



THE OPEN UNIVERSITY OF SRI LANKA

B.Sc. Degree Program –Level 5

Final Examination -2011/2012

CMU 3233 / CHU 3238 / CHE 3238-Polymer Chemistry

Date: 03rd December 2012

9.30am-12.30pm

Instructions to candidates:

- This paper consists of two parts, Part I (MCQ) and part II (essay type).
- Part I consists of 25 MCQs, recommended time to complete this part is 1 hour.
- Part II consists of six essay type questions. You are expected to answer four questions including one compulsory question (Q1). Recommended time to complete this part is 2 hours.

For MCQs

- Answer all questions.
- Choose the most correct answer to each question and mark a cross "X" over the answer on the given answer sheet.
- Use a PEN (not a pencil) in answering.
- Any answer with more than one cross will not be counted.
- 1/6th marks will be deducted for each incorrect answer
- The use of a non – programmable electronic calculator is permitted.

PART I (35 marks)

01. Repeating unit of polyethylene is

1. $\text{CH}_2=\text{CH}_2$ 2. $-\text{CH}_2-\text{CH}_2-$ 3. $-\text{CH}_2-\text{CH}_2-\text{CH}_2-\text{CH}_2-$ 4. $(\text{CH}_2=\text{CH}_2)_n$
 5. $-\text{CH}_2=\text{CH}_2-\text{CH}_2-\text{CH}_2-$

02. What is the functionality of $\text{CH}_3-\text{CH}=\text{CH}_2$

1. 0 2. 1 3. 2 4. 3 5. 4

03. Examples of anionic initiators are

- a) KNH_2 b) BuLi c) BF_3 d) HCl

The correct statement/s is/are

1. a & b only 2. b & c only 3. c & d only 4. a, b & c only 5. All of above

04. What statement is not true about Ziegler-Natta catalyst?

1. It is mainly used to produce stereo-regular polymers.
 2. It is specially used in the polymerization of olefins.
 3. It consists of catalyst only.
 4. It consists of catalyst and co-catalyst only.
 5. It catalyzes coordination polymerization only.

05. Essential ingredient/s for emulsion polymerization is/are

1. monomers 2. emulsifying agents 3. water 4. water soluble initiators 5. All of above

06. Example/s for stereo-regular polymers is/are

- a) atactic polymers b) isotactic polymers c) syndiotactic polymers

The correct statement/s is/are

1. a only 2. b only 3. c only 4. a & b only 5. b & c only

07. Above flow temperature, the polymeric material is in

1. rubbery state 2. visco-elastic state 3. visco-fluid state 4. solid state 5. glassy state

08. Crystalline melting point (T_m) can be determined by

- a) thermal analysis b) X-Ray diffraction c) Infra-red spectroscopy d) NMR spectroscopy

The correct statement/s is/are

1. a & b only 2. b & c only 3. c & d only 4. a, b & c only 5. All of above

09. In a polymeric material, the ratio of crystalline to amorphous depends on

- a) rate of cooling b) chemical nature c) rate of mixing d) temperature of cooling

The correct statement/s is/are

1. a & b only 2. b & c only 3. c & d only 4. a, b & d only 5. All of above

10. In dilatometry method,

1. density change is measured at various temperature.
2. volume change is measured at various temperature.
3. temperature change is measured at various molar masses.
4. viscosity change is measured at various molar masses.
5. variation of pressure is measured at different temperatures.

11. What is true about a polydispersed polymer sample?

1. $\overline{M}_n > M_v > \overline{M}_w$
2. $\overline{M}_n = M_v = \overline{M}_w$
3. $M_v > \overline{M}_n > \overline{M}_w$
4. $\overline{M}_w > M_v > \overline{M}_n$
5. $M_v = \overline{M}_n > \overline{M}_w$

12. Light scattering method is used to determine

1. number average molar mass.
2. weight average molar mass.
3. viscosity average molar mass
4. intrinsic viscosity.
5. solubility of polymer.

13. The viscosity of a dilute polymer solution depends on

1. the nature of the polymer.
2. the nature of the solvent.
3. the rate of mixing.
4. the concentration of the polymer.
5. all of above.

14. Polyethylene molecule has the degree of polymerization of 1000 and the $-C-C-$ bond length of 1.26\AA . The full extended length of this polyethylene molecule is

1. 375 nm
2. 126 nm
3. 1260 nm
4. 3750 nm
5. 1620 nm

15. Polymer is soluble only if

- a) $\Delta G_m < 0$
- b) $\Delta H_m > T\Delta S_m$
- c) $\Delta G_m > 0$
- d) $\Delta H_m < T\Delta S_m$

The correct statement/s is/are

1. a only
2. a & b only
3. c & d only
4. a & d only
5. c only

16. Polymer degradation may occur by

1. heat.
2. radiation.
3. mechanical stress.
4. hydrolysis.
5. all of above.

17. What statement is true about thermoplastics?

1. Hard and brittle.
2. Long chain linear polymers.
3. Cannot be softened by heating.
4. Insoluble in any solvent.
5. Formed by step growth polymerization.

18. During mastication of polymer,

- a) molar mass increases.
- b) molar mass decreases.
- c) viscosity decreases
- d) molar mass remains unchanged.

The correct statement/s is/are

1. a only
2. b only
3. a & c only
4. b & c only
5. d only

19. What statement is not true about poly(vinyl chloride)?

1. It is formed by suspension polymerization of vinyl chloride monomers.
2. It is formed by emulsion polymerization of vinyl chloride monomers.
3. Majority of PVC is formed by bulk polymerization of vinyl chloride monomers.
4. It is slightly branched or linear polymers.
5. It is resistant to many chemicals.

20. What is true about plasticizers?

1. They are high molecular weight compounds.
2. They are volatile substances.
3. They are added to polymers to improve flexibility.
4. They increase the glass transition temperature.
5. They are mostly solids.

21. Polydispersity factor can be expressed as

1. $\frac{1}{(1-P)}$
2. $\frac{1}{(1+P)}$
3. $(1+P)$
4. $(1-P)$
5. $\frac{1}{(1+P)^2}$

22. With certain assumptions, the order of free radical polymerization with respect to monomer concentration is confirmed experimentally as

1. zero or first order
2. first order.
3. zero order
4. second order.
5. first or second order.

23. Kinetic chain length (ν) can be expressed as

1. $\nu = \text{rate of initiation.}$
2. $\nu = \text{rate of propagation.}$
3. $\nu = \text{rate of termination.}$
4. $\nu = \text{rate of initiation/ rate of propagation}$
5. $\nu = \text{rate of propagation/rate of initiation.}$

24. Rate equation for anionic polymerization of styrene is

$$1. \frac{-d[M]}{dt} = \frac{k_r[NH_3]}{k_p[I]M} \quad 2. \frac{-d[M]}{dt} = \frac{k_t[M]^2}{k_p[NH_3]} \quad 3. \frac{-d[M]}{dt} = \frac{k_t k_p [I][M]^2}{k_r[NH_3]}$$

$$4. \frac{-d[M]}{dt} = \frac{k_p[NH_3]}{k_t[I]} \quad 5. \frac{-d[M]}{dt} = \frac{k_r[I]^2[M]}{k_t[NH_3]}$$

25. In free radical polymerization, termination reaction can occur by

1. combination.
2. disproportionation.
3. transfer to solvents.
4. transfer to modifier
5. all of above.

PART II (65 marks)

01. (a) i. What are linear polymers? How do they differ from branched polymers?
- ii. What are the major differences between polymers and simple molecules?
- iii. How does chain polymerization differ from step growth polymerization? List few of them.
- (b) i. What is meant by glass transition temperature? What is the importance of it?
- ii. T_g value of polyacrylonitrile is higher than the corresponding value of polyethylene. Explain.
- iii. How do you distinguish monodispersed system from polydispersed system?
- (c) i. How does autocoagulation take place in natural rubber latex? How do you prevent autocoagulation?
- ii. How do you coagulate natural rubber latex when needed?
- (d) i. What do you mean by ceiling temperature? Explain.
- ii. What are the methods that can be used to determine the rate of polymerization.
02. (a) Write down initiation steps for free radical, cationic and anionic initiation for $\text{CH}_2=\text{CHCH}_3$.
- (b) i. "There are many ways of termination take place in free radical polymerization" What are they? Explain.
- ii. How do these termination steps in free radical polymerization differ from cationic polymerization?
- (c) i. What are copolymers? By giving examples, explain different types of copolymers.
- ii. What are the importance of copolymers?

03. (a) How do you distinguish homo polymers from hetero polymers? Give examples for each.
- (b) "Optical isomerism is possible not only in vinyl polymers" Justify your answers using examples.
- (c) Explain how plasticizers change the value of glass transition temperature.
- (d) i. What are the factors that affect the crystallinity and the melting point of polymers? Discuss.
- ii. Densities of amorphous rubber and 100% crystalline rubber are 850 kgm^{-3} and 950 kgm^{-3} respectively. If the density of crystalline rubber increases by 5% that of amorphous rubber, calculate the degree of crystallinity in crystalline rubber?
04. (a) A polyethylene sample consists of three fractions having molar ratios of 3:2:1. Molar masses of these fractions are 2×10^6 , 3×10^6 and 5×10^6 respectively. Calculate the followings.
- i. Number average molar mass, \overline{M}_n .
- ii. Weight average molar mass, \overline{M}_w .
- iii. The $[\overline{D}_r]_n$ value of polyethylene.
- (b) 1.0504g of polyamide sample was neutralized by 5.05 cm^3 of $0.1023 \text{ moldm}^{-3}$ of alcoholic potassium hydroxide solution. Calculate the number average molar mass of polyamide sample.
05. (a) i. What are the constituents of natural rubber latex?
- ii. How do you produce concentrated latex? Explain.
- iii. What is meant by yellow discoloration? What are the ways of removing it? Explain.
- (b) i. What do you mean by "compounding" in rubber industry?
- ii. What are the requirements of rubber to be vulcanized with sulphur?
- iii. What are the essential chemicals required for vulcanization of rubber with sulphur?
- (c) What is meant by photodegradation? How do you prevent this? Explain.

06. (a) Modified Carother's equation is given as follows.

$$\bar{X}_n = \frac{1+r}{1+r-2rp}$$

- i. Identify terms of above expression.
 - ii. When equal stoichiometric ratios of two monomers present, deduce the Carother's equation from above expression.
- (b) i. In the preparation of Nylon 6:6, hexamethylene diamine and adipic acid are used. If 3% more hexamethylene diamine is used, calculate the degree of polymerization. Assume that the percent conversion is 100%.
- ii. If equimolar ratios of above two monomers use, what will be the molar mass of Nylon 6:6. Assume that the percent conversion is 99%.
- (c) What would be the effect of impurities on the degree of polymerization of polycondensation reactions.