

POLYMER

- 1.1. Cellulose acetate is a** [WBUT 2006]
a) natural polymer b) synthetic polymer
c) semisynthetic polymer d) thermosetting polymer
Answer: (c)
- 1.2. The polydispersity index of a commercial polymer is** [WBUT 2006]
a) 1.0 b) 5.0 c) 50.0 d) 100
Answer: (b)
- 1.3. The monomer unit present in natural rubber is** [WBUT 2006, 2011(JUNE)]
a) 1, 3-butadiene b) 2-methyl-1, 3-butadiene
c) 2-ethyl-1, 3-butadiene d) 2-chloro-1, 3-butadiene
Answer: (b)
- 1.4. A conducting polymer is** [WBUT 2007, 2010(JUNE)]
a) Polyethylene b) Polypropylene c) Polyaniline d) Bakelite
Answer: (c)
- 1.5. Most commonly used vulcanising agent is** [WBUT 2007]
a) Graphite b) Sulphur c) Lampblack d) Softsoap
Answer: (b)
- 1.6. An example of thermosetting plastic is** [WBUT 2008]
a) PVC b) nylon c) polythene d) bakelite
Answer: (d)
- 1.7. Caprolactum is a monomer of** [WBUT 2009]
a) Bakelite b) PVC c) Nylon-66 d) Teflon
Answer: (Nylon 6) All the options are incorrect.
- 1.8. A conducting polymer is** [WBUT 2010(JUNE)]
a) Polyethylene b) Polypropylene c) Polyaniline d) Bakelite
Answer: (c)
- 1.9. An example of step-growth polymer is** [WBUT 2010(DECEMBER)]
a) PVC b) Teflon c) Bakelite d) Poly-butadiene
Answer: (c)
- 1.10. Which of the following is not a polymer?** [WBUT 2011(JUNE)]
a) Silk b) DNA c) TNT d) Starch
Answer: (c)

1.11. Phenol formaldehyde is an example of [WBUT 2011(JUNE)]

- a) Addition polymer b) Isotactic polymer
c) Thermoplastic polymer d) Thermosetting polymer

Answer: (d)

1.12. Tetrafluoroethylene is the monomer of [WBUT 2011(DECEMBER)]

- a) Polyethylene b) Nylon 6 c) Polyvinyl chloride d) Teflon

Answer: (d)

1.13. Proteins are biopolymers. The monomer units present in them are [WBUT 2011(DECEMBER), 2012 (JUNE)]

- a) alkene b) amino acid c) fatty acid d) carbohydrate

Answer: (b)

2.1. What do you understand by polymerisation? What is the degree of polymerisation? Write down the structure and use of Nylon-66 and PVC.

[WBUT 2007, 2010(JUNE)]

Answer:

1st Part:

A polymer is a large molecule with high molecular weight consisting of a repeat unit or 'mer' made from simple molecules. The simple small molecule which is the building block of the giant polymer molecule is called the **monomer**.

The repeat unit in a polymer is usually equivalent or almost equivalent to the monomer molecule.

This process of transformation of a monomer molecule to a polymer molecule is known as **polymerization**.

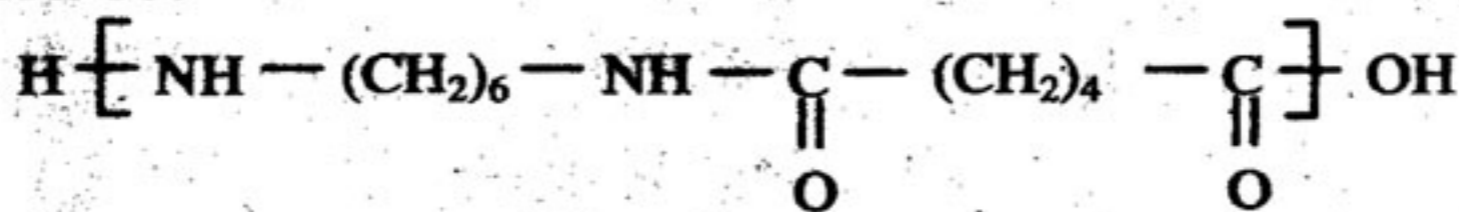
2nd Part:

The largeness of polymer molecule depends on the number of repeat units present in it. The number of repeat units present in a polymer molecule is called the **degree of polymerization (DP)**.

The molecular weight of the polymer is therefore given by the expression $M = DP \times m$, where M and m represents the molecular weight of the polymer and its repeat unit respectively.

3rd Part:

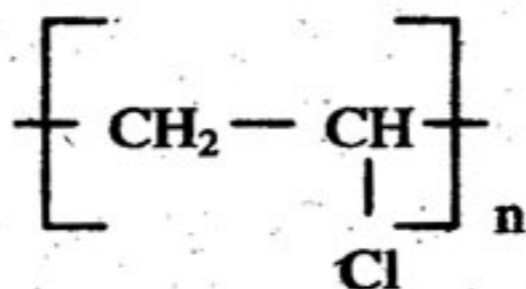
Structure of Nylon 66:



Poly (hexamethylene adipamide)

Use: Sterilizable nylon moldings in medicine and pharmacy, nylon hair combs and nylon film for packaging food stuffs and pharmaceutical products. Other applications of the nylons include textiles, ropes, tows, nets, pipes, tubes, rods, bottles and containers toys, electrical components etc.

Structure of PVC:



Polyvinyl chloride

Use: PVC is used as storage tanks, building items, pipes, sheets, specific molded objects and containers. Building items such as waste piping, window frames and transparent roof sheeting, floor tiles, wall linings etc. Other flexible or semi-rigid applications include packaging items, tubes, pipes and hoses, leather cloths, molded objects, sheets, films, containers, foot wear, belting and wire insulation.

2.2. Explain addition and condensation polymerization with example.

[WBUT 2005, 2007, 2010(JUNE)]

Answer:

Addition Polymerization:

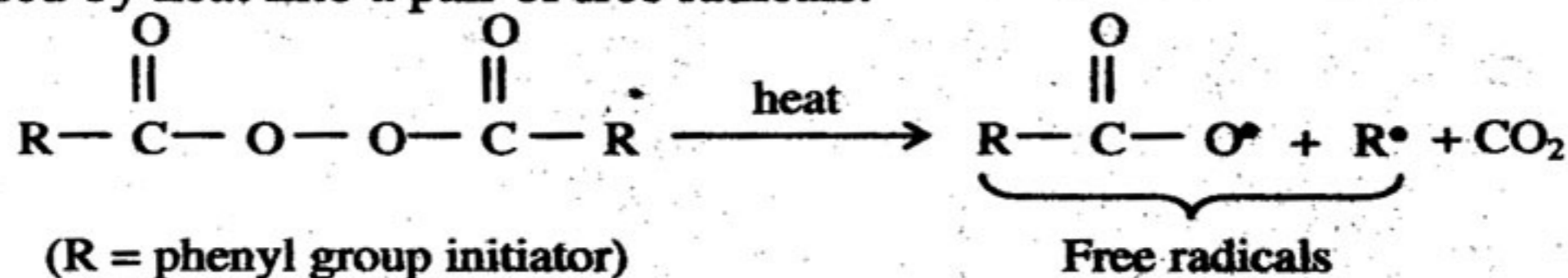
Addition polymerization has got three distinct stages:

- birth of the chain i.e. initiation
- growth of the chain i.e. propagation
- death of the chain i.e. termination

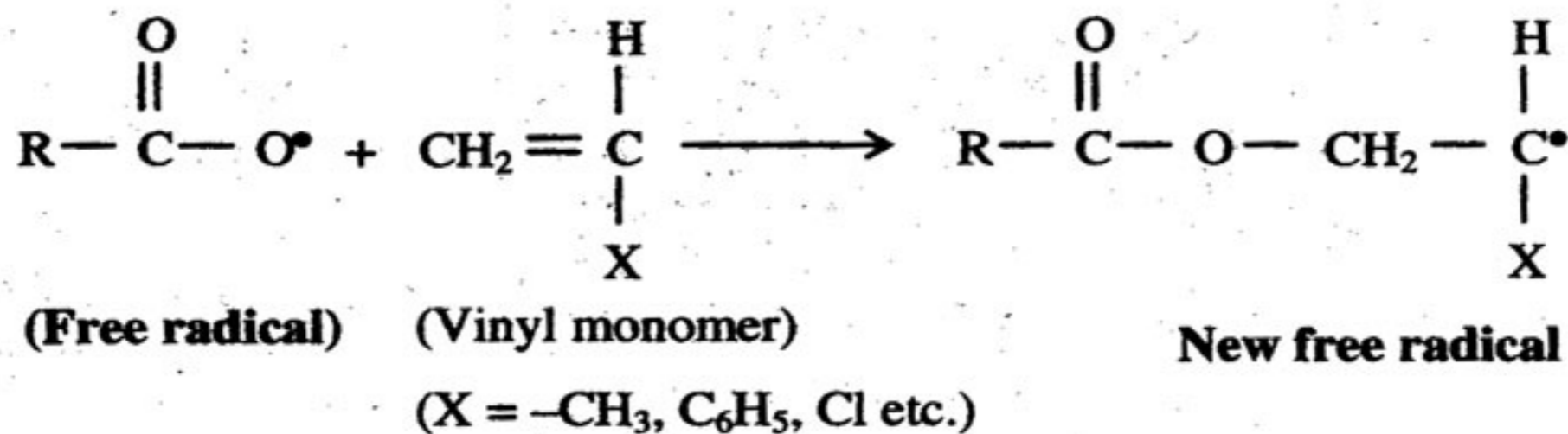
Addition polymerization process involves an active intermediate species as the chain carrier. The chain carrier may be a free radical, an anion or a cation. Depending on the nature of the chain carrier the polymerization may be radical chain, anionic chain or cationic chain polymerization.

Example: (Free radical initiated addition Polymerization)

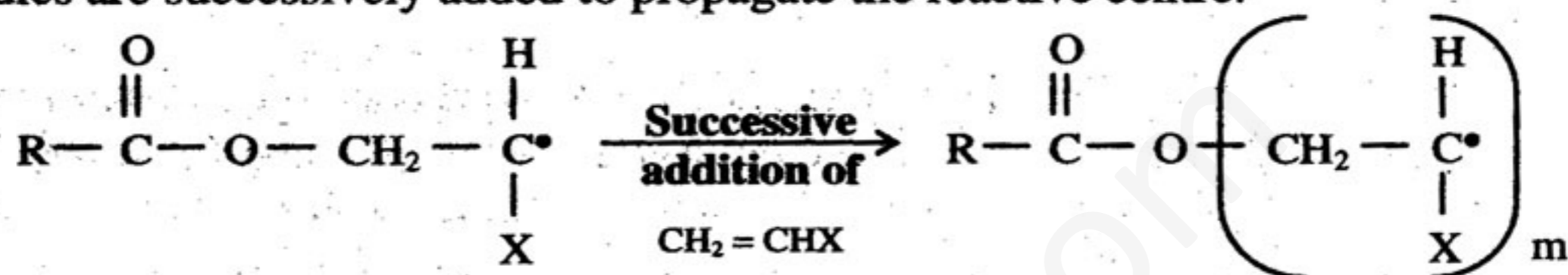
Initiator I is generally a heat sensitive compound, such as benzoyl peroxide, that can be decomposed by heat into a pair of free radicals.



Free radicals are in general, very active because of the presence of unpaired electrons. A free radical species can thus react to open the double bond of a vinyl monomer and add to one side of the broken bond, and the reactive centre being transferred to the other side of the broken bond.



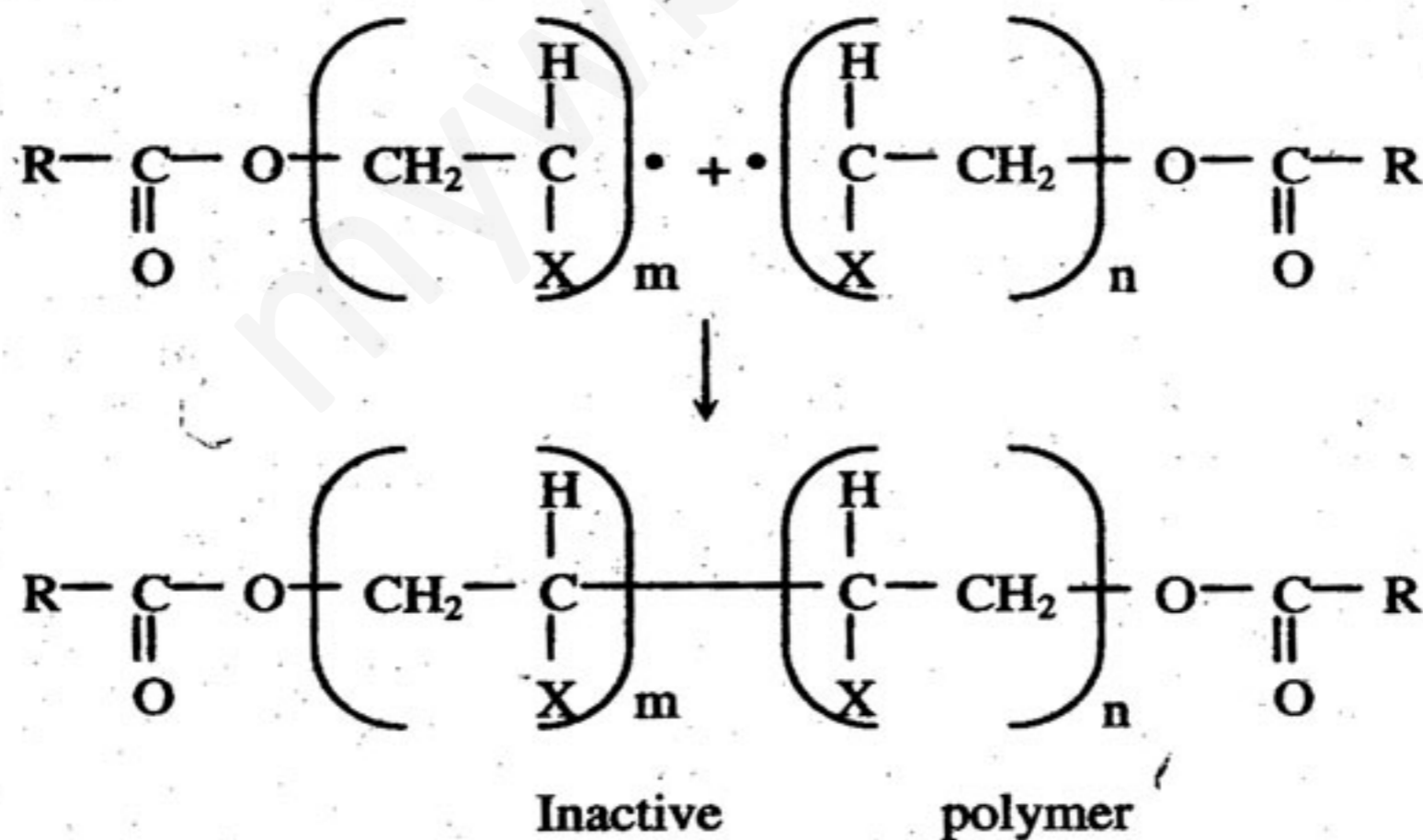
The new species which is also a free radical, is able to attack a second monomer molecule in a similar way, and transferring its reactive centre to the attacked molecule. This process is repeated and the chain continues to grow as a large number of monomer molecules are successively added to propagate the reactive centre.



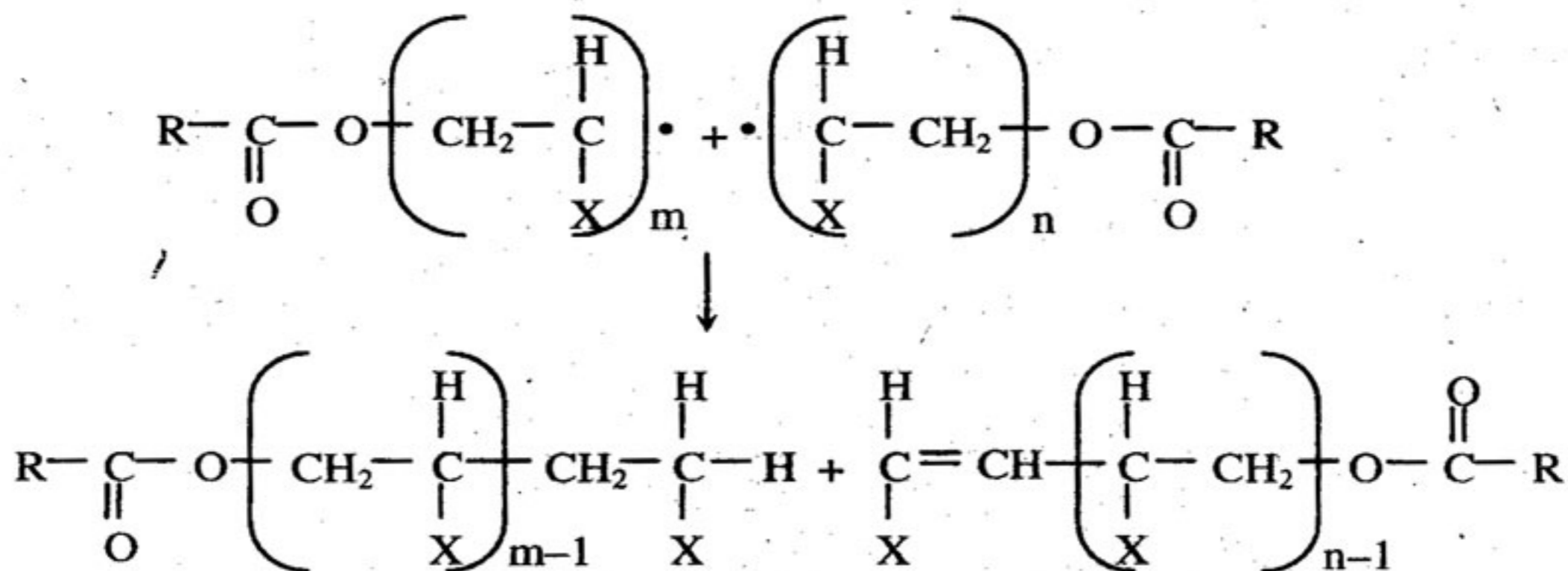
This process of propagation continues until another process intervenes and destroys the reactive centre, resulting in the termination of the polymer growth.

There may be several termination reactions depending on the type of reactive centre and the reaction conditions.

For example, two growing radicals may combine to stop each other growth activity and form an inactive polymer molecule, this is called termination by combination or coupling.

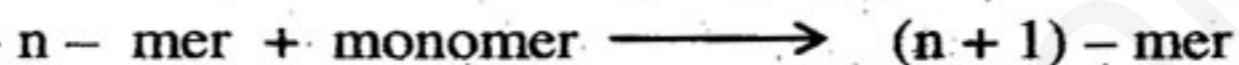


A second termination mechanism is disproportionation



Condensation Polymerization:

Definition: Condensation polymerization occurs by stepwise reaction between functional groups of reactants. The reaction leads successively from monomer to dimer, trimer, tetramer, pentamer and so on, until finally a polymer molecule with large DP is formed.



and

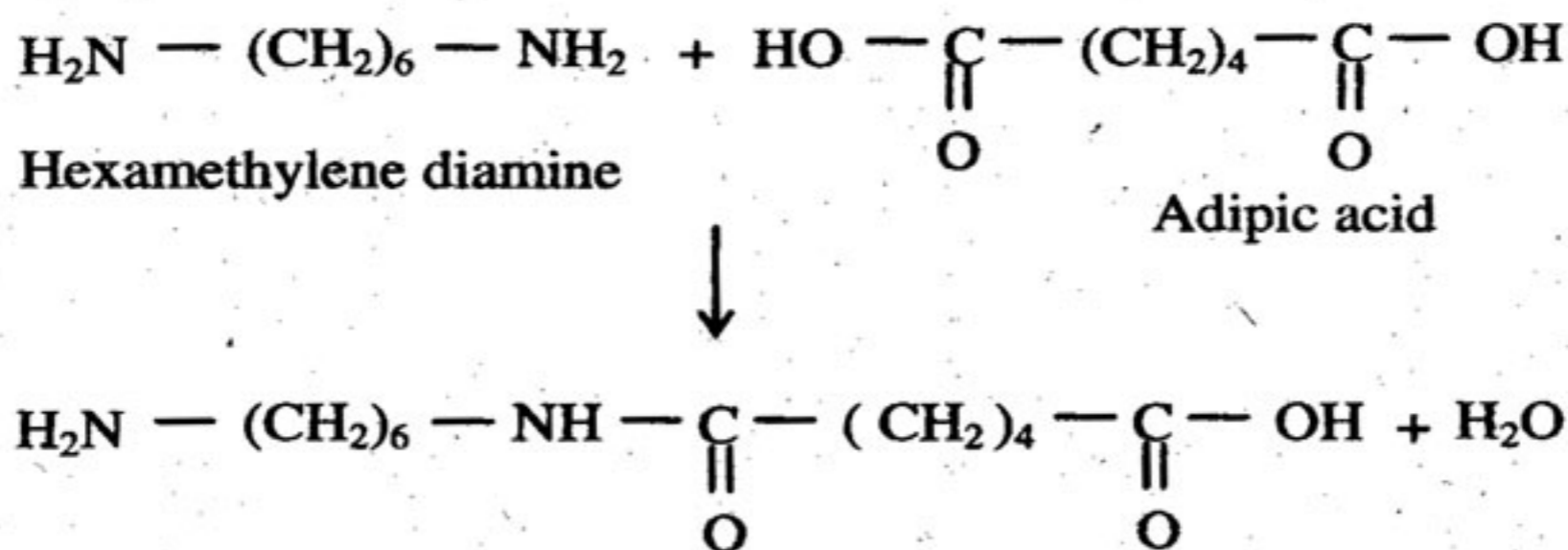


The average molecular weight builds up slowly in the **condensation polymerization** process and a high molecular weight product is formed after a sufficient long reaction time when the conversion is more than 98%.

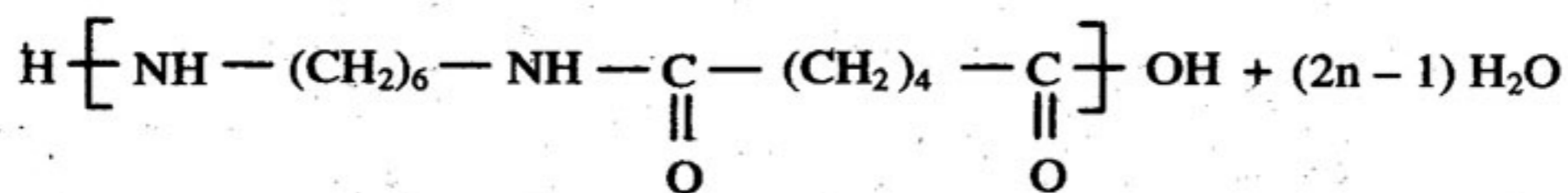
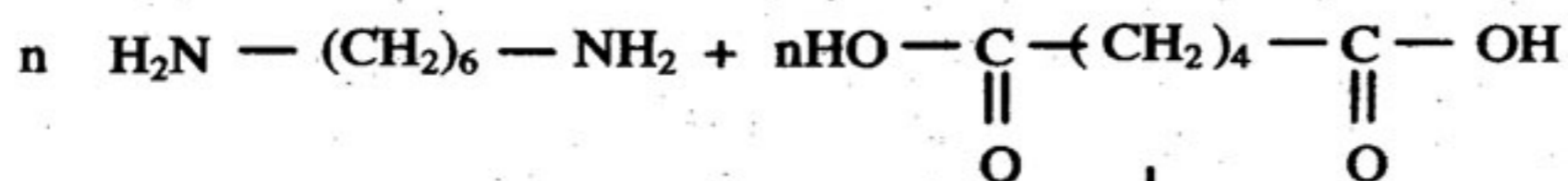
In a condensation reaction between two molecules, each molecule loses one atom or a group of atoms at the reacting end, which leads to the formation of a covalent bond between the two, while the eliminated atoms bond with each other to form a small molecule such as water – hence it is known as **condensation reaction**.

Example:

Polyamide i.e. a polymer with amide as the characteristic linkage.



The reaction continues step by step to give the polyamide nylon 66



Poly (hexamethylene adipamide)

2.3. Distinguish between thermoplastic and thermosetting resins citing examples.
[WBUT 2003, 2005, 2007, 2011(JUNE)]

Answer:

Thermoplastic materials	Thermo setting materials
i) Thermoplastic polymers can be softened on heating and hardened on cooling reversibly.	i) Thermo setting polymers can be hardened during heating and once they have hardened, they can not be softened.
ii) They are formed mostly by addition polymerization	ii) They are formed mostly by condensation polymerization
iii) They are generally soft, weak and flexible material.	iii) They are generally hard, strong and brittle material
iv) They can be reclaimed from waste by simple heating	iv) They can not be reclaimed form waste by simple heating
v) They are usually soluble in organic solvents	v) Due to three dimensional network structure they are insoluble in almost all organic solvents.

2.4. What are raw rubber and vulcanised rubber? [WBUT 2002, 2008, 2010(JUNE)]

Answer:

Raw rubber: Raw rubber can not be used for product application because it is highly viscous, loses its strength with increase in temperature, requires solvent for application or requires mastication for lowering viscosity, and finally it is highly sticky. It is called raw rubber.

Vulcanized rubber: If sulfur is mixed with rubber in large proportion and heated, it produces a three dimensional network structure which is a non-tacky, highly elastic, tough material which is no longer soluble in solvents and which has higher thermal stability. This process of transformation of rubber in presence of sulfur at high temperature was termed as vulcanization and the product is called vulcanized rubber.

2.5. Give the outlines of preparation, structure and uses of SBR and NBR.

[WBUT 2002, 2008, 2010(DECEMBER)]

OR,

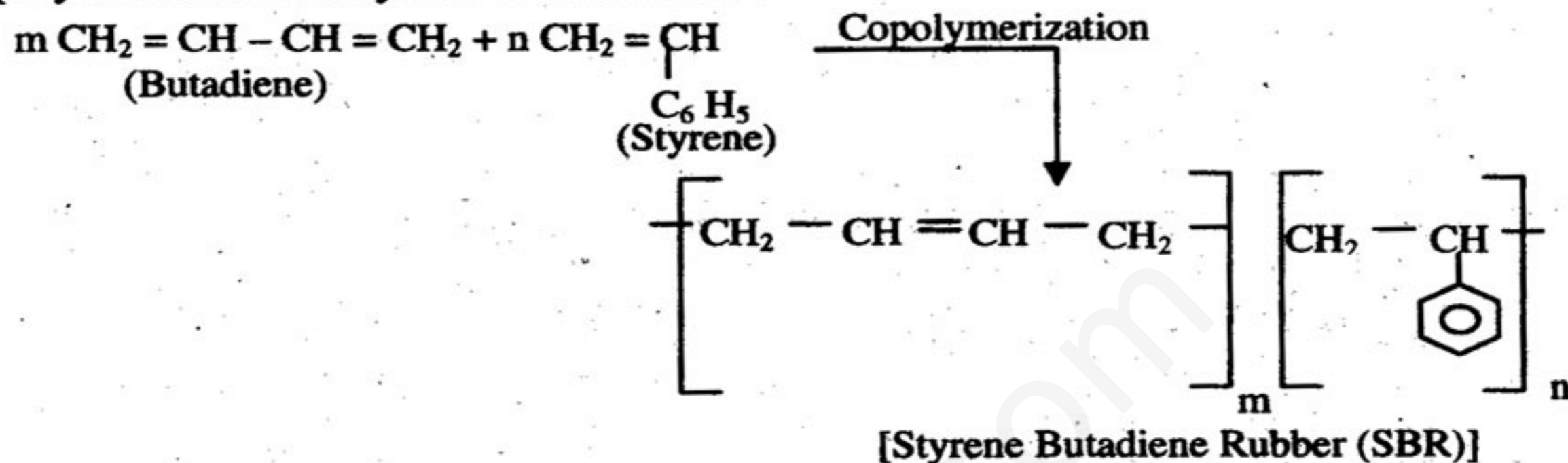
Write about the synthesis and uses of the Buna-S-Rubber.

[WBUT 2011(DECEMBER)]

Answer:

Styrene Butadiene Rubber:

Styrene butadiene rubber is the most important synthetic rubber. It is produced by copolymerization of styrene and butadiene.



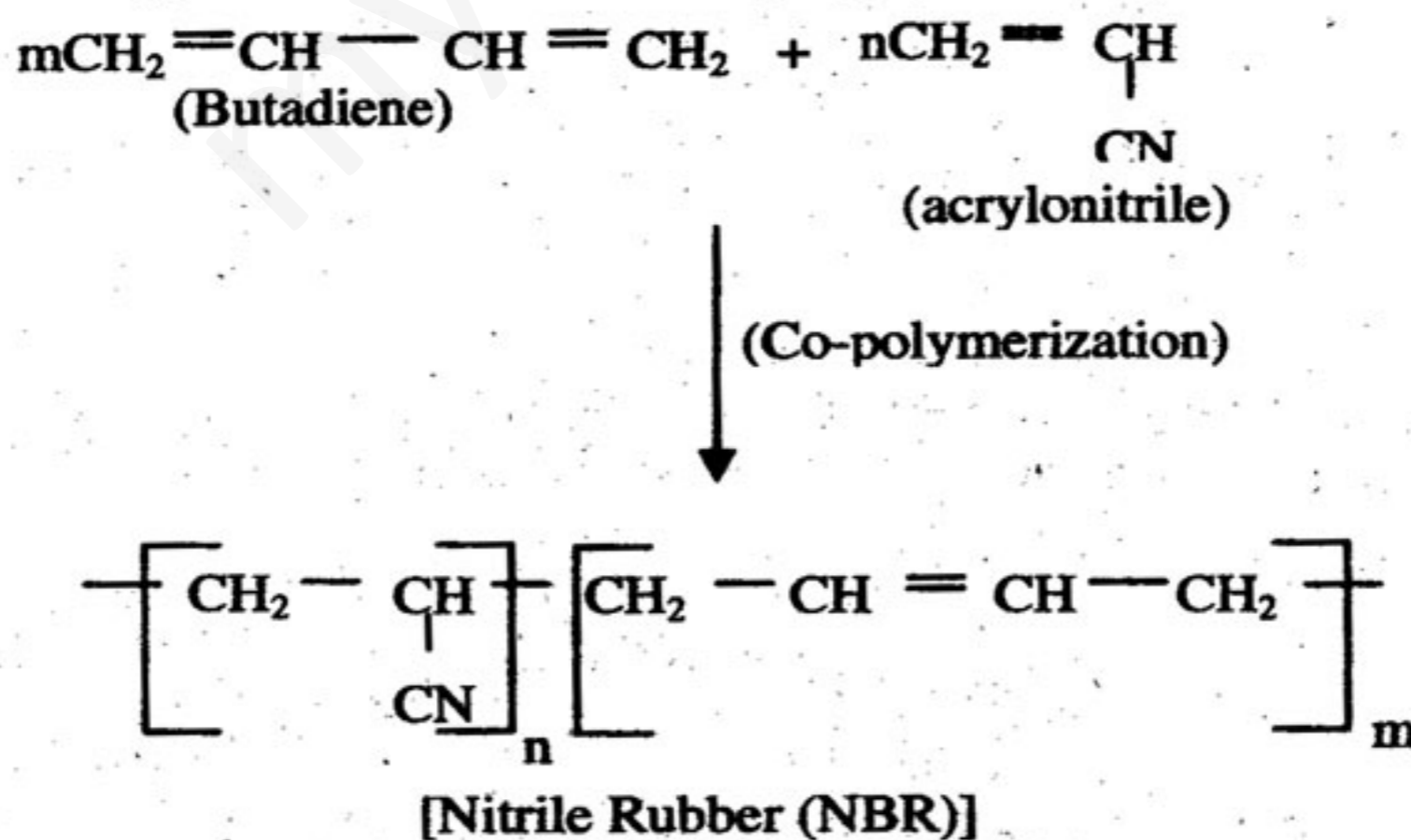
For the preparation of SBR 70 – 75 parts of butadiene and 30 – 25 parts of styrene are taken.

Uses

Major use of SBR is for the manufacture of motor tire. Other uses of this elastomer are floor tiles, shoe soles, gaskets, foot wear components, wire and cable insulation, carpet backing, adhesives, tank lining etc.

Nitrile rubber:

Nitrile rubber is a unique elastomer. It is a copolymer of acrylonitrile and butadiene.



Use

For making gasoline hose, seals, gaskets, printing tools, adhesive, footwear etc. It is also used for making conveyor belts, high altitude aircraft components, tank lining, automobile parts etc.

2.6. Explain number average and weight average molar mass of a polymer.

[WBUT 2008, 2010(JUNE), 2011(DECEMBER)]

Answer:

Number average molecular weight

If the sample contains N_i molecules of the i th kind, total number of molecules $\sum_{i=1}^{\infty} N_i$ and each of the i th kind of molecules has a mass m_i , then the total mass of all the molecules is $\sum_{i=1}^{\infty} N_i m_i$

The number average molecular mass is $\overline{m}_n = \frac{\sum_{i=1}^{\infty} m_i N_i}{\sum_{i=1}^{\infty} N_i}$ and multiplication by

Avogadro's number gives the number average molecular weight $\overline{M}_n = \frac{\sum_{i=1}^{\infty} M_i N_i}{\sum_{i=1}^{\infty} N_i}$

Weight average molecular weight

After \overline{M}_n , the next higher average molecular weight that can be measured by absolute methods is the weight average molecular weight \overline{M}_w .

This quantity is defined as, $\overline{M}_w = \frac{\sum_{i=1}^{\infty} N_i M_i^2}{\sum_{i=1}^{\infty} N_i M_i}$

2.7. How do the properties such as (i) tensile strength (ii) physical state of the polymer (iii) impact strength (iv) melt viscosity of a polymer vary with degree of polymerisation?

[WBUT 2008]

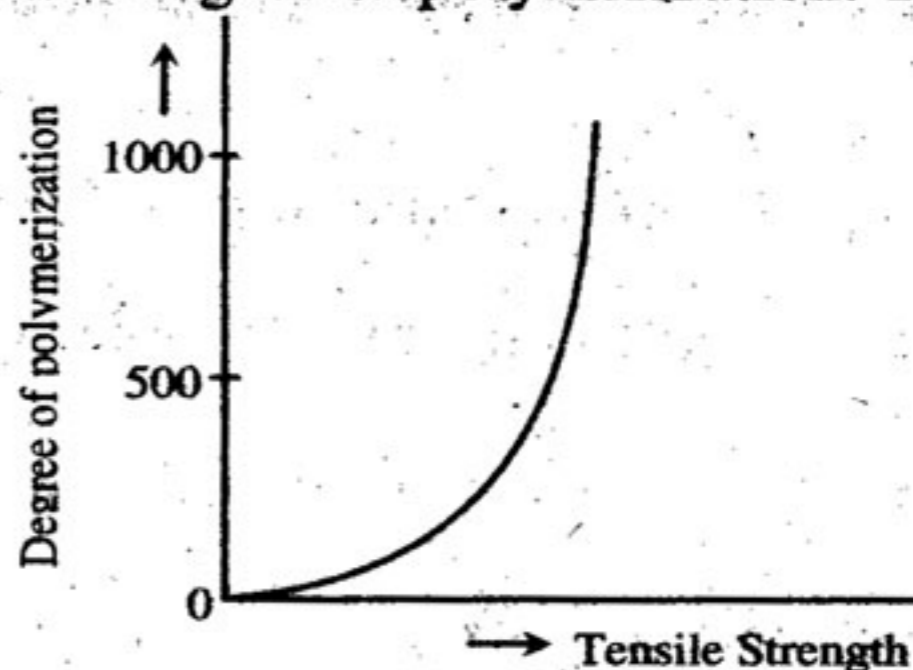
Answer:

Polymer properties such as tensile strength and impact strength also increases with increase in molecular weight and then level off but the melt viscosity continuously increases.

Polymers with very high molecular weights have superior mechanical properties but are difficult to process or fabricated due to their high melt viscosity.

The softening temperature of polyethylene depends on the degree of polymerization. The **dimer** of ethylene is a gas, but oligomers with a DP of 3 or more are liquids and the liquid viscosity increasing with the chain length.

PE with DPs of about 30 are grease like and those with DPs around 50 are waxes. As the DP value exceeds 400 or molecular weight exceeds 10,000, polyethylene become hard resin with softening points about 100°C . But this softening point increase is small in higher molecular weight range.



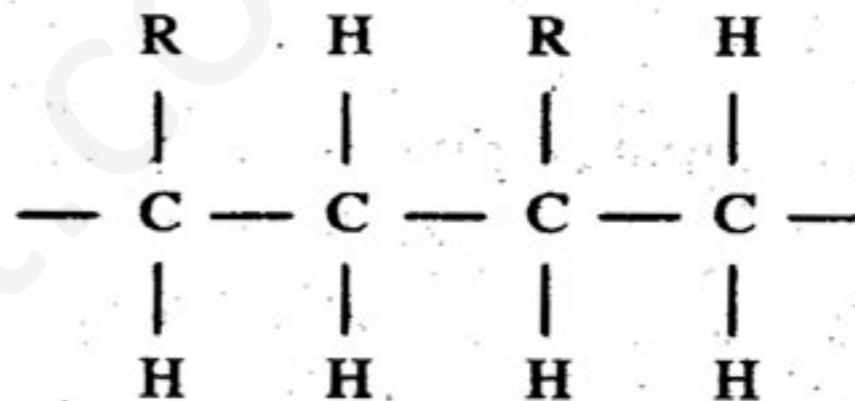
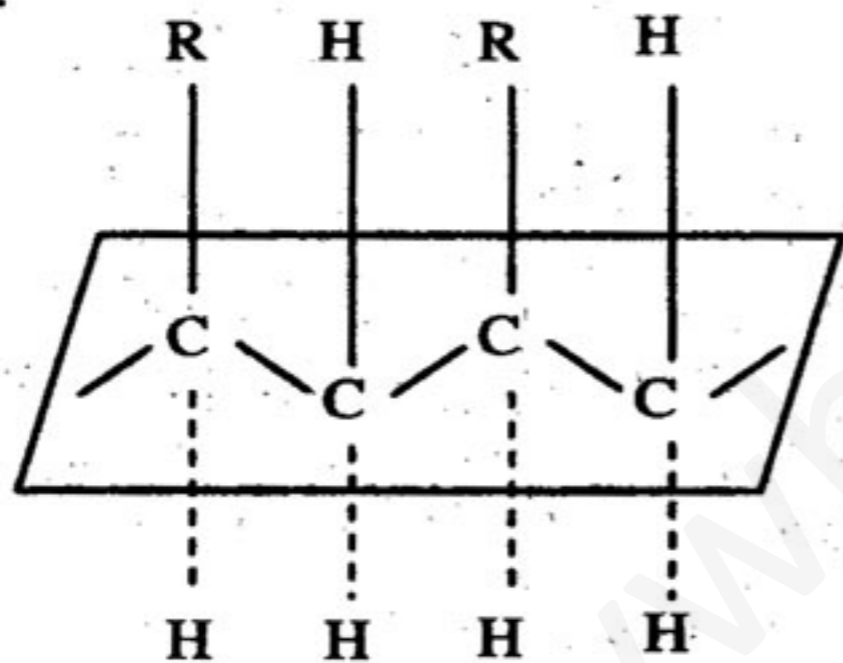
2.8. Discuss the difference among isotactic, syndiotactic and atactic polymers.

[WBUT 2003, 2008]

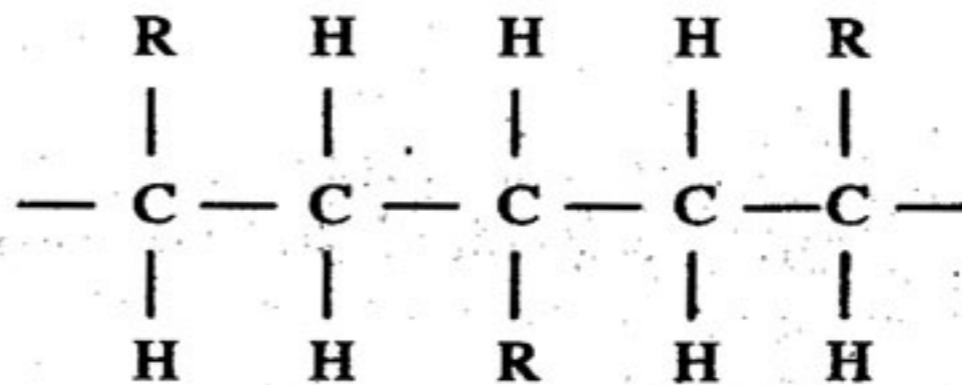
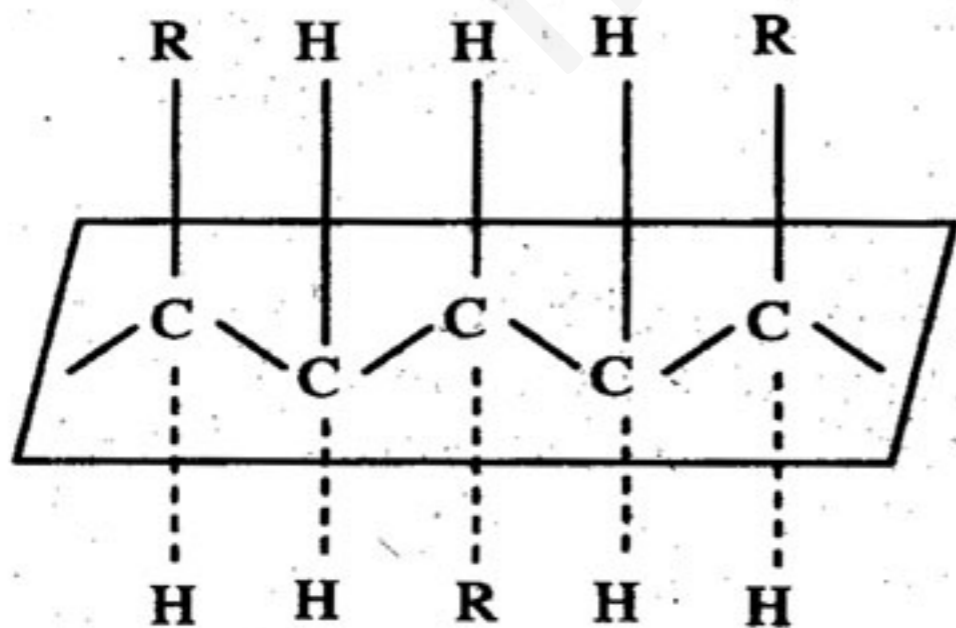
Answer:

The aspect of stereo regularity is **tacticity**. Three configurations can be obtained:

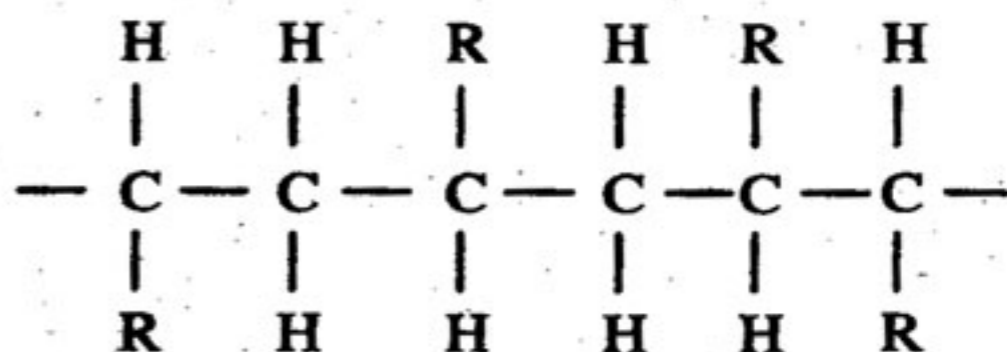
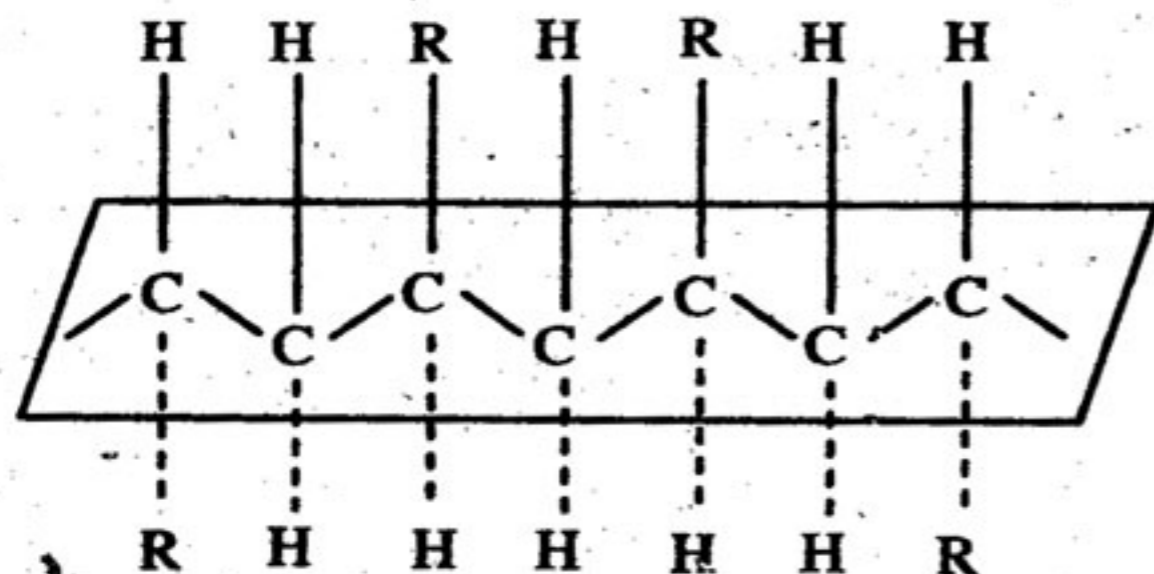
A polymer molecular is **isotactic**, if all the substituted groups lie on the same side of the main chain.



In a **syndiotactic** polymer molecule the substituted groups regularly alternate from one side to the other.



The molecule is **atactic**, if the position of the substituted groups are random.



2.9. Degree of polymerisation of a sample of polymethylmethacrylate (PMMA) is found to be 1000. What is the number average and the weight average molar masses of PMMA? [WBUT 2008]

Answer:

Molecular weight of methyl methacrylate, ($\text{CH}_2 = \underset{\text{COOCH}_3}{\text{C}} - \text{CH}_3$) 100

$$\text{Since, } \overline{DP}_w = \frac{\overline{M}_w}{M_0}$$

$$\text{Thus, } \overline{M}_w = 1000 \times 100 = 100000$$

Thus weight average molecular weight of polymethylmethacrylate (PMMA) is 100000.

$$p_n = \frac{n-1}{n+1} = \frac{1000-1}{1000+1} = \frac{999}{1001} = 0.998$$

$$\overline{M}_n = \frac{M_0}{1-p} = \frac{100}{1-0.998} = 50000$$

Thus number average molecular weight of polymethylmethacrylate (PMMA) is 50000.

2.10. What is synthetic metal? What is electronic polymer? Write notes on conducting polymers and their importance. [WBUT 2002, 2003, 2009]

Answer:

1st Part:

The development of the field of synthetic metal-containing polymers - where metal atoms form an integral part of the main chain or side group structure of a polymer - aims to create new materials which combine the processability of organic polymers with the physical or chemical characteristics associated with the metallic element or complex.

2nd Part:

Electronic polymer is a branch of electronics that deals with conductive polymers, plastics, or small molecules. It is called 'organic' electronics because the polymers and small molecules are carbon-based, like the molecules of living things. This is as opposed to traditional electronics (or metal electronics) which relies on inorganic conductors such as copper or silicon.

Polymer electronics are laminar electronics, that also includes transparent electronic package and paper based electronics.

In addition to organic Charge transfer complexes, technically, electrically conductive polymers are mainly derivatives of polyacetylene black (the "simplest melanin"). Examples include PA (more specifically iodine-doped trans-polyacetylene); polyaniline: PANI, when doped with a protonic acid; and poly(dioctyl-bithiophene): PDOT.

3rd part:

Most polymeric materials are poor conductor of electricity, because of the non-availability of large number of free electrons in the conduction processes. Conducting polymers are classified into four types:

- (i) Intrinsically conducting polymer
- (ii) Doped Conducting Polymer
- (iii) Extrinsicly Conducting Polymer
- (iv) Co-ordination Conducting Polymer

(i) Intrinsically conducting Polymer

In this type the back bones or associated groups of the polymers consist of delocalized electron pair or residual charge. These polymers contain conjugated π - electrons backbone, which is responsible for electrical charge. Under the influence of an electric field, conjugated π - electron of the polymer get excited and can conduct electricity through solid polymer back bone.

Important Conducting Polymer

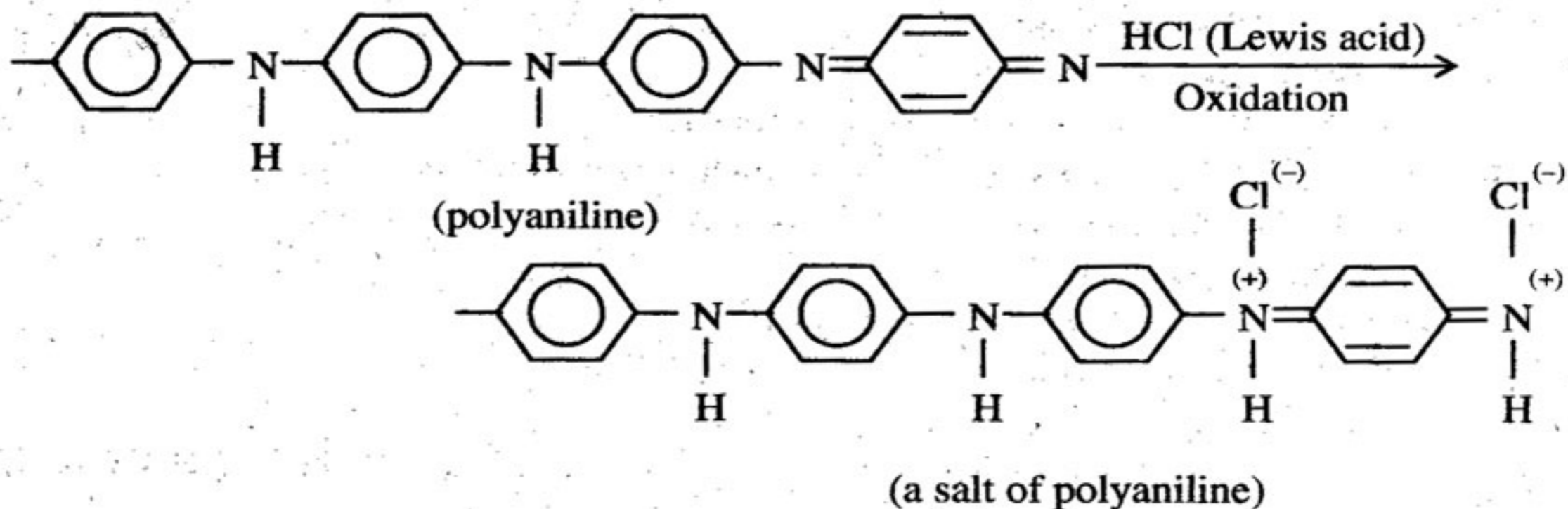
Important commercially produced conducting polymers are poly acetylene, poly aniline poly (pyrrole), poly (thiophenes) etc.

(ii) Doped Conducting Polymer

Doped conducting polymer is prepared by exposing a polymer to a charged transfer agent either gas phase or in solution phase. The conductivity of intrinsically conducting polymer can be enhanced by creating either positive or negative charge on the polymer back bone by oxidation or reduction process. This process is called doping. This may be classified into two types:

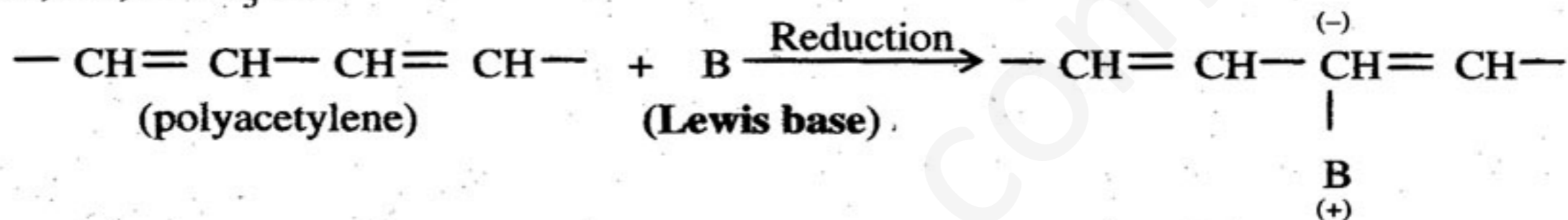
(a) P-doping

When a conducting polymer is treated with a Lewis acid, oxidation process takes place and positive charges are generated on the polymer backbone. The examples of P-dopant are I, HCl, Br₂, AsF₅ etc.



(b) N-doping

When a conducting polymer is treated with a Lewis base, reduction takes place and negative charges are generated on the polymer back bone. The examples of N-dopant are Li, Na, Ca, FeCl₃ etc.



(iii) Extrinsicly Conducting Polymer

The conductivity of these polymers is due to the presence of externally added ingredients in them. It may be classified into two types:

(a) Conductive element filled polymer

It is prepared by incorporation of conducting material such as carbon black, metallic fibers, metal oxides etc into base polymer. Here the polymer acts as a binder to hold the conducting materials together in the solid phase. These polymers possess reasonably good bulk conductivity and are generally low cost, light weight, mechanically durable, strong and easily processable material.

(b) Blended conducting polymer

It is produced by blending a conventional polymer with a conducting polymer either by physical or chemical process. These polymers can be easily processed and have better physical, chemical and mechanical properties.

(iv) Co-ordination conducting polymer

It is a charge transfer complex containing polymer produced by combining a metal atom with a poly dentate ligand. These polymers exhibit corrosion characteristics.

Application of conducting polymer

- (1) In rechargeable light weight batteries e.g. perchlorate doped poly acetylene lithium system.
- (2) In optically display device

- (3) In telecommunication system
- (4) In antistatic coating for clothing
- (5) In electronic devices like transistor, diodes.
- (6) In photovoltaic devices e.g. Al/Polymer/Au photovoltaic cell
- (7) In nonlinear optical material
- (8) In solar cells
- (9) In drug delivery system for human body
- (10) In electromagnetic screening material

2.11. Write short notes on the following:

[WBUT 2009, 2011 (DECEMBER)]

a) Biodegradable polymers

b) LDPE and HDPE

Answer:

a) Biodegradable polymers:

The polymeric materials which are degraded by micro organisms are called biodegradable polymers. Generally the natural polymers fall under this category. They are classified into four broad groups:

- Polysaccharide (Starch, cellulose)
- Proteins (Gelatin, Casein, Silk, Wool)
- Polyesters (Polyhydroxyalkanoates)
- Others (Lignin, Shellac, Natural Rubber)

It can not be automatically assumed that natural polymers, "beautiful for environmental degradation". The rate of degradation and the formation of ultimate metabolites depend very much on the structural complexity of the material and the environmental conditions selected for the degradation trial.

There are a number of biodegradable synthetic resins available in the market such as:

- Polyalkylene esters
- Polylactic acid and its copolymers
- Polyamide esters
- Polyvinyl esters
- Polyvinyl alcohol
- Polyanhydrides

Each of these has its particular properties and potential applications. Polyvinyl alcohol is widely used because of its solubility in water. Polylactic acid is growing in terms of production volume and applications. All of the materials in the list have been found to exhibit degradation promoted by microorganisms often coupled to chemical and or/mechanical degradation.

b) LDPE and HDPE:

Monomer	Polymerization	Major uses
Ethylene	LDPE: Free radical initiated Chain polymerization HDPE: Ziegler – Natta or metal oxide catalyzed chain polymerization	LDPE: Film and sheet (55%), house wares and Toys (16%), wire and Cable coating (5%) HDPE: Bottles (40%), house wares, containers, toys (35%), pipe and fittings (10%), film and sheet (5%)

Polyethylene is a thermoplastic material.

LDPE

Preparation:

It is manufactured by polymerization of ethylene under high pressure (15,000 – 50,000 psi) and elevated temperatures (200 - 350°C) in the presence of oxygen (0.03 – 0.1%).

It is an amorphous and branched product and has a melting range from 107 to 120°C.

HDPE

Preparation:

It is produced in a low pressure process either by Ziegler – Natta catalysis or by metal oxide catalysis. It is essentially linear having much less branching than LDPE and has a melting range from 130 - 180°C.

Properties:

Polyethylene is partially **amorphous** and partially **crystalline**. Linearity of polymer chains affords more efficient packing of molecules and hence a higher degree of **crystallinity**.

On the other hand side chain or branching reduces the degree of **crystallinity**.

Increasing crystallinity increases density, stiffness, hardness, tensile strength, heat and chemical resistance, opacity but it reduces stress crack resistance, permeability and impact strength.

Polyethylene has excellent chemical resistance and is not attacked by acids, bases or salts. (it is however attacked by strong oxidizing agent).

The other characteristics of polyethylenes are **low cost, easy processibility, excellent electrical insulation** properties, **toughness and flexibility** even at **low temperature, freedom from odor and toxicity, reasonable clarity** of thin films and sufficient low permeability to water vapor for many packaging, building and agricultural applications.

2.12. How is HDPE manufactured? What are its uses?

[WBUT 2004, 2010(DECEMBER)]

Answer:

Preparation of HDPE: HDPE is produced in a low pressure process either by Ziegler – Natta catalysis or by metal oxide catalysis. It is essentially linear having much less branching than LDPE and has a melting range from 130 - 180°C.

Uses: HDPE is used for making Bottles (40%), house wares, containers, toys (35%), pipe and fittings (10%), film and sheet (5%).

2.13. The degree of polymerization of polyethylene is 1000. Find the molecular weight of polyethylene. [WBUT 2010(DECEMBER)]

Answer:

$$DP = \frac{M}{m}$$

M = Molecular weight of polyethylene

m = Molecular weight of ethylene

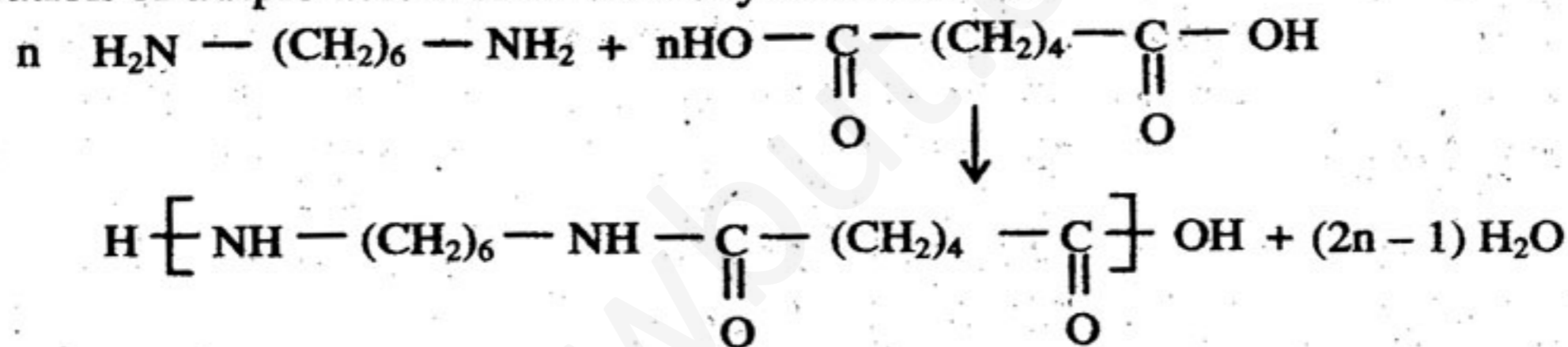
Molecular weight (m) of ethylene ($\text{CH}_2 = \text{CH}_2$) = 28

Thus \overline{M}_w of polyethylene = $28 \times 1000 = 28 \times 10^3$ gm/mole.

2.14. Write the chemical structures of the repeat units of Nylon 6.6 and Nylon 6. Why are they so named? [WBUT 2010(DECEMBER)]

Answer:

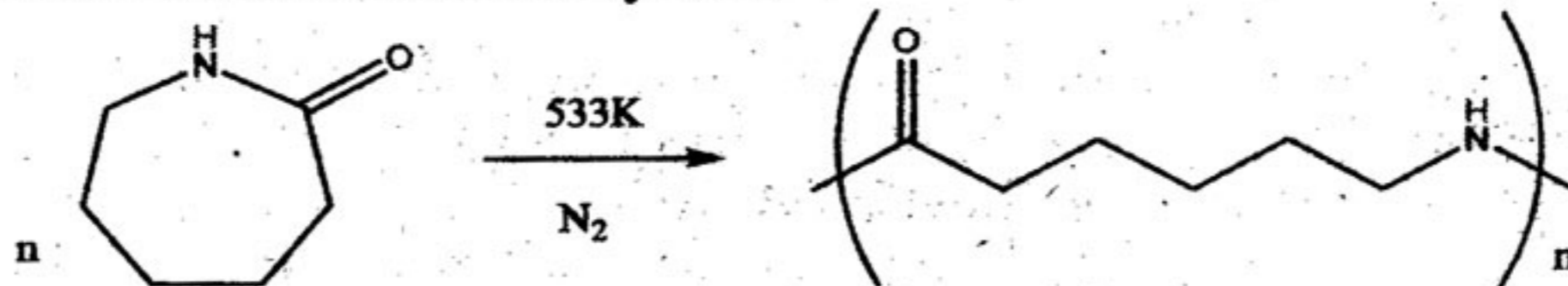
Nylon 6, 6: Nylon 66 or poly (hexamethylene adipamide) is synthesized by polycondensation of adipic acid and hexamethylene diamine.



Poly (hexamethylene adipamide)

As both the monomer unit contain six carbon atoms so it is called Nylon 6, 6.

Nylon 6: Nylon 6 is prepared by ring opening polymerization of caprolactam. When caprolactam is heated at about 533 K in an inert atmosphere of nitrogen for about 4-5 hours, the ring breaks and undergoes polymerization. Then the molten mass is passed through spinnerets to form fibres of Nylon 6.



As the monomer unit contains six carbon atoms so it is called Nylon 6.

2.15. What are conducting polymer? Give examples of conducting polymers.

[WBUT 2010, 2011(JUNE)]

Answer:

The polymers which can conduct electric current is called conducting polymers. The conductive polymers can be classified into following categories

- i) Conductive element filled polymer
- ii) Conjugated π - electrons conducting polymer
- iii) Doped conducting polymer
- iv) Blended conducting polymers

Commercially produced conducting polymers are:

Polyacetylene $[\text{CH} = \text{CH} - (\text{CH} = \text{CH})_n - \text{CH} = \text{CH}]$

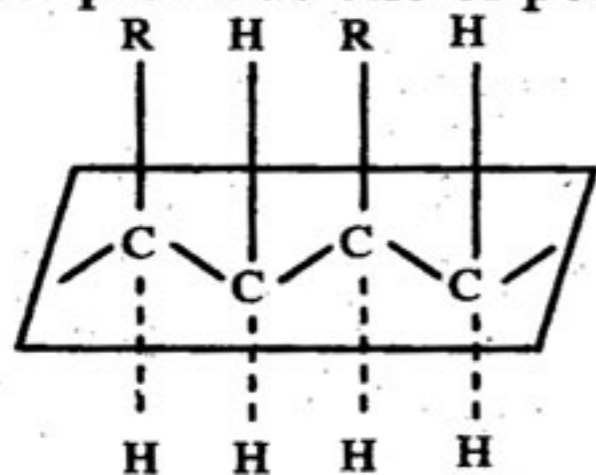
Poly-p- phenylene, polyquiloline, Poly pyrrole etc.

2.16. What is tacticity? Draw the structures of Isotactic, Syndiotactic and atactic polymers with structures.

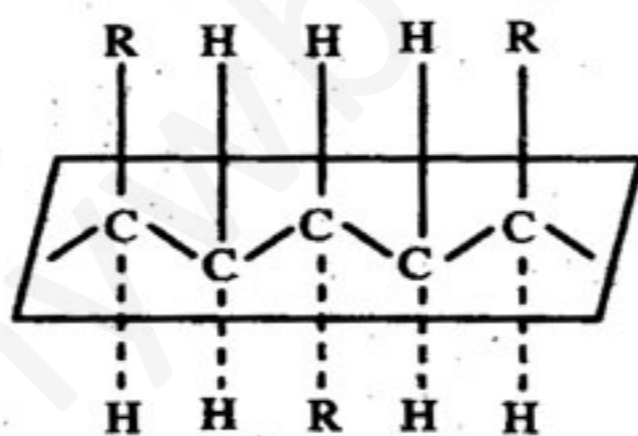
[WBUT 2011(JUNE)]

Answer:

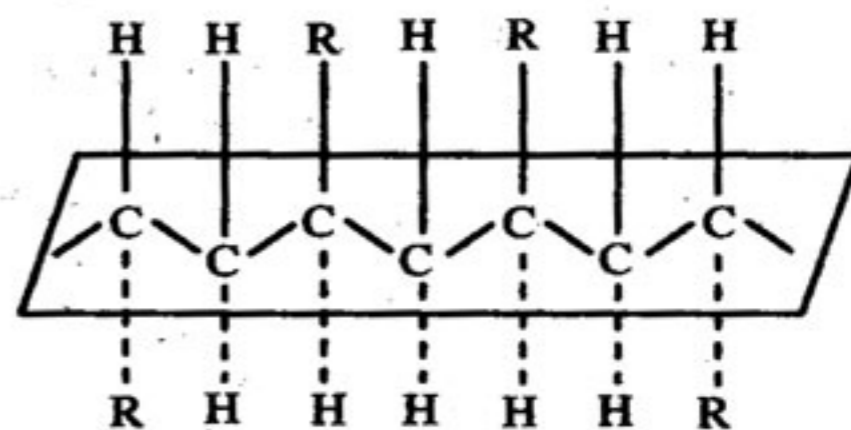
Tacticity is the relative stereochemistry of adjacent chiral centers within a macromolecule. A **tactic macromolecule** in the IUPAC definition is a macromolecule in which essentially all the configurational (repeating) units are identical. Tacticity is particularly significant in vinyl polymers of the type $-\text{H}_2\text{C}-\text{CH}(\text{R})-$ where each repeating unit with a substituent R on one side of the polymer backbone is followed by the next repeating unit with the substituent on the same side as the previous one, the other side as the previous one or positioned randomly with respect to the previous one.



(Isotactic polymer)



(Syndiotactic Polymer)



(Atactic Polymer)

2.17. Write short note on vulcanization of Rubber.

[WBUT 2011(JUNE), 2011(DECEMBER), 2012 (JUNE)]

Answer:

Charles Goodyear in the year 1839 and Thomas Hancock in 1843 found that if sulfur is mixed with rubber in large proportion and heated, it produces/a non-tacky, highly elastic, tough material which is no longer soluble in solvents. This process of transformation of rubber in presence of sulfur at high temperature was termed as **Vulcanization**.

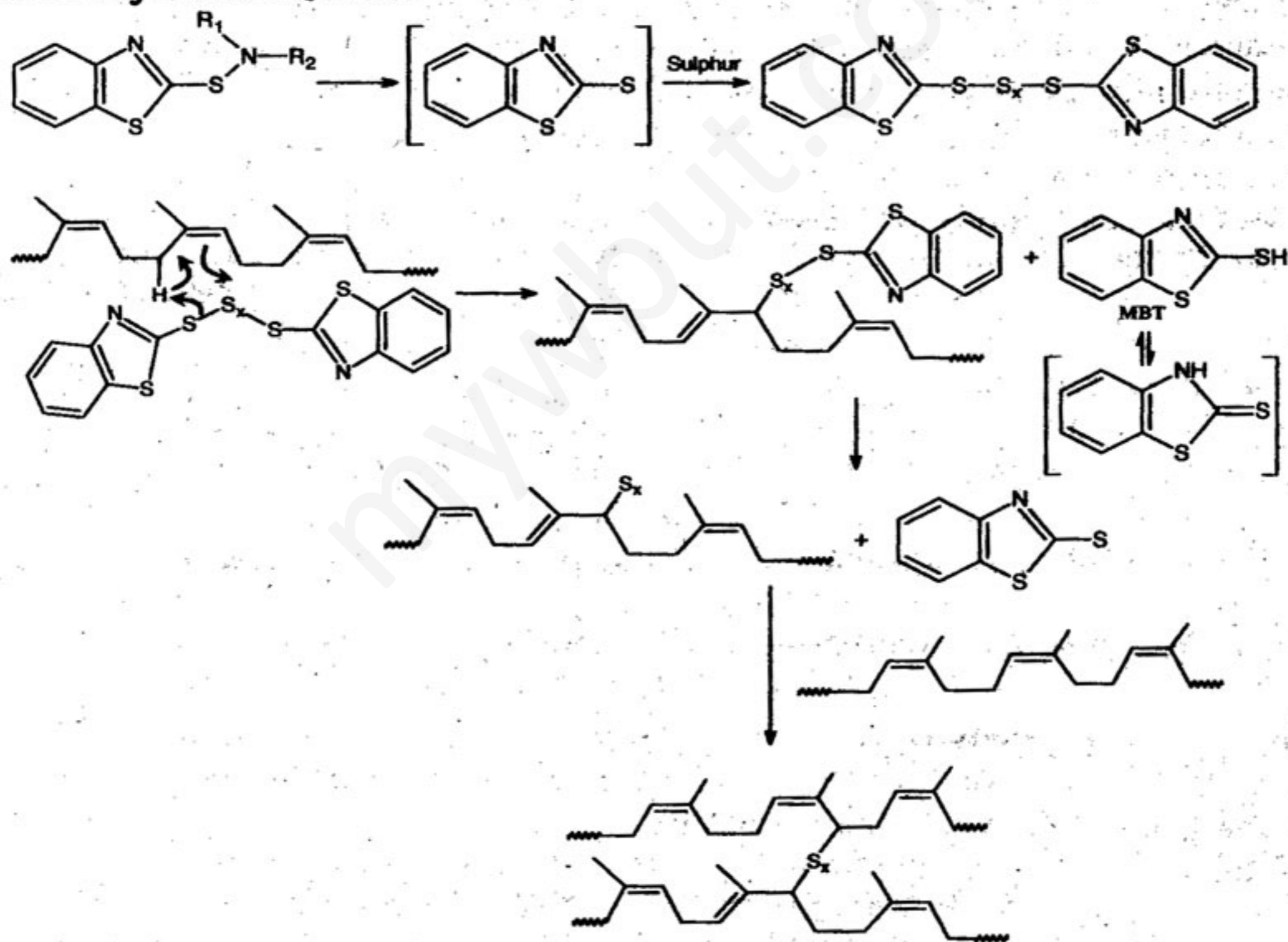
Until the development of accelerators for vulcanization, the reaction of about 8 Phr with rubber was very slow which took 7 – 8 hrs of time. On the development of inorganic accelerators like ZnO or litharge the vulcanization time could be shortened up to 4 hours till World War I. Beyond this time gradually organic accelerator compounds were developed to enhance the time of vulcanization by sulfur.

In actual process of vulcanization sulfur or other chemicals react at elevated temperatures with rubber, which contain double bond either in the main backbone or as a pendant form. The examples of such rubbers are NR, SBR, NBR or IIR. But the development of accelerator compounds not only reduced the time of vulcanization but also lowered the amount of sulfur to be used for an useful stable crosslink system. Gradual devotion and work in the development of a stable rubber vulcanizate with high mechanical properties, good ageing properties and good heat resistant properties result a large number of organic accelerators and cross linking agents.

The cross linking agents in combination with accelerator compounds crosslinks the rubber chain into a three dimensional network which gives the derived physical properties in the final product. The type of cross linking agent required depends on the type of rubber and the nature of cross links desired. However, they are classified as :

- i) sulfur and related elements
- ii) sulfur bearing chemicals
- iii) non sulfur cross linking agents

Mechanism of Vulcanization



2.18. What is glass transition temperature of a polymer? [WBUT 2011(DECEMBER)]

Answer:

The temperature at which the segmental motion of the polymer molecule starts is called the glass transition temperature of the polymer (T_g). T_g is the temperature at which the

amorphous domains of the sample undergo glass transition. Below T_g the amorphous regions are therefore no longer flexible and becomes hard and brittle like a glassy solid.

2.19. Differentiate between the following:

Addition polymerization and condensation polymerization. [WBUT 2012(JUNE)]

Answer:

Addition polymerization	Condensation polymerization
i) Generally vinyl monomers take part in this type of polymerization reaction.	i) Monomers having at least two active functional sites take part in this polymerization reaction.
ii) The polymerization reaction is very fast and a full sized polymer molecule is formed almost instantaneously after chain initiation	ii) Polymer size is independent of reaction time.
iii) There is no by-product in addition polymerization	iii) By-product is formed in condensation polymerization
iv) Examples of addition polymers are polyethylene, poly propylene, poly vinyl chloride etc.	iv) Examples of condensation polymers are Nylon 6, Nylon 66, phenol formaldehyde resin etc.

2.20. Discuss the essential structural criteria for conductivity, environmental stability and processibility in conducting polymer with suitable examples.

[WBUT 2012(JUNE)]

Answer:

Structural criteria for conductivity

In conducting polymer the back bones or associated groups of the polymers consist of delocalized electron pair or residual charge. These polymers contain conjugated π -electrons backbone, which is responsible for electrical charge. Under the influence of an electric field, conjugated π - electron of the polymer get excited and can conduct electricity through solid polymer back bone.

Example: Polyacetylene, Polythiophene, Polyaniline etc.

Structural criteria for environmental stability

If aromatic or heterocyclic system is present in the polymer chain then the conducting polymer has excellent environmental stability.

Example: polythiophene, polyaniline etc.

Structural criteria for processability

By substituting long flexible chains in the 3-position of thiophene one can decrease the interchain interaction and achieve high processibility with some sacrifice in conductivity. For example, poly(3-hexylthiophene) has a room temperature conductivity of 30 S cm⁻¹.