

## INDIAN RUBBER INSTITUTE

## DIRI EXAMINATION – 2019

## Paper – I

Date: 6<sup>th</sup> July, 2019

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) Butyl rubber is  
 (a) Homopolymer (b) Copolymer (c) Terpolymer (d) Fibre
- (ii) A polymer which has oxygen atom in the main chain is  
 a) Thiokol b) NBR c) PMMA d) VQ
- (iii) Most important criteria to form a strong fibre is  
 a) Mixture of syndiotactic & atactic b) Amorphous  
 c) Highly crystalline d) Highly atactic
- (iv) Number-average molecular weight of a polymer can be determined by  
 a) Osmometry b) Light scattering c) Viscometry d) Dialatometry
- (v) Glass transition temperature ( $T_g$ ) of cis-polybutadiene rubber (BR) is  
 a)  $10^\circ\text{C}$  b)  $-100^\circ\text{C}$  c)  $100^\circ\text{C}$  d)  $50^\circ\text{C}$
- (vi) Copolymer of styrene and butadiene which is used in car tyre is  
 a) SBS b) SEBS c) SSBR d) SEPS
- (vii) Example of an oil resistant polymer is  
 a) NR b) IIR c) NBR d) EPDM
- (viii) Gutta-percha is  
 a) Natural polymer b) Synthetic polymer c) Artificial polymer d) Regenerated polymer
- (ix) PET is a  
 a) Polyamide b) Polyether c) Polyimide d) Polyester
- (x) EVA is  
 a) Homopolymer b) Copolymer c) Terpolymer d) Highly crystalline polymer
- (xi) EPDM is commercially prepared by  
 a) Cationic polymerization b) Anionic polymerization  
 c) Ziegler-Natta polymerization d) Radical polymerization
- (xii) Polymers show rubbery properties

- (a) Above  $T_g$  (b) Below  $T_g$   
 (c) Both below and above  $T_g$  (d) None of the above

(xiii) Glass transition temperature ( $T_g$ ) of a polymer is determined by  
 (a) Viscometer (b) Dilatometer (c) Osmometer (d) GPC

(xiv) Which polymerization is called living polymerization?  
 (a) Radical polymerization (b) Anionic polymerization  
 (c) Polycondensation Polymerization (d) Polyaddition polymerization

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

(xix) Elasticity as defined by Stress/Strain is  
 (a) More for rubber than steel (c) Almost similar for both rubber and steel  
 (b) Less for rubber than steel (d) Not possible to calculate for rubber

(xx) In butyl rubber the comonomer used is  
 (a) Butadiene (b) Isoprene (c) Styrene (d) Dicyclopentadiene

20 x 1 = 20

2. (a) Define the terms i) monomer ii) polymer iii) degree of polymerization with an example in each case.  
 (b) Give three examples of natural polymers, three examples of synthetic polymer and name their few major applications.  
 (c) What should be the minimum functionality of a monomer? Explain this with an example.  
 (d) What is the functionality of acrylonitrile ( $\text{CH}_2=\text{CH}-\text{CN}$ ) in polymerization reaction?  
 (e) In polybutadiene (PBR) if the degree of polymerization is 2,000. What will be the average molecular weight of BR?

6+6+3+2+3 = 20

3. Name and write down the structure of the following polymers. Also write down the industrial method of preparation of these polymers and its important properties.

(a) SSBP (b) Q (c) IIR (d) NBR (e) PP

(1.5+1+1.5) x 5 = 20

3. 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) Write down different molecular weights of a polymer and different methods to determine the above mentioned molecular weights. How does the molecular weight of the polymer influence the properties of a polymer?

(b) What is molecular weight distribution (MWD) and what its typical value in the synthetic polymers? Name a method of polymerization in which you can expect the MWD as unity. How does the MWD influence the properties of polymer?

(c) Calculate the number average molecular weight and the weight average molecular weight 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	2	10,000
2	3	20,000
3	2	25,000
4	3	40,000

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

6. a) Draw the stress-strain plots of i) Natural rubber (NR), ii) HDPE 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  $T_g$ . How do you determine  $T_g$  of a polymer?.

c) How you can distinguish a rubber and a plastics in term of  $T_g$ , Molecular weight and Crystallinity?

(6+4)+4+6 = 20

7. Distinguish between the following (with suitable examples):

- Creep and stress relaxation
- Thermoplastics and thermosets
- Random and block copolymers
- Storage modulus & loss modulus
- Syndiotactic and atactic polystyrene
- Cationic polymerization and anionic polymerization
- Suspension polymerization and emulsion polymerization
- Inhibition and retardation

(8 x 2.5) = 20

8. Write short notes on any four of the following

- Gel effect
- Stereo regular polymerization
- Factors affecting  $T_g$  of polymer
- Viscoelasticity
- Living polymerization
- Factors affecting crystallization of polymer

(4 x 5) = 20

