INDIAN RUBBER INSTITUTE

DIRI EXAMINATION – 2023

Paper – I

Date: 9th March, 2024 **Time: 10.00 – 13.00 hrs.**

Duration: 3 Hours **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) Vinyl polymerization is accompanied by
   a) Decrease unsaturation with decrease in molecular weight
   b) Increase unsaturation with no change in molecular weight
   c) Increase unsaturation with increase in molecular weight
   d) Decrease unsaturation with increase in molecular weight

(ii) The glass transition temperature of polystyrene is
   a) 10 °C b) – 38 °C c) 100 °C d) – 100 °C

(iii) Among the following, which one is a polar polymer
   a) NR b) PVC c) SBR d) EPDM

(iv) Crystallinity of a polymer is quantitatively determined by
   a) Viscometer b) Dilatometer c) Osmometer d) XRD

(v) EVA is a
   a) Homopolymer b) Random copolymer c) Block copolymer d) None of the above.

(vi) Dibenzoyl peroxide is a good example of -
   a) Inhibitor b) Initiator c) Antioxidant d) Coagulant

(vii) Gutta-percha is a
   a) Synthetic polymer b) Natural polymer
   c) Regenerated polymer d) non-polymeric material

(viii) The rubber which shows strain-induced crystallization is
   a) Natural rubber b) Silicone rubber c) NBR d) CR

(ix) Nylon 6,6 is -
   a) Addition polymerization product b) Condensation polymerization product
   c) Ring opening polymerization product d) Blend

(x) A polymer which has sulfur (S) atom in the main chain is -
   a) Thiokol – T b) NBR c) PMMA d) Silicone rubber

(xi) Thermoset is a:
a) Non cross-linked polymer b) Remouldable and recyclable
c) Amorphous polymer d) Non remouldable and recyclable

(xii) The chain carriers in case of cationic polymerization are –
a) Carbonium ions c) Hydroxyl ions b) Carbanions d) Carbon radicals

(xiii) Functionality of glycerol is
a) One b) Two c) Three d) Four

(xiv) How many T_gs can be expected from a Triblock copolymer of styrene and butadiene (SBS)?
a) 1 b) 2 c) 3 d) Difficulty to say

(xv) In suspension polymerization technique the initiators used are –
a) Water soluble b) Insoluble in either water or monomer
c) Monomer soluble d) Soluble in both water and monomer.

(xvi) PET is
(a) Polyamide (b) Polyether (c) Polyester (d) Polycarbonate

(xvii) The catalyst (initiator) for cationic polymerization is -
a) $TiCl_4$ / $AlEt_3$ b) BuLi c) AIBN d) $AlCl_3$

(xviii) Starting material for polyvinyl alcohol is
(a) Vinyl amide (b) Vinyl acetamide (c) Vinyl acetate (d) Vinyl alcohol

(xix) Polystyrene has M_w of 2,08,000 g/mol. It has degree of polymerization
(a) 200 (b) 500 (c) 1000 (d) 2000

(xx) Polyurethane rubber has outstanding resistance to -
(a) Acids (b) Hot water (c) Abrasion and tear (d) UV radiation

20 x 1 = 20

2. Write down a) the chemical structure of the polymers, b) name the raw materials to prepare these polymers, c) its method of manufacturing process and d) their important properties (**Any 4**)
i) NBR ii) Silicone rubber iii) PET iv) PBR v) Nylon 6 vi) HDPE vii) SBS

(1.5+1+1+1.5) x 4 = 20

3. (a) Write down the elementary steps of free radical polymerization of styrene starting from initiator decomposition to termination.
(b) What is co-ordination polymerization? How can the formation of stereo-regular polymers by this method be explained? Give two examples of natural polymers, two examples of synthetic polymer and name their few major applications.
(c) Select the right match.

I) Natural rubber	F) Thermosetting polymer
II) Nylon 6,6	B) Gas retention properties
III) Living polymerization	C) Cis-1,4 polyisoprene
IV) Phenolic resin	D) Condensation polymerization
V) Butyl rubber	E) Anionic polymerization

6+(2+3+4)+5 = 20

4. a) Draw the stress-strain plots of i) Natural rubber (NR), ii) Bakelite and iii) Nylon 6 in the same plot mentioning the different important regions. Compare the above mentioned different plots & classify them to what different types of polymers they belong to.
   b) Define T_g. Explain any one method for determination of T_g of a polymer?
   c) Explain the term mastication and mention its significance.

(6+4)+(2+3)+5 = 20

GROUP – B

5. Write down the full name and its application in polymer science of the following:
   i) DSC ii) XRD iii) DMA iv) GPC
   v) IR vi) TGA vii) RPA viii) DCP

(2.5 x 8) = 20

6. (a) Define M_n and M_w. Explain briefly MWD curve of polymer and poly dispesity index of a polymer mixture. Mention its significance.
   (b) Indicate one method of measurement technique for M_n and M_w
   (c) M_w / M_n ratio is always greater than one for all synthetic polymers, Why?
   (d) Calculate polydispersity index of a sample of PP oligomers that consists of 5 mole of pentamer, 10 moles of hexamer and 20 moles of decamer.

10 + 2 + 3 + 5 = 20

7. Explain **any eight** of the following (with suitable examples wherever required):
   (a) PE and PP are semicrystalline plastics but EPR is an amorphous rubber.
   (b) Inhibitors are added during storing of monomers.
   (c) T_g increases with increase in crosslink density.
   (d) Aromatic polyamides (polyaramids) are stronger than aliphatic polyamides.
   (e) Sulfur is added in the compounds of nitrile rubber at the beginning of mixing process.
   (f) EPDM has good resistance to oxidative, ozonolytic and thermal degradation, but not PBR.
   (g) In SBR, as the styrene content increases, the rubbery property decreases.
   (h) Chain transfer agents are used to control molecular weight of a polymer. Why?
   (i) All polymers are macromolecules but all macromolecules are not polymers.
   (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) Electrical properties
   (b) Solubility parameter & cohesive energy density
   (c) Influence of acrylonitrile content in the properties of NBR
   (d) Creep and stress relaxation.
   (e) Viscoelasticity
   (f) Glass transition temperature and its significance

(4 x 5) = 20