



THE OPEN UNIVERSITY OF SRI LANKA

Faculty of Natural Sciences

Department of Chemistry

B.Sc. Degree Program –Level 5

Final Examination -2013/2014

CMU3233/CHU3238 – Polymer Chemistry

Date: 29.11.2014

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. Which one is **not** an example of a monomer?

1. HOCH₂COOH 2. CH₃CH₂OH 3. NH₂CH₂COOH 4. C₆H₅OH
5. CH₃CH=CH₂

02. Isobutene undergoes

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

03. Which of the polymers cannot be recycled?

1. Polystyrene 2. Polypropylene 3. Polyester 4. Urea formaldehyde
5. polyethylene

04. Example for anionic initiator is

1. HCl 2. KNH₂ 3. BF₃ 4. AlCl₃ 5. TiCl₃

05. What statement is **not** true about bulk polymerization?

1. The monomer is in the liquid state and the initiator is dissolved in the monomer.
2. Chain transfer agent is added to control the molar mass.
3. Polymer can be used as it is.
4. Auto acceleration takes place.
5. Product contains lot of contaminants.

06. Example/s of homo polymer/s is/are

- (a) polyethylene. (b) polyadipate. (c) silicon polymer

The correct statement/s is/are

1. (a) only. 2. (b) only. 3. (c) only. 4. (a) and (b) only. 5. (b) and (c) only.

07. Above the flow temperature, T_f , the polymer material is in the

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

08. Glass transition temperature, T_g , can be measured using

1. differential thermal analysis. 2. differential scanning calorimetry.
3. Infra-red spectroscopy. 4. Dilatometry. 5. all of above.

09. What statement is **not** true about plasticizers?

1. They are low molecular weight compounds.
2. They are non-volatile substances.
3. They will reduce cohesive forces between polymer molecules.
4. It will enhance the T_g of the polymer.
5. It will improve the flexibility of the polymer.

10. Crystallinity of polymers can be affected by
1. inter-molecular forces.
 2. tacticity.
 3. symmetry of the molecule.
 4. chain flexibility.
 5. all of above.

11. Osmometry method is used to determine
1. weight average molar mass.
 2. number average molar mass.
 3. intrinsic viscosity.
 4. relative viscosity.
 5. specific viscosity.

12. Swelling of polymers is not affected by
- (a) forces of interactions between solvent and polymer molecules.
 - (b) stirring
 - (c) temperature

The correct statement/s is/are

1. (a) only.
2. (b) only.
3. (c) only.
4. (a) and (b) only.
5. (b) and (c) only.

13. Polymer is soluble if,

1. $\Delta H_m < (T\Delta S_m)$
2. $\Delta G_m > 0$
3. $\Delta H_m > (T\Delta S_m)$
4. $T\Delta S_m = 0$
5. $\Delta H_m = (T\Delta S_m)$

14. Intrinsic viscosity is experimentally determined by

1. Light scattering method.
2. Viscometry.
3. Osmometry.
4. End group analysis.
5. Ultra centrifuge technique.

15. Inter relationship among specific viscosity, η_{sp} viscosity of the polymer solution, η and the viscosity of the solvent, η_0 is

1. $\eta_{sp} = \frac{\eta_0}{\eta}$
2. $\eta_{sp} = \frac{\eta_0 - \eta}{\eta_0}$
3. $\eta_{sp} = \frac{\eta - \eta_0}{\eta_0}$
4. $\eta_{sp} = \frac{\eta}{\eta_0}$
5. $\eta_{sp} = \frac{\eta_0 + \eta}{\eta_0}$

16. Which statement is not true about oxidative degradation?

1. It may occur by atmospheric oxygen or ozone.
2. It results in hardening of the polymer.
3. It will not affect any surface changes of the polymer.
4. It involves three basic steps.
5. It proceeds via a chain mechanism.

17. Consider following statements regarding cure reactions. Which statement is true?

1. Linear polymers containing reactive groups as pendent groups or double bonds undergo these reactions.
2. These reactions help to produce thermo sets.
3. These reactions produce bridged three dimensional stable network.
4. Phenol formaldehyde resin undergoes these reactions.
5. All of above.

18. What parameter is used to grade ribbed smoked sheets.

1. Texture.
2. Colour.
3. Density.
4. Thickness.
5. Elasticity.

19. What statement is **not** true about PVC?

1. It is manufactured by suspension polymerization.
2. It is manufactured by emulsion polymerization.
3. It is not resistant to many chemicals such as acids.
4. It is a hard material.
5. It is a slightly branched linear polymer.

20. Consider following statements regarding thermo sets. Which statement is **not** true?

1. They are formed by step growth polymerization.
2. They are hard and brittle.
3. They have cross linked three dimensional network structure.
4. They cannot be reclaimed.
5. They are soluble in some organic solvents.

21. In polymerization of styrene in liquid NH_3 initiated by KNH_2 , the degree of polymerization is given by

- 1) $(k_p k_{fr}) \frac{[M]}{[NH_3]}$
- 2) $(k_p k_{fr}) \frac{[NH_3]}{[M]}$
- 3) $(k_p) \frac{[M]}{[NH_3]}$
- 4) $\frac{k_p [M]}{k_{fr} [NH_3]}$
- 5) $\frac{k_p [NH_3]}{k_{fr} [M]}$

22. Kinetic chain length (ν) is define as

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

23. What statement is **true** about free radical polymerization?

1. The rate of reaction increases with increase of temperature.
2. The rate of reaction decreases with increase of temperature.
3. The rate of reaction doesn't change with the temperature.
4. The chain length increase with increase of temperature.
5. The chain length doesn't change with the temperature.

24. Consider following statements regarding ceiling temperature? Select the correct statement.

1. The rate of propagation is equal to the rate of depropagation.
2. Polymerization is possible only below this temperature.
3. No polymerization occurs at this temperature.
4. The monomer and the polymer exist in equilibrium.
5. All of above.

25. Rate equation for cationic polymerization of vinyl monomers is equal to

1. $\frac{k_p k_i}{k_t} [M]^2 [H^+]$

2. $\frac{k_p}{k_t} [M] [H^+]^2$

3. $\frac{k_t k_i}{k_p} [M]$

4. $\frac{k_i}{k_t} [M] [H^+]$

5. $k_i k_t [M] [H^+]^2$

PART II (65 marks)

01. (a) i. Write chemical equations for initiation and the propagation steps for the cationic polymerization of $\text{CH}_2=\text{CH}_2$ using I_2 as the initiator.
 ii. Termination step in the cationic polymerization is not possible by combination. Why is this so? If that is so, what are the possible ways of termination?
- (b) i. What is meant by glass transition temperature?
 ii. Discuss the importance of glass transition temperature in polymer industry.
 iii. Explain how the physical properties can be changed at glass transition temperature.
- (c) i. How do you differentiate a monodispersed system from a polydispersed system?
 ii. "Nitrile rubber is used as rubber oil seals". Discuss.
- (d) i. What is meant by compounding in polymer industry?
 ii. What are the ingredients used in rubber formulation? List five of them.
 iii. What is the structural difference between thermo sets and thermoplastics?
- (e) i. What is the importance of modified Carother's equation?
 ii. Starting from the modified Carother's equation, deduce the Carother's equation.

(20 marks)

02. (a) i. Explain the different between co-polymers and homo polymers.
 ii. By giving examples describe different types of copolymers?
 iii. What are the common polymerization methods that can be used to synthesize copolymers?
 iv. Copolymers are important in many ways. What are they?
- (b) i. What are the main features of step growth polymerization?
 ii. How do you synthesize nylon 6:6? What polymerization method can be used?
 iii. List two common uses of nylon 6:6.
- (c) i. What are the essential ingredients needed for emulsion polymerization? Briefly explain the mechanism of emulsion polymerization.
 ii. Give two examples that can be produced by this polymerization technique.
 iii. What are the advantages and disadvantages of this polymerization technique?
- (d) i. Name four polymer based industries in Sri Lanka.
 ii. If the molar mass of polypropylene is 4200 g/mol, calculate the degree of polymerization and length of polypropylene. The bond distance of C-C is 1.54 Å.

(15 marks)

03. (a) i. What is meant by isotactic, syndiotactic and atactic polymers?
ii. Among above mentioned polymers, which polymers are stereo regular polymers? Give reasons.
- (b) i. How do amorphous polymers differ from crystalline polymers? Explain.
ii. The T_g values of polypropylene and poly (vinyl alcohol) are 253K and 358K respectively. Explain.
iii. Describe how the states of a polymeric material changes with temperature.
- (c) i. How does the polymer crystallization take place? Discuss.
ii. List five properties that can be changed at crystallization of polymers.
iii. How does temperature affect the crystallization process of polymers? Explain.
- (d) i. What is meant by degree of crystallinity in terms of volume?
ii. By giving reasons explain how high density polyethylene possesses higher percentage of crystallinity compared to low density polyethylene.

(15 marks)

04. (a) i. Number average molar mass, \bar{M}_n of polyethylene sample is 2×10^5 g/mol. Calculate the number average degree of polymerization, $[\bar{D}_p]_n$ of above sample.
ii. Assuming that the polydispersity factor is 1.5, calculate the weight average molar mass of above polyethylene sample.
iii. If the polydispersity factor of polypropylene sample is 3.6, by comparing with above polyethylene sample, which one has the narrow molar mass distribution curve? Give reasons.
- (b) How does Gel Permeation Chromatography separation technique use to obtain a monodispersed polymer sample?
- (c) i. What is the advantage of using end group analysis?
ii. 0.5321 g of nylon 6,6 sample was neutralized by 8.10 cm^3 of 0.15 mol dm^{-3} of alcoholic KOH solution. Calculate the number average molar mass of nylon 6,6 sample. Show your calculations clearly.
iii. What are the disadvantages of this end group analysis? List three of them.

(15 marks)

05. (a) i. What is meant by the term auto coagulation in rubber latex industry? How does this happen?
ii. The chemicals used as preservatives for natural rubber latex should have some properties. What are they? List four of them.
iii. What are the common preservatives used in rubber latex industry? Explain their role.
- (b) i. What are plasticizers? Explain their role.
ii. Efficiency of plasticizers depends on certain factors. What are they? List three of them and explain.

- (c) i. What is meant by photo degradation?
ii. How do you prevent photo degradation?

- (d) Write brief notes on
- i. Fillers
 - ii. Thermoplastics
 - iii. Activators used in sulphur vulcanization.

(15 marks)

06. (a) Write down the modified Carother's equation and define terms.

- (b) In a diacid-dialcohol polymerization reaction, the percentage conversion is 99.98%.
- i. If the molar ratio is 1:1, calculate the degree of polymerization.
 - ii. Assuming that 8% more diacid is used, calculate the degree of polymerization of above polymerization reaction.
 - iii. What can you infer from above calculations? Discuss.

- (c) i. Write down the relationship between the polydispersity factor and the percentage conversion.
- ii. Percentage conversion of the polycondensation of adipic acid with hexamethylene diamine is 98.99%. Assuming that the weight average molar mass is 2×10^3 g/mol, calculate the number average molar mass of this polycondensation reaction.

(15 marks)

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