The Open University of Sri Lanka
B.Sc Degree/Stand Alone courses in Science-Level 5
Final Examination-2010/2011

CHU 3238/CHE 5238-Polymer Chemistry-Paper I

Date: 06.07.2011 **Time: 9.30 a.m – 11.30 a.m**

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.
- $1/6^{th}$ 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 $mol^{-1}K^{-1}$**
Avogadro Constant (L)	=	**6.023×10^{23} mol^{-1}**
Planks Constant (h)	=	**6.63×10^{-34} Js**
Velocity of light (C)	=	**3.0×10^{8} ms^{-1}**
Atmospheric Pressure(π)	=	**10^5Pa (Nm^{-2})**
Faraday Constant (F)	=	**96,500 C mol^{-1}**
Log_e (X)	=	**2.303 log_{10}(X)**

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01. What is the correct statement?
(1) Physical properties of polymers are different from each other.
(2) Polymers form saturated solutions.
(3) Polymers have fixed melting points.
(4) Polymers form non viscous solutions.
(5) Molar mass of a polymer is always equal to the amount of monomer used.

02.If the molar mass of polyethylene is 5600 g/mol, what is the degree of polymerization X_n?

(1) 1000 (2) 200 (3) 20000 (4) 2000 (5) 100

03. If the –C-C- distance is 0.40Å, the length of the polyethylene sample in Q 02 is ,

(1) 400 Å (2) 80 Å (3) 200 Å (4) 600 Å (5) 700 Å

04. Consider the statements below:

(a) Thermoset polymers can be recycled.
(b) Polymers form viscous solutions.
(c) Polymers take longer time for dissolution.

What is/are the correct statement/s?
(1) a,b,c (2) a,c (3) b,c (4) a,b (5) a only

05. How many reactive sites are there in CH_2=CH- CH=CH_2?
(1) One (2) Two (3) Three (4) Four (5) None of above

06. Molar mass of the polymer formed by addition polymerization is,
(1) less than the molar mass of reactants.
(2) double that of molar mass of reactants.
(3) nearly same as molar mass of reactants.
(4) three times that of molar mass of reactants.
(5) not predictable.

07. Polymerization of isobutene can be initiated by,
(1) free radical polymerization (2) cationic polymerization (3) anionic polymerization
(4) all of above (5) none of above

08. When natural rubber reacts with methyl methacrylate in the presence of peroxide initiator, the copolymer formed is,
(1) graft (2) block (3) alternate (4) random
(5) block and random

09. Which one of the following polymer cannot be recycled?
(1) Nylon (2) Polyethylene (3)PVC (4)Urea-formaldehyde (5)Polystyrene

10. Vigorous exothermic reaction would occur in which of the following polymerization technique?
(1)Solution (2) Bulk (3) Emulsion (4) Melt condensation (5) Suspension

11. The rate of formation of a free radical from a relevant initiator, depends on
(a) reaction temperature (b)solvents (c) chemical nature
The correct statement /s is/are,
(1) a only (2) a,c only (3) b.c only (4) a,b only (5)All of above

12. Zinc oxide acts as,
(a) a catalyst to reduce the activation energy of the vulcanization reaction
(b) an activator in the presence of fatty acids
(c) an essential ingredient in rubber formulation

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

13. Natural rubber latex can be coagulated by adding

(1) sodium hydroxide (2) ammonia (3) calcium chloride (4) soap (5) none of the above

14. During vulcanization, molar mass of rubber
(1) Increases (2) decreases (3) no change
(4) double that of original mass (5) triple that of original mass

15. Oil resistant rubber products are produced by polymerization of
(1) natural rubber with styrene (2) natural rubber with butadiene
(3) styrene with propylene (4) butadiene with arylonitrile
(5) isoprene with styrene

16. When isoprene is polymerized, the products formed are the polymers of
(a) cis 1-4 adduct (b) trans 1-4 adduct (c) 1-2 & 3-4 adducts

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

17. Which structure of Q 16 is similar to Natural Rubber?
(a) cis 1-4 adduct (b) trans 1-4 adduct (c) cis & trans 1-2 & 3-4 adducts
The correct statement/s is/ are
(1) a only (2) b only (3) c only (4) a & b only (5) b & c only

18. Low molar mass results in solution polymerization technique is due to
(1) temperature (2) steric effect (3) solvant transfer reaction
(4) condensation process (5) diffusion

19. What type of nylon is produced by melt polycondensation between adipic acid and tetrametylene diammine?
(1)Nylon 8,6 (2)Nylon 4,6 (3)Nylon 6,10 (4)Nylon 6,6 (5)Nylon 6,8

20. Which one can be used as a cationic initiator?
(1)BuLi (2)Ph_3CK (3)NaOH (4)KNH_2 (5)BF_3/H_2O

21. Polymers with ddddllldll, lllllllll, dldldldldl, ddddddddd tacticities are,
(1) isotactic, syndiotactic, atactic & isotactic respectively
(2) atactic, syndiotactic, isotactic & isotactic respectively
(3) atactic, isotactic, syndiotactic & isotactic respectively
(4) atactic,atactic, isotactic & syndiotactic respectively
(5) syndiotactic, atactic, isotactic & atactic respectively

22. Plasticizers,
(1) are high molecular weight volatile substances
(2) increase the glass transition temperature
(3) are used in large quantities to get the required effect
(4) are mostly solids
(5) reduce the cohesive forces of attraction between polymer chains.

23. Which of the following statement is incorrect?
(1)The change from solid to rubbery state is called glass transition temperature.
(2)Above T_g, polymer shows visco-elastic properties.
(3)Below T_g, polymer is in glassy state.
(4)Above T_g, polymer is in glassy state.
(5)Glass transition is a reversible physical change.

24. The ratio of crystalline polymer to amorphous polymer depends on
(a) rate of cooling (b) temperature of cooling (c) chemical nature

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

25.For unsymmetrical polymers
(1) $T_g = \frac{1}{3}T_m$ (2) $T_g = 2T_m$ (3) $T_g = \frac{2}{3}T_m$ (4) $T_g = \frac{1}{2}T_m$ (5)$T_g = T_m$

26. Which of the following statement is incorrect?
(1)Crystalline & amorphous components influence properties of polymers.
(2)Overall property (Q) of semicrystalline polymer is given by $Q = Q_{amor} + Q_{cryst}$
(3)For symmetrical polymers $T_m = 2T_g$
(4)Density of a polymer substance increases from liquid phase to crystal
(5)Amorphous region is similar to arrangements in solids

27. Syndiotactic polymers form
(a) crystalline polymers (b) semi- crystalline polymers (c) amorphous polymers

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

28. Which one has the highest T_g value?
(1) polyproplylene (2) polystyrene (3) poly(vinyl biphenyl)
(4) poly(vinyl acetate) (5) poly(vinyl chloride)

29.T_g is increased by
(a) the presence of aromatic rings in the chain backbone
(b) addition of plasticizers
(c) introducing cross links among polymer chains

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

30. Which of the following method cannot be used to determine Tg?

(1)NMR spectroscopy (2) Dilatometry (3) Differential scanning calorimetry
(4) UV-visible spectroscopy (5) Infrared spectroscopy

31. Solubility of polymers depend on
(a) the temperature
(b) stirring
(c)force of interaction between solvent and polymer molecules

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

32. Polymer is soluble only if
(1)$\Delta H_m = T\Delta S_m$ (2)$\Delta S_m = \Delta H_m$ (3)$\Delta G_m > 0$ (4) $\Delta H_m < T\Delta S_m$ (5) $\Delta H_m > T\Delta S_m$

33.If V_1, V_2 and δ_1, δ_2 are volume fractions and attractive forces of solvent and polymer respectively, The heat of mixing of polymer can be expressed as

(1) $\delta_1\delta_2(V_1-V_2)$ (2) $V_1V_2(\delta_1-\delta_2)$ (3) $V_1V_2(\delta_1+\delta_2)$ (4) $V_1V_2(\delta_1+\delta_2)^2$ (5) $V_1V_2(\delta_1-\delta_2)^2$

34. Weight average molar mass can be determined using
(a) osmometry (b) light scattering method (c) ultracentrifuge technique

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

35. Flow time taken by a polymer solution and the solvent is 1000 s and 100 s respectively. Specific viscosity of the polymer is
(1) 10 (2) 9 (3) 15 (4)100 (5) 12

36.If the polymer sample having 3 molecules of molar masses 1×10^5, 2×10^5 and 3×10^5 g/mol , the number average molar mass, M_n of the polymer sample is

(1) 3×10^5 g/mol (2) 2×10^5 g/mol (3) 5×10^5 g/mol
(4) 1×10^5 g/mol (5) none of above

37. Weight average molar mass, M_w of the sample in Q36 is
(1) 1.56×10^5 g/mol (2) 5.28×10^5 g/mol (3)2.33×10^5g/mol
(4) 1.0×10^5 g/mol (5) none of above

38. Polydispersity factor of the sample in Q36 is,
(1) 5.28/3.0 (2) 1.00/5.28 (3) 1.56/5.00 (4) 2.33/2.0 (5) 2.0/2.33

For Q_{39} –Q_{40}, the polydispersity values of five polymer samples are
(1) 3.0 (2) 1.0 (3) 2.8 (4) 1.1 (5) 2.5

39. Which polymer sample has comparatively narrower distribution curve?

40. Which polymer sample has number average molar mass, M_n nearly equal to the weight average molar mass?

41. Carother's equation for the polymerization of A-B type monomer is,

(1) $X_n=(1-p)^2$ (2) $X_n=1/(1-p)$ (3) $X_n=(1-p)$ (4) $X_n=1/(1-p)^2$
(5) $X_n=(1+p)$

42. Polydispersity factor of the monomer in Q 41 can be represented as

(1) p (2) 3p (3) (1-p) (4) (1+p) (5) $(1-p)^2$

43. If the monomer conversion (p) in Q 41 is 0.99, the degree of polymerization(X_n) is
(1) 10000 (2)1000 (3) 1 (4) 100 (5) 10

44. In the free radical polymerization, the chain length of a polymer
(1) increases (2) decreases (3) doubles (4) triples
(5) does not affect with increasing temperature

45. What is the main difference between rate equation for cationic polymerization & free radical polymerization?

(1) Second order with respect to monomer in cationic polymerization where as it is first order in free radical polymerization
(2) First order with respect to monomer in cationic polymerization where as it is second order in free radical polymerization
(3) Zero order with respect to monomer in cationic polymerization where as it is first order in free radical polymerization
(4) First order with respect to monomer in cationic polymerization where as it is zero order in free radical polymerization
(5) Second order with respect to monomer in cationic polymerization where as it is zero order in free radical polymerization

46. The chain length of polymers
(1) increase (2) decrease (3) do not change (4) double
(5) triple when transfer agents are used in termination step.

47. Kinetic chain length(υ) is defined as
(1) (rate of initiation)/(rate of termination)
(2) (rate of propagation)/(rate of initiation)
(3) (length of repeat unit) × (number of repeat units)
(4) root mean square end to end distance
(5) none of above.

48 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

49. Rate equation for anionic polymerization of styrene in liquid NH_3 is,

(1) $-\frac{d[M]}{dt}=\frac{k_{fr}[NH_3]}{k_1k_p[I][M]^2}$ (2) $-\frac{d[M]}{dt}=\frac{k_ik_p[I][M]^2}{k_{fr}[NH_3]}$ (3) $\frac{d[M]}{dt}=\frac{k_{fr}[NH_3]}{k_1k_p[I][M]}$

(4) $\frac{d[M]}{dt}=\frac{k_ik_p[I][M]}{k_{fr}[NH_3]}$ (5) $\frac{d[M]}{dt}=\frac{k_{fr}[NH_3]}{k_1k_p[I][M]^3}$

50 In polymerization of styrene in liquid NH_3 initiated by KNH_2, the degree of polymerization is given by

(1) $(k_pk_{fr})\frac{[M]}{[NH_3]}$ (2) $(k_pk_{fr})\frac{[NH_3]}{[M]}$ (3) $(k_p)\frac{[M]}{[NH_3]}$ (4) $\frac{k_p[M]}{k_{fr}[NH_3]}$ (5) $\frac{k_p[NH_3]}{k_{fr}[M]}$

The Open University of Sri Lanka

B.Sc Degree/Stand alone courses in Science-Level 5
Final Examination-2010/2011

CHU3238/CHE 5238-Polymer Chemistry-Paper II

Duration: 2 Hours

Date: 06.07.11 **Time: 1.30 p.m-4.30 p.m**

Gas Constant (R)	=	**8.314 J $mol^{-1}K^{-1}$**
Avogadro Constant (L)	=	**6.023×10^{23} mol^{-1}**
Planks Constant (h)	=	**6.63×10^{-34} Js**
Velocity of light (C)	=	**3.0×10^{8} ms^{-1}**
Atmospheric Pressure()	=	**10^5Pa (Nm^{-2})**
Faraday Constant (F)	=	**96,500 C mol^{-1}**
Log_e (X)	=	**2.303 log_{10}(X)**

Instructions to candidates.

Answer any **four questions** out of six.
If more than four questions are answered **only the first four** answers will be marked.
The use of a **non-programmable** calculator is permitted.

01. (a) i. What type of initiators can be used to polymerize CH_2=CH-C≡N
Explain your answer.
ii. Comment on the differences between free radical & ionic polymerization.

iii. The degree of polymerization of a sample of poly propylene is 200. What is the molar mass of this polymer?

(40 marks)

(b) i. Explain how graft copolymers are prepared.
ii. ABS (Acrylonitrile – Butadiene – Styrene) is a tough polymer.
Why this is so?

(30 marks)

(c) i. Discuss the difference between solution and emulsion polymerization?
ii. Name one industrial application of each polymerization technique mentioned in(i).

(30 marks)

2. (a) i. What factors expedite the breakdown of polymers?
ii. Explain the reasons for the yellowing of polystyrene on prolong exposure to sunlight.
iii. What precautions you can take to prevent the problem mentioned in (ii)?
(40 marks)

(b) What are the common preservatives used in latex industry? Explain the role of each preservative.
(15 marks)

(c) Why does excess sulphur result in hard rubber? Explain this by taking natural rubber as an example.
(15 marks)

(d) i. What are the types of fillers used in polymer industry?
ii. Give examples for each type of fillers.
iii. What are the industrial applications of these type of fillers?
(30 marks)

3.(a) What factors result regular arrangements in polymers?
(20 marks)

(b) "Natural rubber and synthetic rubber are made up of isoprene units but their properties are different" Comment on this statement.
(20 marks)

(c) Describe the changes in the molecular behaviour of glassy state polymer as the temperature increases above T, below T_g.
(30 marks)

(d) i. The T_g values of four acrylates are given below.

poly (methyl acrylate) 279K
poly (ethyl acrylate) 249K
poly (propyl acrylate) 225K
poly (butyl acrylate) 218K

What trend you can observe from above data? Give reasons.

ii. Describe the significance of glass transition temperature.
(30 marks)

4.(a) Briefly explain the factors affecting the crystallinity of a polymer.
(20 marks)

(b) How does the crystallinity change the physical properties of polymers? Explain.
(20 marks)

(c) Polyisobutyl has unit cell dimension of approximately 18 Å×12 Å ×7 Å and contains two chains of eight repeat units each per unit cell. Calculate the density of 100% crystalline poly isobutyl.
(40 marks)

(d) Why do crystalline polymers are less soluble than amorphous polymer?
(20 marks)

5. (a) i. Define the term "specific viscosity" in terms of flow time.
ii. Intrinsic viscosity of a polystyrene sample is 0.04 dl/g. If $k=1.6\times10^{-4}$ dl/g and $\alpha = 0.60$, calculate the molecular mass of polystyrene sample.

(40 marks)

(b) i. What are the methods you could used to determine number average molar mass (M_n)? List three of them.

ii. A hypothetical sample consists of equal weights of polymer having molecular weights of 30, 000, 60, 000 and 90, 000 g/mol.
Calculate the number average molar mass (M_n), weight average molar(M_w) and polydispersity factor of above polymer sample.

iii. Describe (by giving relevant equations) how you would use osmometry technique to determine the number molar mass of a polymer.

(60 marks)

6. (a) i. What is meant by ceiling temperature?
ii. What type of reactions occurs at the ceiling temperature?

(20 marks)

(b) i. What are the assumptions used in the derivation of equation for rate of polymerization? Briefly outline the reason for each.

ii. When acrylonitrile polymerize in a homogeneous solution of benzene, calculate the initial rate of polymerization if the k_I(in benzene)$=1.5\times10^{-5}$ s^{-1}, $k_p=2.0\times10^3 dm^3mol^{-1}s$, $k_t=7.3\times10^8 dm^3mol^{-1}s^{-1}$.

(50 marks)

(c) Suggest a method to determine the rate of polymerization of polystyrene.

(20 marks)

(d) "Average molar mass of the polymer formed in anionic polymerization is smaller than those formed by the free radical polymerization" Comment on this statement.

(10 marks)