MODULE III

PHASE - II

PART - A [SHORT ANSWER QUESTIONS]

11) Q) State the monomers used in making the thiokol rubber & Buna-S rubber.

Ans) Thiokol is prepared by the condensation polymerization of sodium poly sulphide (Na_2S_x) and ethylene dichloride ($ClCH_2CH_2Cl$)

EXTRA FOR REFERENCE

$$n\ Cl-CH_2-CH_2-Cl + Na_2S_4 \xrightarrow{Mg(OH)_2} \{CH_2-CH_2-S-S-CH_2-CH_2\}_n + NaCl$$

Thiokol

[Ethylene polysulphide polymer]

→ Monomers of Buna-S rubber are 1,3-butadiene and styrene and prepared by a process known as co-polymerization

EXTRA FOR REFERENCE

$$CH_2=CH-CH=CH_2 + n\times$$

1,3-butadiene

Styrene

$$\longrightarrow \{CH_2-CH=CH-CH_2-CH(C_6H_5)-CH_2\}_n$$

Buna S

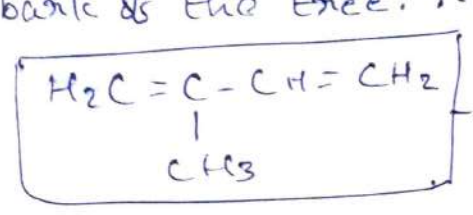
Q12) Write the properties and applications of natural rubber.

Ans) Natural rubber has flexibility and strength, as well as impurities & vulnerability to environmental conditions. Compared to other rubbers, natural rubber is one of the most flexible types, and its resistance to water and other chemicals [not all]. It is also resistant to cutting, tearing, wear, fatigue, and abrasion, with a working range of -58 to 212°F.

Natural rubber is used for the manufacturing of boots, belts, bumpers, tubing, etc,.

Q13) What is natural rubber? Write the disadvantages of natural rubber

Ans) Natural rubber is a high molecular weight hydrocarbon polymer represented by the formula $(C_5H_8)_x$. It is obtained from a milk emulsion called latex by tapping the bark of the tree. Natural rubber [Isoprene]



→ Isoprene

→ Natural rubber doesn't perform well exposed to chemicals & petroleum derivatives. It is not recommended for outdoor applications where sunlight, ozone, oxygen, heat aging are the main factors.

Q14) Explain why natural rubber needs vulcanization and how its carried out.

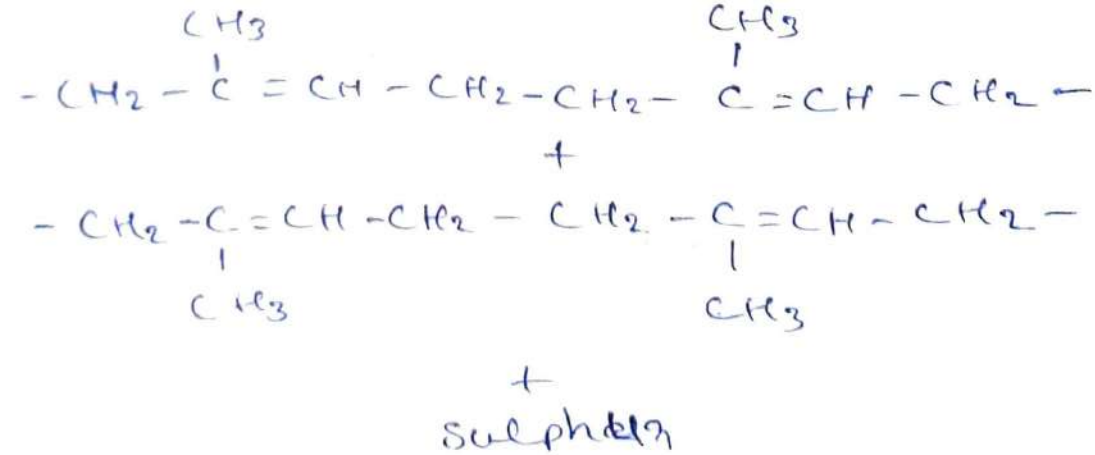
Ans) (1) Natural rubber has less strength, poor resistance over abrasion.

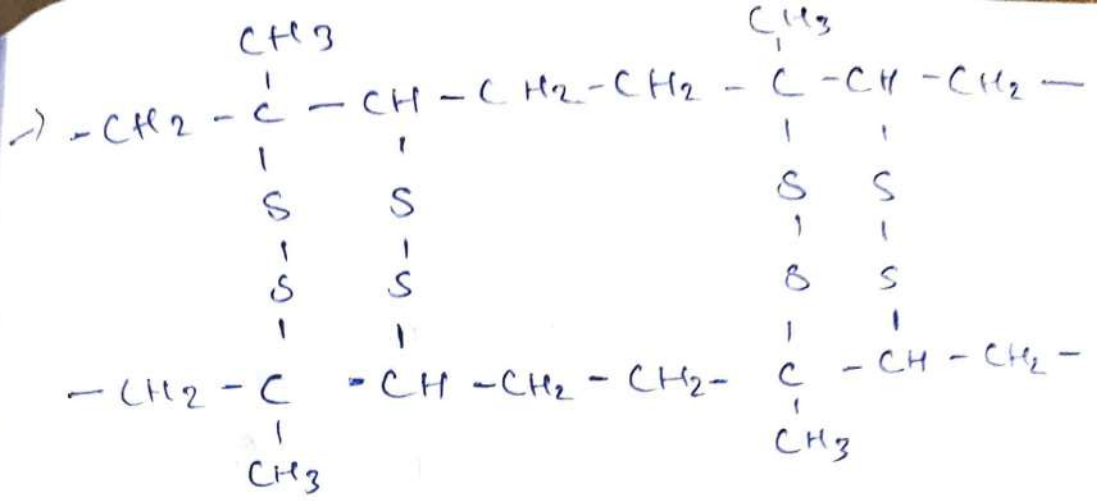
(2) It will be soft over wide range of temperature.

(3) We can't produce enough natural rubber to meet all our needs.

(4) To overcome the disadvantages of the natural ~~rub~~ rubber ~~vulcanization not~~ undergoes through a process called vulcanization

Vulcanization is a process where addition of sulphur takes place under 140 - 160 °C temperature. Here cross linking of rubber molecules takes place and ~~this~~ hardens the rubber material.





(Vulcanized rubber)

Q15) What is a lubricant?

Ans) A lubricant can be of solid, semi-solid and liquid which is used to reduce friction between surfaces in contact, which ultimately reduces the heat generated when the surface moves. It may also have the function of transmitting forces, heating or cooling of the surface, etc,..

Q16) What is viscosity of lubricating oil?

Ans) Viscosity is a measure of the internal friction of a fluid. The viscosity of a lubricant varies with temperature and pressure.

Q17) What are the characteristics of a good lubricant.

Ans)
- high boiling point & low freezing point
- high viscosity index.
- Thermal stability

- Hydraulic stability.
- Demulsibility
- Corrosion prevention
- High resistance to oxidation

Q.18) Define flash point & fire point of a lubricant by Pensky Marten's method

Ans) Flash point: The flash point of a volatile material is the lowest temperature at which vapours of the material ignite, given an ignition source.

Fire Point: The fire point of a fuel is the lowest temperature at which the vapours of that fuel will continue to burn for at least 5 seconds ~~of tea~~ after ignition by an open flame.

Q.19) Define cloud point and pour point of a lubricant

Ans) Cloud point: The temperature at which the impurities begin to separate from the solution & lubricating oil becomes cloudy or hazy in appearance is called cloud point.

Pour Point: The temperature at which the oil ceases to flow is called pour point.

(two) What is thick film & thin film lubrication?

Ans) THICK FILM:

-> Thick film or hydrodynamic lubrication occurs when non-parallel rigid bearing surfaces lubricated by a film-fluid slide over each other, forming a converging wedge of fluid and forming a lifting pressure

-> used when speed is more & load is less

THIN FILM:

-> It is formed where thick film lubrication fails, thin film lubrication is done. Thin film or boundary lubrication is done for those cases ~~to~~ in which the continuous film of lubrication cannot persist and direct metal to metal contact is possible

-> used when speed is low & load is more

PART - B LONG ANSWERS

Q11) Explain the process of natural rubber and write the disadvantages of natural rubber

Ans) Processing of natural rubber:-

-> By cutting the bark of rubber tree the milky colloidal rubber milk is obtained. The main constituent of rubber latex is 25-45% of rubber and the remaining are water, protein & resinous materials. The

PART B (Long Answer Questions)

1. Explain different types of polymerisation reactions with examples.

Ans The process in which monomers combine to produce polymers is called as polymerisation. It is classified into two types

i) Additional polymerisation ii) Condensation polymerisation.

i) **Additional polymerisation:** Addition polymers are formed by adding monomer units without any loss of atoms or groups

Ex: $n CH_2 = CH_2 \xrightarrow[C]{T/P} [H_2C - CH_2]_n$

Polyethene

$n H_2C = CH$ (Styrene) $\xrightarrow[T/P/C]{Poly}$ $[H_2C - CH]_n$ (Polystyrene)

ii) **Condensation polymerisation:** C.P are those in which two like or unlike monomers join each other by elimination of small molecules such as H_2O, HCl, etc

Ex: Nylon-6,6

$H_2N - (CH_2)_6 - NH_2$ (Hexamethylene diamine) + $HOC - (CH_2)_4 - COH$ (Adipic Acid)

$\rightarrow \left(H_2N - (CH_2)_6 - NH - CO - (CH_2)_4 - CO - OH + H_2O \right)$

(Nylon-6,6)

2. Compare thermoplastic resins and thermosetting resins

Ans

Thermoplastic Resins	Thermosetting resins
1] Produced by additional polymerisation	1. Produced by condensation polymerisation
2] Resins are made of long chains attached by weak vanderwaal's force of attraction.	2. Resins have 3-D network structure connected bonds.
3] Can be remoulded.	3. Cannot be remoulded.
4] Scrap can be used.	4. Scrap cannot be used.
5] On heating they soften & on cooling they become stiff.	5. On heating they become stiff & hard. No change when cooled.
6] Resins are soft, weak & less brittle	6. Resins are usually hard, strong & more brittle
7. Easily soluble in organic substances	7. Resins are not soluble in organic solvents.
Ex: PVC, polyethylene, etc	Ex: Nylon, Bakelite, etc.

3. What is meant by compounding of plastics? Explain the role of ingredients used in compounding of plastics.

Ans C·O·P can be defined as the mixing of different materials like plasticizers, fillers of extenders, lubricants, pigments to the thermoplastic & thermosetting resins to increase their useful properties like strength, toughness, etc.

→ Resins have plasticity or binding properties, but need other ingredients to be mixed with them for fabrication into a useful shapes.

→ Ingredients used in C·O·P are:

i] Resins, ~~2~~ Fillers (3) ~~3~~ Stabilizers (5), ~~4~~ Antioxidants, ~~5~~ Plasticizers (2)
~~6~~ Pigments (4), ~~7~~ Lubricants, ~~8~~ Fire retardents ~~9~~ Catalyst & colourants, etc (6)

Role of ingredients:

i] Resins: Product of polymerisation is called resins, this forms the major portion of body of plastics. It is the binder, which holds different constituents together.

ii] Plasticizers: are the substances added to enhance the plasticity of the material and to reduce the cracking on the surface. They are added to plastics to ↑se the flexibility & toughness. Also ↑ the flow property of plasticizers.

Ex: Tricresylphosphate, Dibutyl oxalate, castor oil.

iii] Fillers or extenders: Fillers are generally added to thermosetting plastics to ↑ elasticity and crack resistance. Fillers improve thermal stability, strength, non combustibility, water resistance, electrical insulation properties & external appearance.

Ex: Mica, cotton, carbon black, graphite, $BaSO_4$, etc.

iv] Dyes & pigments: These are added to impart the desired colour to the plastics & give decorative effect.

v] Stabilizers: Stabilizers are used to improve thermal stability of plastics, eg Eg PVC at moulding temp., PVC undergoes decomposition & decolorisation. So during " stabilizers are used.

Ex: white lead, lead chromate.

vi] Coloring materials: Organic dyestuffs and inorganic pigments are used as colouring materials. They give bright transparent colours.

Ex: Carbon-black-black, anthraquinone-yellow & phthalocyanine.

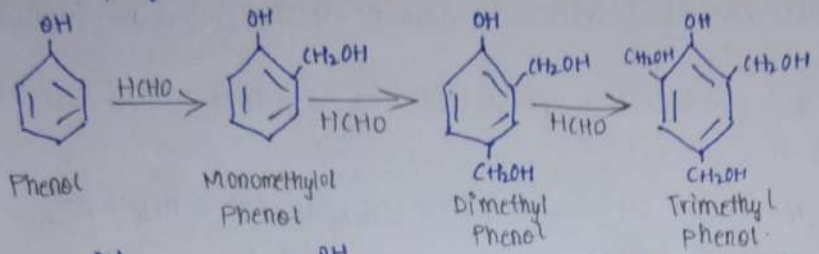
4. Explain briefly about thermoplastic and thermosetting resins with example?

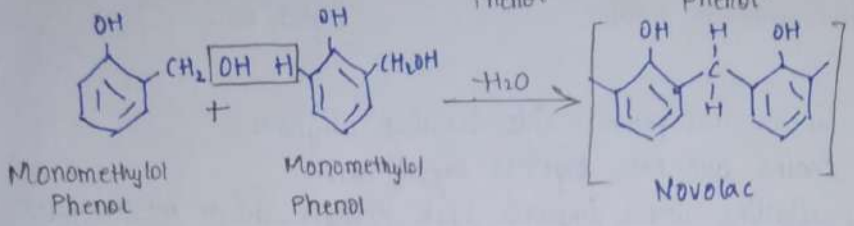
Ans Same as Q-2.

5. Describe the preparation, properties and engineering applications of phenol formaldehyde resins.

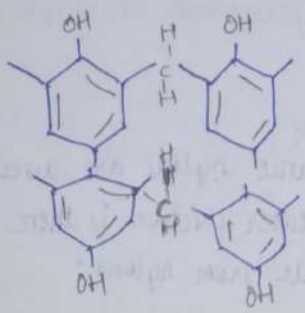
A: Bakelite (or) phenolformaldehyde resins:

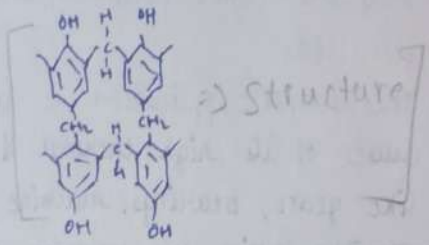
Phenol formaldehyde resins are synthetic polymers obtained by the reaction of phenol or substituted phenol with formaldehyde. Bakelite is commercial name for the polymer obtained by the polymerization of phenol and formaldehyde.





When novolac resin is further heated in presence of HCHO producer i.e hexamethelenediamine (curing agent) a cross linked polymer, bakelite can be obtained.





Properties:

-> Can be quickly mould.
-> Very smooth moulding can be obtained from this polymer.
-> Bakelite moldings are heat-resistant and scratch-resistance.
-> They are also resistance to several destructive solvents.
-> Owing to its low electrical conductivity, bakelite is resistant to electric current.

Applications:

-> Used for making electric insulator parts like switches, plug, switchboards, etc.
-> For making moulded articles like telephone parts cabinet of radio & television.
-> As an anion exchanger in water purification by ion exchange method in boilers.
-> As an adhesive (binder) for grinding wheels etc.
-> In paints and varnish.
-> For making bearings used in propeller shafts, paper industry & rolling mills.

6. Describe the synthesis, properties and eng. app of following:
i] Nylon-6,6 ii] Teflon.

Ans i] Nylon-6,6: Nylon is a polyamide resin containing recurring amide groups (-NHCO-) in its structure produced by copolymerisation of diamine with acid.

→ Depending on no. of C atoms in diamine & dioxide there are different types of nylons like nylon 6,6, nylon 6,10, etc.

→ where the first no. indicates no. of 'C' atoms in diamine & the second no. indicates the no. of 'C' atoms in diacid.

→ Nylon 6,6: It is prepared by condensation polymerization of adipic acid & hexamethylene diamine in the absence of air.

$$n\,HOOC-(CH_2)_4-COOH + n\,H_2N-(CH_2)_6-NH_2 \longrightarrow [-OC-(CH_2)_4-CO-NH-(CH_2)_6-NH-]_n$$

Adipic Acid — Hexamethylene diamine — Nylon-6,6

Properties:

→ Structures of nylons are linear that permits side by side alignment

→ Moreover, the molecular chains are held together by 'H' bonds

→ Thus, nylons have high crystalline which imparts high strength, high melting point, elasticity, toughness, abrasion resistance and retention of good mechanical properties upto 125°C.

→ They are polar polymers, they have good hydrocarbon resistance.

Applications:

→ This major application is in textile industry

→ Cause of its high thermal & abrasion resistance nylons are used in mech. eng. app. like gears, bearings, machine parts where greater friction is there.

→ Flexible tubings for conveying petrol etc are made from nylons.

→ Nylons are used as electrical insulators.

→ Nylon-6 is used for making tire cords.

→ Nylon are used in automobile industry & telecommunication industry for making radiator parts & coil formers respectively.

ii] Teflon (Poly tetra fluoro ethylene): Teflon is obtained by polymerization of water-emulsion tetrafluoro ethylene under pressure in presence of benzoyl peroxide as catalyst.

$$n\,F_2C=CF_2 \xrightarrow[\text{Benzoyl Peroxide}/H_2O]{\text{Polymerization}} -(F_2C-CF_2)-_n$$

Teflon

Properties:

→ Teflon is also known as Fluon.

→ Due to the presence of highly electronegative fluorine atoms

→ There are strong attractive force is responsible for high toughness & high chemical resistance towards all chemicals except hot alkali metal & hot fluorine.

Uses:

→ It is used in making seals & gaskets, which have to withstand high temp.

→ It is also used for insulation of electrical items and for making non-sticky surface coating, particularly for cooking utensils.

→ Teflon used as insulating material for motors, transformers, cables, wires, fittings, etc.

7] Describe the synthesis, properties and eng. app. of following

i] Teflon - Q6 - ii An ii] Bakelite - 5An

8] Describe -- following:

i] Polytetra fluoro ethylene ii] Polyvinyl chloride

A i] Poly tetra fluoro ethylene - 6 ii An

ii] Poly vinyl chloride: Monomer used for manufacture of PVC is vinyl chloride. Vinyl chloride is prepared by treating acetylene with HCl at 60-80°C & in presence of a metal oxide catalyst.

$$\underset{\text{Acetylene}}{CH\equiv CH} + HCl \xrightarrow[60-80^{\circ}C]{\text{Metal Oxide}} \underset{\text{Vinyl chloride}}{CH_2=CHCl}$$

PVC is produced by heating vinyl chloride in presence of benzyl peroxide or H_2O_2.

$$\underset{\text{Vinyl chloride}}{n(CH_2=CH)\,Cl} \xrightarrow[\text{Polymerization at } 30-80^{\circ}C]{\text{Benzyl Peroxide}} \underset{\text{PVC}}{-(CH_2-CH)_n-\,Cl}$$

Applications:

→ Used for sewarage pipes and other pipe application.

→ PVC is relatively low cost, biological and chemical resistance & workability have resulted in it being used for wide variety of applications.

→ With addition of modifiers and stabilizers, it has become a popular material for window and door frames.

→ By adding plasticizers, it can become flexible enough to be used in cabling applications as a wire insulator.

9] Describe prep, prop, eng. app. of Bakelite.

A: 5Ans

10] Explain biodegradable polymers with example?

A Biodegradable polymers are defined as a degradable polymer in which degradation results from action of naturally occuring micro organisms as bacteria, fungi, algae. The biodegradable polymers may be "naturally occuring" or may be "synthesized by chemical" means.

i] Naturally occuring biodegradable polymers: A wide variety of naturally occuring polymers

are available, the fact that these substances were polymers were available not known. In many quarters this ignorance persists. The natural biodegradable polymers classified into four groups.

Naturally occuring Biodegradable Polymers →
- → Polysaccharides [Ex: starch & cellulose]
- → Proteins [Ex: silk, wool, gelatin]
- → Polyesters [Ex: Polyhydroxy alkanoits]
- → others [Ex: Lignine]

ii] Synthesized biodegradable polymers; There are many polymers produced from derived from petrochemical or biological sources that are biodegradable. There are a no. of biodegradable synthetic resins that are; polylactic acid and its polymers Polyvinyl esters; Polyvinyl alcohol; polyamide esters.

11. Explain the process of natural rubber and write disadvantages of natural rubber.

A Natural Rubber: High molecular weight hydrocarbon polymer represents $(C_5H_8)_x$ formula. Obtained by milk emulsion called latex by tapping the bark of tree.

$$n\,CH_2=C(CH_3)-CH=CH_2 \xrightarrow{\text{Polymerisation}} \left[CH_2-C(CH_3)=CH-CH_2\right]_n$$

Isoprene → Natural Rubber.

Processing of Natural Rubber:

By cutting the bark of rubber tree the milky colloidal rubber milk is obtained. The main constituent of rubber latex is 25-45% of rubber & the remaining are water, protein & resinous materials. The rubber latex is coagulated by using 5% acetic acid and made into sheets. The rubber sheets are cured under mild heat & then subjected to further processing.

12. Explain the vulcanization of rubber & write advantages of vulcanized rubber.

A Vulcanization of rubber: Heating of raw rubber at 100-140°C with sulphur. They combine chemically at double bonds of diff. rubber spring and provides cross-linking b/w chains. This cross linking during vulcanization brings about a stiffening of rubber by anchoring & consequently preventing intermolecular movement of rubber springs. Amount of 'S' added determines the extent of stiffness of vulcanized rubber.

For example, ordinary rubber (say for battery case) may certain as much as 30% sulphur.

$$-CH_2-C(CH_3)=CH-CH_2-CH_2-C(CH_3)=CH-CH_2- + -CH_2-C(CH_3)=CH-CH_2-CH_2-C(CH_3)=CH-CH_2- + \text{Sulphur}$$

$$-CH_2-C(CH_3)(-S-)-CH-CH_2-CH_2-C(CH_3)(-S-)-CH-CH_2-$$

Sulphur cross linkage.

Advantages of V·R:

→ Has excellent resilience.
→ Tensile strength increase
→ Has better resistance to moisture, oxidation & abrasion.
→ It is resistance to organic solvents like CCl_4, Benzene petrol, etc.
→ Has slight thickness, low elasticity.

13. What are elastomers? Explain prep, prop, app of Buna-S.

A Elastomers: An elastomer is a polymer with viscoelasticity (i.e, viscosity and elasticity) and with weak intermolecular forces.

Buna-S-Rubber: Copolymer of butadiene (75%) and styrene (25%). In early days of its synthetic sodium was used as catalyst. Hence it is bu(butadiene), na(sodium) and s (styrene) & also called as GRS (govt. rubber styrene) or SBR (styrene butadiene rubber). It is the first synthetic rubber developed during 2nd world war by US in order to overcome the scarcity of natural rubber

Preparation: Prepared by copolymerization of butadiene & styrene.

$$n CH_2=CH-CH=CH_2 + n \text{ (C}_6\text{H}_5\text{-CH=CH}_2\text{)} \xrightarrow{\text{catalyst}} \left[(CH_2-CH=CH-CH_2)-(CH-CH_2)\right]_n$$

Butadiene — Styrene — Buna-S.

Properties:

→ Good electrical insulator.
→ Strong & tough polymer
→ Possess excellent abrasion resistance.
→ Possess high load bearing capacity & resilience.
→ Resistance to chemicals but swell in oils & attacked by even traces of ozone present in atm.

Applications:

→ Major app. is in manufacture of tyres.
→ Used in foot wear industry for making shoe soles.
→ Used for production of floor tiles, tank linings in chemical industries.
→ Used in making wires and cables, insulators.

14. What is synthetic rubber? Explain prep., prop., app of thiokol rubber.

A Synthetic rubber: is an artificial elastomer. They are polymers synthesized from petroleum by products.

Thiokol rubber (or) poly sulphide rubber (or) GR-P:

Thiokol is prepared by the condensation of polymerization of sodium poly sulphide (Na_2S_x) and ethylene dichloride ($Cl-CH_2-CH_2-Cl$). In these elastomers, 'S' forms a part of polymer chains.

$$Cl-CH_2-CH_2-Cl + Na-S_5-S_5-Na + Cl-CH_2-CH_2-Cl \xrightarrow{\text{Polymerization}} \left[H_2C-CH_2-S-S-CH_2-CH_2\right]_n + NaCl$$

1,2 dichloroethane — Sodium poly sulphide — Thiokol Rubber (ethylene poly sulphide polymer)

Properties:
→ Possess strength and impermeability to gases.
→ This rubber cannot be vulcanized because its structure is not similar to natural rubber & it can't form hard rubber.
→ Possesses extremely good resistance to mineral oils, fuels, oxygen solvents ozone & sunlight.

Applications:
→ Fabrics coated with thiokol are used for barrage balloons.
→ Mainly used as solid propellant fuel for rocket.
→ Also used for making gaskets, hoses, cable linings, tank linings, etc.
→ Used for printing rolls.
→ Containers for transporting solvents.
→ Diaphragms and seals in contact with solvents.

15] What are the characteristics of lubricants? Describe the mechanism of lubrication that is applied to delicate instruments.

A = A lubricant is a substance, usually organic, introduced to reduce friction b/w surfaces in mutual contact, which ultimately reduces the heat generated when the surfaces move. Property of reducing friction is known as lubricity.

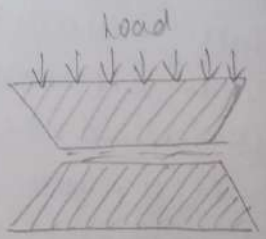
Characteristics of lubricants:
i] High boiling point & low freezing point
ii] High viscosity index
iii] Corrosion prevention
iv] High resistance to oxidation
v] Thermal stability.
vi] Hydraulic "
vii] Demulsibility.

Mechanism of lubrication:
Lubrication film b/w 2 contact surfaces is thick enough & 2 contact surfaces are seperated completely by viscous oil film. At this time, frictional force of 2 contact surfaces are determined by viscous resistance of lubricant & can be very small value (coeff. of friction can be 0.0001).

i] Thick film lubrication (Fluid film lubrication)
ii] Thin " " (Boundary ")
iii] Extreme pressure lubrication.

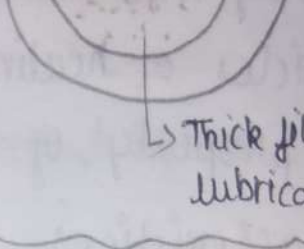
Delicate instruments ⇒ Thick film.

Thick film or hydrodynamic lubrication occurs when non-parallel rigid bearings surfaces lubricated by film-fluid slide over eachother, forming converging wedge of fluid & forming a lifting pressure.
→ Sliding surfaces are seperated by thick layer of lubricant.



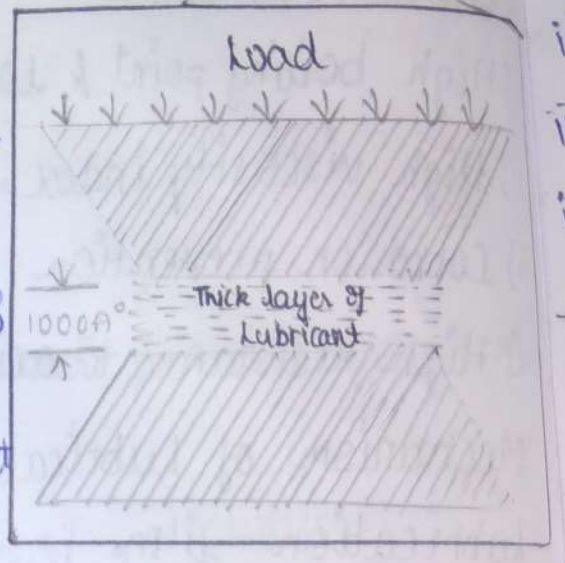
into direct contact with each other.

→ Thus, the resistance to movement is only due to internal resistance of the lubricant



1. Thick film:

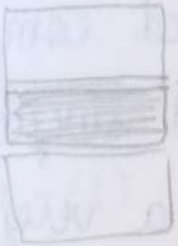
"Thick film" or "hydrodynamic lubrication" occurs when non-parallel rigid bearing surfaces lubricated by a film-fluid slide over each other, forming a converging wedge of fluid and forming a lifting pressure.



→ Sliding surfaces are seperated by thick layer of lubricant

→ Thickness of layer is 1000A°, low load & high speed

→ Coefficient of friction is 0.001 - 0.03



Example: Rotation of shaft (Fig: 1)

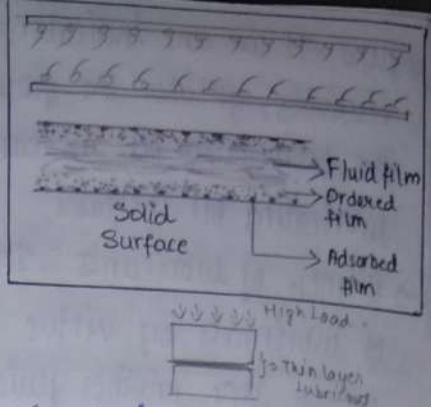
i] Viscosity of lubricant plays important role.

ii] Too High - Lubricant will create friction.

iii] Too low - Lubricant will not be able to maintain thick layer.

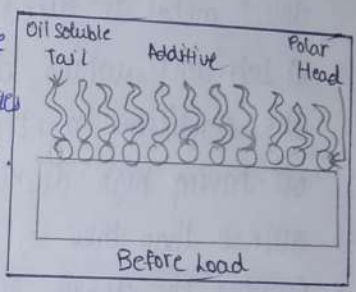
Other examples are gun, sewing machines, internal combustion engine, watch, scientific instruments in which speed of machine is high & load on machine is low; where oil is used as lubricant.

Thin film:
It is formed where thick film lubrication fails, thin film lubrication is done. "Thin film" or "boundary lubrication" is done for those cases in which the continuous film of lubrication cannot persist and direct metal to metal contact is possible.



→ Sliding surfaces are seperated by thin layer of lubricant, high load & low speed.
→ Coefficient of friction is 0.05 - 0.15
Example: Rollers, gear box (when load is very high & speed is low on machine), tractors, rail, axle, etc.

Extreme pressure lubrication:
The fast moving or sliding metallic surfaces under very high pressure produce a large amount of heat & temperature becomes very high. At high temperature the ordinary liquid lubricants decompose or even vaporise at such a high temperature and fail to stick over the metallic surfaces. To face such conditions extreme pressure additives are added to mineral oil.



Properties of lubricants:
i] Cloud and Pour point
ii] Flash and Fire point
iii] Viscosity
iv] Oiliness of lubricants

→ Cloud Point: The temperature at which the impurities being to seperate from the solution and lubricating oil becomes cloudy or hazy in appearance is called cloud point.
→ Pour point: The temperature at which the oil ceases to flow and pour is called pour point.
→ Flash point: The flash point of a volatile material is the lowest temperature at which vapors of the material will ignite, given an ignition source.
→ Fire point: The fire point of a fuel is the lowest temperature at which the vapour of that fuel will continue to burn for atleast 5 sec after ignition by an open flame.
→ Viscosity: It is the property of a fluid that determines its resistance to

flow. It is an indicator of flow ability of lubricating oil. The lower viscosity, greater the flow ability. If temperature increases viscosity of the lubricating oil decreases and pressure increases viscosity of lubricating oil increases.

→ Oiliness of lubricants: The term "oiliness" is defined as that property of lubricants by virtue of which one fluid gives lower coefficients of friction than another fluid of same viscosity

- It is the property of the lubricant to stick onto the surface under the conditions of high speed and heavy load.
- It is an important property in selecting a lubricant for a particular application. Generally under conditions of high speed & heavy load, oil may be squeezed out from the sliding surfaces and the oil film may be reduced in thickness, with the result, the lubricating action will stop & direct metal to ~~direct~~ metal contact will take place.
- A lubricant which does not squeeze out from the sliding surface under the conditions mentioned above & maintains a continuous film is known as oil having high degree of oiliness. Normally fatty oils have high degree of oiliness than those of lubricating oils obtained from petroleum.

Further the degree of oiliness of lubricating oils obtained from petroleum can be improved by adding little quantity of oleic acid, stearic acid, etc.