The Open University of Sri Lanka
Faculty of Natural Sciences
B.Sc/ B. Ed Degree Programme

Department	: Chemistry
Level	: 5
Name of the Examination	: Final Examination
Course Code and Title	: CYU5633/CMU3233, Polymer Chemistry
Academic Year	: 2019/2020
Date	: 14.11.2020
Time	: 9.30 am – 12.30 pm
Duration	: 3 hours
Index number	:

General Instructions

1. Read all instructions carefully before answering the questions.

2. This question paper consists of 25 MCQs and 6 essay questions in 09 pages.

3. Answer **all 25 MCQs and 4 essay questions** only. Use MCQ sheet to mark the correct answer. Recommended time for MCQs is 1 hour.

4. Answer for each essay question should commence from a new page.

5. Non programmable calculators are permitted.

6. Having any unauthorized documents/ mobile phones in your possession is a punishable offense

7. Use blue or black ink to answer the questions.

8. Circle the number of the questions you answered in the front cover of your answer script.

9. Clearly state your index number in your answer script

PART I (35 marks)

01. If the Molar mass of polyethylene is 56,000 g/mol, what is the degree of polymerization of this polyethylene sample?

1) 140 2) 1000 3) 2000 4) 6000 5) 4000

02. Example for anionic initiator is?
1) KNH_2 2) BF_3 3) $HClO_4$ 4) $TiCl_3$ 5) HCl

03. Formation of nylon 6,6 using hexamethylene diamine and adipic acid is an example for
1) addition polymerization. 2) ring opening polymerization.
3) polycondensation polymerization. 4) free radical polymerization.
5) cationic polymerization.

04. What statement is **not true** about chain polymerization?
1) Three basic steps (initiation, propagation and termination) are involved in this polymerization.
2) Polymer molar mass retain throughout the reaction.
3) Monomer concentration drops steadily throughout the reaction.
4) By products can be water, HCl etc.
5) Repeating units are added one at a time.

05. What statement is **true** about suspension polymerization?
1) Only water soluble monomers can be polymerized. 2) Emulsifying agents are added.
3) Auto-acceleration takes place. 4) Polymer produced appears as a white milky dispersion.
5) Surface active agents are added.

06. Highest T_g can be found in
1) Polypropylene 2) Poly(4-methyl-pent-1-ene) 3) Poly(butyl acrylate)
4) Poly(pent-1-ene) 5) Poly(but-1-ene)

07. The relationship between the molar mass of a polymer (M) and the T_g value 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) $T_g = T_g{}^a + \frac{k}{2M}$

08. In dilatometry method,
1) Density change is measured at different time intervals.
2) Volume change is measured at different temperatures.
3) Temperature change is measured at different time intervals.
4) Mass change is measured at different time intervals.
5) Pressure change is measured at different time intervals.

09. What property cannot be changed at the melting point (T_m) of a polymer?
1) Density 2) Heat capacity 3) Transparency 4) Refractive index 5) Composition

10. Calculate the number average molar mass of polystyrene sample containing three molecules with molar masses 1×10^6, 3×10^6, and 5×10^6 g/mol respectively.
1) 2×10^6g/mol 2) 4×10^6g/mol 3) 3×10^6g/mol 4) 6×10^6g/mol 5) 1×10^6g/mol

11. What statement is **not** true about end group analysis?
1) Polymers must contain reactive functional groups at one or both ends of the polymer.
2) Used to calculate $\bar{M}_n$ of polymer samples.
3) Time consuming
4) Difficult to find a suitable solvent to dissolve polymers.
5) Suitable for highly branched polymers

12. If polydispersity factors of five polymer samples, A, B, C, D and E are 0.9, 2.1, 2.3, 2.8 and 3.2 respectively, which sample has the **broadest** molar mass distribution curve?
1) A 2) B 3) C 4) D 5) E

13. If the degree of polymerization of polyethylene is 1000 and –C-C- length is 1.26Å, what is the root mean square distance of polyethylene sample?
1) 3.75nm 2) 6.12nm 3) 1.33nm 4) 2.13nm 5) 5.13nm

14. Concentration of field latex can be increased up to 60% by
a) electrolysis b) adding thiols c) creaming d) centrifuging e) bleaching
The correct method/s is/are
1) (b) only 2) (a) and (c) only 3) (b), (d) and (e) 4) (a), (c) and (d) 5) (e) only

15. What statement is **not** true about cyclisation of natural rubber?
1) Cyclisation of natural rubber occurs at 130^0C.
2) Cyclisation agents should be strong bases such as NaOH.
3) Friedal-Craft catalysts can be added for the cyclisation of natural rubber.
4) Polycyclic structure can be obtained after cyclisation.
5) Sulphuric acid and p-toluenesulphonic acid can be added for the cyclisation process.

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

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

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

18. Consider a polymerization of hydroxycarboxylic acid reaction. If the percent conversion of hydroxycarboxylic acid is 0.90, the degree of polymerization is
1) 20 2) 10 3) 35 4) 12 5) 44

19. What statement is **true** about free radical polymerization?
1) Increase of temperature increases the rate of polymerization and the chain length.
2) Increase of temperature decreases the rate of polymerization and the chain length.
3) Temperature does not affect on the rate of polymerization and the chain length.
4) Increase of temperature increases the rate of polymerization but decreases the chain length.
5) Increase of temperature decreases the rate of polymerization but increases the chain length.

20. Rate equation for cationic polymerization is
1) 0^{th} order with respect to monomer concentration.
2) 1^{st} order with respect to catalyst concentration.
3) 1^{st} order with respect to monomer concentration.
4) 2^{nd} order with respect to monomer concentration.
5) independent of catalyst 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.

22. The rate equation for cationic polymerization is
1) $\frac{k_p k_i}{k_t}[M]^2[H^+]$ 2) $\frac{k_t k_p}{k_t}[M]^2[H^+]$ 3) $\frac{k_t k_i}{k_t}[M][H^+]$
4) $\frac{k_p k_i}{k_t}[M]^{1/2}[H^+]$ 5) $\frac{k_p k_i}{k_t}[M][H^+]$

23. What statement is **not true** about FTIR spectroscopy?
1) It can be used only as a qualitative tool in the characterization of polymers.
2) It can be used as a qualitative as well as quantitative tool in the characterization of polymers.
3) It can be used to work out the stereo regularity of polymers.
4) It provides important information about crystallinity of certain polymeric materials.
5) It can be used to determine the extent of crystallinity

24. What statement is **true** about Raman spectroscopy?
1) It is a very popular method than IR spectroscopy in polymer characterization.
2) It can be used to determine the crystallinity of polymers.
3) It can be used to determine the composition of copolymers.
4) It can be used to identify tacticity of Polypropylene.
5) Raman effect responds to the symmetric vibrational modes.

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.

PART II (65 marks)

01.(a) Write chemical equations for initiation and the propagation steps for the free radical polymerization of CH_2=CHCl using I_2 as the initiator. You are required to write clear equations using correct arrows (20 marks)

(b) Average molar mass of polystyrene polymer is 5410 g/mol. Calculate the degree of polymerization of this polymer. (10 marks)

(c) i. What is meant by copolymers?
ii. Describe different types of copolymers with examples. (20marks)

(d) i. What are the main features of step growth polymerization? List 4 of them.
ii. State common features of polycondensation reactions.
iii. Draw the structure of polymer formed after polycondensation of adipic acid with hexamethylene diamine. Give the name.
iv. What is the reason for having high melting point for this polymer? (30 marks)

(e) i. Explain the chemical process of suspension polymerization.
ii. How does it differ from emulsion polymerization? Explain (20 marks)

02. a) How do you classify polymers based on their basic structure? Explain. (10 marks)

b) i. Synthetic rubber and natural rubber have different properties. Explain why?
ii. What do you by geometrical isomerism in polymers? Illustrate using an example. (20 marks)

c) i. What is meant by glass transition temperature?
ii. What are the techniques that can be used to determine T_g of a given polymer?
iii. Describe one of the techniques listed in (ii).
iv. Glass transition temperature of poly(methyl acrylate) is 279K while the corresponding value for poly(butyl acrylate) is 218K. Explain. (35 marks)

d) i. What is meant by degree of crystallinity? Explain in terms of density and volume.
ii. Assume that the density of the crystalline rubber increases by 5% that of the amorphous rubber, calculate the degree of crystallinity in crystalline rubber. Densities of amorphous rubber and 100% crystalline rubber are 850 kgm^{-3} and 980 kgm^{-3} respectively.
iii.What are the factors that change the ratio of crystalline to amorphous contents of polymers? Explain briefly. (35 marks)

03. a) i. A polyethylene sample is made up of three fractions having molar masses of 20,000, 50,000 and 100,000 g/mol. If equal number of molecules in each fraction, calculate the number average molar mass, $\bar{M}_n$, of the polyethylene sample.

ii. Calculate the number average degree of polymerization of above polyethylene sample.

iii. If the weight average molar mass, $\bar{M}_w$ of above polyethylene sample is 75,000 g/mol, calculate the polydispersity factor of this polyethylene sample. (60 marks)

b) Following table summarizes the average relative molar masses of two polymer samples, X and Y, measured using three methods, osmometry, viscometry and light scattering.

	Sample X	Sample Y
Method 1	80,000	190,500
Method 2	56,500	168,000
Method 3	22,100	108,000

Identify method 1, 2 and 3 by giving possible reasons. (20 marks)

c) (i) Write down Mark-Houwink equation and define terms.
(ii) Calculate the molar mass of a polymer sample if $\alpha = 0.60$, $K = 1.6\times10^{-4}$ dl/g and $[\eta] = 0.04$ dl/g,
(20 marks)

04. a) i. What is meant by vulcanization of rubber?
ii. "Vulcanized rubber has different properties from pre-vulcanized rubber" Justify the statement.
(10 marks)
b) What is meant by storage hardening of natural rubber? How do you prevent it? Explain.
(20 marks)
c) i. What do you mean by "yellow discoloration of rubber latex"? Explain.
ii. What are the methods of doing it? Briefly describe.
(20 marks)
d) i. What is the most common vulcanization method used in rubber industry?
ii. What are the essential ingredients necessary for that vulcanization process?
(20 marks)
e) What do you mean by oxidative degradation? How do you prevent it? (10 marks)
f) Write brief accounts on
i. Antioxidants ii. Fillers iii. Ribbed smoked sheets
(20 marks)

05. a) What are the assumptions used in the derivation of rate equation in free radical polymerization? Explain. (20 marks)
b) Polymers formed by free radical polymerization have higher average molar mass than polymers formed by anionic polymerization. Discuss. (20 marks)
c) i. Write down modified Carother's equation and define terms.
ii. Nylon 6:6 is produced by using hexamethylene diammine and adipic acid. If the percent conversion is 100% and 3% more hexamethylene diammine is used, calculate the degree of polymerization.
iii. When molar ratios are equal, deduce Carother's equation from modified Carother's equation.
(50 marks)
d) Give kinetic interpretation for auto acceleration. (10 marks)

06. a) i. Using mass fractions of X and Y, write down the fox equation to predict the T_g of a random copolymer.

ii. Plasticizers are added to reduce Tg. When 100g of PVC is mixed with 25g of a plasticizer, the Tg of the PVC is lowered from 87°C to 0°C. What is the Tg you expect to obtain by mixing 100g of PVC with 100g of plasticizer? (40 marks)

b) Assume that the polymeric material obeys Voight-Kelvin behavior. Suppose that a creep test carried out with an applied stress of 3MPa and the maximum strain observed was 0.01. After a period of one hour, the stain was measured as 0.006. Calculate the elastic modulus, retardation time and the viscosity of the polymeric material.

(40 marks)

c) i. What is meant by Differential Scanning Calorimetry?

ii. What information can you gather from this technique? Briefly explain two of them.

(20 marks)

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B.Sc DEGREE/STAND ALONE COURSE IN SCIENCE - LEVEL 5
Final Examination– 2019/2020
CYU5633/CMU3233 - POLYMER CHEMISTRY
MCQ ANSWER SHEET: Mark a cross (x) over the most suitable answer.

Index No.

		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												