

INDIAN RUBBER INSTITUTE

DIRI EXAMINATION – 2018

Paper – I

Date: 14th July 2018

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.

1. a) Choose the correct answer from the given alternatives
- i) Name a rubber which is prepared by anionic polymerization
a) SBR b) IIR c) NBR d) PVC
- ii) Name a rubber which is prepared by condensation polymerization
a) NBR b) Silicon rubber c) IR d) EPDM
- iii) 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
- iv) Name a polymer which is self-extinguishing
a) NR b) NBR c) FKM d) SBR
- v) Crystallinity of a polymer is quantitatively determined by
a) XRD b) TGA c) Dilatometry d) Ostwald's viscometer
- vi) Glass transition temperature (T_g) of a polymer is determined by
a) DSC b) XRD c) GPC d) Vapor phase osmometry
- vii) If a polyethylene has an average degree of polymerization of 1,000, its average molecular weight would be
a) 2,80,000 g/mol b) 28,000 g/mol c) 14,000 g/mol d) 30,000 g/mol
- viii) 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
- ix) Which rubber shows strain induced crystallization?
a) NR b) NBR c) Silicone rubber d) EPDM
- x) In DMA analysis $\tan\delta$ is defined by
a) Storage modulus / loss modulus b) Loss modulus / storage modulus
c) Stress relaxation / creep d) Creep / stress
- xi) 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.

- xii) Name a polymer which has sulphur (s) in the backbone
 a) SBR b) IIR c) MQ d) Thiokol – T
- xiii) Name a polymer which has maximum trans content
 a) PVC b) CR c) NBR d) SBR
- xiv) Name an initiator which is used in anionic polymerization
 a) $AlCl_3$ b) AIBN c) BuLi d) Potassium persulfate
- xv) Resorcinol-formaldehyde resin is an example of
 (a) Natural polymer (c) Semi-synthetic polymer
 (b) Thermoplastic polymer (d) Thermosetting polymer
- xvi) A polymer which has oxygen atom in the main chain is
 a) SBR b) NBR c) PMMA d) MQ
- xvii) Most important criteria of a polymer to form strong fibre is
 a) Partially crystalline b) Amorphous
 c) Highly crystalline d) Highly atactic
- xviii) Number-average molecular weight of a polymer can be determined by
 a) Osmometry b) Light scattering c) Viscometry d) Dialatometry
- xix) Nylon is a
 a) Polyester b) Polyamide c) Polyolefin d) None of the above
- xx) EVA is a
 a) Homopolymer b) Copolymer c) Terpolymer d) Highly crystalline polymer

1 x 20 = 20

GROUP – A

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) Nylon 6 iii) PET iv) IIR v) EPDM vi) LDPE vii) CR
 (1.5+1+1+1.5) x 4 = 20
- 3) (a) i) Write down the four main technical methods of polymerization with their advantages and disadvantages ii) Cite at least one example of preparing polymers in each case.
 iii) Among those methods which method is widely used in industry and why?
 (b) i) Write down the essential steps for the polymerization of styrene ($CH_2=CH-C_6H_5$) using benzoyl peroxide ($C_6H_5COO-OOCC_6H_5$) as the initiator. ii) If you add dodecyl mercaptan ($C_{12}H_{25}SH$), what will happen to this polymerization reaction?

(c) Select the right match.

- | | |
|---------------------|---------------------------------|
| I) Ethylene | A) Cis1,4 polyisoprene |
| II) Butadiene | B) Condensation polymerization |
| III) Ethylene oxide | C) Cationic polymerization |
| IV) Nylon 66 | D) Ring opening polymerization |
| V) Butyl rubber | E) Anionic polymerization |
| VI) NR | F) Ziegler-Natta polymerization |

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

4. a) Draw the stress-strain curve for these polymers.

- i) HDPE ii) Raw natural rubber (NR) iii) Vulcanized NR iv) Nylon 6 (fiber)

b) i) How does crystallinity affect the properties of polymers? ii) Write down with how the different the factors influence the crystallinity in a polymer? iii) How can you determine the crystallinity in a polymer? Write down with example. iv) What were the different types of crystals are possible in polymer? v) Out of HDPE & LDPE which had higher crystallinity and why?

$$(1.5 \times 4) + (3+3+3+3+3) = 20$$

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. Weight	50,000	1,00,000	2,00,000

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

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 ethylene glycol via condensation polymerization at 99.9% conversion. What will be the degree of polymerization and the M_w of the polymer?

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

i) Block copolymer and Graft copolymer

ii) Inhibitor and short stop

iii) Atactic and isotactic polypropylene

iv) SSBR and ESBR

v) DSC and TGA

$$(3 + 3 + 5) + (3 \times 3) = 20$$

7. Explain the following (any five)

- (a) In NBR, as the acrylonitrile content increases, the rubbery property decreases.
- (b) EPDM has good resistance to oxidative, ozonolytic and thermal degradation, but not BR.
- (c) Butyl rubber (IIR) has excellent impermeability to gases, but not NR.
- (d) CR is oil resistant, but not SBR.
- (e) BR is vulcanized with sulfur, but silicone rubber is usually vulcanized by peroxide.
- (f) Butadiene has a single molecular weight, but polybutadiene has several average molecular weights.
- (g) EPDM is soluble in most of the organic solvents, but polyethylene is not.
- (h) IR is commercially prepared via Ziegler-Natta polymerization, but IIR is prepared via cationic polymerization.

4 x 5 = 20

8. Write short notes on: (Any four)

- a) Styrene-butadiene-styrene block copolymer.
- b) Influence of acrylonitrile content in the properties of NBR.
- c) Maxwell model in rubber elasticity.
- d) Time-temperature superposition.
- e) Solubility parameter & cohesive energy density.
- f) Vulcanization of rubber.
- g) Chain transfer in radical polymerization.

5 x 4 = 20