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THE OPEN UNIVERSITY OF SRI LANKA

B.Sc. DEGREE/STAND ALONE COURSES IN SCIENCE – LEVEL 5

FINAL EXAMINATION -2009/2010

CHU3238/CHE5238 – POLYMER CHEMISTRY – I

DURATION : THREE (03) HOURS

Date : 18th June 2010 Time : 9.30 a.m. 11.30 a.m.

- 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.**
- **1/6th marks** will be deducted for each incorrect answer.
- The use of a **non-programmable** electronic calculator is permitted.
- Logarithm tables and graph paper will be provided.

Gas Constant (R)	=	**8.314 JK^{-1} mol^{-1}**
Avogadro Constant (L)	=	**6.023×10^{23} mol^{-1}**
Planck Constant (h)	=	**6.63×10^{-34} Js**
Velocity of light (C)	=	**3.0×10^{8} ms^{-1}**
Atmospheric Pressure (π)	=	**$10^5 Pa(Nm^{-2})$**
Faraday constant (F)	=	**96,500 C mol^{-1}**
$Log_e(X)$	=	**2,303 log_{10} (X)**

01. Which monomer can be easily polymerized by using KNH_2 as an initiator.

i. $CH_2 = CH_2$ ii. $CH_2 = C(CN)(COOC_2H_5)$
iii. $CH_2 = CHCN$ iv. $CH_2 = C(CH_3)_2$
v. $CH_2 = CHCl$

02. Polymers differ from simple organic molecules by not having fixed (definite)

i. melting point
ii. boiling point
iii. dissolution
iv. molar mass
v. all of the above

What is the most probable answer?

03. Polymer physical properties are dependent on

i. degree of crystallinity
ii. amorphous nature
iii. T_g
iv. size
v. none of the above

What is the irrelevant statement?

04. Molar mass of polyester during polymerisation can be controlled by mixing

i. Acetic acid ii. Alcohol
iii. Different ratios of the two monomers
iv. Stoichiometric ratios of the monomers
v. inhibitor

What is the wrong answer?

05. What is the most favourable mode of addition in the polymerisation of styrene by $I^{\bullet}$ radical

i. Head to Head ii. Head to tail iii. Tail to head
iv. tail to tail v. none of the above.

06. Name the probable mechanism involved in the termination process of the polymerisations of propylene by cationic initiator.

i. combination ii. Disproportionation
iii. Solvent transfer iv. Monomer transfer
v. rearrangement

07. Which of the following does not form polymer with toluene di isocyanate

i. $HO - CH_2 - CH_2 - OH$ ii. H_2O iii. CO_2
iv. $(CH_2)_4$ $HOOC(CH_2)_4COOH$ v. $H_2N\text{-}(CH_2)_6 - NH_2$

08. When 100 molecules of dimethyl terepthalate is condensed with equal number of glycol molecules, mass of the byproduct formed is

i. 3168 ii. 1782 iii. 6368
iv. 3568 v. 6000gm

09. When natural rubber is fully hydrogenated, the resulting polymer appears as

i. random ethylene and isoprene
ii. alternate ethylene and isoprene
iii. alternate ethylene and propylene
iv. block ethylene and propylene
v. alternate copolymer ethylene and isoprene

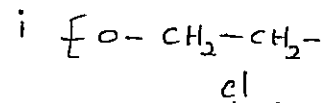
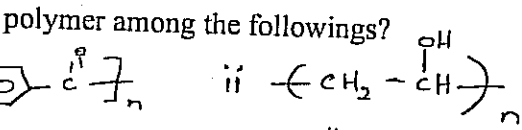
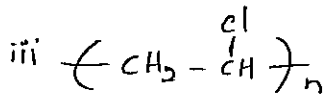
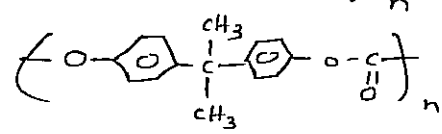
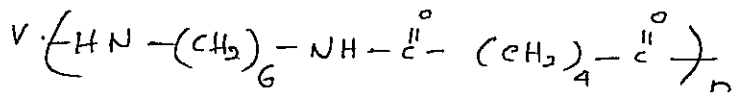
10. Name the wrong observation, when a rigidform sample was exposed to sun light for a lengthy period.

i. yellow discolouration ii. No colour change
iii. molar mass change iv. Hardness change
vi. solubility change

11. The most effective way of deteriorating tyre in service is by

i. O_3 ii. O_2 + heat iii. O_2 + light
iv. O_3 + mechanical stress v. O_3 + light

12. Which one is the most heat resistant polymer among the followings?

i 
ii 
iii 
iv. 
v 

13. Which one is the most impact resistant polymer in Q 12?

i. ii. iii. iv. or v.

14. Which polymer is insoluble in methyl ethyl ketone?

i. phenol – formaldehyde resin
ii. chloroform rubber
iii. nitro cellulose
iv. nitrile rubber
v. natural rubber

15. A Crystalline and an amorphous polymer (same repeating unit) can be distinguished from each other by
    i. solubility
    ii. plasticizing effect
    iii. density
    iv. hardness
    v. none of the above
    what is the wrong answer?

16. Polymer-$(CH_2 - \underset{X}{CH})_n$- has high T_g when X is

    i. OH ii. -CN iii. $-C_6H_5$
    iv. $-C_2H_5$ v. -Cl

17. Teflon $(-CF_2-CF_2-)_n$ is used as a heat resistant coating material due to its
    i. inorganic nature
    ii. high fractional coefficient
    iii. helix structure arrangement
    iv. crystallinity
    v. all of the above
    What is the most relevant statement?

18. Phthalates are used as plasticizers for PVC because they have
    i. high volatility ii. same polarity
    iii. similar density iv. similar solubility
    vi. lower volatility
    what is the wrong statement?

19. The volumes of five polyethylene samples of the same mass are given below.
    i. $\frac{10}{0.917}$ ii. $\frac{10}{0.932}$ iii. $\frac{10}{0.945}$
    iv. $\frac{10}{0.952}$ v. $\frac{10}{0.98}$
    Which sample has the lowest degree of crystalinity?

20. Assume combination as the only termination process in the polymansation of propylene ($CH_2 = CH\ CH_3$) and the kinetic chain length is x, the number average molar mass $\overline{M}_n$ is
    i. 21x ii. 14x iii. 42x iv. 84x v. 28x

21. If disproponation is the prominent termination process in the polymerisation of ethylene and kinetic chain length is v, then $\overline{M}_n$ is
    i. 14v ii. 9v iii. 28v iv. 56v v. 42v

22. What is the wrong assumption stated in the derivation of rate equation for free radical polymensation is
    i. monomer concentration in the initiation step is negligible.
    ii. activity of all polymer radicals are equal
    iii. rate of initiation is equal to rate of termination.
    iv. Steady state assumption
    v. Rate of initiation is equal to rate of propagation

23. Rate equation for cationic polymerisation is
    i. 1^{st} order w. r. t. monomer concentration
    ii. 2^{nd} order w.r.t. monomer concentration
    iii. 0^{th} order w.r.t. monomer concentration
    iv. 1^{st} order w.r.t. catalyst concentration
    v. Is independent of catalyst concentration
    What is the correct statement?

24. A mixture of 3 different polymers formed when monomer $CH_2 = CHX - CH=CH_2$ is polymerized if X is
    i. H ii. CH_3 iii. Cl iv. C_2H_5 v. OH

25. In butadiene polymensation syndiotactic polymer is produced by
    i. 1, 2 addition
    ii. 1, 4 addition
    iii. 1, 4 addition cis structure
    iv. 1,4 addition trans structure
    v. None of the above

26. Which one of the following catalysts is most suitable to produce a living polymer from $CH_2 = CH\text{-}CN$
    i. benzoyl peroxide ii. $Al(CH_3)_3/TiCl_3$
    iii. BF_3/H_2O iv. HCl
    vi. KNH_2

27. Lowest activation energy complex is formed by
    i. rubber + sulphur
    ii. rubber + sulphur + accelerator
    iii. rubber + sulphur + accelerator + ZnO
    iv. rubber + sulphur + accelerator + ZnO + stearic acid
    v. rubber + sulphur + accelerator + ZnO + antioxidant

28. Disadvantage of solution polymerisation is
    i. expensive process
    ii. results low molar mass
    iii. recovery of solvent is expensive
    iv. cannot be used as it is in application
    v. termination occurs through solvent transfer
    what is the wrong answer?

29. What is the percentage conversion of the monomer caprolactum required to produce nylon 6, its degree of polymerisation being 10,000?
    i. 99% ii. 99.90% iii. 99.990%
    iv. 99.9990% v. 99.91%

30. What is the molar mass (g/mol) of the polymer, if the % conversion is 99.90 in Q. 29?
    i. 11,300 ii. 113,000 iii. 22,600
    iv. 226,000 v. 5650

31. A polymer will dissolve in a given solvent at a given temperature if
    i. ΔH is + ve and > $T\Delta S$(> greater than)
    ii. ΔH is - ve and > $T\Delta S$
    iii. $\Delta H = 0$
    iv. ΔH is + ve and less than $T\Delta S$
    v. ΔH is –ve and less than $T\Delta S$
    What is the wrong statement?

32. Exothermic nature of free radical polymerisation is due to conversion of
    i. σ to σ^* bond
    ii. σ to π bond
    iii. π to π bond
    iv. π to σ bond
    v. π to π^* bond

33. Number of NMR peaks possible for the polymer – CH_2-$C(CH_3)_2$ – is
    i. 1 ii. 2 iii. 3 iv. 4 v. zero

34. Number of vibrational degree of freedom in polystyrene is
    i. 0 ii. 21 iii. 42 iv. 6 v. 12

35. With the increase of molar mass and crystallinity
    i. elasticity increases
    ii. hardness increases
    iii. solubility decreases
    iv. heat resistivity decreases
    v. air permeability increases
    What is the incorrect statement?

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36. Concentrated natural rubber latex
    i. contains 60% of dry rubber
    ii. stabilized by adding ammonia
    iii. is coagulated by adding Ca^{2+} ions
    iv. is coagulated by adding acetic acid
    v. yellow colour is due to Mg^{2+} ions
    What is the wrong statement?

37. Field latex (natural rubber)
    i. iso-electric point is pH 4.5
    ii. is auto coagulated by bacteria
    iii. viscosity decreases due to presence of rubber bound aldehyde
    iv. can be concentrated by dichloro decantation process
    v. Yellow color can be removed by bleaching
    What is the wrong statement?

38. Accelerators are used in rubber formation
    i. to reduce the vulcanizing time
    ii. to reduce the activation energy
    iii. to increase rate of valcanisation
    iv. to form sulphur intermediate compounds.
    v. to vulcanize at room temperature.
    What is the irrelevant statement?

39. Rate of vulcanization is increased
    i. by adding accelerator only
    ii. by adding ZnO only
    iii. by adding stearic acid only
    iv. by adding ZnO+ stearic acid only.
    v. by adding accelerator + ZnO + stearic acid
    What is the most correct answer?

40. The glass transition temperature of five different polymer samples are
    i. -10^0C ii. 20^0C iii. 27^0C
    iv. 35^0C v. 100^0C
    What is the most flexible polymer?

41. Which one of the polymers in Q 40 has high modulus?

42. Five polymer samples A, B ,C D and E of density 0.90, 0.92, 0.95, 0.97, 0.99 respectively, when sudden cooled after melting, found to be having the same density. Which one of the above polymers has high elasticity?
    i. A ii. B iii. C iv. D v. E

43. Which one of the polymers in Q.42, has poor air permeability.

44. Polydispersity factor of five polymer samples of the same repeat unit are
i. 3.5 ii. 3.0 iii. 4.0 iv. 2.0 v. 1.2
Assuming $\overline{M}_n$ of all the samples are the same; which one is having the highest $\overline{M}_w$?

45. Highest polydispersity factor of the above Q 44 is the polymer synthesised by
i. free radical emulsion polymerisation
ii. free radical suspension polymerisation
iii. free radical solution polymerisation
iv. free radical bulk polymerisation
v. condensation polymerisation

46. If $\overline{M}_n$ is the molar mass of unvulcanised rubber after vulcanization,
i. molar mass increases
ii. viscosity increases
iii. viscosity decreases
iv. molar mass and viscosity decreases
v. molar mass and viscosity increases.
What is most relevant answer?

47. If $\overline{M}_n$ is 10^5 g/mol and after vulcanization only disulphides are formed, then the molar mass of the rubber is
i. 100032 ii. 100064 iii. 100016
iv. 100048 v. 100096

48. What is the minimum quantity of pure phenol required to produce phenol - formaldehyde thermoset from 550 (g) of 40% formaldehyde?.
i. 94 ii. 47 iii. 141
iii. 188 v. 160grm

49. Average molar mass of a polymer sample determined by light scattering is 27000 g/mol. If the polydispersity factor of the polymer sample is 1.8, what is the molar mass of the polymer determined by osmometry?
i. 18000 ii. 15000 iii. 12000
iv. 21000 v. 24000

50. Molar masses of five polymer samples determined by osmometry are
i. 18000 ii. 15000 iii. 12000
iv. 21000 v. 24000
Assume molar masses of the polymer samples determined by light scattering is 27000 g/mol. Which of the above samples shows a narrow distribution curve?

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B.Sc. DEGREE/STAND ALONE COURSES IN SCIENCE – LEVEL 5

FINAL EXAMINATION -2009/2010

CHU3238/CHE5238 – POLYMER CHEMISTRY – II

DURATION : THREE (03) HOURS

Date : 18th June 2010 Time : 1.30 p.m. 4.30 p.m.

Gas Constant (R)	=	**8.314 JK^{-1} mol^{-1}**
Avogadro Constant (L)	=	**6.023×10^{23} mol^{-1}**
Planck Constant (h)	=	**6.63×10^{-34} Js**
Velocity of light (C)	=	**3.0×10^{8} ms^{-1}**
Atmospheric Pressure (π)	=	**10^{5}Pa(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) What are the initiators used for the polymerization of following monomers?
$CH_2 = C(CH_3)_2$, $CH_2 = CH(CN)$, $CH_2 = C(CN)(COOC_2H_5)$

b) Give reasons for your selection.

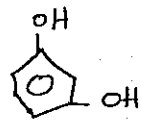
c) Write down the initiation step for each of the above monomers. Discuss the stability of first monomer radical formed.

d) What are the main differences between free radical and cationic polymerization? Discuss with suitable examples.

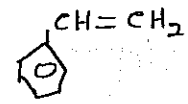
e) What are the advantages and disadvantages of bulk polymerization?

(100 marks)

02. a) How many reactive sites are there in the following monomers?



, HOOC – CH = CH – COOH,



Explain how to produce thermoset or thermoplastic polymers from the above three monomers separately with suitable chemicals.

b) Write down one application for each of the thermosets or thermoplastics mentioned above.

c) Name the catalyst used in the preparation of stereo regular poly propylene from propylene, $CH_2 = CH\ CH_3$

d) Draw the structure responsible for crystallinity in polypropylene.

e) Write brief notes on
i. fillers ii. mechanical degradation
iii. Ribbed smoked sheets

(100 marks)

03. a) Draw the structures of high density polyethylene and nylon 6,6. Which polymer is having more moisture absorbing property? Give reasons for your answer.

b) i. Write down the basic principles involved in the oxidation of polymers.
ii. What are the main factors which expedite the deterioration of polymers?

c) Polypropylene is easily degraded by the atmosphere than polyethylene. Give reasons for this difference.

d) What is storage hardening of field latex? Suggest methods adopted to overcome this problem.

e) Explain why physical properties of cross linked polymers are different from their pre-polymers?

(100 marks)

04. a) What is glass transition temperature (T_g)of a polymer?

b) Describe a physical property used to determine T_g.

c) i. Explain the effects of plasticizers mixing with polymers on T_g.

ii. What are the important properties to be considered in selecting a suitable plasticizer for a polymer?

d) A semi crystalline polymer sample of mass 5g was melted and by sudden cooling, it's volume was increased by 2%. When the same sample was fully crystallized, it's volume was decreased by 1%.

i. Calculate the degree of crystallinity.

ii. What are the assumptions used in the calculation?

(100 marks)

05. a) Four polymer molecules of molar masses 12,000; 24000; 30,000 and 36,000 g/mol are mixed and their respective mole fractions in the sample are 0.2, 0.3, 0.4 and x.

i. Calculate $\overline{M}_n$ and $\overline{M}_w$ for the polymer sample. Derive all equations used in the calculation.

ii. Comment on the molar mass distribution curve.

b) Heat of dissolution (ΔH_{mixing}) is an important parameter governing solubility of polymers in solvent. Explain reasons for the above.

(100 marks)

06. a) A polyester of average molar mass of 192,000 g/mol was prepared by condensing equal concentrations of 2 mol/dm^3 of phthalic anhydride and glycol (HO-CH_2-CH_2 - OH) without a catalyst.

i. How long the above reaction to be carried out to produce the required polyester.
Rate constant of the reaction is 3.5×10^{-1} (mol/dm^3)$^{-2}$ s^{-1} at mass of
C = 12.00 H = 1.00 O = 16.00

b) If the molar ratio is changed to 1:1.05 (phthalic to glycol), what is the molar mass of the polyester? Assume same percentage conversion as in question a) i..

c) Comment on the differences in molar mass when the molar ratios are changed from 1:1 to 1:1.05.

(100 marks)