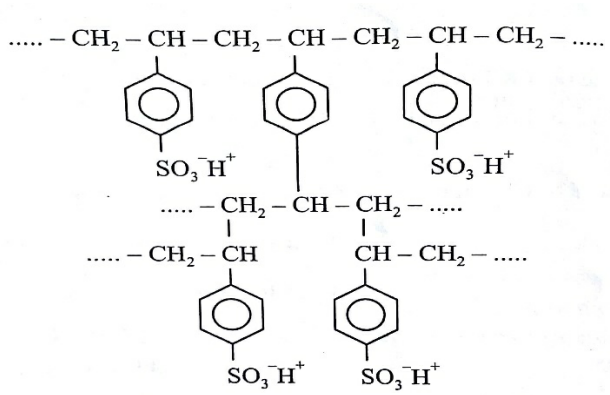


Fig. 1.4 : Acidic or cation exchange resin (sulphonate form)

- *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 .

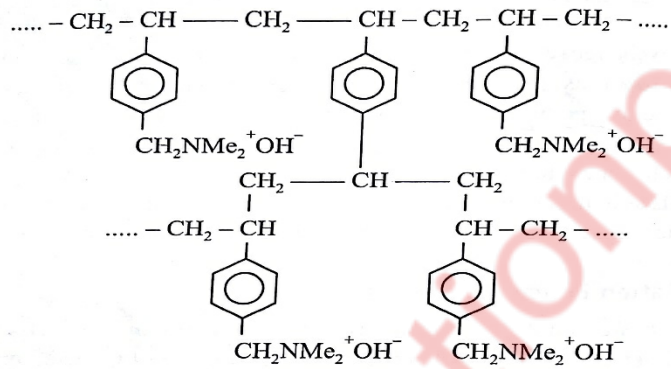


Fig. 1.5 : Basic or anion exchange resin (hydroxide form)

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.

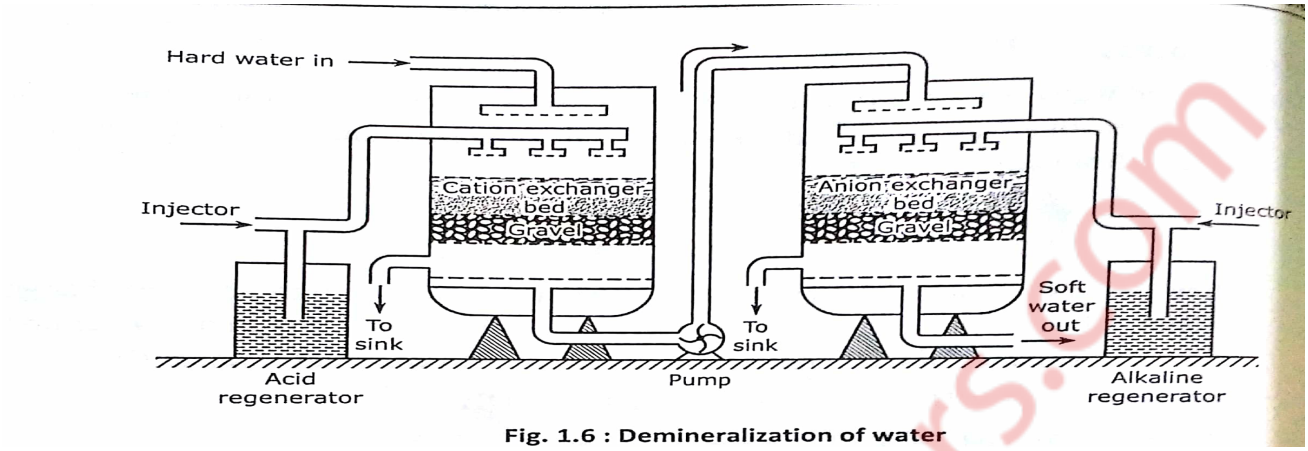


Fig. 1.6 : Demineralization of water

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 .

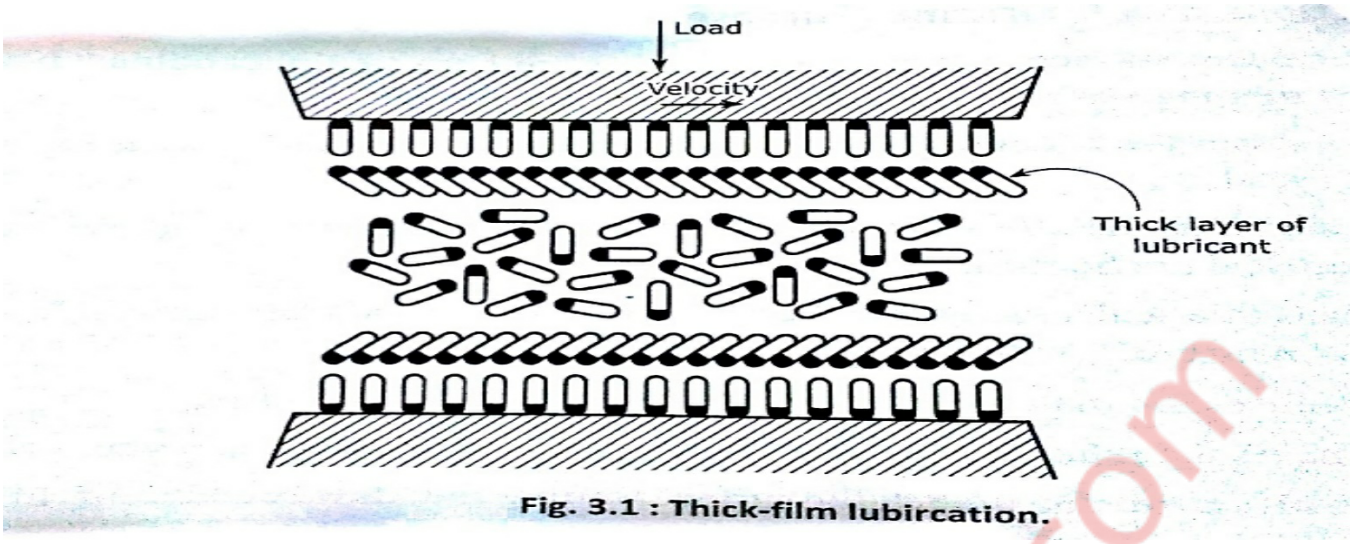


Fig. 3.1 : Thick-film lubircation.

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.

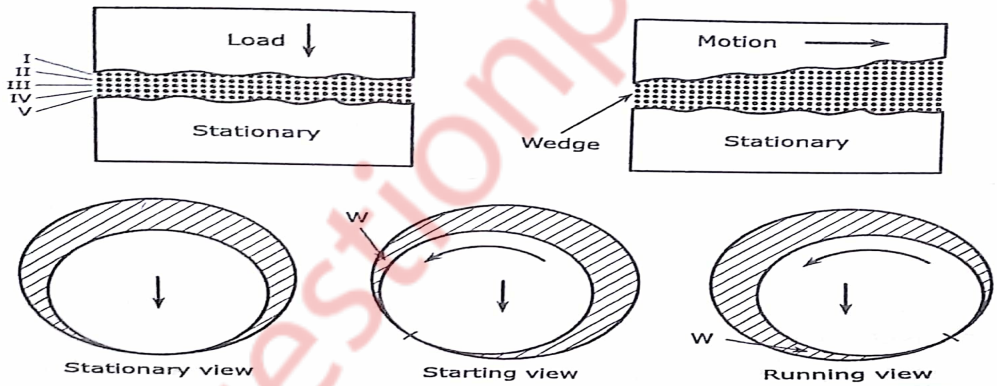


Fig. 3.2 : Thick-film lubrication

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*

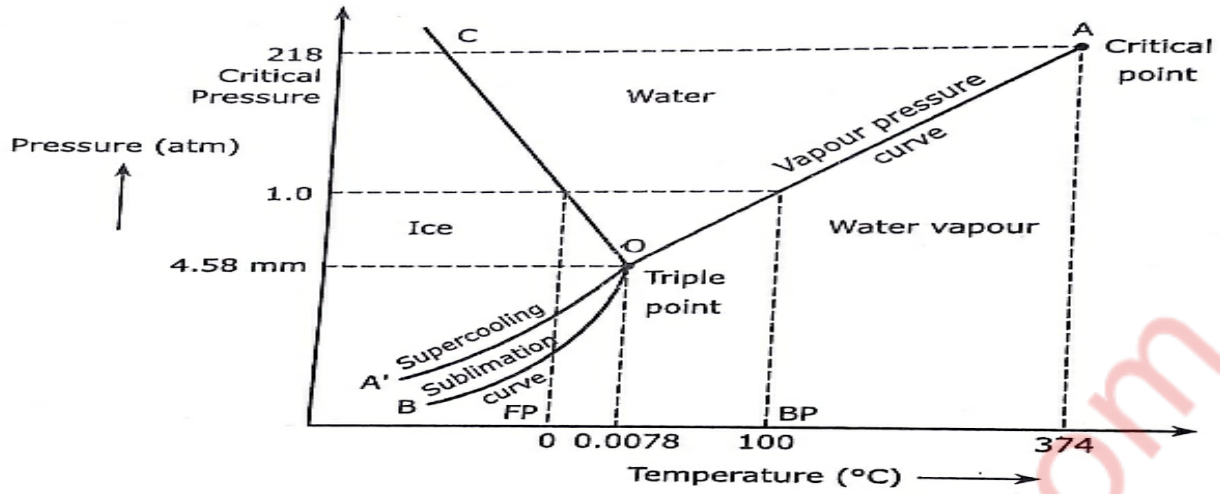


Fig. 4.1 : Phase diagram of water system

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.