



**THE OPEN UNIVERSITY OF SRI LANKA**

**Faculty of Natural Sciences**

**Department of Chemistry**

**B.Sc. Degree Program –Level 5**

**Final Examination -2014/2015**

**CMU 3233/CHU 3238-Polymer Chemistry**

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**Date: 03.11.2015**

**9.30am-12.30pm**

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**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.
- 1/6<sup>th</sup> marks will be deducted for each incorrect answer
- The use of a non – programmable electronic calculator is permitted.

**THE OPEN UNIVERSITY OF SRI LANKA**

**B.Sc DEGREE/STAND ALONE COURSE IN SCIENCE - LEVEL 5**

**Final Examination- 2014/2015**

**CHU 3238/CMU 3233 - 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
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2. 

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3. 

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4. 

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7. 

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9. 

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10. 

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11. 

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12. 

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13. 

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14. 

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15. 

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16. 

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17. 

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18. 

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19. 

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20. 

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21. 

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22. 

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23. 

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24. 

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25. 

1	2	3	4	5
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**PART I (35 marks)**

01. The degree of polymerization of polyethylene is 2000; What is the molar mass of the polymer?

1. 2800g/mol    2. 56000g/mol    3. 36000g/mol    4. 24000g/mol    5. 32000g/mol

02. Consider the following molecules

- i.  $\text{CH}_3\text{COCH}_2\text{COOH}$     ii.  $\text{HO}(\text{CH}_2)\text{COOH}$     iii.  $\text{CH}_3\text{COOH}$     iv.  $\text{H}_2\text{N}(\text{CH}_2)_5\text{NH}_2$   
v.  $\text{C}_6\text{H}_5\text{OH}$

Which molecule/s cannot act as monomers? The **correct** statement/s is/are

1. i and ii only    2. ii and iv only    3. iii only    4. ii only    5. i, ii and iii only

03. What statement/s is/are **true** about step growth polymerization?

- a) Any two molecular species can react.    b) Three basic steps are involved.  
c) Monomer disappears early in the reaction.

The **correct** statement/s is/are

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

04. What type of initiators can be used to polymerize isobutene?

1. Cationic.    2. Anionic.    3. Free radical.    4. Anionic and cationic    5. Free radical and cationic.

05. What is / are the most favoured mode/s of addition of the incoming monomer to the growing polymer radical is / are

1. Head to head.    2. Head to tail.    3. Tail to tail.    4. Tail to Head.  
5. Tail to tail and tail to head.

06. During crystallization, following property/properties can be changed.

1. Hardness    2. Volume    3. Refractive index    4. Density    5. All of above.

07. Atactic polymers can be represented as

1.  $\sim\sim$  dldldl  $\sim\sim$     2.  $\sim\sim$  ddddd  $\sim\sim$     3.  $\sim\sim$  dddld  $\sim\sim$     4.  $\sim\sim$  llllll  $\sim\sim$   
5.  $\sim\sim$  ldldld  $\sim\sim$

08. At  $T_g$ , following properties can be changed.

1. Specific volume    2. Density    3. Hardness    4. Heat capacity    5. All of above

09. What is/are the method/s that can be used to determine crystalline melting point ( $T_m$ )?

- a) Thermal analysis    b) X-Ray diffraction    c) Infra-red spectroscopy    d) NMR spectroscopy

The **correct** statement/s is/are

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

10. Which statement is **true** about cis and trans polyisoprene?

1. Both cis and trans isomers have same  $T_g$  values.
2. Both cis and trans isomers have same  $T_m$  values
3. Cis isomers have higher  $T_g$  values than trans isomers.
4. Cis isomers have higher  $T_m$  values than trans isomers.
5. Trans isomers have higher  $T_m$  values than cis isomers.

11. In a polydispersed system, which statement is **true**?

1.  $\overline{M}_n > M_v > \overline{M}_w$
2.  $\overline{M}_n = M_v = \overline{M}_w$
3.  $M_v > \overline{M}_n > \overline{M}_w$
4.  $\overline{M}_w > M_v > \overline{M}_n$
5.  $M_v = \overline{M}_n > \overline{M}_w$

12. Polymer sample contains three molecules with molar masses  $1 \times 10^5$ ,  $2 \times 10^5$ , and  $3 \times 10^5$  g/mol respectively. Number average molar mass of this polymer sample is

1.  $2 \times 10^5$  g/mol
2.  $1.2 \times 10^5$  g/mol
3.  $0.8 \times 10^5$  g/mol
4.  $6 \times 10^5$  g/mol
5.  $1 \times 10^5$  g/mol

13. Light scattering method is used to determined

1. Number average molar mass.
2. Weight average molar mass.
3. Viscosity average molar mass.
4. Number average molar mass and weight average molar mass.
5. Intrinsic viscosity.

14. Number average molar mass can be determined using

1. End group analysis.
3. Osmometry.
2. Ebulliometry
4. Cryoscopy.
5. all of above.

15. Consider the following statements about nitrile rubber?

- a) It is a polymer that can be cross linked.
- b) Swelling can be observed in the presence of a solvent.
- c) It dissolved in any organic solvent.
- d) It is used as oil seals.

The correct statement/s is/are

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

16. Polymer degradation takes place due to

1. atmospheric oxygen.
2. heat.
3. radiation.
4. mechanical stress.
5. all of above.

17. Consider following statements regarding polyacrylonitrile (PAN)?

- a) It is produced by free radical polymerization of acrylonitrile.
- b) It is soluble in polar solvents.
- c) It is not resistant to heat.

What statement/s is/are **true** about polyacrylonitrile (PAN)?

The correct statement/s is/are

1. a only
2. b only
3. c only
4. a and b only
5. a, b and c only.

18. Which compound cannot be used as a preservative in latex industry?

1. Ammonia solution.
2. Sodium sulphite.
3. Formaldehyde.
4. Hydrochloric acid.
5. Sodium carbonate.

19. During mastication of polymer,  
 a) viscosity decreases      b) molar mass decreases.      c) molar mass increases  
 d) molar mass remains unchanged.

The **correct** statement/s is/are

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

20. What statement is **true** about thermoplastics?

1. They are formed by step growth polymerization.      3. They are hard and brittle.  
 2. They are cross linked polymers.      4. They can be softened by heating.  
 4. They can be softened by heating.      5. They are insoluble in any solvent.

21. Kinetic chain length ( $\nu$ ) can be expressed as

1.  $\nu = \text{rate of propagation}/\text{rate of initiation}$       2.  $\nu = \text{rate of initiation}/\text{rate of propagation}$   
 4.  $\nu = \text{rate of propagation}$ .      5.  $\nu = \text{rate of initiation}$ .

22. Rate of polymerization can be determined by

- a) molar refractivity      b) discoloration method      c) density method.

The **correct** statement/s is/are

- 1) a only      2) b only      3) c only      4) a & c only      5) all of above.

23. Rate equation for cationic polymerization is

1. 1<sup>st</sup> order w.r.t monomer concentration.  
 2. 1<sup>st</sup> order w.r.t. catalyst concentration.  
 3. 2<sup>nd</sup> order w.r.t. monomer concentration.  
 4. 0<sup>th</sup> order w.r.t. monomer concentration.  
 5. independent of catalyst concentration.

24. For a linear poly-condensation reaction, polydispersity factor can be expressed as

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

25. When transfer agents are used in free radical reactions, the chain length of polymers

1. increases.      2. decreases.      3. does not change.      4. doubles its original value.  
 5. triples its original value.

**PART II (65 marks)**

01. (a) i. What are the major differences between a polymer and a simple compound?  
ii. What do you mean by the functionality of a monomer? (15 marks)
- (b) i. What is meant by copolymers?  
ii. Describe different types of copolymers with examples. (25 marks)
- (c) i. The Degree of polymerization of two samples of same polymer is 225 and 750. By calculating molar masses of two polymer samples, predict their properties.  
ii. Following parameters were given for a Polystyrene sample. Intrinsic viscosity  $[\eta] = 0.04 \text{ dl/g}$ ,  $\alpha = 0.60$  and  $K = 1.6 \times 10^{-4} \text{ dl/g}$ . Calculate the molar mass of polystyrene. (25 marks)
- (d) i. What do you mean by "yellow discoloration of rubber latex"?  
ii. Describe two methods of preventing yellow discoloration of rubber latex.  
iii. "Ribbed smoked sheets are resistant to oxidation than pale crepe" Justify the statement. (15 marks)
- (e) i. Write down modified Carother's equation and define terms.  
ii. Starting from modified Carother's equation, deduce Carother's equation. (20 marks)
02. (a) i. What is meant by step growth polymerization?  
ii. How does it differ from chain polymerization? Explain.  
iii. "Acrylonitrile-Butadiene-Styrene (ABS) polymer is a very tough polymer" Justify this statement. (35 marks)
- (b) i. Write chemical equations for initiation and the propagation steps for the free radical polymerization of  $\text{CH}_2=\text{CHCl}$  using  $\text{I}_2$  as the initiator.  
ii. Describe the common termination methods of free radical polymerization?  
iii. How does it differ from cationic polymerization? Explain. (35 marks)

- (c) i. Explain the chemical process of suspension polymerization.
- ii. What are the different kinds of polymers produced by this technique?
- ii. How does it differ from emulsion polymerization? Discuss.
- (30 marks)
03. (a) i. By giving examples, explain the difference between homo polymers and hetero polymers.
- ii. What is meant by the term “microstructure of polymers”? Explain using chemical structures of polymers.
- (20 marks)
- (b) i. What do you mean 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. By giving reasons, compare the  $T_g$  values of poly(vinyl alcohol) and polypropylene.
- (40 marks)
- (c) i. What are the differences between amorphous and crystalline polymers?
- ii. Describe the effects of temperature on nucleation and chain mobility during crystallization.
- iii. Crystalline and amorphous polymers have different solubilities. Discuss.
- iv. How does the crystallinity change the physical properties of polymers? Explain.
- (40 marks)
04. (a) A polypropylene sample consists of three fractions having molar ratios of 3:2:1. Molar masses of these fractions are  $2 \times 10^6$ ,  $3 \times 10^6$  and  $6 \times 10^6$  respectively. Calculate the number average molar mass,  $\overline{M}_n$ , weight average molar mass,  $\overline{M}_w$ , and the number average degree of polymerization,  $[\overline{D}_p]_n$  of polypropylene.
- (70 marks)

- (b) The average relative molar masses of two polymer samples, A and B were measured using light scattering, osmometry and viscometry. Results are tabulated as follows.

	Sample A	Sample B
Method 1	91,500	187,000
Method 2	68,000	176,000
Method 3	33,000	112,000

- i. By giving reasons, identify method 1, 2 and 3.  
 ii. Why the values obtained for a particular sample are different in three methods?  
 (30 marks)
05. (a) i. What is meant by vulcanization of rubber?  
 ii. What are the essential ingredients necessary for sulphur vulcanization of rubber?  
 iii. "Physical properties of cross linked polymers are different from pre polymers".  
 Explain  
 (30 marks)
- (b) i. What are plastisol?  
 ii. Describe two types of fillers.  
 iii. What are the structural difference between thermoplastics and thermosets?  
 (30 marks)
- (c) i. What is meant by storage hardening of rubber?  
 ii. How do you prevent storage hardening of rubber? Explain.  
 (20 marks)
- (d) Write brief notes on  
 i. Ribbed smoked sheets.  
 ii. Antioxidants.  
 iii. Plasticizers.  
 (20 marks)
06. (a) What is meant by auto acceleration and give kinetic interpretation.  
 (20 marks)
- (b) i. List the assumptions used in the derivation of rate equation in free radical polymerization and briefly outline reasons.  
 ii. Explain the reason for having higher average molar mass in polymers formed by free radical polymerization than those formed by anionic polymerization.  
 (35 marks)
- (c) i. What would be the effect on degree of polymerization when monofunctional impurities are present in a bi-functional polymerization reaction?  
 ii. Assuming that percent conversion is 95%, when 10% of more adipic acid is used in the preparation of nylon 6,6 with hexamethylene diammine, calculate the degree of polymerization?

(45 marks)

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