THE OPEN UNIVERSITY OF SRI LANKA

B.Sc. Degree Program –Level 5

Final Examination -2017/2018

CYU5633/CMU3233 - Polymer Chemistry

Date: 24.04.2019	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 among six. 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.
- $1/6^{th}$ marks will be deducted for each incorrect answer
- The use of a non – programmable electronic calculator is permitted.

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PART I (35 marks)

01. What is the correct definition about the degree of polymerization?
1) It is the molar mass of the monomer.
2) It is the number of polymer molecules.
3) It is the molar mass of the repeating unit.
4) It is the number of repeating units in a polymer.
5) It is the molar mass of the polymer.

02. Which of the following polymer **cannot** be recycled?
1) Urea formaldehyde.   2) Polystyrene.   3) Polyester   4) Polypropylene
5) Polyethylene.

03. Living polymers can be produced by
1) cationic polymerization.   2) anionic polymerization.   3) free radical polymerization.
4) poly addition polymerization.   5) poly condensation reaction.

04. What statement is **not true** about step growth polymerization?
1) Three basic steps (initiation, propagation and termination) are involved in this polymerization.
2) Any two molecular species can react.   3) Monomer disappears early in the reaction.
4) By products can be water, HCl etc.   5) Polymer molar mass retain throughout the reaction.

05. Atactic polymers can be represented as
1) $\sim\sim$ d d d d d d d $\sim\sim$ 2) $\sim\sim$ l l l l l l l l $\sim\sim$ 3) $\sim\sim$ d l d l d l d l $\sim\sim$
4) $\sim\sim$ l d l d l d l d $\sim\sim$ 5) $\sim\sim$ d d d d d l l l d $\sim\sim$

06. What is **not true** about amorphous polymers?
1) It can be thought simply as frozen polymer liquid.
2) It is a solid or powder having structure characteristics of a liquid state.
3) Distribution of polymer chains is random.
4) It has a regular arrangement.
5) T_g can be observed in these polymers.

07. What is the **incorrect** statement?
1) High T_g value can be observed in high molar mass polymers.
2) The value of T_g can be raised by inserting bulky group.
3) Plasticizers can be used to enhance the T_g value of a polymer.
4) Presence of hydrogen bonding affects the value of T_g.
5) T_g value of polypropylene is less than that of polyvinylchloride.

08. Which molecule has the highest T_g?
1) Poly propylene   2) Poly(vinyl acetate)   3) Polystyrene
4) Poly (vinyl chloride)   5) Poly(vinyl biphenyl)

09. What thermodynamic parameters should polymer satisfy in order to dissolve it in a suitable solvent?

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) b only 3) c & d 4) a & d 5) c only.

10. 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).

11. What is the relationship among specific viscosity ((η_{sp}), viscosity of the polymer solution (η) and the viscosity of the solvent (η_0)?

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

12. Swelling process of polymers can be enhanced by
a) forces of interactions between solvent and polymer molecules. b) stirring
c) temperature d) increasing surface area of the polymer

The correct statement/s is/are,
1) a only. 2) a and c only. 3) c and d only. 4) a and d only. 5) a, b and d only.

13. What statement is **not true** about polystyrene?
1) It is industrially produced by free radical polymerization.
2) It is industrially produced by suspension polymerization.
3) It is industrially produced by bulk polymerization.
4) It is soluble in aromatic hydrocarbons. 5) It has a high softening point.

14. Consider following statements regarding thermoplastics. Which statement is true?
1) They are formed by step growth polymerization. 2) They cannot be reused.
3) They have cross linked three dimensional network structure. 4) They cannot be reclaimed.
5) They are soluble in some organic solvents.

15. What statement is **not** true about rubber latex?
1) Iso-electric point is 4.5-5.0. 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) It is slightly negatively charged.

16. Consider following statements regarding plasticizers. Which one is **true**?
1) They are mostly solids.   2. They are volatile substances.
3) They are high molecular weight compounds.
4) They are added to polymers to improve flexibility.
5) They increase the glass transition temperature.

17. During sulphur vulcanization, high concentration of accelerator and activator relative to sulphur will favour
1) rubber with low thermal stability.   2) low degree of cross linking.
3) products stable to oxidation.   4) products with poor physical properties.
5) cyclic sulphides and olefinic groups.

18. Field latex can be stabilized by
1) ammonia solution.   2) silicon tetrafluoride.   3) ethanol.
4) calcium chloride.   5) acetic acid solution.

19. Which one of the following is not an assumption made in deriving the rate equation of free radical polymerization?
1) Consumption of monomer in the initiation step is negligible compared to the consumption of monomer in the propagation step.
2) Initiator and monomer concentrations are equal.
3) Rates of reaction of polymer radicals in propagation steps are independent of their chain lengths.
4) Rate of production of radicals in the initiation step is balanced by the rate of termination.
5) Consumption of initiator remains constant since initiator is used as a catalyst and small amount is needed for initiation.

20. What is **true** about free radical polymerization?
1) Degree of polymerization is dependent of monomer concentration.
2) Degree of polymerization is independent of the temperature at which reaction is carried out.
3) Rate equation is zero order with respect to monomer concentration.
4) Rate equation is first order with respect to monomer concentration.
5) Rate equation is second order with respect to monomer concentration.

21. Rate of polymerization can be determined by
a) discoloration of bromine.   b) molar refractivity.   c) dilatometry method.
d) density method.

The correct statement/s is/are,
1) a only.   2) b and c only.   3) c and d only.   4) a, c and d only.   5) a, b and d only.

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22. The rate equation for cationic polymerization is

1) $\dfrac{k_p k_i}{k_t}[M]^2[H^+]$

2) $\dfrac{k_i k_p}{k_t}[M]^2[H^+]$

3) $\dfrac{k_i k_i}{k_t}[M][H^+]$

4) $\dfrac{k_p k_i}{k_t}[M]^{1/2}[H^+]$

5) $\dfrac{k_p k_i}{k_t}[M][H^+]$

23. Beilstein test can be used to identify
1) PE   2) PP   3) HDPE   4) LDPE   5) PVC

24. What statement is **true** about Raman spectroscopy?
1) Raman spectra are indicative of asymmetric bond stretching and bending.
2) It is a very popular method than IR spectroscopy in polymer characterization.
3) It can be used to determine the crystallinity of polymers.
4) It can be used to determine the composition of copolymers.
5) It can be used to identify tacticity of PP.

25. Melt flow index (MFI) of a given polymer is affected by
a) Viscosity.   b) The degree of chain branching.   c) Crystallinity.
d) Molecular weight distribution.

The correct statement/s is/are,
1) a only.   2) b and c only.   3) c and d only.   4) a, c and d only.   5) all of above.

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PART II (65 marks)

01. a) i. What do you mean by the functionality of a monomer?
    ii. By giving examples, explain the differences among mono-functional molecules, bi-functional and tri-functional monomers.   (20 marks)
  b) i. What are stereo regular polymers? Explain.
    ii. Briefly describe the types of stereo regular polymers?
    iii. What is the basis of classifying stereo regular polymers?
    iv. What type of catalysts can be used to produce stereo regular polymer?   (20 marks)
  c) i. What is meant by cationic polymerization? Explain.
    ii. What are the two types of initiators used in cationic polymerization?
    iii. Name two monomers that can be polymerized by cationic initiators but not by anionic or free radical initiators.   (20 marks)
  d) i What are the common features of step growth polymerization? List five of them.
    ii. What are the three main step growth polymerization processes? Explain how they differ in each other.   (20 marks)
  e) i. What is meant by auto acceleration?
    ii. How does solution polymerization differ from emulsion polymerization? Explain.
    iii. Name one industrial application of emulsion and solution polymerizations. (20 marks)

02. a) i. What is the difference between homo polymers and hetero polymers? Explain using examples.
    ii. "Two polymers have same chemical nature but may have different properties" Justify this statement by giving appropriate examples.
    iii. What is/are the possible mode of addition/s in free radical polymerization of styrene? Explain reasons.
                                  (30 marks)
  b) i. Briefly 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?
    iv. The T_g values of polyethylene is 188K while corresponding value for polystyrene is 373K. Explain the difference.
    v. Describe how the states of a polymeric material changes with temperature
                                  (40 marks)
  c) i. What are the differences between amorphous and crystalline polymers? List 3 of them.
    ii. What are the factors that affect the melting point of polymers? Explain 3 of them.
    iii. Explain the reason for having higher melting point in trans polyisoprene than that of cis polyisoprene.
    iv. What are the physical properties that can be changed at the melting point of a polymer? List 4 of them.
                                  (30 marks)

03. a) A polystyrene sample consists of three fractions with molar ratios of 1:2:1. Molar masses of these fractions are 1.2×10^5, 1×10^5 and 4×10^5 respectively.

   i. Calculate the number average molar mass, $\overline{M}_n$, weight average molar mass, $\overline{M}_w$, and the number average degree of polymerization, $\left[\overline{D}_p\right]_n$ of polystyrene.

   ii. Calculate the polydispersity factor of this polystyrene sample.

(70 marks)

   b) End group analysis is the common method of determining number average of a polymer sample. 0.8154g of polyester sample was neutralized by 5.05 cm^3 of 0.1 M alcoholic potassium hydroxide solution. Calculate the number average molar mass of polyester sample.

(30 marks)

04. a) i. What is meant by photodegradation? How does it happen? Explain briefly.

   ii. How do you prevent photodegradation?

(15 marks)

   b) i. What are the constituents of natural rubber latex?

   ii. How does auto coagulation takes place in field latex? Explain.

   iii. How do you preserve rubber latex? Briefly explain common preservatives.

   iv. How do you produce concentrated latex? Explain.

   v. What is meant by yellow discoloration? Describe different ways of doing it?

(50 marks)

   c) i. What is the most common vulcanization method used in rubber industry?

   ii. What are the essential ingredients necessary for that vulcanization process?

(10 marks)

   d) Write brief accounts on

   i. Plastisol   ii. Ribbed smoked sheets   iii. Fillers

(25 marks)

05. a) i. Write down the assumptions used in the derivation of rate equation in free radical polymerization and briefly outline reasons.

   ii. "Molar mass of polymers formed by free radical polymerization have higher average molar mass than those formed by anionic polymerization". Justify this statement.

(40 marks)

   b) What is meant by auto acceleration? Give kinetic interpretation.   (20 marks)

   c) i. Write down Carother's equation and define terms.
      The polyester, poly(ethylene terephthalate) (PET), is produced through the condensation polymerization of a **dialcohol** with a **diacid**. In this polymerization reaction, the percentage conversion is 98.98%.

   ii. If the molar ratio is 1:1, calculate the degree of polymerization.

   iii. Assuming that 3% more diacid is used, calculate the degree of polymerization of above polymerization reaction.

   iv. What can you infer from above calculations? Discuss.

(40 marks)

06. a) i. What is the basis of electron diffraction?
   ii. Write down three advantages of electron diffraction over X-Ray diffraction.
   iii. Write down a disadvantage of electron diffraction.

(20 marks)

b) A creep test was carried out with an applied stress of 3MPa on a polymer specimen. The maximum strain observed was 0.01. After a period of one hour, the stain was measured as 0.006. Assuming Voight-Kelvin behavior for the material, calculate the elastic modulus, retardation time and the viscosity of the material. (40 marks)

c) i. What is meant by Melt flow index (MFI)?
   ii. What factors affect a polymer's MFI? Explain. (20 marks)

d) i. What do you understand by Differential Scanning Calorimetry?
   ii. What information can you gather from this technique? Briefly explain. (20 marks)