

**INDIAN RUBBER INSTITUTE  
PGDIRI EXAMINATION – 2012**

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**Paper – I**

**Date : 20<sup>th</sup> July, 2012**  
**Duration : 3 Hours**

**Time : 10.00 – 13.00 hrs.**  
**Full Marks : 100**

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**Polymer Science**

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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. Multiple choice questions: select the correct answer from the given alternatives:

- (i) Among the following rubbers which rubber is commercially prepared by Ziegler-Natta polymerization  
(a) NBR      (b) SBR      (c) IIR      (d) BR
- (ii) The functionality of acrylonitrile ( $\text{CH}_2 = \text{CH} - \text{CN}$ ) in polymerization is  
(a) One      (b) Two      (c) Three      (d) Four
- (iii) Chain transfer agent is used in polymerizations:  
(a) To control the polymer structure  
(b) To control crystallinity in polymer  
(c) To control the molecular weight of the polymer  
(d) To retard the polymerization reaction
- (iv) Atactic polymers are:  
(a) High melting and easily soluble      (b) High melting and less soluble  
(c) Low melting and less soluble      (d) Low melting and easily soluble
- (v) The chemical substance added towards the end of a polymerization reaction for purpose of arresting the reaction is called:  
(a) Antioxidant      (b) Stabiliser      (c) Short stop      (d) Catalyst
- (vi) SSBR is:  
(a) Suspension SBR      (b) Solution SBR      (c) Soluble SBR      (d) High styrene SBR
- (vii) The decrease in stress value experienced in a polymer specimen subjected to constant strain is known as:  
(a) Creep      (b) Stress relaxation      (c) Cold drawing      (d) Elastic response
- (viii) For a Hookean material stress is directly proportional to:  
(a) Shear rate      (b) Temperature      (c) Viscosity      (d) Strain

- (ix) Mark-Houwink equation is related to  
(a) Melting (b) Crystallinity (c) Viscosity (d) Elasticity
- (x) The following are the stereo regular structures  
(a) Atactic and syndiotactic (b) Isotactic and syndiotactic forms  
(c) Isotactic and atactic forms (d) Atactic
- (xi) Anionic polymerization can be initiated by  
(a) Azo bis isobutyro nitrile (AIBN) (b)  $\text{TiCl}_3$   
(c) Butyl lithium (d) Lewis acids such as  $\text{BF}_3$
- (xii) In suspension polymerization, the initiators used should be  
(a) Water soluble (b) Monomer soluble  
(c) Monomer soluble or water soluble (d) None of these
- (xiii) An amorphous polymer is characterized by  
(a) Sharp melting temperature (b) Glass transition temperature  
(c) Broad crystallization temperature (d) One spring and one dashpot in parallel
- (xiv) The polymer which has hetero-atom in the main chain is  
(a) Polysulphide rubber (b) CR (c) SBS (d) NBR
- (xv) Which polymerization gives a latex?  
(a) Bulk polymerization (b) Solution polymerization  
(c) Suspension polymerization (d) Emulsion polymerization
- (xvi) Among these polymers which one is prepared by ring opening polymerization  
(a) IIR (b) EPDM  
(c) NBR (d) Poly(epichlorohydrin) (CO)
- (xvii) CED, an important parameter to determine miscibility characteristic of a polymer is  
(a) Cohesive electron density (b) Cohesive energy density  
(c) Cohesive electron dispersion (d) Coherent energy density
- (xviii) A good inhibitor in vinyl polymerization is  
(a) Potassium sulfate (b) Butyl mercaptan (c) Hydroquinone (d) Nitrogen
- (xix) Name the catalyst which is used in cationic polymerization  
(a) AIBN (b) BuLi (c)  $\text{Al}(\text{C}_2\text{H}_5)_3$  (d)  $\text{AlCl}_3$
- (xx) Melt flow index (MFI) of polymers is the measure of  
(a) Molecular weight (b) Density (c) Crystallinity (d) Tacticity

(1 x 20) = 20

2. Explain the following with proper reasons (**any four**):
- Random copolymer of butadiene and acrylonitrile (NBR) of composition 75:25 and 25:75 (by weight) have different characteristics.
  - SBR and SBS are prepared differently and have different properties.
  - Polyethylene and polypropylene are both thermoplastics, but random copolymer of ethylene and propylene is rubber-like.
  - The rubbers, IR and IIR are prepared differently and have different properties.
  - NR and Gutta-percha have the same repeating unit but they behave quite differently.
  - Nylon 6 and general purpose polystyrene are thermoplastics, but polystyrene is amorphous while Nylon 6 is partially crystalline.
- (4 x 5) = 20**
3. (a) (i) What is living polymerization? Explain with a typical example.  
 (ii) What is the value of typical MWD in living polymerization? Why is it so?  
 (iii) Name two rubbers which are prepared by this polymerization method.
- (b) (i) Write down the different steps in the mechanism of the polymerization of propylene by using  $\text{TiCl}_4$  and  $\text{Al}(\text{CH}_3)_3$ .  
 (ii) Name two rubbers which are prepared by this polymerization method.
- (c) What is depolymerization?
- (5+2+2)+(5+2)+4 = 20**
4. (a) What is  $T_g$  of polymer? Briefly explain with suitable example. Name with example the important factors which control  $T_g$  of a polymer. Name two methods by which you can determine the  $T_g$  of a polymer.
- (b) What is  $T_m$  of a polymer? Briefly explain with suitable example. What are the important factors which control  $T_m$  of a polymer?
- (c) Describe a suitable method by which you can determine  $T_g$  and  $T_m$  of a polymer.
- (3+4+2)+(3+3)+5 = 20**

GROUP – B

5. (a) Write down the polymerization reaction between ethylene glycol and terephthalic acid. What is name of this polymerization? What is name of this polymer?  
 (b) Write down the equation which controls the reaction kinetic of this polymerization reaction. Explain all the terms in this equation.  
 (c) What is gel point? How can you predict this using this equation?  
 (d) What are the basic differences between this polymerization reaction and polymerization of ethylene (addition polymerization)?  
 (e) Name two rubbers which are prepared by this polymerization method.  
 (f) Name two engineering plastics prepared by this method.

$$(3+1+1)+3+(1+3)+4+2+2 = 20$$

6. (a) Ethylene has a single molecular weight of 28. But polyethylené has several molecular weights. Why?  
 (b) Write down the general expression of any two different types of molecular weight of a polymer. Name different methods by which you can determine them?  
 (c) What is molecular weight distribution (MWD)? Usually what is the value of MWD for synthetic polymers? Under which conditions MWD is one?  
 (d) How do the molecular weights influence the mechanical and processing characteristic of a polymer?  
 (e) A polymer sample contains several fractions of the same repeating unit (monomers); Fraction A with 500 molecules having molecular weight 1000 each and fraction B with 300 molecules having molecular weight 9000 each. Calculate the number and weight average molecular weight of the polymer sample.

$$3+4+(1+1+2) + 4+5 = 20$$

7. (a) Draw a neat diagram of the stress-strain plot with proper justification for the following polymers.

- (i) Polybutadiene rubber (BR)  
 (ii) Poly(methyl methacrylate) (PMMA)  
 (iii) Nylon 66

(b)

- (i) Draw a typical stress-strain plot of NR, gum vulcanizate.  
 (ii) Explain why in natural rubber (NR) there is a second rise in the curve.  
 (iii) How can you find out the toughness from this curve?  
 (iv) What will be the nature of the plot when you add carbon black in the rubber and vulcanize this?

- (c) What is WLF equation? Explain its significance.

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

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

- (a) Tacticity in polymer  
 (b) Emulsion polymerization  
 (c) Voigt-Kelvin Model  
 (d) Stress relaxation  
 (e) Power Law  
 (f) Chain Transfer agent

$$(4 \times 5) = 20$$