



THE OPEN UNIVERSITY OF SRI LANKA

Faculty of Natural Sciences

Department of Chemistry

B.Sc. Degree Program –Level 5

Final Examination -2012/2013

CMU3233/CME5233/CHU3238/CHE5238 – Polymer Chemistry

Date: 14.12.2013

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. What statement is true about polymers?

1. They are low molecular weight compounds.
2. They have a sharp melting point.
3. They have a saturation point.
4. They form a viscous solution.
5. They dissolve very quickly in a suitable solvent.

02. The functionality of HO-CH₂-CH₂-COOH is,

1. one 2. two 3. three 4. four 5. zero

03. What statement is true about chain polymerization?

1. Three basic steps are involved.
2. No by-products are formed.
3. Monomer concentration drops steadily throughout the reaction.
4. Repeating units are added one at a time.
5. All of above.

04. Living polymers are produced by

1. anionic polymerization. 2. cationic polymerization 3. free radical polymerization
4. anionic and cationic polymerizations. 5. cationic and free radical polymerizations.

05. What statement is true about suspension polymerization?

1. Only water insoluble monomers are added.
2. Surface active agents are added.
3. Product is obtained in the form of beads or pearl.
4. Percent conversion of monomer is 100%.
5. All of above.

06. Consider following compounds.

a) polyethylene

b) polybutadiene

c) poly(oxyethylene)

The variation of T_g can be represented as

1. $a = b = c$ 2. $a = b > c$ 3. $a < b = c$ 4. $a > b > c$ 5. $a < b < c$

07. The extend of reduction of T_g depends on,

1. polarity 2. density 3. solubility parameters 4. efficiency 5. all of above.

08. The relationship between the molar mass (M) and the T_g value of a polymer can be represented as

1. $T_g^a = T_g + \frac{k}{M}$ 2. $T_g = T_g^a - \frac{k}{M}$ 3. $T_g = T_g^a + \frac{k}{M}$ 4. $T_g = T_g^a - \frac{2k}{M}$
 5. $T_g = T_g^a + \frac{k}{2M}$

09. Physical properties change at T_g are

1. hardness 2. density 3. specific volume 4. heat capacity 5. all of above.

10. Consider following polymers.

a) Polystyrene

b. Polyethylene

c. Chlorinated natural rubber

d. Polypropyleneoxide

Which polymer/s is/are optically active?

1. a and b only 2. b only 3. b and c only 4. a, c and d only 5. all of above.

11. Polydispersity factors of three polymer samples, (a), (b) and (c) are 1.2, 2.3 and 3.4 respectively. Which statement is true?

1. Polymer (a) has the narrowest molar mass distribution curve.
 2. Polymer (b) has the narrowest molar mass distribution curve.
 3. Polymer (c) has the narrowest molar mass distribution curve.
 4. Both (b) and (c) have narrower distribution curves than (a).
 5. Both (a) and (c) have narrower distribution curves than (b).

12. Polymers take longer time for dissolution due to

- a. the size of the polymer. b. Coil entangled nature of the polymer. c. Weak attractive forces of polymer molecules

The correct statement/s is/are

1. a only 2. b only 3. c only 4. a and b only 5. all of above

13. Suppose that the flow times taken by a polymer solution and the solvent are 1200 and 200 s respectively. Specific viscosity of the polymer will be

1. 10 2. 5 3. 2 4. 20 5. 6

14. Which one is the most suitable technique to determine weight average molar mass of a given polymer?

1. Osmometry 2. Light scattering method 3. Viscometry
4. Vapor phase osmometry 5. Cryoscopy

15. End group analysis is a chemical method used to determine number average molar mass of a given polymer. Some of the drawbacks of this method are

- a. limited insolubility of the polymer. b. not suitable for polymers with low molar masses.
c. suitable only for linear molecules.

The correct statement/s is/are

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

16. Field latex can be stabilized by adding

1. Ethanol 2. Ammonia solution 3. Silicon tetrafluoride 4. Acetic acid solution
5. Calcium chloride solution

17. What statement is true about the thermal stability of following polymers?

1. Thermal stability of polymethyl styrene > polystyrene.
2. Thermal stability of polymethyl styrene > polyethylene
3. Thermal stability of polymethyl styrene and polystyrene are the same.
4. Thermal stability of polymethyl styrene < polystyrene.
5. Thermal stability of polymethyl styrene and polyethylene are the same.

18. Preservatives can be used in latex industry are

1. Sodium sulphite.
2. Ammonia solution.
3. Formaldehyde
4. Sodium carbonate.
5. All of above.

19. What statement is true about poly(vinyl acetate)?

1. It is prepared by bulk polymerization.
2. It is prepared by emulsion polymerization.
3. It is prepared by suspension polymerization.
4. Poly(vinyl alcohol) can be prepared by the hydrolysis of poly (vinyl acetate).
5. All of above.

20. What statement is **not** true about rubber latex?

1. It is slightly negatively charged.
2. It can be neutralized by adding Ca^{2+} or Mg^{2+} ions.
3. Strong bases are added to coagulate.
4. Yellow colour is due to carotenoid type pigments.
5. Iso-electric point is 4.5-5.0.

21. When the percentage conversion (p) approaches one for a stoichiometrically balanced system,

1. The degree of polymerization decreases.
2. The degree of polymerization doubles.
3. The degree of polymerization remains unchanged.
4. The degree of polymerization approaches infinity.
5. The degree of polymerization approaches zero.

22. If the conversion of an A-B type monomer to a polymer is 98%, the degree of polymerization will be

1. 20
2. 50
3. 5
4. 2
5. Data given is not sufficient.

23. In order to use Carother's equation, the stoichiometric ratio of monomers of types A-B and A-A + B-B must be

1. 10
2. 1
3. 2
4. 3
5. 5

24. In Gel permeation Chromatography, the separation of molecules depends on

1. Colour
2. Size
3. Polarity
4. Ionic strength
5. None of above.

25. Rate equation for the anionic polymerization of styrene is

$$1. \frac{d[M]}{dt} = \frac{k_f[NH_3]}{k_1 k_p [I][M]^3} \quad 2. \frac{d[M]}{dt} = \frac{k_f[NH_3]}{k_1 k_p [I][M]^2} \quad 3. \frac{d[M]}{dt} = \frac{k_i k_p [I][M]^2}{k_f [NH_3]}$$

$$4. \frac{d[M]}{dt} = \frac{k_f [NH_3]}{k_1 k_p [I][M]} \quad 5. \frac{d[M]}{dt} = \frac{k_i k_p [I][M]}{k_f [NH_3]}$$

PART II (65 marks)

01. (a) i. What are the main differences between free radical and cationic polymerization?

ii. What are the common features of step growth polymerization?

iii. "Even though suspension polymerization has few drawbacks; it is one of the most widely used polymerization technique in polymer industry" Discuss.

(30 marks)

(b) i. Explain how specific volume of an amorphous polymer changes with temperature.

ii. Consider the following atactic polymer of the general type $-(\text{CH}_2\text{-CHX})_n$. When X = CN in polyacrylonitrile the T_g value is 378K where as when X = 1 in polyethylene the corresponding T_g value is 188K. Explain the difference.

(25 marks)

(c) Suppose that the intrinsic viscosity $[\eta]$ of a polystyrene sample is 0.04dl/g and the values of α and K are 0.60 and 1.6×10^{-4} dl/g respectively, calculate the molecular mass of polystyrene.

(20 marks)

(d) What are the methods of increasing the concentration of field latex? Explain.

(10 marks)

(e) i. What is the importance of modified Carother's equation?

ii. Starting from modified Carother's equation, deduce Carother's equation.

(15 marks)

02. (a) i. What is meant by functionality of monomers?

ii. "All small molecules cannot act as monomers in polymer industry" Explain.

(20 marks)

(b) What is meant by photo initiated polymerization? Explain using $\text{CH}_2=\text{CHCH}_3$ monomer.

(20 marks)

(c) i. What are the different modes of additions in chain polymerization? Illustrate using $\text{CH}_2=\text{CHCH}_3$ as an example.

ii. From above mentioned modes, what are the most favored modes? Give reasons.

(30 marks)

(d) i. What are the constituents of Zeiglar-Natta catalyst?

ii. What is the importance of it?

(10 marks)

(e) i. How do you synthesize numerous numbers of polymers with different properties?

ii. Name three polymers which can be synthesized using styrene with different properties.

(20 marks)

03. (a) i. "Ice melts at 0°C where as natural rubber melts within the range of $36^{\circ}\text{C} - 4^{\circ}\text{C}$ ".

Discuss this statement.

ii. Describe the visco-elastic property of rubber.

(20 marks)

(b) i. What is meant by degree of crystallinity?

ii. Obtain the degree of crystallinity as a volume and weight fractions in terms of density.

iii. What is the accurate method that can be used to determine the degree of crystallinity.

(35 marks)

(c) i. What are plasticizers?

ii. Explain the difference between internal plasticization and external plasticization.

iii. What will happen when small quantity of plasticize is added to a polymer? Explain.

(25 marks)

(d) i. Describe the importance of the glass transition temperature.

ii. Explain how dilatometry method can be used to determine the glass transition temperature.

iii. What are the other methods used to determine glass transition temperature?

(20 marks)

04. (a) Vulcanized rubber is not dissolved in solvents but swelled. How does this happen?

(10 marks)

(b) i. Define specific viscosity in terms of viscosity of the polymer solution and the viscosity of the solvent.

ii. Derive an expression for relative viscosity in terms of specific viscosity.

(15marks)

(c) Following data was obtained from a viscometry experiment in order to calculate viscosity average molar mass of a solution of polyester in THF at 20°C.

Concentration of the solution (g/dL^{-1})	Flow time (s)
0.000	250
0.100	350
0.300	500

Suppose that the values of $\alpha = 0.50$ and $k = 1 \times 10^{-4}$. Calculate the viscosity average molar mass.

(75 marks)

05. (a) i. What is meant by vulcanization of rubber?

ii. What are the main types of vulcanization? Explain.

iii. How do you obtain vulcanized rubber with monosulphide cross linked net work structure?

iv. What are the importances of these monosulphide linkages in vulcanized rubber?

(50 marks)

(b) i. What are antioxidants? Explain.

ii. Give an example for a commercially used antioxidant?

(10 marks)

(c) i. What is meant by storage hardening?

ii. How do you prevent storage hardening? Discuss.

(15 marks)

(d) i. What do you mean by yellow discoloration?

ii. What methods can be used for yellow discoloration? Explain. (15 marks)

(e) "Polyethylene is more resistant to oxidation than polypropylene" Justify this statement.

(10 marks)

06. (a) i. What is meant by ceiling temperature?
ii. What types of reactions occur at the ceiling temperature (310°C) of polystyrene?
(10 marks)
- (b) i. What methods can be used to determine the rate of polymerization in free radical polymerization?
ii. What is the major difference between kinetics of free radical and cationic polymerization?
(40 marks)
- (c) i. Suppose that the concentration of initiator is 0.0009 mol/dm^3 , calculate the chain length of the polymer formed in free radical polymerization.
ii. If the concentration of 0.0009 mol/dm^3 transfer agent is added to the same concentration of monomer, calculate the chain length of polymer formed.
iii. What can you infer from above calculations?
(50 marks)