MODULE IV

METALS AND ALLOYS

PROPERTIES OF METALS

1. All metals are solids except mercury
2. Ductility
3. Malleabilty
4. Weldability
5. Elasticity
6. Hardness
7. Toughness
8. Brittleness
9. Stiffness
10. mechinability

Alloys

It is a homogeneous solid mixture of two or elements in which at least one should be a metal.

Eg- brass(Cu=60%, Zn=40%)
bronze(Cu=90%,Sn=10%)
steel(iron, carbon=0.3 to 2.5%)
solder(Pb=37-60%,Sn=31-60%)

Purpose of making alloys

1. To increase the resistance to corrosion
2. To increase the hardness of the metal
3. To lower the melting point of the metal and to make it easily fusible
4. To modify the chemical activity of the metal
5. To modify the colour
6. To provide the better castability

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GLASS

- **glass is a amorpnous, hard ,brittle , transparent super cooled liquid of infinte viscosity obtained by fusing sodium carbonate , calcium carbonate and silica**

General properties of glass

1.amorphous
2.it can be moulded to any shape
3.very brittle
4.good electric insulators
5.it can absord, reflect and transmitt light
6.on heating it softens
7.affected bt alkalies

Types of glasses

1. **soda glass or soft glass**

- **Mixture of sodium and calicum silicate**
- **cheap, easily attacked by acids and easily fusible**
- **used for making windowlass,bottles,bulbs,jars and dishes**

2.Borosilicate glass or pyrex glass

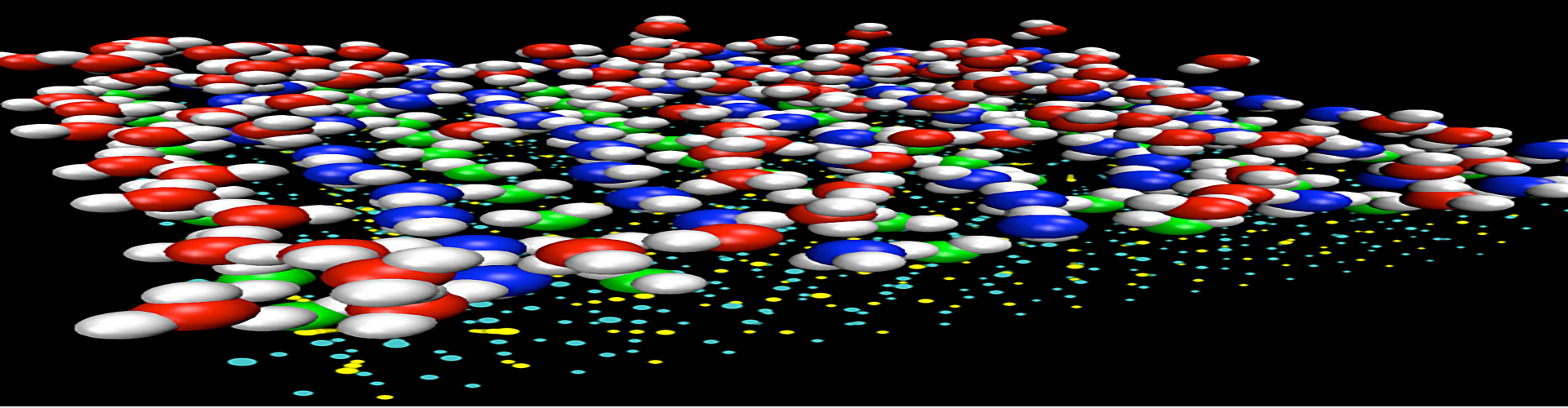
- Mixture of sodium and aluminium
- can withstand high temperature
- resistant to chemicals and low coifficient of expasion
- used for making laboratory glassware, kitchen wares,television tubes and industrial pipelines

3.safty glass

- when breaks does not allows the pieces to fly apart
- obtained by placing a thin layer of vinyl plastic between the two sheet of glasses.
- plastic and glass are pressed together under heat .
- it is commonly used in automobile and aero plain window shield.

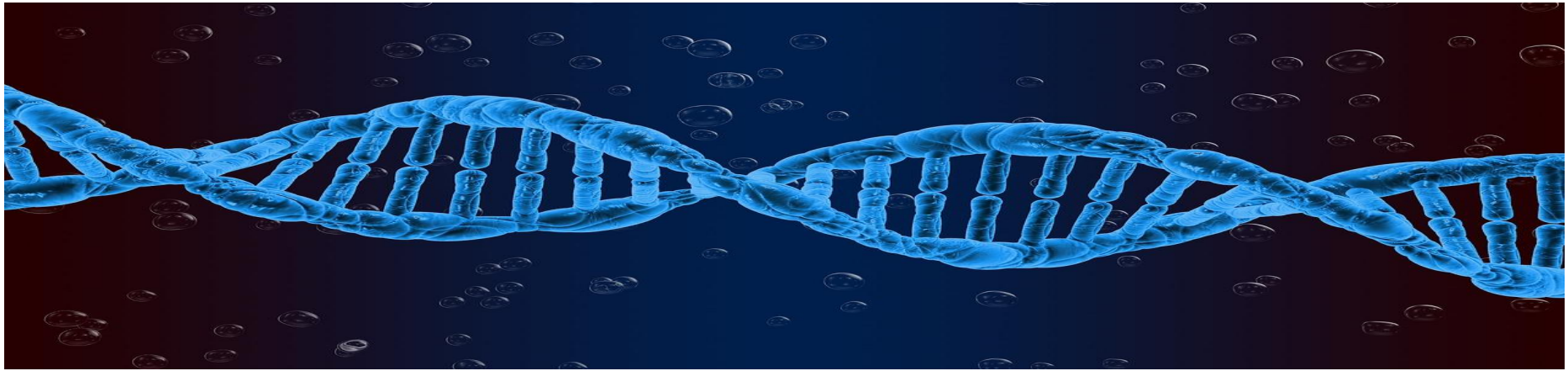
4. insulating glass

- prepared by two or more plate of glass separated by 6-13 mm gap filled with dehydrated air and sealing around the edges.
- this air gap provided high insulating against heat.
- used for separating rooms in apartments
- the apartments will remain cool at summer and warm at winter.



NANOCHEMISTRY AND NANOMETERIALS

- NANOSCIENCE-Branch of science deals with nanometrials , their properties and applications



Nano scale:1nm=10^{-9}m

Nano chemistry- Study of materials of the size 1 to 100 nm .

Examples for nano merterials :

DNA,RNA, nanogold,Carbon nanotube, fullerene etc

Based on the physical dimension nanoparticles are classified in to :-

1.Zero Dimensional:

eg-Fullerenes,Quantum dots

2.One Dimensional:

eg-CNT,Nanowires

3.Two Dimensional:

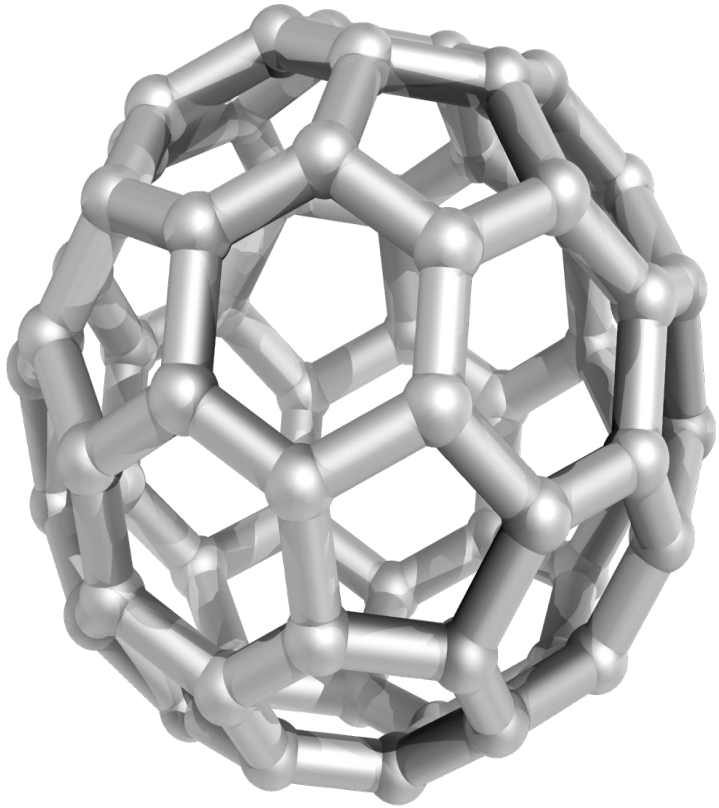
Eg-graphene

4. Three Dimensional:

eg-Boxshaped graphene(BSG)

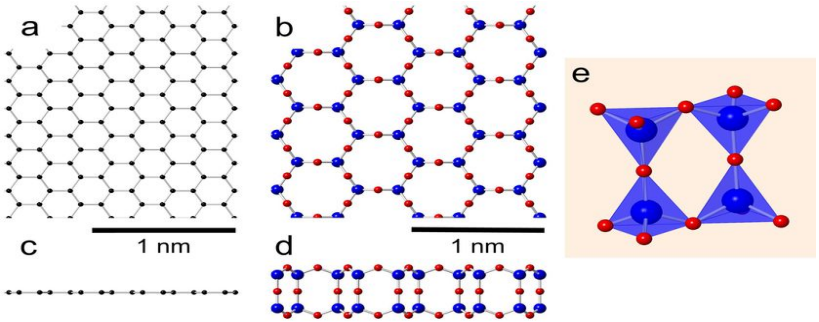
FULLERENE

- Allotropes of carbon
- It is also known as buckyballs,molecules of carbons connected with single and double bonds
- The first fullerene molecule is buckminsterfullerene(C-60)
- Diameter equal to 1.01nm
- It has 20 hexagons and 12 pentagons,with carbon atom at each vertex



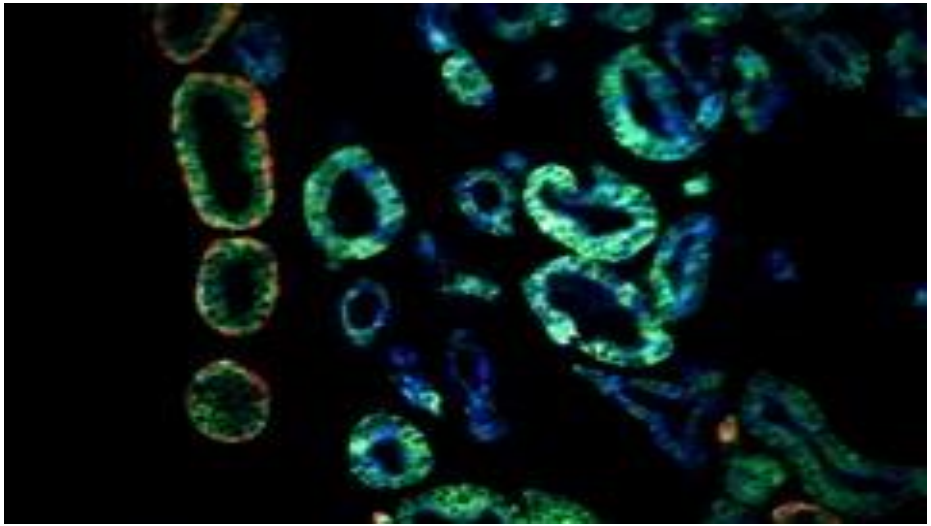
Graphene:-

- Allotrope of carbon
- Hexagonal lattice
- Consist of graphite sheet of SP^2 hybridised carbon atom
-



Quantum dots:-

Nanocrystals reffered as quantum dots

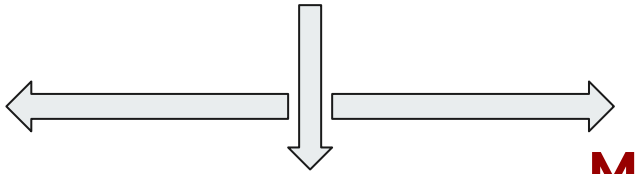


Applications of Nanomaterials:-

1. **Act as better catalyst**
2. **Tumours can be detected and located with high accuracy**
3. **DNA mapping of newborns**
4. **Used for drug delivery to the exact spot in the body**
5. **Used in the cancer treatment**
6. **Used in cosmetics , sun screen ,electronics etc…**
7. https://www.youtube.com/watch?v=1QwyMWM0Jjg

CARBON NANOTUBES(CNT)

- They are cylindrical tubes formed by rolling one or more graphene sheets
- ➔ Base on the lyres of graphene sheets CNT classified as



Multiwalled
Consist multiple lyer

Single walled
Consist a single lyer

Refractories

Refractory substance means any substance that can withstand high temperature without softening , melting or deformation.

Ex- Alumina bricks, silica refractories etc

General properties of refractory meterials

1.Refractoriness

It is the property of meterial to withstand high temperature without undergoing softness.

2.Porosity

It is the ratio between the pore volume to bulk volume.A good refractory meterials should have lower porosity.

3.**Thermal spalling**

Property of refractory brick for undergoing fracturing , peeling or cracking under high temperature. A good refractory brick having minimum tendency of thermal spalling.

4.strength

A good refractory brick should have high mechanical strength even at operating temperature.

Fireclay bricks collapse under heavy load,where silica brick exert good load bearing strength.

5.**chemical inertness**

It should be inert towards slag, fuel furnace gas etc.

6. Thermal expansion

A good refractory should have least possible thermal expasion

7.Electrical conductivity

They should have low electrical conductivity.

Classification of refractory

They are classified on the basis of chemical nature.

1.acidic refractory

They are not attacked by acidic slag but easily attacked by basic substances.

eg-Alumina,silica and fire refractories.

2.Basic refractory

They are not attacked by basic substances but attacked by acidic substances.

eg-Magnesite,dolomite

3.**Neutral refractory**

They are not attacked by slightly acidic or basic substances.

Eg- chromite, graphite, silicon carbide

Polymers

Poly - many

Mer-- units

Polymers- many units

Polymers formed by joining of repeating structura units using covalent bond on large scale.

The process of formation of polymers from monomers is calls polymerisation.

$$n CH_2=CH_2 \rightarrow -(CH-CH)_n-$$

Ethene **polythene**

Classification of polymers

1. **Based on the monomeric units**

   I. Homopolymers

   Polymers whose repeating structural units are only one type of monomers.

   Eg-polythene- monomer is ethene

   PVC(vinyl chloride)

   Natural rubber(isoprene)

li.copolymers

Whose repeating units are different monomers

Eg- nylon -6,6 (hexamethylenediamine and adipic acid.

Buna-S (butadiene and styrene)

Classification based on sources of availability

1.Natural polymers

Polymers are found in nature ie in plants and animals,

Eg- protein , starch cellulose

2. Semi- synthetic polymers

Polymers which obtained from nature but modified by some chemical treatment.

Eg-rayon (cellulose acetate)

Gun cotton(cellulose trinitrate)

3.synthetic polymers

Which are man made .

Eg-fibers(nylon-66)

plastic(polyethene, polypropene)

Synthetic rubber(Buna-s)

Classification based on structure

1.linear polymers

Consist of long and straight chains of polymer molecules.

Because of the close packing these polymers have High density , high M.P, and high tensile strength

eg-High density polyethylene(HDPE),nylon-66

2.branched chain polymers

These polymers contains linear chains having some branches.

They do not pack well , so they have low M.P, low density, and low tensile strength.

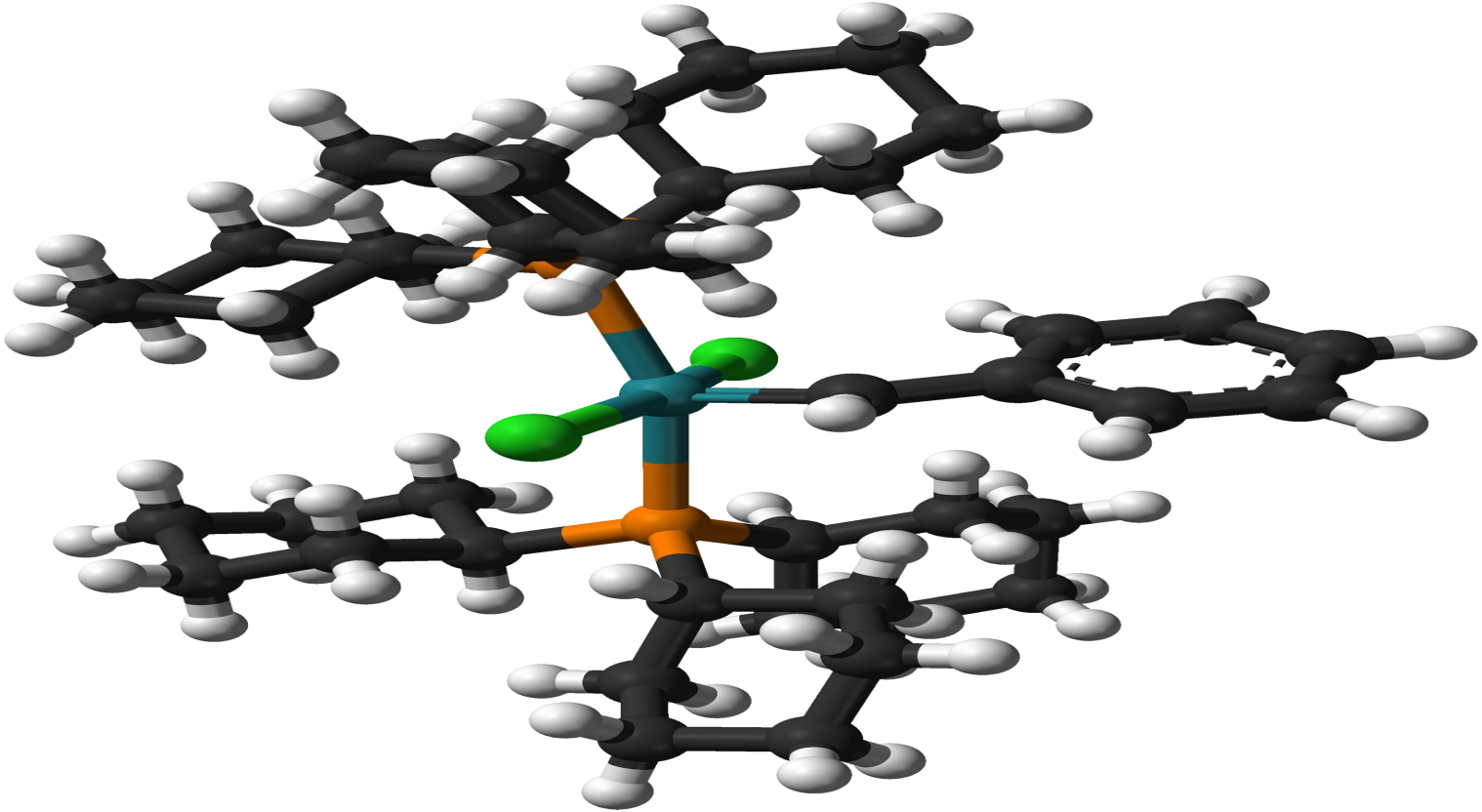
eg-Low density polyethylene(LDPE)

glycogen

3.Three -dimensional network polymers or crosslinked polymers

These polymers contain strong covalent bond between various linear polymers.They have cross linking between the polymeric chain.

- **They are hard,rigid and brittle**
  Eg-bakelite, urea formaldehyde polymers.



Classification based on the mode of polymerisation

1.Addition polymers

Formed by the repeated addition of monomers .

They are also called chain growth polymers.

Eg-formation of polyethene from ethene

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

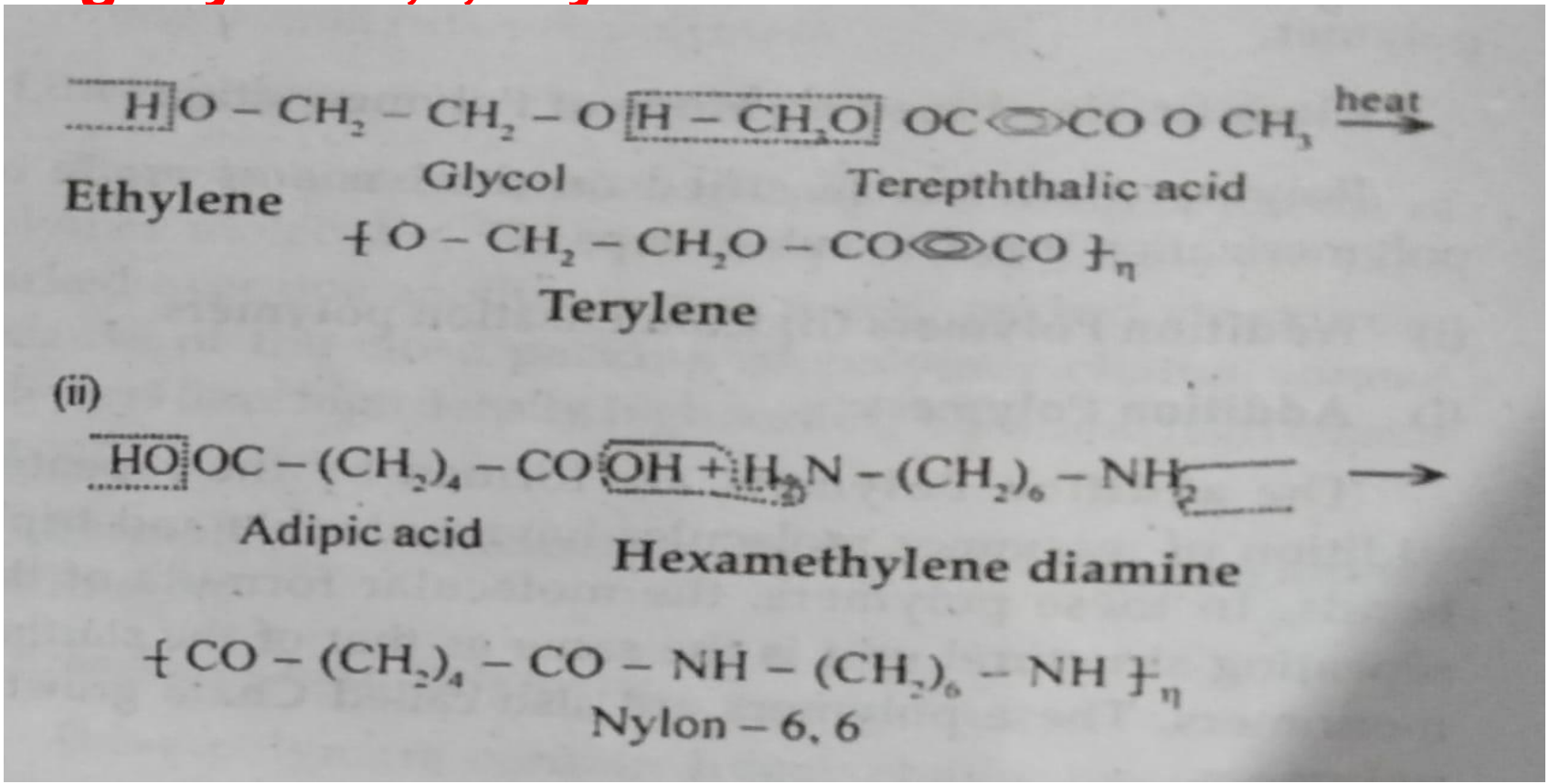
Buna-S,Teflon, Rubber, PVC etc

CH2=CH2+ CH2=CH2------CH2-CH2-CH2-CH2-

2.Condensation polymers

- These polymers are formed by repeated reaction between the two different bi-functional or Tri- functional monomeric unit.
- In these polymeric reaction elimination of small molecule like water, alcohol, hydrogen chloride etc take place.
- These polymers are also called as step growth polymers.

Eg- nylon-6,6,terylene etc



Classification based on molecular forces

Depending upon the magnitude of intermolecular forces, polymers are classified in to-

1.Elastomers

- ➔ In which the intermolecular force of attraction between the polymer chains are weakest.
- ➔ They have elastic properties.
- ➔ These weak bond permit the polymers to be stretched, and retain its original form.
- ➔ Eg- rubber,Buna-S, Buna-N

2.fibers

- Polymers in which the intermolecular force of attraction are strongest .
- These forces are either hydrogen bonding or dipole-dipole interaction.
- Fibers have high tensile strength.
- Long , thin and treadlike which lead to close packing , which impact crystalline nature with high M.P
- Eg-nylon-66,polyester'..

3.Thermoplastic polymers

- Polymers in which intermolecular forces of attraction are between elastomers and fibers.
- They are softening on heating and hardening on cooling.
- These polymers can be moulded into any shapes.
- eg-polyethene,polypropene,P.V.C., teflon.

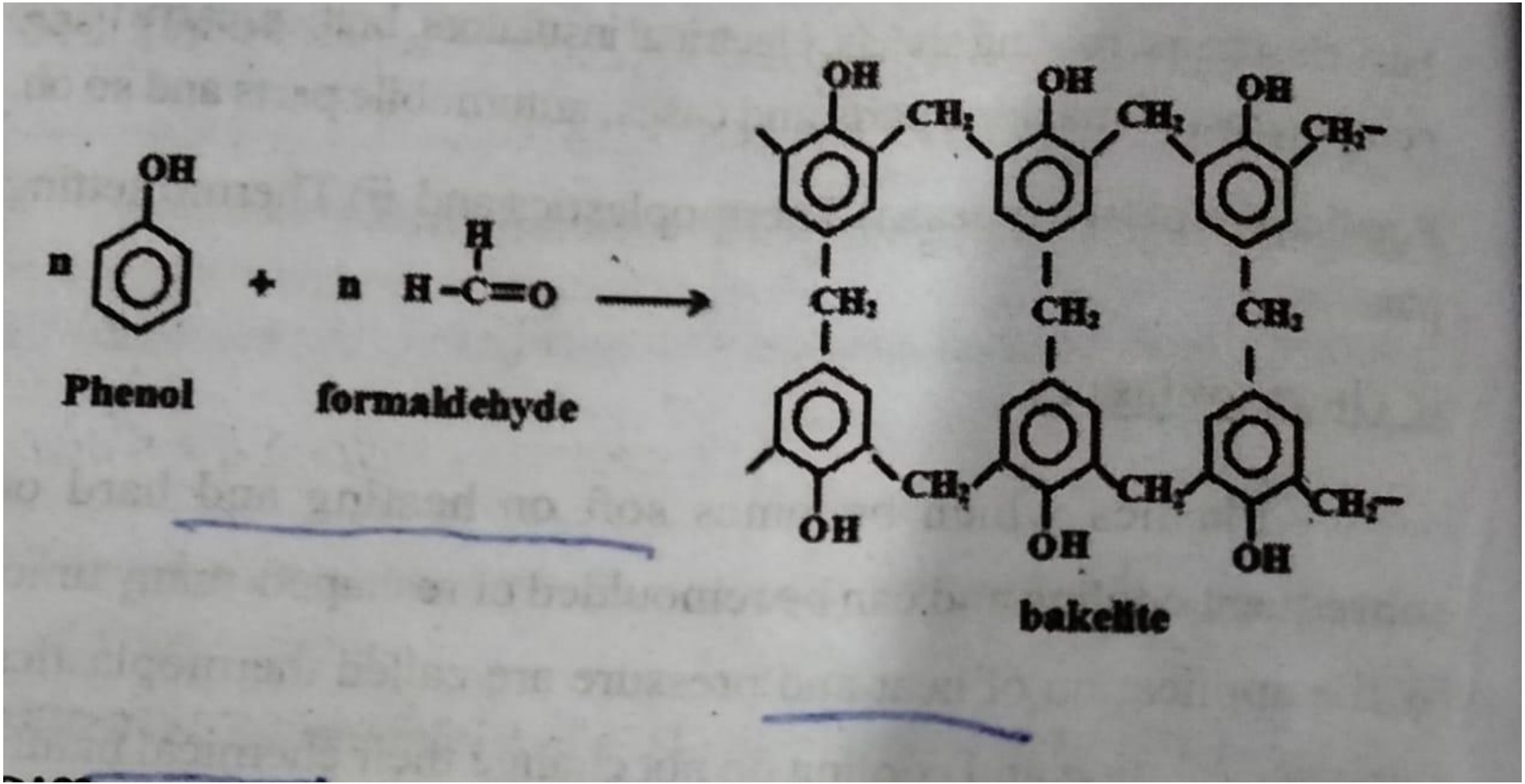
4. Thermosetting plastics

- Plastic which can be moulded only once and cannot be remoulded by the application of heat and pressure.
- When heated it becomes hard and further heating result chemical decomposition.
- Non recyclable
- Cross linked polymers
- Eg-bakelite,melemine polymers.

Thermoplastics	Thermosetting plastics
1.It is recyclable plastic.	1. It is non recyclable plastic.
2.It can be remoulded and reshaped many times by applying heat and pressure	2. It cannot be remoulded and reshaped by applying heat and pressure.
3.It becomes soft on heating and hard on subsequent cooling.	3. It becomes hard and decomposed on heating.
4. These are linear polymers	4.These are cross linked polymers
5.Formed by addition polymerization.: Eg. Polyvinyl chloride, polyethelene, poly styrene.	5.Formed by condensation polymerization. Example: Bakelite, melamine polymers.

Bakelite

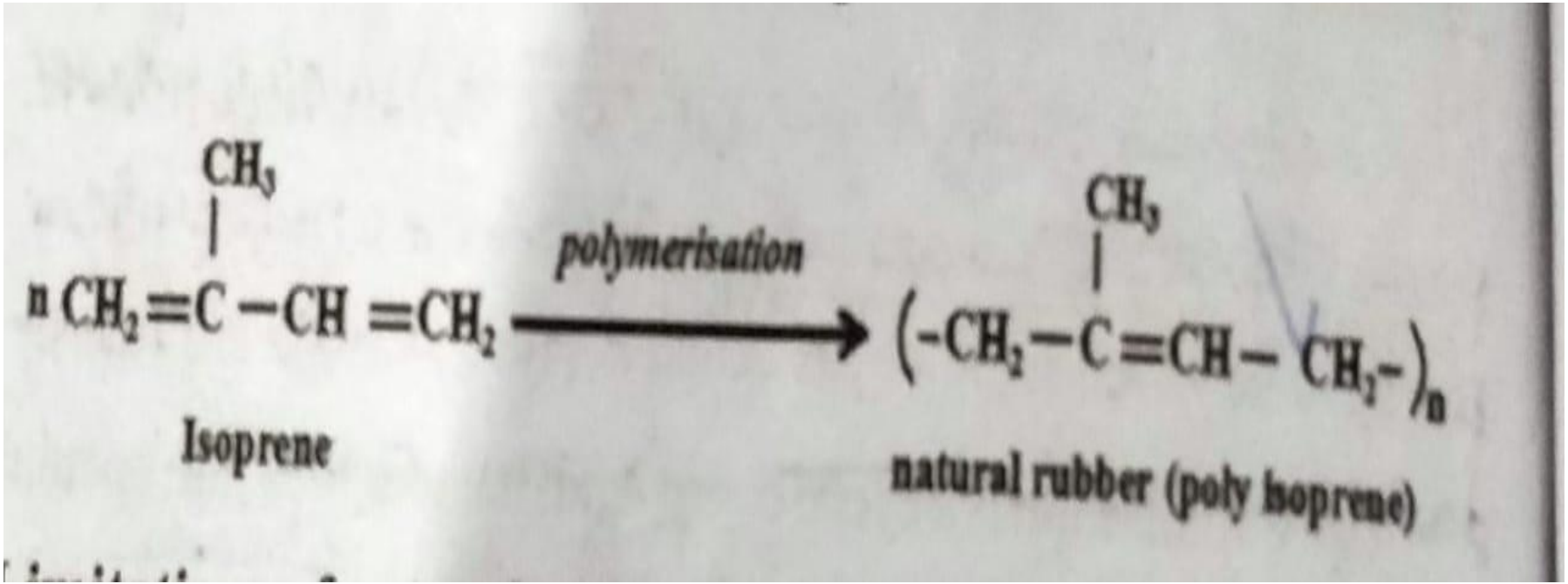
- ★ Cross-linked thermosetting plastic.
- ★ Formed by the condensation reaction of phenol and formaldehyde.
- ★ Does not conduct electricity, resistant to heat, non inflammable.
- ★ Resistant to chemicals.


OH
n
+
n
H
H–C=O
Phenol
formaldehyde
OH
CH₂
bakelite

Rubber

1. **Nature rubber;-**

- Linear polymer of isoprene(2-methyl-1,3 buta diene)
- It have weak van der waals force and has coiled structure.
- Stretched like a spring and exhibits elastic properties.
- Used for making tyres, rubberbands, gloves etc


CH3
n CH2=C−CH=CH2
polymerisation
(-CH2−C=CH−CH2-)n
Isoprene
natural rubber (poly hoprene)

Limitation of natural rubber

- *Low strength and elasticity.*
- *Quality is very poor.*
- *Damaged by atmospheric oxidation.*
- *Absorb water and swell.*
- *Used only at 10-50^{o}c*
- *In hot weather it become soft and sticky.*
- *In cold weather it become hard and brittle .*

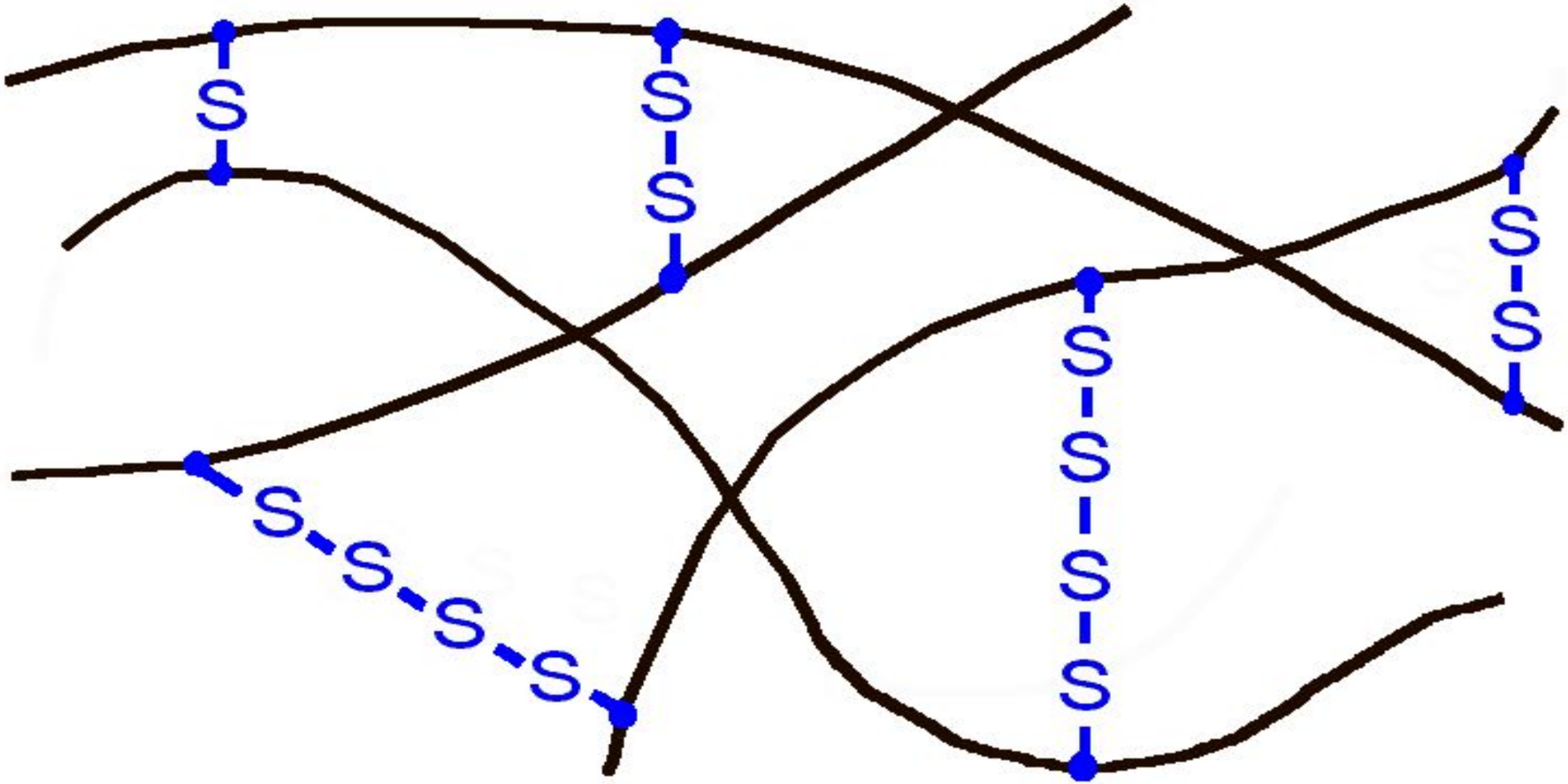
★ **So it cannot be used in tyre production.**

Vulcanization

- ➔ It is the process of heating natural rubber with sulphur (3-5%) and zinc oxide at temperature range of 110-140°C.
- ➔ It form sulphur cross linking between the rubber chain.

Merits of vulcanization

- ❖ It improve the elasticity , tensile strength , abrasion resistance and rigidity.
- ❖ Make rubber less sensitive to temperature changes
- ❖ Resistance the rubber from oxidation and swelling.
- ❖ Vulcanization make the rubber suitable for tyre making.


S
S
S
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S
S
S
S
S
S
S
S

Synthetic rubber

Artificially produced elastomers are called synthetic rubber.

Eg- Buna -S, Buna-N, Neoprene.

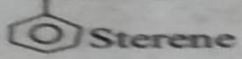
SBR, Buna-N , Neoprene etc.

Buna-S or SBR

Buna-S is produced by the copolymerization of butadiene and styrene in presence of sodium.

$$n\,CH_2=CH-CH=CH_2 + n\,CH_2=CH \rightarrow$$

Butadiene



Sterene

$$(-CH_2-CH-CH_2-CH=CH-CH_2-)_n$$

Buna S of SBR

Buna-N

Buna-N is produced by the copolymerization of butadiene and acrylo nitrile in presence of sodium

$$n\,CH_2=CH-CH=CH_2 + n\,CH_2=CH(CN) \xrightarrow{Na}$$

Butadiene

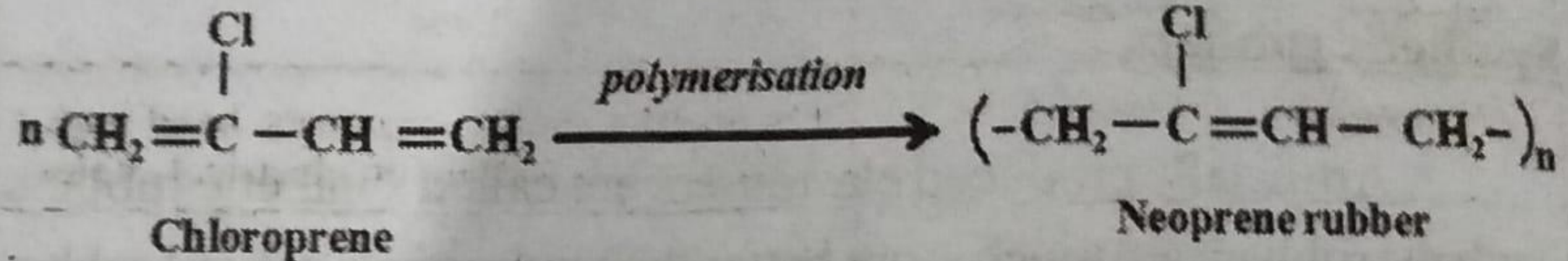
Acrylo nitrile

$$(-CH_2-CH(CN)-CH_2-CH=CH-CH_2-)_n$$

Buna-N

Neoprene

Neoprene rubber is produced by the polymerization of chloroprene.



Natural rubber	Synthetic rubber
1. Obtained from natural source (from rubber tree)	1. Produced artificially. Raw materials are mainly petrochemicals.
2. Quality is very poor. Requires vulcanization. Useful only within a narrow temperature range.	2. Quality is very good. vulcanization may be done. Useful within a wide range of temperature.
3. Low rigidity, tensile strength.	3. High rigidity, tensile strength.
4. Low abrasion and chemical resistance.	4. High abrasion and chemical resistance.
5. Absorb water and swell. Less resistance to oil and solvents.	5. Very low absorption of water and swelling. High resistance to oil and solvents.
6. Low resistance to atmospheric attack. Very short life.	6. High resistance to atmospheric attack. Long life.
7. Inflammable.	7. Generally non inflammable.

Polymer	Monomer	Uses
1. Polythene	Ethene	For making sheets, rain coats, hand bu table clothes, coating on electrical cab
2. Poly propene	Propene	Fibres for carpets, clothing, car bumpe dash boards, transparent bottles etc
3. PVC	Vinyl Chloride	For making housewares such as bucke chair, tables, doors, containers, bottles pipes, toys. Window frames, cable an wire insulation, footware, credit cards
4. Neoprene	Chloroprene	Oil seals, gaskets, hoses, belts etc
5. Polystyrene	Styrene	For making toys, thermocol,cases of television and refrigerators etc.
6. Bakelite	Phenol and form aldehyde	For making handless or kitchen wares electric switches, plug tops, telephone instruments etc.
7. Teflon	Tetrafluro ethylene	For making non-stick cookwares, industrial gaskets, leak proof sealing for pipe fittings etc.
8. Nylor - 6 or Perlon L	Caprolactum	For making carpets, fabrics, rops, tyre cords, fisherman net etc
9. Nylon-6,6	Hexamethylne diamine and adipicacid	For making carpets, fabrics, rops, tyre cords, fisherman net etc
10. Buna N	Butadiene & acrylo nitrile	For making conveyer belts, fuel tanks hoses, printing rollers.
11. Buna-S	Butadiene and Styrene	For making tyres, hoses, shoe soles.