

INDIAN RUBBER INSTITUTE
DIRI EXAMINATION – 2022

Paper – I

Date: 25th March, 2023
Duration: 3 Hours

Time: 10.00 – 13.00 hrs.
Full Marks : 100

Polymer Science

Answers should be illustrated with sketches wherever helpful
Total **five** questions are to be answered. **Question number 1** is compulsory.
Answer **four** from the remaining questions taking **two** from each group.

GROUP – A

1. Select the right answer from the given alternatives:

- (i) Which polymerization produces living polymer?
a) Radical polymerization c) Polycondensation polymerization
b) Anionic polymerization d) Polyaddition polymerization
- (ii) The glass transition temperature of polybutadiene rubber (BR) is
a) 10 °C b) – 38 °C
c) – 55 °C and 95 °C d) – 100 °C
- (iii) The polymer having lowest coefficient of friction is
a) NR b) PVC c) PTFE d) EPDM
- (iv) Glass transition temperature (T_g) of a polymer is determined by
a) Viscometer b) Dilatometer c) Osmometer d) GPC
- (v) If the repeat units are joined in a 3-dimensional array, the resulting polymer will be
a) Linear polymer b) Branched polymer
c) Cross linked polymer d) None of the above.
- (vi) Nitrobenzene and atmospheric oxygen are good examples of -
a) Inhibitor b) Initiator c) Antioxidant d) Coagulant
- (vii) Nylon 6,6 is-
a) Radical polymerization product b) Copolymer
c) Blend d) Condensation polymer product
- (viii) Resorcinol-formaldehyde resin is an example of-
a) Natural polymer c) Semi-synthetic polymer
b) Thermoplastic polymer d) Thermosetting polymer
- (ix) Among these, which one is aromatic polyamide?
a) Nylon 12 b) Kevlar c) Nylon 6,12 d) Polycarbonate
- (x) A polymer which has oxygen atom in the main chain is a
a) SBR b) NBR c) PMMA d) Silicone rubber
- (xi) Which of the following is man made fibre:
a) Jute b) Cotton c) Silk d) Polyester.

- (xii) The chain carrier in case of anionic polymerization are –
 a) Carbonium ions b) Hydroxyl ions c) Carbanions d) Carbon radicals
- (xiii) Example of an oil resistant polymer is
 a) NR b) IIR c) NBR d) EPDM
- (xiv) In an ideal living polymerization which one is correct?
 a) $M_n > M_w$ b) $M_n = M_w$ c) Generally $M_n < M_w$ d) Difficulty to say
- (xv) Which one is incorrect in case of a polymer?
 a) Below T_g it is glassy b) Above T_g it is a rubber
 c) Above T_m it is plastic d) Below T_m it is plastic.
- (xvi) Butyl rubber is
 (a) Homopolymer (b) Copolymer (c) Terpolymer (d) Blend
- (xvii) The rubber modulus is
 a) Same as Young's modulus b) Stress at specific elongation
 c) Ratio of stress by strain d) None of the above
- (xviii) T_g of copolymer can be calculated using
 (a) Carother's Equation (b) Bragg Equation
 (c) Fox Equation (d) Hildebrand Equation
- (xix) Polystyrene has M_w of 1,04,000. It has degree of polymerization
 (a) 100 (b) 500 (c) 1000 (d) 10000
- (xx) The one among the following is plasticizer
 (a) Dibutyl phthalate (b) Sodium peroxydisulfate
 (c) Dibutyl tin dilaurate (d) Dodecyl mercaptan
- 20 x 1 = 20**
2. (a) Write down a) the chemical structure of the polymers, b) name of the raw materials to prepare these polymers, c) its method of manufacturing process and d) their important properties (Any 4)
 i) SBR ii) Nylon 6,6 iii) PET iv) IIR v) EPDM vi) LDPE vii) CR
(1.5+1+1+1.5) x 4 = 20
3. (a) Write down the elementary steps of cationic polymerization of isobutylene starting from initiation to termination.
 (b) Write the inter-unit linkages for the following combinations of member functional groups. Name the polymer type and give an example for each category.
 (i) –NCO and –OH (ii) –COOH and –NH₂ (iii) –COOH and –OH
 (c) Select the right match.
- | | |
|---------------------|---------------------------------|
| I) Ethylene | A) Ziegler-Natta polymerization |
| II) Butadiene | B) Condensation polymerization |
| III) Ethylene oxide | C) Cationic polymerization |
| IV) Nylon 66 | D) Ring opening polymerization |
| V) Butyl rubber | E) Anionic polymerization |
- 6+(3x3)+5 = 20**

4. Write down the full name and its application in polymer science of the following:

- | | | | |
|--------|---------|----------|-----------|
| i) DMA | ii) XRD | iii) NMR | iv) SEC |
| v) IR | vi) MFI | vii) RPA | viii) DCP |

(2.5 x 8) = 20

GROUP - B

5. (a) What is polymer? What is polydispersity?

(b) How do you classify polymer based on thermal response? Give example.

(c) What is the important of polydispersity in rubber industries?

(d) Calculate number average molecular weight and weight average molecular weight for a polydispersed polymer composed of the following mixture of fractions (mass % and molecular weight of each of the fraction are given). Calculate the polydispersity of this polymer.

Mass %	20	30	50
Mol. Wt.	1,00,000	2,00,000	50,000

4+4+4+(6+2) = 20

6. a) i) How does the condensation polymerization differ from addition polymerization?

ii) Name and write down the famous equation which gives the molecular weights of polymers in condensation polymerization.

iii) You are carrying out the polymerization of terephthalic acid and ethylene glycol via condensation polymerization at 99.9% conversion. What will be the degree of polymerization and the Mw of the polymer?

b) Difference between the following pair of terms giving suitable example (any two)

i) Block copolymer and Graft copolymer ii) Inhibitor and short stop

iii) Atactic and isotactic polypropylene iv) SSBR and ESBR

(4 + 4 + 6) + (2x3) = 20

7. Explain **any eight** of the following (with suitable examples wherever required):

(a) Butyl rubber (IIR) has excellent impermeability to gases, but not NR.

(b) Why plastics exhibit lesser elongation at break than rubbers?

(c) CR is oil resistant, but not SBR.

(d) Aromatic polyamides (polyaramids) are stronger than aliphatic polyamides.

(e) Butadiene has a single molecular weight, but polybutadiene has average molecular weight.

(f) IR is commercially prepared via Ziegler-Natta polymerization, but IIR is prepared via cationic polymerization.

(g) In NBR, as the acrylonitrile content increases, the rubbery property decreases.

(h) T_g of Polyethylene is well below room temperature like rubber but it is plastics. Why?

(i) Why cationic polymerization is normally done at low temperature?

(j) Cis 1,4-polyisoprene is rubber, whereas its' trans isomer is plastic.

(8 x 2.5) = 20

8. Write short notes on **any four** of the following

(a) Stereo regular polymerization

(b) Factors affecting T_g of polymer

(c) Anionic polymerization

(d) Vulcanization of rubbers

(e) Ring opening polymerization

(f) Chain transfer in radical polymerization

(g) Interfacial polymerization

(4 x 5) = 20