

INDIAN INSTITUTE OF SCIENCE EDUCATION AND RESEARCH KOLKATA

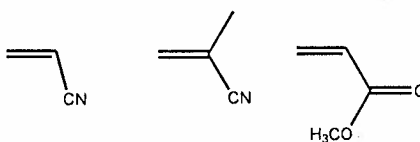
Spring Semester 2019; Final Examination – Polymer Chemistry (ID4210)

Time : 2.5 hour

Date: May 04, 2019

Part A: Answer All Questions (25 marks)

1. Why high molecular weight polypropylene cannot be prepared by free radical polymerization? [1 mark]
2. What is Ceiling temperature in polymer chemistry? [1 mark]
3. Why ionic polymerizations are generally carried out at lower temperatures? [1 mark]
4. Write down the magnitude of  $r_1$  and  $r_2$  in case of (a) alternating copolymerization, (b) random copolymerization and (c) block copolymerization. [1.5 marks]
5. Which one will show highest rate of anionic polymerization from the following three vinyl monomers? [1 mark]



6. Write down polymer dissolution steps in a good solvent. [1 mark]
7. Write down the name of the detectors you need to have for determining  $M_n$  of a polymer from a GPC measurements using Universal Calibration? [1 mark]
8. A polymer with  $M_n = 100,000$  g/mol obeys the Mark-Houwink-Sakurada equation in acetone with  $K = 0.0001$  and  $a = 0.8$ . Calculate the relative viscosity at 0.001 g/mL polymer concentration? [1 mark]
9. Draw the erythro-diosyndiotactic structure of the polymer  $-(\text{CHR}-\text{CHR}')-$ . [1 mark]
10. Following sentences are true or false? [2 marks]
  - (a) In GPC, polymer chains are separated by their size not by chemical affinity.
  - (b) Vinyl ether monomers can be polymerized only by cationic polymerization.
  - (c) In living polymerization  $M_n$  increases linearly with conversion.
  - (d) Measurement of colligative properties such as cryoscopy and ebulliometry does not give reliable  $M_n$  if the polymer has molecular weight above 40,000 g/mol.
11. What is second virial co-efficient ( $A_2$ )? How it depends on the solvent quality for a particular polymer? [2 marks]

12. Cationic copolymerization of styrene (St) and isobutylene (IB) produces a random copolymer. Structural analysis of the copolymer by  $^1\text{H}$  NMR spectroscopy gives 0.4 weight fractions of IB in the copolymer. Polystyrene has a  $T_g = 100^\circ\text{C}$ , and polyisobutylene has a  $T_g = -70^\circ\text{C}$ . Estimate the  $T_g$  of the statistical copolymer, poly(St-stat-IB). MW of styrene = 104.1 g/mol, and MW of IB = 56.1 g/mol.

[1.5 marks]

13. Write down name of three methods to determine % crystallinity for a semi-crystalline polymer?

Explain one method in detail.

[2 marks]

14. What kind of materials is generally used in the SEC columns?

[1 mark]

15. Calculate the solubility parameter of polyisobutene  $[-\text{CH}_2-\text{C}(\text{CH}_3)_2-]_n$  from the following Table.

Density of polyisobutene =  $0.917\text{ g/cm}^3$ . MW of IB = 56.1 g/mol.

Group	G-value $(\text{cal}\cdot\text{cm}^3)^{1/2}/\text{mol}$
$-\text{CH}_2-$	133
$>\text{C}<$	-93
$-\text{CH}_3$	214

The solubility parameters of solvent 1, 2, 3 and 4 are 3.5, 7.5, 10.5 and 14.5, respectively. Which solvent you will choose to dissolve polyisobutene?

[2 marks]

16. How plasticizers changes glass transition temperature of poly(vinyl chloride)?

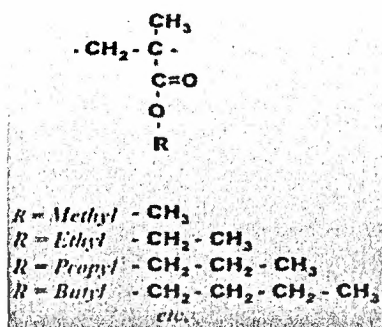
[1 mark]

17. Define Young's elasticity modulus (E). Write down two different types of unit for E. If you know the value of E for a polymer, how can you determine compliance (softness) value for that polymer?

[3 marks]

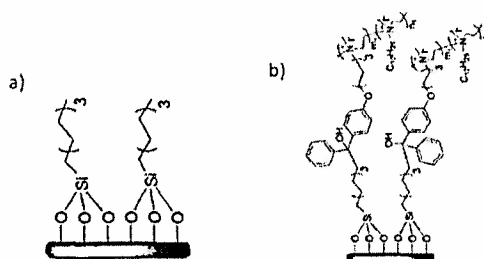
18. Based on free volume theory how  $T_g$  changes in the following structure if R = methyl, ethyl, propyl or butyl group?

[1 mark]

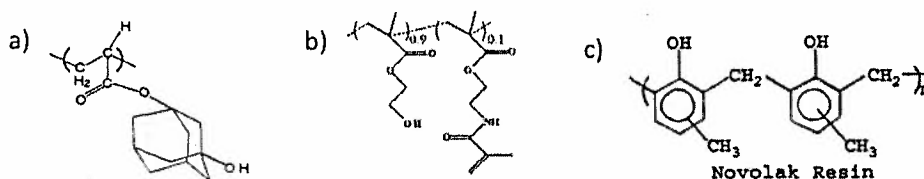


**PART B: Answer All Questions (15 marks)**

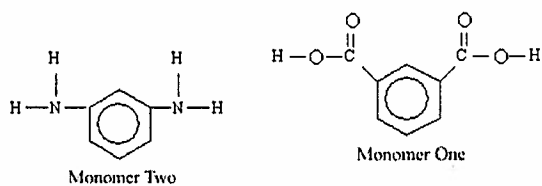
1. Using contact angle measurement, predict the  $\Theta$  value of a) and b). Justify your answer. How shall we distinguish cis-, trans- configuration on the surface? **(2 marks)**



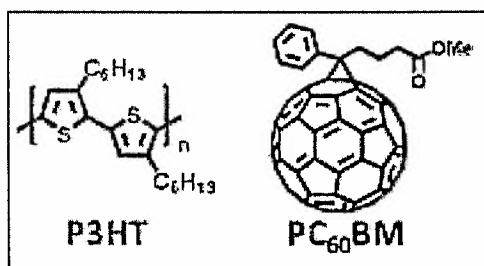
2. Explain the difference between positive and negative resist using examples. What is a developer for negative resist? Shall a same developer be used for both positive and negative resist? From a) to c), identify the write chemical structure as an example for negative and positive resist material. **(4 marks)**



3. Synthesis nylon-6 from benzene. Give IUPAC name of nylon-6. **(1.5 marks)**
4. Nylon is a highly polar molecule but not soluble in water. Why? **(0.5 marks)**
5. Mention 3 important differences between step growth vs chain growth polymer. **(1 marks)**
6. What is self-assembly? Draw one amphiphilic copolymer of your choice and explain it's self-assembly in aqueous environment. Provide instrument names to measure the size and shape of the nano-aggregates. **(2 marks)**
7. When these two monomers join, choose right answer below. What is the name of the polymer? **(1 marks)**



- a. a molecule of  $\text{CO}_2$  will be eliminated, and an ester linkage will form.
  - b. nothing will be eliminated, and the two monomers will be linked using a hydrogen-to-hydrogen bond.
  - c. a molecule of  $\text{H}_2\text{O}$  will be eliminated, and an amide (peptide) linkage will form.
  - d. nothing will be eliminated, and the two monomers will be linked using a carbon-to-carbon bond.
8. What are these molecules? Which field are they used for? [1 marks]



9. What are the limitations that determine the minimum sized feature that can be produced by photolithography? [1 marks]
10. P3HT is used as electron donor in polymer solar cell. Why? [1 marks]

