Unit: Polymer Science

Important Questions with Answers

1. What are monomers and polymers? Give suitable examples.
Hints: Monomers are reactive molecules from which polymer are derived.
Polymers are high molecular mass macromolecules, which consists of repeating structural units derived from the monomers.
Examples: Monomers: Ethylene, vinyl chloride, acetylene, etc.
Polymers: Polythene, poly(vinyl chloride), benzene, etc.

2. Define the term polymerization.
Hints: The process of formation of polymers from respective monomers is termed as polymerization.

3. What do you mean by copolymer and give two examples?
Hints: The polymer obtained from more than one different monomer is called copolymers and the process is known as copolymerization. For examples Buna-S is a copolymer of 1,3-butadiene and styrene. Bakelite is a copolymer of phenol and formaldehyde.

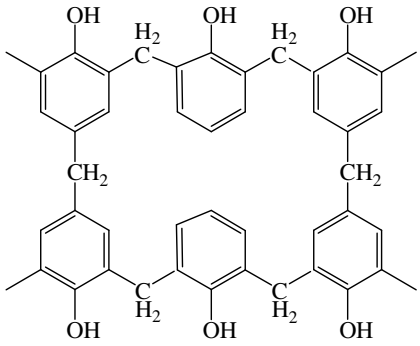
4. How are polymers are classified on the basis of their structure?
Hints: On the basis of structure polymers are classified as-

(i) Linear polymer: These polymers consist of long and straight chain. Examples includes high density polyethylene (HDPE), poly(vinyl chloride) (PVC), etc.
(ii) Branched chain polymers: These polymers contain linear chain having some branches. Examples includes low density polyethylene (LDPE), glycogen, etc.
(iii) Cross linked or Network polymers: These polymers have some cross-links between various linear chains. Examples are Bakelite, melamine, etc.

5. Is $-[-CH_2=CH(C_6H_5)-]_n-$ – a homoplymer or copolymer? Write the name of monomer.
Hints: It is a homopolymer and the monomer is styrene, $C_6H_5CH=CH_2$

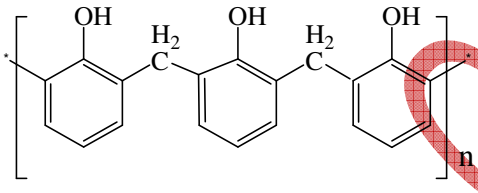
6. Give one example of
(a) addition polymer, (b) condensation polymer, (c) copolymer
Hints: (a) Polyethene, (b) Dacron, (c) Bakelite

7. Differentiate the following pair of polymers based on the property mentioned against each.
(i) Novolac and Bakelite (structure)
(ii) Buna-s and Terylene (intermolecular force
Hints: Bakelite is obtained from phenol and formaldehyde



Bakelite (Cross linked polymer)

Novolac is obtained from *o*-hydroxy benzyl alcohol or *p*-hydroxy benzyl alcohol.



Novolac (Linear polymer)

(ii) In Buna-s intermolecular forces of attraction is stronger as compared to terylene.

8. Write name of monomers of the following polymers and classify them as addition or condensation polymers-

Teflon, Bakelite, Natural rubber

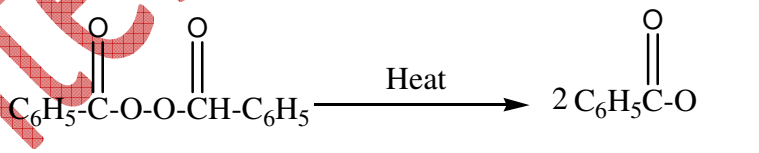
Hints: Teflon is an addition polymer of tetrafluoro ethylene.

Bakelite is a condensation polymer of phenol and formaldehyde

Natural rubber is a natural polymer of isoprene.

9. What is the role of benzyl peroxide in polymerization of ethane?

Hints: The benzyl peroxide is commonly used as initiator because it decomposes under mild condition to form free radicals.



Benzyl peroxide Benzyloxy radical

10. What are LDPE and HDPE? How they are prepared?

Hints: LDPE is a low density polymer and HDPE is a high density polymer.

LDPE is prepared by free radical addition and hydrogen atom abstraction. HDPE is prepared by heating ethene under a pressure of 1-2 atm. in the presence of a catalyst known as Zeigler Natta catalyst.

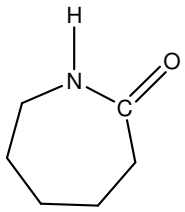
11. Draw the structure of the monomer each of the following polymers-

(a) Poly(vinyl chloride), (b) Nylon-6.

Hints: Monomer of poly(vinyl chloride) is vinyl chloride

$CH_2=CHCl$

Monomer of Nylon-6 is caprolactum



12. Why the numbers 6, 6 and 6 are put in the name of nylon-6, 6 and nylon-6?

Hints: In nylon-6, 6, two six stands for hexameyhylene diamine (as monomer with 6-carbon atoms) and adipic acid (another monomer with 6-carbon atoms).

In nylon-6, six stands for the only monomer caprolactam with 6-carbon atoms.

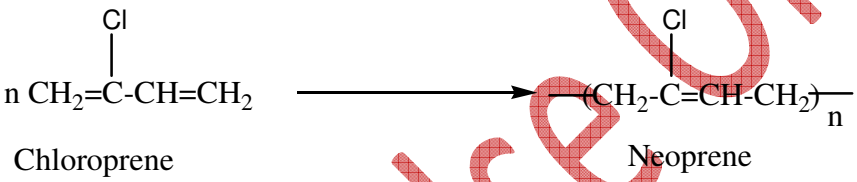
13. How does vulcanization change the properties of natural rubber?

Hints: During vulcanization (with sulphur), natural rubber gets cross-linked through –S-S- bonds and become hard.

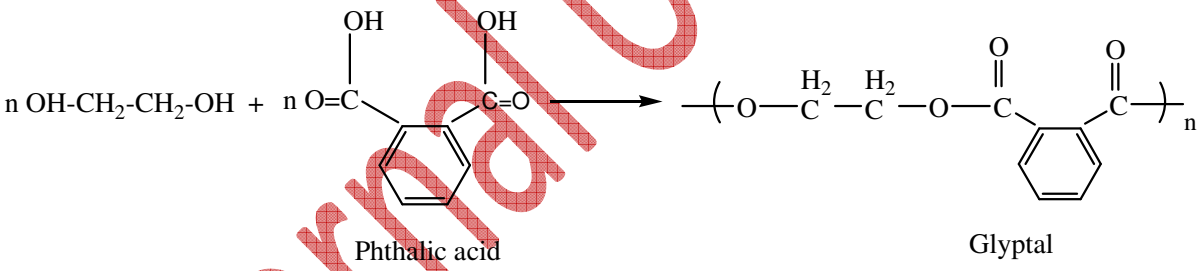
14. Write the equation for the synthesis of:

(a) Neoprene, (b) Glyptal

Hints: (a) Neoprene:

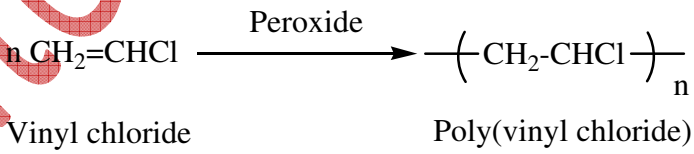


(b) Glyptal:



15. Describe the synthesis of poly(vinyl chloride).

Hints: It is prepared by heating vinyl chloride in an inert solvent in the presence of peroxide.



16. Write down the addition polymerization and condensation polymerization.

Hints: Addition polymerization: It is a polymerization reaction in which monomer units combine without loss of any small molecules such as H_2O, NH_3, etc. e.g. Preparation of polythene, poly(vinyl chloride), etc.

Condensation polymerization: It is a polymerization reaction in which monomer units combine with loss of small molecules such as H_2O, NH_3, etc. e.g. preparation of nylon, bakelite, etc.

17. Why plasticizer is used during moulding of plastics? [2012C, 2014C]

Hints: Addition of plasticizer helps to improve the plasticity and flexibility of the plastic and to reduce the cracking on the surface. Also plasticizers reduce the temperature and pressure required for moulding.

18. Write down the characteristic property of a good plasticizer. Give examples of good plasticizer.

Hints: A good plasticizer should be-

(i) less volatile than base polymer
(ii) miscible with the polymer
(iii) inert
(iv) a high molecular mass, high boiling and non-volatile substance

Examples: Dibutyl phthalate, tributyl phosphate, triphenyl phosphate, diiso-octyl phthalate.

19. Why is bakelite a thermosetting polymer?

Hints: Bakelite being a high cross-linked polymer and cannot be reshaped on heating. Hence, bakelite is thermosetting polymer.

20. What is vulcanization? How it is done?

Hints: Vulcanization is a process in which the natural rubber is heated with sulphur to improve the physical and mechanical properties such as tensile strength, elasticity, temperature stable, etc. of the polymer.

Vulcanization is carried out by heating raw rubber with sulphur in appropriate ratio and a suitable additive at a temperature range between 373K to 415K. On vulcanization sulphur form cross links at reactive sites of double bonds and thus rubber gets stiffened. In the manufacture of rubber, 5% sulphur is used as a vulcanizing agent.

21. What is a biodegradable polymer? Give example of a biodegradable polymer which was used for the first time in surgery.

Hints: The polymers that can be broken down rapidly by enzyme catalysed reactions are called biodegradable polymers. Dextron was the first bio-absorbable suture.

22. What are thermosetting and thermoplastic polymers? Give examples for each.

Hints: Thermosetting polymers are the class of plastics, which on heating in a mould, becomes infusible and form an insoluble hard mass due to extensive cross-linking between different chains forming three dimensional network bonds. They cannot be used again and again. Examples: Bakelite, terylene, etc.

Thermoplastics are linear polymers which are hard at normal temperature and on heating become soft or fluid and hence can be moulded in any shape. They show reversible changes when heated and cooled. Thus, they can be used again and again. Examples: Polythene, polystyrene, etc.

23. What do you mean by Engineering plastics? Give examples.

Hints: The term engineering plastics is applied to those materials which command a premium price, usually associated with relatively low production volume, because of their unique balance properties which allows them to complete successfully with other general purpose materials such as ceramics, metals etc. in engineering applications. These materials are stiff, strong, abration-resistant, capable of withstanding high temperatures and resistance to attack chemicals and polluted environment. The unique property of engineering plastics is mainly due to their crystalline nature and strong intermolecular forces. Most of the engineering plastics have high melting points and can retain their physical properties at very

high temperatures. Some important examples are Silicone, Polycarbonate, Acetal, Nylon, ABS, Polysulfone etc.

24. What do you mean by synthetic metal? Explain with examples.

Hints: An organic polymer that possesses the electrical, electronic, magnetic, and optical properties of a metal while retaining the mechanical properties, processibility, etc. commonly associated with a conventional polymer, is termed as '*intrinsically conducting polymer* (ICP)' more commonly known as a '*synthetic metal'*. Its properties are intrinsic to a 'doped' form of the polymer. This class of polymer is completely different from 'conducting polymers' which are merely a physical mixture of a nonconductive polymer with a conducting material such as a metal or carbon powder distributed throughout the material.

Polyacetylene (-CH-)x , now commonly known as the prototype conducting polymer, could be p- or n-doped either chemically or electrochemically to the metallic state. In the 'doped' state, the backbone of a conducting polymer consists of a delocalized p system. In the undoped state, the polymer may have a conjugated backbone such as in trans-(CH)x which is retained in a modified form after doping, or it may have a nonconjugated backbone, as in polyaniline (leucoemeraldine base form), which becomes truly conjugated only after p-doping, or a nonconjugated structure as in the emeraldine base form of polyaniline which becomes conjugated only after protonic acid doping.

All conducting polymers (and most of their derivatives), for example, poly-(para-phenylene), poly(phenylenevinylene), polypyrrole, polythiophene, polyfuran, poly(heteroaromatic vinylenes), polyaniline etc., undergo either p- and/or n-redox doping by chemical and/or electrochemical processes during which the number of electrons associated with the polymer backbone changes.

Chemical and Electrochemical p-Doping, that is, partial oxidation of the p backbone of an organic polymer, was first discovered by treating trans-(-CH-)x with an oxidizing agent such as iodine. This process was accompanied by an increase in conductivity from ca. 10^{-5} Scm^{-1} to ca. 10^{3} Scm^{-1}. If the polymer is stretch-oriented five- to six-fold before doping, conductivities parallel to the direction of stretching up to around 10^{5} Scm^{-1} can be obtained. Approximately 85% of the positive charge is delocalized over 15 CH units.

n-Doping, that is, partial reduction of the backbone p system of an organic polymer, was also discovered using trans-(CH)x by treating it with a reducing agent such as liquid sodium amalgam or preferably sodium naphthaline (Nphth.naphthaline). The antibonding p system is partially populated by this process which is accompanied by an increase in conductivity of about 10^{3} Scm^{-1}

Practice yourself

1. What is polymethanes? What is the principal linkage in polymethanes? Classify the following polymers on the basis of action of heat on them. [2010]

(a) Bakelite

(b) Teflon

(c) Polyethylene

(d) Nylon

2. Write short notes on

(a) Conductive polymer [2011C]

(b) Vulcanization [2012C, 2013C]

(c) Engineering plastics [2014C, 2015C]

3. Write about the various polymers related to natural rubber with emphasis on their preparation, properties and uses.

Mention three advantages of synthetic rubber over natural rubber. [2011C]

4. What do you mean by Engineering plastics? How the following Engineering plastics can be synthesized? [2012]

(a) Polycarbonates [2012]

(b) Nylon 6,6 [2012]

(c) Teflon [2013C]

5. What do you mean by plasticity? Why plasticizer is used during moulding of plastics? Mention the advantages and disadvantages of using plasticizer [2012, 2013]

6. Name the important properties of plastics. [2013]

Materials collected and prepared from:
J. Borah *etal*, Chemistry for Polytechnic, Kalyani Publishers
P.C. Jain *etal*, Engineering Chemistry, Dhanpat Rai Publishing Company(P) Ltd.
F.W. Billmeyer, Text Book of Polymer Science, John Wiely & Sons
J. Borah, Advanced Sensor And Detection Materials, Ch 12, WILEY-Scrivener Publisher's, USA
