**INDIAN RUBBER INSTITUTE**

**DIRI EXAMINATION – 2021**

**Paper – I**

**Date: 26th March, 2022**  **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:

1. Natural rubber is

a) 1,3 – Polybutadiene b) cis 1,4 – Polyisoprene

c) trans 1,4 –Polyisoprene d) Polyisobutylene

1. The glass transition temperature of SBR is

a) – 50 °C b) – 38 °C c) – 55 °C and 95 °C d) – 127 °C

(iii) Carothers equation is applicable to

a) Free radical polymerization b) Condensation polymerization

c) Anionic polymerization d) Coordination polymerization

(iv) Number-average molecular weight of a polymer can be determined by

a) Osmometry b) Light scattering c) Viscometry d) Dialatometry

(v) How many glass transition temperatures are expected from a block copolymer of styrene and butadiene?

a) 2 b) 1 c) no Tg d) 3

(vi) The rubber well known for gas retention is:

1. Natural rubber b) Polybutadiene rubber

c) Polychloroprene rubber d) Butyl rubber

(vii) The catalyst for cationic polymerization is:

a) TiCl4/AlEt3 b) AIBN c) AlCl3 d) BuLi

(viii) Initiator for emulsion polymerization is:

a) Sodium dodecylsulfate b) Bu-Li c) Sodium persulfate d) AIBN

(ix) Among these, which one is aromatic polyamide?

a) Nylon 12 b) Kevlar c) Nylon 6,12 d) Polycarbonate

1. EVA is

a) Homopolymer b) Copolymer c) Terpolymer d) Highly crystalline polymer

1. Starting material for polyvinyl alcohol is:

a) Vinyl alcohol b) Vinyl acetamide c) Vinyl acetate d) Vinyl amine

(xii) In suspension polymerization technique the initiator used are

(a) Water soluble (b) Monomer soluble

(c) Insoluble in either water or monomer(d) Soluble in both water and monomer

(xiii) 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.

(xiv) PET is

a) Polyamide b) Polyimide c) Polyether d) Polyester

(xv) Functionality of glycerol is

(a) One (b) Two (c) Three (d) Four

(xvi) Cellulose is

(a) A natural polymer (b) A synthetic polymer

(c) A regenerated polymer (d) Not a polymer

(xvii) In radical polymerization, AIBN (azo-bisisobutyro nitrile) is used as

(a) Inhibitor (b) Initiator (c) Co-catalyst (d) Chain transfer agent

(xviii) In butyl rubber the comonomer used is

* 1. Butadiene (b) Isoprene (c) Styrene (d) Dicyclopentediene

(xix) Toughness is

(a) The area under the Hookean region (b) The stress at break

1. The maximum stress (d) The whole area under stress/strain plot

(xx) The one among the following is plasticizer

* 1. Dibutyl phthalate (b) Sodium dodecyl sulfate

(c) Dibutyl tin dilaurate (d) Dodecyl mercaptan

**20 x 1 = 20**

2. (a) Define the terms i) monomer ii) polymer iii) degree of polymerization. Why polymers have average molecular weights?

(b) Give three examples of natural polymers, three examples of synthetic polymer and name their few major applications.

(c) What are thermoplastics and themosets? Give examples for each cases.

(d) What is the effect of acrylonitrile content in nitrile rubber?

(e) What is the molecular weight of polystyrene sample having degree of polymerization 200?

**5+6+4+2+3 = 20**

3. (a) Write down the elementary steps of free radical polymerization of styrene starting from initiator decomposition till termination taking example of AIBN or dibenzoylperoxide as initiator.

(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) What are inhibitors and what is inhibition period? Write down the methods to remove inhibitors from the monomers prior to polymerization?

**6+(3x3)+(1+2+2) = 20**

4. 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**

**GROUP – B**

5.(a) Draw the Degree of polymerization vs. % conversion plots of radical polymerization, controlled radical polymerization and condensation polymerization.

(b) Write down the advantages and disadvantages of bulk polymerization. What are the ingredients in emulsion polymerization? How can you control the particle size in suspension polymerization? How can you prevent the monomer droplets to coalesce? Which polymerization technique will you recommend to prepare a polymer (for example, PVC) for electrical insulation application?

(c) Calculate the number average molecular weight, weight average molecular weight and polydispersity index (PDI) of a polymer for the data shown below:

|  |  |  |
| --- | --- | --- |
| Interval no. (i) | Number of chains in interval (Ni) | g/mol of polymer chains in interval (Mi) |
| 1 | 4 | 10,000 |
| 2 | 5 | 20,000 |
| 3 | 2 | 25,000 |
| 4 | 3 | 40,000 |

**3+(4+3+2+1)+7 = 20**

6. 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 Tg. Explain any one method for determination of Tg  of a polymer?.

c) Explain the term tacticity with suitable examples for each types of tacticities.

**(6+4)+(1+3)+6 = 20**

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

1. Propylene cannot be polymerized by radical polymerization
2. Tg is a second order transition
3. PE and PP are semicrystalline plastics but EPR is an amorphous rubber
4. Polyaramids are stronger than polyamides
5. Sulfur is added in the compounds of nitrile rubber at the beginning of mixing process
6. Stabilizers are added to the PVC compounds.
7. MFI (melt flow index) cannot be measured for PVC.
8. Tg increases with increase in crosslink density.
9. Anionic polymerization is called as living polymerization.
10. All polymers are macromolecules but all macromolecules are not polymers.

**(8 x 2.5) = 20**

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

1. Gel effect
2. Cationic polymerization
3. Mastication
4. Solubility parameter & cohesive energy density.
5. Rubber like elasticity
6. Interfacial polymerization

**(4 x 5) = 20**