



The Open University of Sri Lanka

B Sc Degree/ Stand Alone courses in Science – Level 5

Final Examination – 2006/2007

CHU 3238/CHE 5238 – Polymer Chemistry – Paper I

Duration : 2 hours

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Date : Saturday 28<sup>th</sup> April 2007

Time : 10.00 am – 12.00 noon

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Instructions to candidates:

- Answer all 50 questions.
- Choose the most correct answer to each question and mark this answer with an “X” on the answer script.
- Use a PEN (not a pencil) in answering.
- Any question with more than one answer will be counted as incorrect answer.
- 1/6<sup>th</sup> marks will be deducted for each incorrect answer.
- The use of a **non-programmable** calculator is permitted.
- Logarithm tables and graph paper will be provided.

Gas Constant (R )	=	8.314 J K <sup>-1</sup> mol <sup>-1</sup>
Avogadro Constant (L)	=	6.023 x 10 <sup>23</sup> mol <sup>-1</sup>
Planck Constant (h)	=	6.63 x 10 <sup>-34</sup> Js
Velocity of light (C )	=	3.0 x 10 <sup>8</sup> ms <sup>-1</sup>
Atmospheric Pressure ( π )	=	10 <sup>5</sup> Pa (Nm <sup>-2</sup> )
Faraday constant (F)	=	96,500 C mol <sup>-1</sup>
Log <sub>e</sub> (X)	=	2.303 log <sub>10</sub> (X)

1. A degree of polymerization of a polymer is 100 and its molar mass is 4200 g/mol. The monomer used in this polymerization is,
  - (1) ethylene
  - (2) propylene
  - (3) vinyl chloride
  - (4) styrene
  - (5) vinyl alcohol
  
2. Which initiator/catalyst cannot be used to polymerise the monomer in Q1?
  - (1) benzoyl peroxide
  - (2) azobisisobutyronitrile (AIBN)
  - (3) Ziegler-Natta catalyst
  - (4) anionic
  - (5) cationic
  
3. Which of the above catalyst results in stereo regular polymer.
  - (1) benzoyl peroxide
  - (2) azobisisobutyronitrile (AIBN)
  - (3) Ziegler-Natta catalyst
  - (4) anionic
  - (5) cationic
  
4. The stereo regular polymers consist
  - (1) d form only (isotactic)
  - (2) l form only (isotactic)
  - (3) alternate d,l forms (syndiotactic)
  - (4) random d,l forms (atactic)
  - (5) isotactic and syndiotactic forms
  
5. Which form is more optically active if the degree of polymerization are equal in all cases,
  - (1) d form
  - (2) l form
  - (3) alternate d and l forms
  - (4) random d and l forms
  - (5) both d and l forms
  
6. Reasons for using stearic acid with zinc oxide are,
  - (a) to improve compatibilities of ZnO with rubber
  - (b) to produce  $Zn^{2+}$  ions
  - (c) to form intermediate activated complexes

The correct answers are:

  - (1) ab
  - (2) bc
  - (3) ac
  - (4) abc
  - (5) none of the above
  
7. During accelerated sulphur vulcanization, the types of sulphide linkages formed are
  - (1) sulphides of reacting rubber, sulphur with accelerator only
  - (2) monosulphides and disulphides only
  - (3) cyclic, mono and higher sulphides only
  - (4) ZnS only
  - (5) All above
  
8. Thermally stable rubber vulcanisate can be obtained by introducing
  - (1) monosulphide + disulphide linkages
  - (2) disulphide and trisulphide linkages
  - (3) cyclic and higher sulphide linkages
  - (4) presence of dienes and trienes
  - (5) intermediate rubber, sulphur accelerator complex

9. Polymers are degraded  
 (1) during processing only  
 (2) during services only  
 (3) by mechanical stress heat and solar radiation only  
 (4) by atmospheric  $O_2 + O_3$  only  
 (5) all above
10. During oxidation of polymers  
 (a) colour can be changed  
 (b) molar mass increased or decreased  
 (c) aldehydes, ketones can be formed  
 (d) physical properties are deteriorated  
 The correct answers are;  
 (1) a, b, c only                      (2) b, c, d only                      (3) a, c, d only  
 (4) a, b, d only                      (5) all above
11. (a) Polymer oxidation is a chain reaction  
 (b) Initiation, propagation and termination reactions are the key steps involved during oxidation  
 (c) Antioxidant function is to inhibit initiation step only  
 The correct answers are;  
 (1) a, b only                      (2) b, c only                      (3) a, c only  
 (4) a, b, c                      (5) a only
12. What is the incorrect answer.  
 Polytetrafluoroethylene (PTFE)  
 (1) is produced by emulsion polymerization  
 (2) consists of linear, highly regular helical structure  
 (3) is an oil resistant, thermally unstable polymer  
 (4) is a crystalline polymer resistant to solvents  
 (5) is produced by polymerization of  $CF_2=CF_2$
13. What is the correct statement  
 Polyvinyl alcohol (PVA)  
 (1) is insoluble in water  
 (2) produced by emulsion polymerization  
 (3) cannot be used as an adhesive  
 (4) synthesis by hydrolysis of polyvinyl acetate  
 (5) is unstable at room temperature
14. (1) Field latex is used to manufacture dipped products  
 (2) Ribbed smoked sheets contain phenolic antioxidants  
 (3) Pale crepe is more pure than smoked sheets or latex  
 (4) Quality of dry raw rubber is examined by visual appearance  
 (5) Field latex contains 30% of rubber  
 What is the incorrect statement?

15. Carbon fiber can be prepared by heating under controlled condition of poly,  
(1) acrylo nitrile (-CH<sub>2</sub>CH(CN)-)  
(2) vinyl chloride (-CH<sub>2</sub>-CH(Cl)-)  
(3) vinyl acetate (-CH<sub>2</sub>-CH(OCOEt)-)  
(4) vinyl alcohol (-CH<sub>2</sub>-CH(OH)-)  
(5) methyl methacrylate (-CH<sub>2</sub>-C(CH<sub>3</sub>)COOEt-)

16. Phenol formaldehyde  
(a) resin is water soluble  
(b) can be used as an adhesive  
(c) is polymerized by addition polymerization  
(d) polymerization needed 1:3 mole ratio of phenol and formaldehyde

The correct answers are;

- (1) a, b, c only      (2) a, b, d only      (3) b, c, d only  
(4) a, c, d only      (5) all above

17. Storage hardening of rubber,  
(a) Results in increase in viscosity  
(b) is due to a cross linking reaction  
(c) results lowering molar mass

The correct statements are;

- (1) a,b      (2) a,c      (3) b,c      (4) a,b,c      (5) a only

18. Polyurethane foam  
(a) is produced by reacting diisocyanate with phenol  
(b) cellular structure is due to liberation of CO<sub>2</sub>  
(c) is used in automobile and building industry

The correct statements are;

- (1) ab      (2) ac      (3) bc      (4) abc      (5) a only

19. Molar masses of polymer samples drawn from polymerization flask at various times are given below  
(1) 1400      (2) 2100      (3) 2800      (4) 3500      (5) 4200

Which sample has the lowest T<sub>g</sub>?

20. Following changes may occur at the glass transition temperature (T<sub>g</sub>)  
(a) changes in vibrational, rotational and translational motions  
(b) changes in Physical properties  
(c) changes in Chemical properties  
(d) Thermal co-efficient of expansion

The correct answers are;

- (1) abc only      (2) abd only      (3) bcd only      (4) acd only      (5) abcd

21. When an amorphous polymer is changed to crystalline polymer which of the following properties do not change,  
 (1) density (2) optical properties  
 (3) chemical reactivity (4) permeability (5) hardness
22. To improve the thermal stability of polymers,  
 (1) benzene rings are introduced to the main chain  
 (2) ring structures are introduced like a ladder  
 (3) polymers are cross linked  
 (4) bulky pendent groups are introduced  
 (5) aromaticity of the backbone is reduced  
 What is the incorrect statement?
23. What is the incorrect statement among the followings,  
 (1) polymers are not 100% crystalline  
 (2) crystalline polymer structure is 100% random  
 (3) elasticity of polymers increases with increase of the temperature  
 (4) hardness of polymers decreases with decrease of the temperature  
 (5) crystalline polymers do not have fixed melting point
24. What is the percentage increase in crystallinity when fully amorphous polymer of density  $0.910 \text{ g/cm}^3$  is converted to semicrystalline polymer of density  $0.937 \text{ g/cm}^3$ . Assume the density of 100% crystalline polymer is  $1.0 \text{ g/cm}^3$ .  
 (1) 30% (2) 40% (3) 97% (4) 3% (5) 70%
25. (a) crystalline polymer can be obtained by very slow cooling of polymer melt  
 (b) amorphous polymer can be obtained by sudden cooling of polymer melt  
 (c) density of 100% crystalline polymer can be determined by X-ray diffraction method  
 (d) density of 100% amorphous polymer can be determined by normal methods

The correct statements are;

- (1) abcd (2) abc (3) abd (4) bcd (5) adc

26. State the correct statements.  
 Molar mass distribution,  
 (a) is similar to Boltzmann's Distribution curves  
 (b) gives an indication about the distribution of polymer molecules in a sample  
 (c) curve can be experimentally obtained by Gas Liquid Chromatography  
 (1) ab (2) bc (3) abc (4) ac (5) b only

Answer question 27 to 33 using the following data.

$\overline{M}_w$  and  $\overline{M}_n$  (weight and number average) of five polymer sample are,

Sample	(1)	(2)	(3)	(4)	(5)
$\overline{M}_w$ kg/mol $\times 10^3$	8.18	5.5	6	3	4
$\overline{M}_n$ kg/mol $\times 10^3$	8.0	5	4	1.5	2.5

27. Which sample is nearly mono dispersed?
28. Which sample has the highest poly dispersity factor?
29. Which sample shows narrow molar mass distribution curve?
30. Which sample has broader molar mass distribution curve?
31. Which sample do you think gives consistent physical properties?
32. What is the lowest degree of polymerization among the above sample if the polymer is a linear polyethylene?
33. The assumption used in the calculation in Q 32 is that polymer is,
  - (1) a linear
  - (2) slightly branched
  - (3) highly branched
  - (4) cross linked
  - (5) all above
34. Polycondensation reaction of HO-R-COOH results a polymer of 10000 repeat units. The extent of the reaction is,
  - (1) 90%
  - (2) 99%
  - (3) 99.9%
  - (4) 99.99%
  - (5) 100%
35. Polymer dissolution rate can be increased by
  - (1) stirring
  - (2) increasing temperature
  - (3) increasing surface area
  - (4) increasing molar mass
  - (5) by milling
36. Polymer solutions behave as ideal solution if,
  - (a) the sizes of th polymer and the solvent molecules are equal
  - (b) equal accommodation of the two molecules are impossible
  - (c) polymer-solvent attractive forces are same

The correct statements are,

- (1) a only
- (2) b only
- (3) ab only
- (4) ac only
- (5) all above

37. Which polymerization technique is cheap and suitable in controlling heat evolved in vinyl polymerization,  
(1) condensation (2) bulk (3) suspension  
(4) solution (5) emulsion polymerization

38. Degree of polymerization of polyamide (nylon type) can be controlled by,  
(1) mixing stoichiometric ratios of the two monomers  
(2) adding small amount of acetic acid  
(3) adding small amount of amine  
(4) cooling  
(5) adding slightly excess amount of one of the monomer  
What is the incorrect statement?

39. In chain polymerization degree of polymerization depends on,  
(a) concentration of the monomer  
(b) concentration of the initiator  
(c) temperature

The correct statements are,

(1) abc (2) a only (3) b only (4) ab only  
(5) ac only

40. According to steady state assumption,  
(1) rate of initiation is equal to rate of propagation  
(2) rate of initiation is equal to rate of termination  
(3) rate of propagation is equal to rate of termination  
(4) radicals form at the initiation step should be at the same rate as propagation step  
(5) rate of initiation, propagation and termination are all equal

41. If the number average degree of polymerization is 250, what is the molar mass of the polymer, if the termination is by disproportionation in free radical polymerization.  
(1) 250 (2) 500 (3) 125 (4) 750  
(5) none of the above

42. What is the amount of ethylene required to produce the above polymer in kg?  
(1) 7 (2) 14 (3) 3.5 (4) 21 (5) none of the above

43. Derivation of rate equation for free radical and ionic polymerization differ only in  
(1) initiation step  
(2) propagation step  
(3) termination step  
(4) in all three steps  
(5) initiation and propagation steps

44. The equation  $\sqrt{r^2} = 1\sqrt{n}$  can be more accurately use to determine root mean square distance of,
- (1) linear
  - (2) slightly branched
  - (3) highly branched
  - (4) cross linked
  - (5) co-polymerised polyethylene
45. Accuracy of  $\overline{M}_n$  determined by osmotic pressure depends on the following experimental conditions
- (1) temperature variable
  - (2) concentration of polymer solution
  - (3) purity of the solvent
  - (4) polymer-solvent solubility
  - (5) dilution of the polymer solution
46. Which monomer concentration results faster auto acceleration in vinyl free radical polymerization?
- (1) 5%                      (2) 10%                      (3) 15%                      (4) 20%                      (5) 25%
47. In a typical (linear) polycondensation reaction the polydispersity factor is 1.30. What is the extent of the reaction?
- (1) 13%                      (2) 30%                      (3) 60%                      (4) 80%                      (5) 99%
48. If the polymerization of ethylene polymer by free radical initiator ( $I_2$ ) is terminated by combination reaction, then the end groups are,
- (1)  $-CH_3$  and  $-CH=CH_2$
  - (2)  $-CH_3$  and  $-I$
  - (3)  $-I$  and  $-I$
  - (4)  $-CH_3$  and  $-CH_3$
  - (5) None of the above
49. The polymer used in rubber, plastic, fiber and paint industry is,
- (1) styrene butadiene rubber
  - (2) polyacrylate
  - (3) polyurethane
  - (4) phenol - formaldehyde
  - (5) melamine - formaldehyde
50. Which polymer is insoluble in Methyl Ethyl Ketone?
- (1) Polyvinyl alcohol
  - (2) Chloroprene rubber
  - (3) Nitro cellulose
  - (4) Natural rubber
  - (5) Poly methyl methacrylate