INDIAN RUBBER INSTITUTE
PGD-IRI EXAMINATION – 2015
Paper - I

Date: 17th July, 2015	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 No. 1** is compulsory and 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) A polymer which has a hetero atom in the main chain backbone
   (a) CR   (b) NBR   (c) PVC   (d) Thiokol

ii) Usually polybutadiene is commercially prepared by
   (a) Condensation polymerization   (b) Ziegler-Natta polymerization
   (c) Ring opening polymerization   (d) Cationic polymerization

iii) Anionic polymerization can be initiated by
   (a) Azo bis isobutyro nitrile (AIBN)   (b) Butyl lithium
   (c) Dicumyl peroxide   (d) BF_3

iv) In emulsion polymerization, the initiators used should be
   (a) Water soluble   (b) Monomer soluble
   (c) Both monomer in soluble or water in soluble   (d) None of these

v) The catalyst used for cationic polymerization is
   (a) $AlCl_3$ (b) BPO
   (c) $TiCl_4$/TEAL   (d) Redox initiator

vi) Which polymerization process gives a latex?
   (a) Bulk polymerization   (b) Solution polymerization
   (c) Suspension polymerization   (d) Emulsion polymerization

vii) Molecular weight distribution is:

   (a) $\overline{M_n}/\overline{M_w}$ (b) $\overline{M_w}/n$ (c) $\overline{M_n}/\overline{N}$ (d) $\overline{M_w}/\overline{M_n}$

viii) The following is not an example of ring opening polymerization:
   (a) Nylon 6   (b) Nylon 66   (c) Poly alkenamer   (d) Poly epichlorohydrin

[Turn Over]

(ix) GPC gives
(a) Number average molecular weight   (b) Molecular weight distribution
(c) Weight average molecular weight   (d) All of these

(x) Glass transition temperature of a polymer is determined by
(a) Infrared spectrophotometer   (b) Differential scanning calorimeter
(c) X-ray diffraction (XRD)   (d) Scanning electron microscopy

(xi) If polystyrene has a molecular weight (M_n) of 52,000 what is its degree of polymerization?
(a) 100   (b) 500   (c) 10000   (d) None of the these

(xii) Atactic polymers are
(a) Crystalline   (b) Semi-crystalline   (c) Amorphous   (d) None of these

(xiii) SBS is a
(a) Random copolymer   (b) Alternate copolymer
(c) Block copolymer   (d) Statistical copolymer

(xiv) Aramids are high performance
(a) Polyesters   (b) Polyethers   (c) Polyimides   (d) Polyamides

(xv) A rubber having good biocompatibility is
(a) NR   (b) SBR   (c) NBR   (d) PDMS

(xvi) A rubber prepared by condensation polymerization is
(a) SBR   (b) NBR   (c) Thiokol   (d) Polychloroprene rubber

(xvii) Gutta percha is
a) Cis 1,4 polyisoprene   (b) Trans 1,4 polyisoprene
(c) 1,2 polyisoprene   (d) 3, 4 polyisoprene

(xviii) Mercaptans are generally used in polymerizations as
(a) Initiator   (b) Chain transfer agent
(c) Short stop   (d) Emulsifier

(xix) Crystallinity in a polymer is measured by using
(a) SEM   (b) XRD   (c) GPC   (d) Viscometry

(xx) Which rubber has high Iodine value.
(a) BR   (b) IIR   (c) EPDM   (d) Thiokol

(1x20) = 20

2.

3.(a) i)
ii)
iii)
iv)

b)

4.

a)
b)
c)
d)
e)
f)
g)
h)
i)
j)

5. (a)
ii)
iii)
iv

b) i)
ii)

6.a) i

[Turn Over]

2. Write the full name of the following abbreviations and briefly explain their importance in polymer science with proper example: (any ten)

i) Q   ii) DMA   iii) NMR   iv) IR   v) MBTS

vi) XRD   vii) KPS   viii) SEM   ix) IIR   x) ECO

xi) CTA   xii) SEC   xiii) M- H. Constant

$(10 \times 2) = 20$

3.(a) i) Taking benzoyl peroxide (BPO) as an initiator show the different steps in the polymerization of styrene at 60^0C. Write down the final rate equation of this polymerization reaction.

ii) If you add benzyl mercaptan to this polymerization process what will happen?

iii) What will happen if the temperature is increased to 80^0C ?

iv) What will happen if you increase the concentration of BPO in the polymerization reaction?

$(4 + 2 + 2 + 2) = 10$

b) Write down the raw materials, method of preparation and chemical structure of the following polymer (any five)

i) EPDM   ii) Nylon 6, 10   iii) Cis- BR   iv) Syndiotactic PP

v) CPE   vi) PTFE   vii) SBS

$(5 \times 2) = 10$

4. Explain the following statement. If any of the statement is incorrect, please correct this with proper explanation.

a) Trans-BR is more rubbery than Cis-BR.

b) The properties of NBR depend on the acrylonitrile (ACN) content.

c) Polychloroprene rubber (CR) has more heat and oil resistant properties than fluoro elastomer.

d) As the styrene content increases, the rubbery properties of SBR gets improved.

e) NR is more prone to undergo strain induced crystallization than NBR.

f) Syndiotactic polystyrene is more crystalline than atactic polystyrene.

g) Polypropylene has higher Tg than polyethylene.

h) Butyl rubber is usually prepared by using redox initiators.

i) Anionic polymerization is called stereo-regular polymerization.

j) Carothers's equation is usually used for the polymerization of vinyl monomer.

$(10 \times 2) = 20$

Group - B

5. (a) i) What are the different factors which contribute to crystallinity in a polymer?

ii) What are the different crystal structures possible in a crystalline polymer?

iii) Describe a method with its working principle by which the crystallinity of a polymer can be determined.

iv) Among polybutadiene and HDPE which one will be easily soluble in toluene? Why?

$4 + 3 + 3 + 2 = 12$

b) i) Explain with schematic figures what are the different types of tacticity possible in polystyrene.

ii) Polystyrene prepared by using BPO as an initiator is highly soluble in toluene, but polystyrene prepared by certain stereo-specific Ziglar-Natta catalyst is insoluble in toluene. Why?

$5 + 3 = 8$

6.a) i) Write down the stress-strain plot of NR, Nylon 6 (a fibre) and Steel in the same plot. Explain the different regions in each plot.

ii) What is Hook's law? Show the validity of this law in each of the above plots with proper explanation

$$6 + (2 + 4) = 1$$

b) i) What are the different criteria that a polymer should fulfill to be called as rubber? Explain this with specif examples.

ii) Polyethylene has very low Tg, but it's not a rubber. Why?

$$5 + 3 = 8$$

7. Discuss the differences between the following terms with examples:

(a) Maxwell model and Voigt model.

(b) Newtonian fluid and non-Newtonian fluid.

(c) Stress relaxation and creep

(d) Hook's law and Power law

(e) Atactic polymer & syndiotactic polymer.

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

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

(a) Solution SBR

(b) Solubility parameter

(c) Poisson's ratio

(d) Dilatometry

(e) WLF Equation

(f) Strain induced crystallization

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