

## INDIAN RUBBER INSTITUTE

## DIRI EXAMINATION – 2012

## Paper – I

Date: 20<sup>th</sup> July, 2012

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. Select the right answer from the given alternatives:
- (i) Vinyl polymerization is accompanied by
    - (a) Increase in unsaturation with increase in molecular weight
    - (b) Decrease in unsaturation with increase in molecular weight
    - (c) Decrease in unsaturation with decrease in molecular weight
    - (d) Increase in unsaturation with no change in molecular weight
  - (ii) A polymer which has oxygen atom in the main chain is
    - a) SBR
    - b) NBR
    - c) PMMA
    - d) MQ
  - (iii) Most important criteria of a polymer to form strong fibre is
    - a) Partially crystalline
    - 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 polybutadiene rubber (BR) is
    - a) 10°C
    - b) -100°C
    - c) 100°C
    - d) 50°C
  - (vi) Copolymer of styrene and butadiene which is used in car tyre is
    - a) SBR
    - b) SEBS
    - c) SBS
    - d) SEPS
  - (vii) In the typical stress-strain curve, the stiffness is measured by calculating the
    - a) Total area under the curve till the point of rupture
    - b) Area within the Hookean region
    - c) Slope of straight portion within the Hookean region
    - d) Energy at break
  - (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) Rheometer
- (xiv) Which polymerization is called living polymerization?  
(a) Radical polymerization    (b) Anionic polymerization  
(c) Polycondensation Polymerization    (d) Polyaddition polymerization
- (xv) Polystyrene has  $M_w$  of 1,04,000. It has degree of polymerization  
(a) 100    (b) 500    (c) 1000    (d) 10000
- (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  
(b) Less for rubber than steel  
(c) Almost similar for both rubber and steel  
(d) Not possible to calculate for rubber
- (xx) In butyl rubber (IIR) the comonomer used is  
(a) Butadiene    (b) Isoprene    (c) Styrene    (d) Dicyclopentadiene

**20 x 1 = 20**

- 2) (a) What are 'monomer' and 'polymer'? Explain them with an example in each case.  
 (b) Give two examples of natural polymer and two examples of synthetic polymer.  
 (c) What should be the minimum functionality of a monomer? Give an example.  
 (d) What is the functionality of vinyl chloride ( $\text{CH}_2=\text{CH-Cl}$ ) in polymerization reaction.  
 (e) Write down the stress-strain curves in the same plot for the following:  
 i) a rubber    ii) a rigid plastic    iii) a fiber

6+4+3+3+4= 20

3. (a) Write down the full name and an application of the following: **(any five)**:  
 i) ABS    ii) LDPE    iii) PET    iv) SBR    v) IR    vi) DSC

- (b) Name the repeating units and its chemical structure for the following polymer **(any five)**.

- i) Poly (vinyl chloride)    ii) Poly(ethylene glycol)    iii) BR  
 iv) Nylon 6    v) NBR    vi) Teflon    vii) NR

(5x2)+(5x 2) = 20

- 4) (a) Write down the four main technical methods of polymerization citing at least one example in each case. among those methods which method is widely used in industry and why?  
 (b) Write down the essential steps for the polymerization of styrene ( $\text{CH}_2=\text{CH-C}_6\text{H}_5$ ) using benzoyl peroxide ( $\text{C}_6\text{H}_5\text{COO-OOCC}_6\text{H}_5$ ) as the initiator. If you add dodecyl mercaptan ( $\text{C}_{12}\text{H}_{25}\text{SH}$ ), what will happen to this polymerization reaction?

- (c) Select the right match.

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

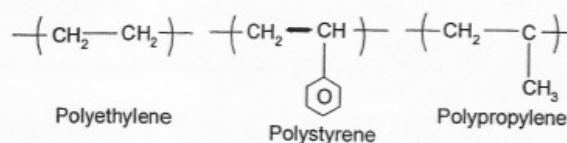
(5+2)+(5+2)+6 = 20

**GROUP – B**

5. Name and write down the structure of the rubbers used in each case, Also write down the industrial method of preparation of these rubbers.
- A copolymer which is oil resistant.
  - An inorganic rubber.
  - A copolymer which is widely used in tyre industry.
  - A flame resistant rubber.
  - A hetero rubber having high heat resistant property.
  - A rubber which has lowest  $T_g$  widely used in tyre industry.

**(1+2+1) x 5 = 20**

6. (a) What do you mean by glass transition temperature ( $T_g$ )? Explain this with an example.
- (b) How can you determine the  $T_g$  of a polymer?
- (c) How can you distinguish a rubber and a plastic in terms of their  $T_g$ ? Explain this with an example in each case?
- (e) Among the following polymers which one has highest  $T_g$  and which one has lowest  $T_g$ ? Justify your answer.



- (f) What is  $T_m$  of a polymer? Explain this with an example.

**4+3+4+5+4 = 20**

7. Explain the following (**any four**)

- EPDM has good resistance to oxidative, ozonolytic and thermal degradation, but not BR.
- Butyl rubber (IIR) has excellent impermeability to gases, but not NR.
- NBR is oil resistant, but not SBR.
- BR is vulcanized with sulfur, but silicone rubber is usually vulcanized by peroxide.
- Butadiene has a single molecular weight, but polybutadiene has several average molecular weights.
- EPDM is soluble in most of the organic solvents, but polyethylene is not.

**5 x 4 = 20**

8. Write short notes (with suitable example) on any **Four** of the following:-

- Creep in polymer
- Polyurethane
- Step growth polymerization
- Block copolymer
- Viscoelasticity
- Vulcanization

**5 x 4 = 20**