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THE OPEN UNIVERSITY OF SRI LANKA

B.Sc. Degree Program –Level 5

Final Examination -2016/2017

CMU 3233 Polymer Chemistry

Date: 17.01.2018 **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.

PART I (35 marks)

01. Select the **incorrect** statement.
1) Polymers do not have saturated points.
2) Polymers take longer time for dissolution.
3) Olefins and acetylenes can act as monomers.
4) Phenol has only two reactive sites.
5) Monomers contain two or more functional groups.

02. In cationic polymerization, termination takes place by
a) combination b) disproportionation c) rearrangement d) transfer reactions

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

03. What statement is **not true** about Ziegiar-Natta catalyst?
1) It consists of catalyst only.
2) It consists of catalyst and co-catalyst only.
3) It is mainly used to produce stereo-regular polymers.
4) It is specially used in the polymerization of olefins.
5) It catalyzes only coordination polymerization.

04. What statement is **not true** about suspension polymerization?
1) This is an economical process.
2) Initiators are water soluble.
3) Only water insoluble polymers can be polymerized.
4) Surface active agents need to be used.
5) Auto-acceleration takes place.

05. Living polymers can be produced by
1) cationic polymerization 2) anionic polymerization. 3) free radical polymerization
4) anionic and cationic polymerizations. 5) cationic and free radical polymerizations.

06. Example/s for stereo-regular polymers is/are
a) isotactic polymers b) atactic polymers c) syndiotactic polymers

The correct response/s is/are
1) (a) only 2) (b) only 3) (c) only 4) (a) & (b) only 5) (a) & (c) only

07. Crystalline melting point (T_m) can be measured using
1) thermal analysis. 2) Infra-red spectroscopy. 3) X-Ray diffraction. 4) NMR spectroscopy 5) all of above.

08. Amorphous nature of polymers can be affected by
a) molar mass or size of the polymer. b) cross linking and branching. c) chain flexibility
d) plasticisation.

The correct response/s is/are
1) (a), (b) and (c) only 2) (b) and (c) only 3) (c) only 4) (c) and (d) only 5) All of above

09. Select the **correct** statement regarding T_g values of the following compounds?
1) Polyacrylonitrile = polyvinylchloride = polypropylene.
2) Polyacrylonitrile > polyvinylchloride > polypropylene.
3) Polyacrylonitrile < polyvinylchloride < polypropylene.
4) Polyacrylonitrile = polyvinylchloride > polypropylene.
5) Polyacrylonitrile < polyvinylchloride = polypropylene.

10. Which statement is **not true** about cis polyisoprene?
1) Natural rubber is a good example. 2) It is not a crystalline polymer.
3) It has a coiled structure. 4) It has a rod like structure 5) It has lower T_g and T_m values compare to the trans isomer.

11. The relationship between polydispersity factor and the percentage conversion is,

1) $\frac{\bar{M}_n}{\bar{M}_w} = (p-1)$ 2) $\frac{\bar{M}_W}{\bar{M}_n} = (1+p)$ 3) $\frac{\bar{M}_n}{\bar{M}_w} = p$ 4) $\frac{\bar{M}_n}{\bar{M}_w} = (1-p)$ 5) $\frac{\bar{M}_W}{\bar{M}_n} = 2p$

12. Number average molar mass of a given polymer can be determined by
a) Cryoscopy. b) Light scattering method. c) Viscometry. d) Osmometry

The correct response/s/s is/are
1) (a), (b) and (c) only 2) (b) and (c) only 3) (c) only 4) (a) and (d) only 5) All of above

13. The viscosity of a dilute polymer solution depends on following factors.
a) nature of the solvent. b) polymer molecular mass c) concentration of the polymer.
d) rate of mixing.

The correct response/s/s is/are
1) (a), (b) and (c) only 2) (b) and (c) only 3) (c) only 4) (a) and (d) only 5) All of above

14. Which molecule has the highest Tg?
1) Poly(vinyl biphenyl) 2) Polyethylene 3) Poly(vinyl)acetate 4)Poly(vinyl)acrylate
5) Polystyrene

15. What statement is **true** about nitrile rubber?
1) It belongs to non-vulcanized rubber. 2) It is a polymer that cannot be cross linked.
3) It is used as oil seals. 4) Swelling can be observed in the presence of any solvent.
5) It dissolves in any organic solvent.

16. What statement is **not true** about cure reactions?
1) These reactions are irreversible. 2) They help to produce thermoplastics.
3) Linear polymers containing reactive groups as pendent groups or double bonds undergo these reactions. 4) They produce bridged three dimensional stable networks.
5. Phenol formaldehyde resin undergoes these reactions.

17. What statement is **not true** about monosulphide linkages?
1. High concentration of accelerators and activators relative to sulphur will favour these linkages.
2. It has high degree of cross linking. 3. They are resistant to ageing.
4. They undergo decomposition during service. 5. They are thermally stable

18. What statement is **not true** about thermosets?
1. They are formed by step growth polymerization.
2. They are cross linked polymers. 3. They are hard and brittle.
4. They can be soften by heating. 5. They are insoluble in any solvent.

19. Common preservatives used in latex industry are
a) sodium bisulphite. b) ammonia solution. c) formaldehyde. d) hydrochloric acid.

The correct response/s is/are,
1) (a) only. 2) (b) and (c) only. 3) (c) and (d) only. 4) (a), (b) and (c) only.
5) None of above.

20. Ribbed smoke sheets are classified as RSS1, RSS2...etc according to its
1) thickness. 2) texture. 3) colour. 4) density. 5) elasticity.

21. The degree of polymerization in polymerization of styrene in liquid NH_3 initiated by KNH_2 is

1. $k_p k_{fr} \frac{[M]}{NH_3}$ 2. $\frac{k_p[M]}{k_{fr}[NH_3]}$ 3. $\frac{k_p[NH_3]^2}{k_{fr}[H]}$ 4. $\frac{k_p[NH_3]^3}{k_{fr}[H]}$

5. $k_p k_{fr} \frac{[M]^2}{NH_3}$

22. In free radical polymerization, when the temperature increases
1) the degree of polymerization increases. 2) the rate of polymerization decreases.
3) the degree of polymerization doesn't change.
4) the rate the rate of polymerization doesn't change
5) the rate of polymerization increases whereas the degree of polymerization decreases.

23. At celing temperature
1) $k_p[M] = k_{dp}$ 2) $k_{ap}[M]^2 = k_p$ 3) $k_p[M][I] = k_{dp}$ 4) $k_{dp}[M]^2[I] = k_p$ 5) $k_p = k_{dp}$

24. The nature of deformation of a given polymer depends on
a) temperature b) previous loading history c) rate of loading d) mass

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

25. Thermogravimetric Analysis (TGA) is a very useful technique to determine following characteristics of a polymer.
a) Thermal stability b) Estimated lifetime c) Decomposition kinetics d) Density

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

PART II (65 marks)

01. a) How does a simple compound differ from a polymer? Explain. (10 marks)

b) i. What are the basic steps involve in free radical polymerization?

ii. Write down the initiation and propagation steps of free radical polymerization of CH_2=$CHCH_2CH_3$ with I_2 initiator.

iii. What are the main differences between free radical polymerization and cationic polymerization? Discuss. (40 marks)

c) i. State main features of step growth polymerization.

ii. What are the common features of polycondensation reactions? Explain.

iii. Draw the structure of nylon 6,6 after polycondensation of adipic acid with hexamethylene diamine. (30 marks)

iv. What is the reason for having high melting point of nylon 6,6.

d) i. What are copolymers? Explain.

ii. Briefly discuss the importance of copolymerization. (10 marks)

e) i. Describe the chemical process involve in suspension polymerization.

ii. How does it differ from emulsion polymerization? Discuss. (10 marks)

02. a) i. What is meant by geometrical isomerism in polymers? Illustrate using examples.

ii. Synthetic rubber and natural rubber have different properties. Give reasons. (20 marks)

b) i. Explain the structure of amorphous polymers.

ii. What is meant by glass transition temperature? What is the importance of it?

iii. Glass transition temperature of poly(methyl acrylate) is 279K whereas the corresponding value for poly(butyl acrylate) is 218K. Explain. (30 marks)

c) i. Define the degree of crystallinity in terms of density.

ii. Densities of amorphous rubber and 100% crystalline rubber are 950 kg/m^3 and 1200 kg/m^3 respectively. If the density of crystalline rubber increases 6% that of amorphous rubber, calculate the degree of crystallinity in crystalline rubber.

iii. "Though simple compounds have fixed melting points, polymers do not have fixed melting points". Justify the statement.

iv. Melting point of nylon 6.6 is 540K while corresponding value of polyethylene is 410K. Explain the difference.

v. Crystalline polymers are less soluble than amorphous polymers. Discuss. (50 marks)

03. a) Following results were obtained using three methods, light scattering, osmometry and viscometry to measure Average relative molecular masses of two polymer samples, A and B.

	Sample A	Sample B
Method 1	188,000	94,000
Method 2	179,000	75,000
Method 3	121,000	36,000

i. By giving reasons, identify each method 1, 2 and 3.
ii. Between two samples, which one is more polydispersed? Why? (30 marks)

b) i. Polymer dissolution is a very slow process. Give reasons.
ii. What is the importance of polymer solubility in industry? Explain. (20 marks)

c) i. What is meant by mono-dispersed system?
ii. Explain how gel permeation chromatography separation technique can be used to obtain mono-dispersed polymer sample. (20 marks)

d) i. Write down Mark-Houwink equation and define terms.
ii. If $\alpha = 0.60$, $K = 1.6\times10^{-4}$ dl/g and $[\eta] = 0.04$ dl/g, calculate the molecular mass of a given polymer sample. (30 marks)

04. a) i. What is meant by cure reactions in polymer industry?
ii. What are pre polymers or resin or half cured polymers?
iii. List down three commercially important cure reactions. (15 marks)

b) i. Polymer degradation occurs in many ways. What are they? Briefly explain.
ii. During service, physical properties of polymers are changed. What are they? (15 marks)

c) i. What is meant by storage hardening of natural rubber? How do you prevent it? Explain.
ii. Ribbed smoked sheets are less resistant to oxidation than pale crepe. Why is that so?
iii. What do you mean by oil resistant rubber? Using an example, explain its role?
iv. Natural rubber cannot be used as oil seals. Explain the reason. (40 marks)

d) How do you produce concentrated latex? Describe briefly. (10 marks)

e) Write brief accounts on
i. Compounding of plastics. ii. Plasticizers iii. Curing agents iv. Antidegredants. (20 marks)

05. a) i. Write down Carother's equation for a 1:1 bi functional reaction mixture. Define terms.

ii. Write down modified Carother's equation and define terms for systems with stoichiometric imbalance..

iii. When molar ratios are equal, deduce Carother's equation from modified Carother's equation.

iv. When mono functional impurities are present in 1:1 bi functional reaction mixture, what could be the effect on degree of polymerization? Discuss.

v. Hexamethylene diammine and adipic acid are used to produce Nylon 6:6. If 3% more hexamethylene diammine is used, calculate the degree of polymerization. Assume that the percent conversion is 100%.

vi. If equimolar ratios of above two monomers use, what will be the molar mass of Nylon 6;6. Assume that the percent conversion is 100%.

(60 marks)

b) What do you understand the term kinetic chain length? Write down the expression.

(10 marks)

c) "Average molar mass of polymer formed in anionic polymerization is smaller than those formed in free radical polymerization". Discuss. (30 marks)

06. a) i. Write down the fox equation to predict the T_g of a random copolymer by using mass fractions of components, A and B and define terms.

ii. When 100g of PVC is mixed with 25g of a plasticizer, the Tg of the PVC is lowered from 87°C to 0°C. Predict the Tg you expect to obtain by mixing 100g of PVC and 100g of plasticizer. (40 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)

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Final Examination– 2016/2017
CMU 3233 - POLYMER CHEMISTRY
MCQ ANSWER SHEET: Mark a cross (x) over the most suitable answer.

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		Marks
Unanswered		
Correct Answers		
Wrong Answers		
Total		

1.	1	2	3	4	5	2.	1	2	3	4	5	3.	1	2	3	4	5
4.	1	2	3	4	5	5.	1	2	3	4	5	6.	1	2	3	4	5
7.	1	2	3	4	5	8.	1	2	3	4	5	9.	1	2	3	4	5
10.	1	2	3	4	5	11.	1	2	3	4	5	12.	1	2	3	4	5
13.	1	2	3	4	5	14.	1	2	3	4	5	15.	1	2	3	4	5
16.	1	2	3	4	5	17.	1	2	3	4	5	18.	1	2	3	4	5
19.	1	2	3	4	5	20.	1	2	3	4	5	21.	1	2	3	4	5
22.	1	2	3	4	5	23.	1	2	3	4	5	24.	1	2	3	4	5
25.	1	2	3	4	5												