[4228]-301
M.Sc.
POLYMER SCIENCE
PS - 310 : Chain Polymerization
(2008 Pattern) (Semester - III)

Time : 3 Hours]   *[Max. Marks : 80*

Instructions to the candidates:
1) *All questions are compulsory.*
2) *Answers to the two sections should be written in separate answer books.*
3) *Figures to the right indicate full marks.*
4) *Use of logarithmic table / calculator is allowed.*

SECTION - I

Q1) Attempt any four of the following :   **[20]**

   a) Differentiate between initiator and catalyst. List the various stages in the free radical polymerization.

   b) How can one control the molecular weight in free radical polymerization?

   c) Derive the expression for overall rate of polymerization as a function of conversion in free radical polymerization.

   d) Temperature and pressure have a profound effect in radical polymerizations. Discuss.

   e) Describe the cationic mechanism of chain polymerization.

   f) Write a note on kinetic chain length in free radical polymerization.

Q2) Attempt any four of the following :   **[20]**

   a) What is cross propagation in controlled radical co-polymerization? Discuss its significance.

   b) Write a short note on Reversible Addition Fragmentation Termination polymerization.

   c) Describe Mayo method for determination of r_1 and r_2.

   d) Derive the expression for degree of polymerization in cationic polymerization.

   e) What is emulsion polymerization? Is it possible to adapt to cationic and anionic polymerization?

   f) Distinguish between random, graft and block copolymers. Describe one method of preparation of graft and block co polymers.

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Q3) Attempt any four of the following : **[20]**

a) What is azeotropic copolymer composition? Discuss the conditions under which azeotropic copolymer composition is possible for binary systems.

b) For the following values of r_1 and r_2 what type of polymers will be expected?

   i) $r_1 = 0, r_2 = 0,$

   ii) $r_2 \gg 0, r_2 \gg 1,$

   iii) r_1 infinity, r_2 infinity. Justify your answer.

c) Explain why monomers show different reacting tendencies in binary copolymerization.

d) Describe importance of reactivity of monomers and radicals in explaining mechanism of copolymer formation.

e) Describe any one method for the synthesis of following

   i)   copolymers of polystyrene and

   ii)   fluoro carbon polymers.

f) Describe the bulk polymerization process for the preparation of polystyrene. State the advantages and limitations of bulk polymerization.

Q4) Attempt any four of the following : **[20]**

a) With suitable chemical equations state if it is possible to obtain structural variation when vinyl chloride is polymerized? State important applications of the resulting polymer.

b) Write a note on Ziegler - Natta catalyzed manufacture of polypropylene.

c) What is SBR? Give its preparation and important applications.

d) How is isoprene prepared? Comment on its polymerization to give polyisoprene.

e) Write a short note on SAN polymers.

f) Describe a method for the synthesis of 2 - chloro - 1, 3 - butadiene. How is it polymerized? Give its applications.

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[4228]-302
M.Sc.
POLYMER SCIENCE
PS - 311 : Condensation Polymerization
(Semester - III) (2008 Pattern)

Time : 3 Hours]   *[Max. Marks : 80*

Instructions to the candidates:
1) *All questions are compulsory.*
2) *Answers to the two sections should be written in separate answer books.*
3) *Figures to the right indicate full marks.*
4) *Use of logarithmic table / calculator is allowed.*

SECTION - I

Q1) Attempt <u>any four</u> of the following :   **[20]**

a) In the absence of an externally added acid catalyst, the diacid monomer acts as a catalyst in esterification reaction. Please elaborate.

b) Enlist the factors responsible for the non - linearity in the third order plot for self - catalyzed step polymerization reaction.

c) Calculate the weight fraction of trimer in step polymerization carried to 99.6 % conversion.

d) In the preparation of linear polymers by step polymerization of polyfunctional monomers, there is a competitive cyclization reaction. Please explain.

e) Write a short note on Carothers Equation.

f) Write a short note on synthesis and utility of alternating and block copolymers.

**Q2)** Attempt any four of the following :   **[20]**

a) Give two examples of step growth polymerization reaction wherein there is no formation of by product.

b) Write in detail how stoichiometric balance affects the DP in condensation polymers.

c) In a typical polyesterification reaction, time taken from start to 98% conversion is equal to the time taken for the conversion from 98% to 99%. Comment.

d) Write a note on the synthesis of polycarbonates by melt polycondensation.

e) Differentiate between dendrimers and hyperbranched polymers. Explain the concept of generation in hyperbranched polymers.

f) Write a note on divergent and convergent approaches for preparing hyperbranched polymers.

SECTION - II

Q3) Attempt <u>any four</u> of the following :   **[20]**

a) Give at least three methods of synthesis of polyimides. Give at least four applications.

b) Comment on the Tg of the polycarbonates shown below.
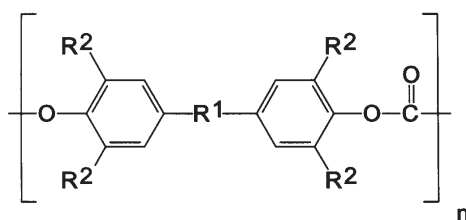
R^1	R^2	Tg, °C
CH_2	H	147
$C(CH_3)_2$	H	149
$C(PH)_2$	H	121
$C(CH_3)_2$	CH_3	210
SO_2	CH_3	260

c) Show by equations the polymerization of melamine and formaldehyde to form a crosslinked structure.

d) Typically how is polyurethane flexible foam prepared? Explain your answer with suitable equations.

e) Write a short note on unsaturated polyesters and alkyds.

f) Compare crosslinking reactions in phenol - formaldehyde and urea - formaldehyde resins.

Q4) Attempt <u>any four</u> of the following :   **[20]**

a) Write a note on 5-membered heterocyclic polymers.

b) In the manufacture of epoxy polymer, how is the molecular weight of the prepolymer controlled?

c) Hydroxyl terminated polyethers are preferred over hydroxyl terminated polyesters in the alcohol - isocyanate reactions. Explain why?

d) In the manufacture of silicone containing polymers, describe the change in reaction conditions leading to the change in the properties of the polymer obtained.

e) What are UF resins? With suitable chemical reactions, explain curing of UF resins.

f) What are resol polymers? How do they differ from Novolak polymers?

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[4228]-303
M.Sc.
POLYMER SCIENCE
PS - 312 : Physical Chemistry of Polymers
(2008 Pattern) (Sem. - III)

Time : 3 Hours]   *[Max. Marks : 80*

Instructions to the candidates:
1) *All questions are compulsory.*
2) *Answers to the two sections should be written in separate answer books.*
3) *Figures to the right indicate full marks.*
4) *Use of logarithmic table / calculator is allowed.*

SECTION - I

Q1) Attempt any four of the following :   **[20]**

a) Explain how the thermal transitions in polymers are measured using dialatometry and DSC techniques.

b) What is secondary glass transition temperature? How is it different from the primary glass transition temperature?

c) What is quenching? Comment on the thermal/mechanical properties of melt and solution crystallized polymers.

d) Define heat capacity. Describe the construction of a suitable instrument and its use in the determination of glass transition temperature of polymers.

e) Explain why
  i) nylon 6 is highly crystalline,
  ii) poly(vinyl carbazole) is amorphous and
  iii) polyvinyl alcohol is crystalline.

f) What is Schatzki crankshaft model? Give examples to explain your answer.

Q2) Attempt any four of the following :   **[20]**

a) Define heat capacity and heat flow in polymers. Write the structure of the following polymers and arrange them in increasing order of Tg. Give reasons for your answer.

   Natural rubber (cis and trans) and polybutadiene (cis and trans).

b) What is "shish kebab" model? How is it obtained? What does it signify?

c) Discuss the phenomenon of chain folding in polymers. Provide evidence in support of chain folding and the conditions under which it occurs.

d) How does hydrogen bonding in polymers affect the Tg and Tm in polymers? Nylon 66 and Kevlar form fibers. Which is more crystalline and why?

e) What is quenching? Comment on the thermal / mechanical properties of melt and solution crystallized polymers.

f) Name two techniques to study the kinetics of the development of crystallinity in polymers. What is Avrami expression? Explain the terms involved in it.

SECTION - II

Q3) Attempt any four of the following :   **[20]**

a) Write a note on the different models to explain chain dimensions.

b) Write a note on Hildebrand solubility parameter? What are the units?

c) Citing examples, bring out the differences in solubility of amorphous and crystalline polymers.

d) What is the importance of LCST and UCST?

e) Explain with diagrams the virial coefficients.

f) Write a note on Flory Huggins interaction parameter.

Q4) Attempt any four of the following :   **[20]**

a) Write a short note on hydrodynamic volume and excluded volume? What is the origin of excluded volume?

b) What are the different types of solutions formed when a polymer solute is added to a solvent. Explain with suitable diagrams.

c) Explain the role of high energy radiation in bringing out chemical changes in polymers? How are the properties of polymers affected?

d) Mention and describe industrial applications of radiation chemistry relevant to polymers.

e) Write a short note on radiation induced polymerization.

f) Determine the solubility parameter of poly - n - hexyl acrylate assume the following :

Group	Fsmall	Fvolume
$-CH_2-$	133	16.45
$>C<$	–93	4.75
$-CH_3$	214	22.8
$-COO-$	310	21.0

Density of poly - n - hexyl acrylate is 1.05.

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[4228]-304

M.Sc.

POLYMER SCIENCE

PS - 313 : Analytical Chemistry of Polymers

(2008 Pattern) (Sem. - III)

Time : 3 Hours]   *[Max. Marks : 80*

Instructions to the candidates:

    1)   *All questions are compulsory.*

    2)   *Answers to the two sections should be written in separate answer books.*

    3)   *Figures to the right indicate full marks.*

    4)   *Use of logarithmic table / calculator is allowed.*

SECTION - I

Q1) Attempt the following :

    a) Determine the structures of the monomer **A**, the copolymer **B** and the derived polymer **C**. Determine the ratio of the two monomers in **B** from the data given below. Explain your answer.
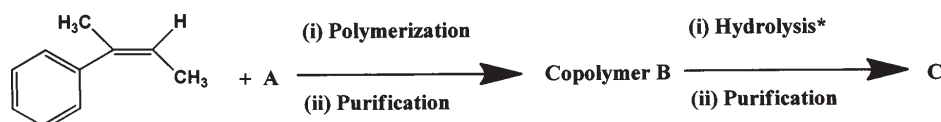
    * Assume no backbone degradation during hydrolysis.

        A : C_5H_7N; IR: 2150, 1625, 960 cm^{-1}. UV : 212 nm $\varepsilon \sim 10000$.

        B :   Mol. Wt. 11160; IR : 2200, 1605, 1495, 765, 695 cm^{-1}.

   **C** :   Mol. Wt. 11920; IR : 3300 to 2500 broad, 1720, 1605, 1495, 765, 695 cm^{-1} **[4]**

    b) Draw structures of six olefinic esters with the formula $C_4H_6O_2$. Indicate, giving approximate values, how each of these can be differentiated from their IR spectra.   **[8]**

Q2) Answer any one of the following : **[10]**

a) The hydroxy acid 1 could be used as a monomer for the preparation of polyesters. Make a neat sketch of its ^{1}H-NMR. Consider chemical shift, multiplicity, coupling constants, intensity of lines within a multiplet and intensity of lines in different multiplets. Assume integration for one hydrogen as 16 mm, and coupling of A and B equal to that of A and C and no coupling of A with OH.

1
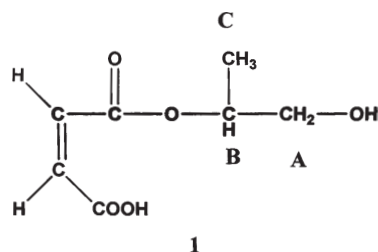
b) Identify the compounds given below which in ^{1}H-NMR show all peaks as singlets

   i) C_3H_6O only one peak,

   ii) $C_2H_4Cl_2$ only one peak,

   iii) C_3H_9N only one peak,

   iv) C_5H_{12} only one peak,

   v) $C_3H_8O_2$ only two peaks,

   vi) $C_5H_{10}O$ only two peaks,

   vii) $C_8H_6O_2$ only two peaks.

Q3) Attempt any two of the following : **[12]**

a) Identify the seven isomers of carbonyl compounds, all with the formula $C_5H_{10}O$ from their CMR spectral data given below. Isomer A,B,C all show singlets in 190 to 200 region whereas D, E, F and G all show doublets (in off resonance) in this region. Isomers A and D each show three signals in PND spectrum while isomers B and E each show four signals. Isomer C, F, and G all show five signals each. Isomer F is the only one which shows one doublet (in off resonance) in the region 0 to 50 ppm.

b) Identify the three pyridine derivatives all with the formula C_6H_7N from the CMR data given below :

   i)   18(q), 122(d,st*), 145(s), 149(d, st*) st* = strong

   ii)   23(q), 121(d), 123(d), 127(d), 149(d), 157(s)

   iii)   18(q), 122(d), 133(s), 136(d), 147(d), 150(d)

c) Identify the two compounds both with formula $C_6H_{11}NO$ from their CMR data. Assign the signals.

    i)   Amide - 22(t), 29(t), 31(t), 36(t), 42(t), 180(s)

    ii)   Oxime - 24(t), 25(t), 25.2(t), 27(t), 32(t), 161(s)

Q4) Deduce the structure of an important polymer raw material C_3H_6O from its spectral data. Comment on the chemical shifts in ^1H and ^{13}C-NMR. Explain the couplings seen in ^1H-NMR. Explain your answer. **[6]**

IR   :   No significant peak above 1500 cm^{-1}

CMR   :   13.1, 47.3, 47.6

DEPT1 :   13.1, 47.6, up, 47.3 down; DEPT 2 : 47.6 up

^1H-NMR: 1.32(d, J = 6 Hz, 15 mm); 2.42(dd, J = 2.5 and 3.5Hz, 5mm); 2.72 (dd, J = 3 and 3.5Hz, 5mm); 2.98(ddq, J = 2.5, 3 and 6Hz, 5 mm).

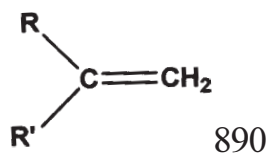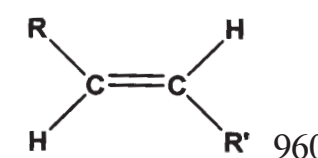Table 1 : Some characteristic IR data in cm^{-1}; Values are approximate.

OH - 3600 (free)	NH - 3300	≡C-H 3300
C≡N 2250	C≡C 2200	C = C 1620
Vinyl ester 1760	Saturated ester 1740	Saturated ketone 1720
Saturated amide 1650	$\overset{R}{\underset{R'}{\diagdown}}C{=}CH_2$ 890	$\overset{R}{\underset{H}{\diagdown}}C{=}C\overset{H}{\underset{R'}{\diagup}}$ 960

Table 2 : Approximate chemical shifts (δ values)

CH_3-C 0.9	C = C – CH_3 1.6	O = C - CH_3 2.0
R-OCH_3 3.3	O = C – OCH_3 3.8	H_2C = C 4.6
C = C – H 5.1	HC = C – CO 6.3	C = CH – CO 5.7
Ph – OCH_3 3.8		

Table 3 : Approximate CMR chemical shifts

RCH_3 10 – 30	R_2CH_2 25 – 40	R_3 – CH 30 – 50
H_3C – O 53 – 75	C≡C 75 – 100	C ≡ N 110 – 125
Benzene 128.5	C= C 100 – 140	C = N 145 – 162
RCOOR, RCONHR, RCOOH 165 – 180	RCOR, RCHO 190 – 210	

SECTION - II

Q5) Attempt any four of the following : **[20]**

a) Explain the term dichroic ratio and infra red dichroism. Comment on the information that is obtained from the dichroism absorption band.

b) Discuss, citing suitable example, factors effecting TGA curves.

c) Explain the phenomenon of glass transition temperature.

d) Write a note on the different detectors used for detecting X - rays.

e) Sketch and explain the X-ray diffraction pattern obtained for oriented and unoriented polymers.

f) Write a note on the birefringence and dielectric properties of polymeric materials.

Q6) Attempt any four of the following : **[20]**

a) What is the role of DTA in the characterization of copolymers and blends?

b) Write a note on Freeman and Carrol method on TGA analysis.

c) Explain with suitable examples how DTA, DSC and TGA are supplementary techniques of predicting thermal behaviour of polymers.

d) Draw and label the different transitions obtained when a semicrystalline polymer is analyzed by DSC.

e) Discuss heat of fusion and degree of crystallinity in polymers and give one method of their determination.

f) Give a comparative account of DTA and DSC and mention their typical applications in polymer analysis.

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[4228]-401

M.Sc.

POLYMER SCIENCE

PS - 404 : Special Topics

(2008 Pattern) (Sem. - IV)

Time : 3 Hours]   *[Max. Marks : 80*

Instructions to the candidates:

1) *All questions are compulsory.*
2) *Answers to the two sections should be written in separate answer books.*
3) *Figures to the right indicate full marks.*
4) *Use of logarithmic table / calculator is allowed.*

SECTION - I

Q1) Attempt any four of the following :   **[20]**

a) Describe various protecting groups in the preparation of functional polymers.

b) What are polymeric membranes? Discuss the mechanism of pervaporation.

c) Polymers are the most suitable materials for biomedical applications. Explain.

d) With the help of neat diagrams, explain the classification of liquid crystals with reference to polymers.

e) Write a note on the mechanism of conduction in polymer filled with conducting fillers?

f) What are the industrial applications of water soluble polymers?

Q2) Attempt any four of the following :   **[20]**

a) What is the "Green Polymer Synthesis and Processing"? What can chemists do to reduce the ill - effects of conventional chemistries?

b) Define polymer gels. Give examples of polymer gels in personal products and in industrial applications.

c) Write a note on the theoretical development in predicting behaviour of nanomaterials.

d) Write a note on factors that favour biodegradation and methods to study degradation.

e) Write a note on the recycling of PVC.

f) What are miscible and immiscible blends? Give industrial examples of the two types of blends.

SECTION - II

Q3) Attempt any four of the following : **[20]**

a) What are functional polymers? Why are functional polymers preferred over ordinary unfunctionalized polymers?

b) Suggest polymeric membranes for the following separation processes : Ultrafiltration, microfiltration and nanofiltration.

c) Suggest polymers to replace the following :
   i)   heart,
   ii) bones,
   iii) blood,
   iv) teeth and
   v)   skin.
   Explain your choice.

d) What are mesogens? Give examples. Draw diagrams and explain nematic and smectic (A and C).

e) What are n and p dopants? Describe the function of dopants in enhancing conductivity of polymeric materials.

f) Describe the technological applications of water soluble polymers.

Q4) Attempt any four of the following : **[20]**

a) Explain the principles of green chemistry.

b) What are hydrogels? What are the advantages and disadvantages of hydrogels?

c) Describe various applications of nanomaterials using polymer matrix.

d) Write a note on biodegradable polymers for suture application.

e) Write a note on recycling polyurethanes.

f) Describe the classification/codes for polymers with respect to recycling.

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[4228]-402

M.Sc.

POLYMER SCIENCE

PS - 410 : Polymer Processing

(2008 Pattern) (Semester - IV)

Time : 3 Hours]   *[Max. Marks : 80*

Instructions to the candidates:

   1) All questions are compulsory.

   2) Answers to the two sections should be written in separate answer books.

   3) Figures to the right indicate full marks.

   4) Use of logarithmic table / calculator is allowed.

<u>**SECTION - I**</u>

Q1) Attempt any four of the following :   **[20]**

   a) With a suitable diagram describe twin screw counter rotating extruder.

   b) With the help of a neat diagram describe blow molding.

   c) With the help of a neat diagram describe compression molding.

   d) Describe with examples RIM and RRIM.

   e) Explain the reasons for the variation of thickness in products formed by thermoforming process.

   f) What is pultrusion? What are its specific applications?

Q2) Attempt any four of the following :   **[20]**

   a) Enlist thermal and uv stabilizers. Explain their role in polymer processing.

   b) Describe transfer molding. Enlist the advantages of transfer molding over compression molding.

   c) Discuss the variation in screw design in the processing of polymeric materials.

   d) With the help of a neat diagram describe rotational molding process.

   e) Describe the process of coextrusion. Give examples of products made by coextrusion process.

   f) Write a note on the calendering. Give examples of products made by calendering process.

Q3) Attempt any four of the following : **[20]**

    a) Define compounding. Discuss the significance of compounding in rubber industry.

    b) Discuss reinforcing and non-reinforcing fillers. Discuss in brief the reinforcing action of carbon black.

    c) Discuss the property changes that can be achieved by sulfur vulcanization process.

    d) Explain the terms

        i) crimp,

        ii) tenacity,

        iii) deniere,

        iv) staple and continuous filament.

    e) What are non-woven fibers? How are they prepared? Write their applications.

    f) Citing examples, explain the role of plasticizers in polymers processing.

Q4) Attempt any four of the following : **[20]**

    a) How do the stress - strain properties of fibers change with draw ratio?

    b) What is scorching of rubber? Explain the conditions leading to scorching.

    c) Differentiate between accelerators and activators. Discuss their importance in processing.

    d) What is the approximate Deniere of a fiber of 0.02 mm in diameter if the specific gravity of the polymer is 1.2?

    e) Give chemical structure of five elastomers and explain the special properties and applications.

    f) Describe Banbury Mixing? Explain its use in polymer processing.

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[4228]-403
M.Sc.
POLYMER SCIENCE
PS - 411 : Rheology and Mechanical Properties of Polymers
(2008 Pattern) (Sem. - IV)

Time : 3 Hours]

[Max. Marks : 80

Instructions to the candidates:
1) *All questions are compulsory.*
2) *Answers to the two sections should be written in separate answer books.*
3) *Figures to the right indicate full marks.*
4) *Use of logarithmic table / calculator is allowed.*

SECTION - I

Q1) Attempt any four of the following :
[20]

a) Discuss three material functions of that are useful in understanding rheological behavior of polymeric materials.

b) What is the relevance of Hooke's law and Newton's law in rheology of polymers?

c) Describe the rheological properties of solid, fluid and polymeric melt.

d) Discuss relaxation and retardation of polymeric materials.

e) How can Burger model be used to describe deformation behavior of polymers?

f) Describe the principle of time temperature superposition.

Q2) Attempt any four of the following :
[20]

a) Discuss the traditional methods of joining two materials. What are the advantages of using adhesives?

b) Discuss the criteria for the selection of adhesives.

c) Define the term "Paint". Bring out the differences between paint and varnish.

d) Describe the hiding power or covering power of pigments used in surface coating.

e) Write a note on failure adhesive joint.

f) Write a note on mechanism of adhesion.

SECTION - II

Q3) Attempt any four of the following : **[20]**

a) What is the difference between adhesion and cohesion? Write a note on the mechanism of adhesion of a substrate to metal, wood and paper surface.

b) Write a note on pressure sensitive adhesives.

c) What is tinting and tint resistance? Explain tinting resistance of white pigment and tinting power of dye pigment.

d) Write a note on the classification of adhesives.

e) How does one test the adhesives during their manufacture? What are the quality control tests?

f) What are the salient features to be considered before adhesive application on a surface?

Q4) Attempt any four of the following : **[20]**

a) How is pigment to binder ratio important in the preparation of a paint formulation?

b) Why is polylactic acid preferred as a packaging material in several commercial applications?

c) In what polymeric material are electronic gadgets normally packed and why?

d) Write a note on the equipments used in the paint industry. Explain the working of any one of the equipments.

e) Suggest packaging material for

i) milk and dairy products,

ii) confectionary items

iii) agrochemicals,

iv) printed circuit boards, and

v) glass wares.

f) Write a note on oil bound paints, enamel paints and powder coating.

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[4228] - 31
M.Sc.
POLYMER SCIENCE
PS - 310 : Kinetics & Mechanism of Polymerization Process
(2004 Pattern)

Time : 3 Hours]   *[Max. Marks : 80*

Instructions to the candidates :

1) *All questions are compulsory.*
2) *Answers to the two sections should be written in separate answer books.*
3) *Figures to the right indicate full marks.*
4) *Use of logarithmic table/calculator is allowed.*

SECTION - I

Q1) Attempt <u>any four</u> of the following :   **[20]**

a) Give five different examples of condensation polymerizations. Specify any one reaction which does not involve reversibility due to equilibrium.

b) In a typical polyesterification reaction, time taken from start to the 98% conversion is equal to the time taken for the conversion from 98% to 99%. Comment.

c) Describe dependence of $X_w X_n$ on various factors in polyesterification reaction.

d) Calculate $X_w X_n$ for an equimolar mixture of a diacid and a glycol at the following extent of reaction 0.990, 0.999 when the stoichiometric imbalance is 0.99.

e) What will be the effect of monofunctional and trifunctional chemicals in condensation polymerization? How will it affect gel point?

f) Derive relation between number average degree of polymerization extent of reaction for step reaction polymerization process, when stoichiometry is not maintained.

Q2) Attempt <u>any four</u> of the following :   **[20]**

a) Discuss cationic mechanism of addition polymerization.

b) In a radical polymerization, is it advisable to use retarder for inhibiting the reaction? Comment on it.

c) Derive the expression for overall rate of polymerization as a function of conversion in radical polymerization.

d) Write a note on kinetic chain length in free radical polymerization.

e) A radical polymerization is carried out in presence of chain transfer agent. Depending on the relative competition between propagation and transfer, what are different effects possible on the rate of reaction and molecular weight achieved.

f) Discuss effect of temperature and pressure on chain polymerization.

SECTION - II

Q3) Attempt <u>any four</u> of the following : **[20]**

a) Compare dependence of rate of reaction on temperature in case on radical and anionic polymerizations.

b) In aqueous solution polymerization of acrylamide, hydrogen peroxide was used as initiator in two different reactions at the same concentration. Out of the two, one reaction was carried out using redox initiation. Comment on the rate expression of both the reactions.

c) Under which conditions geling takes place? Write significance of gel point.

d) What is living polymerization? Why does it occur? Write its use.

e) Write different steps involved in the initiation process of free radical polymerization using different types of initiators.

f) Is it possible to control molecular weight and MWD in cationic and anionic polymerization? Explain.

Q4) Attempt <u>any four</u> of the following : **[20]**

a) Vinyl Cinnamate does not readily form copolymer with acrylic acid. However it forms copolymer very easily with vinyl acetate. Explain this phenomenon. Predict copolymerization of vinyl acetate with acrylic acid.

b) What are advantages of Q and e scheme in copolymerization? State its limitations.

c) For estimating reactivity ratios, most of the methods require very low conversions of the copolymerisations. Why? Justify the answer with suitable examples.

d) Write any one graphical method of determining reactivity ratio of binary copolymerization. State its limitations.

e) State the conditions of reactivity ratios for obtaining the copolymers as described below for the following values of r_1 and r_2 what type of polymers will be expected?

    i)   Random polymer,

    ii)   Block of 1 with short group of 2 and

    iii) Long block of 1 separate by one unit of 2.

f) Is it possible to take a feed ratio of copolymerisation that is directly observed in the copolymer formed? Comment.

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[4228] - 32

M.Sc.

POLYMER SCIENCE

PS - 311 : Synthesis, Structural Aspects, Properties and Applications of Polymers

(2004 Pattern)

Time : 3 Hours]   *[Max. Marks : 80*

Instructions to the candidates :

    1)   *All questions are compulsory.*

    2)   *Figures to the right indicate full marks.*

    3)   *All questions carry equal marks.*

**Q1)**   Answer <u>any four</u> of the following :   **[16]**

    a)   Explain the following regarding manufacture of adipic acid

        i)   Cyclohexane may be directly converted to adipic acid with HNO_3 in on step yet the two step procedure is favoured.

        ii)   Oxidation of cyclohexane to cyclohexanol-cyclohexanone mixture is carried out in practice even though the conversion is 10-12%. What is the intermediate in this reaction?

        iii)   In the above reaction use of boric acid helps.

    b)   Comment on the properties of different nylons given below.

Nylon	6.6	6	6, 10	11	12
TS*	11.5	11	8.5	5.5	6.6
%WA#	8.0	9.0	2.4	2.0	1.8
%Elongation	80-100	100-200	100-150	200-300	200

    TS* Tensile strength in 1000 lbs/in^2,

    %WA Water Absorption at saturation.

    c)   Give reaction to prepare the polyamide shown below. Why are these polyamides preferred to Kevlar?
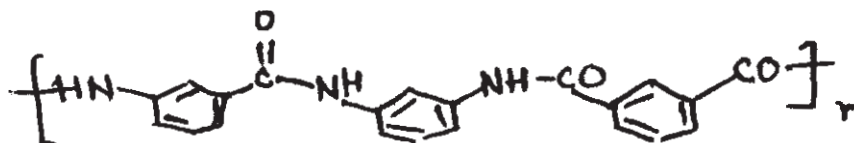
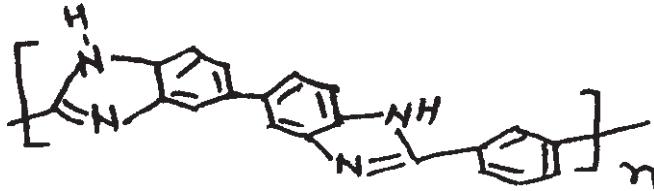*P.T.O.*

d) What are the starting materials used fro the preparation of the polybenzmidazole shown below? The non-nitrogenous monomer used could be

i) the diacid.

ii) the diacid chloride.

iii) the dimethyl ester yet a different monomer is used. Why?

Why is the reaction carried out in two steps?

e) How are the different grades of tolylene di isocyanate made from toluene. What is a possible side product in the reaction of an amine with isocyanate? How is this prevented?

f) A typical formulation for a rigid foam is given below. Comment on the role of different components and their quantities. In this formulation water is absent but glycerine is present where as for flexible foams water is present and glycerine is absent. Why? Low mol. Wt polyether polyol 100 parts by weight; Crude MDI (stoichiometric + 5%) ; silicone block copolymer 1.0 part.

g) What are the disadvantages of cast elastomers, that led to millable elastomers based on polyurethane? Isocyanate curing of polyurethane elastomer is shown below, indicate the nature of crosslinks obtained. How are the urea amide groups introduced in the starting polymer?

i) 2 ~~NHCONH~~ + OCN-R-NCO > ?

ii) 2 ~~NH-CO ~~ + OCN-R-NCO > ?

What is the structure of the dimer of TDI? How does this act as a curing agent at about 150°C?

Q2) Answer <u>any four</u> of the following : [16]

a) Explain the following regarding the preparation of linear unsaturated polyester.

i) Phthalic anhydride is preferred to phthalic acid.

ii) In the conversion of naphthalene to phthalic anhydride 4.5 moles of oxygen are used to give CO_2 H_2O (2 moles each) as by products.

iii) For the manufactures of the anhydride, O-xylene is preferred to naphthalene.

b) How is purified terephthalic acid prepared? In the conversion of DMT to PET two steps are required, both involve exter interchange. Explain.

c) Explain the structural differences in the alkyl resins prepared

    i)   using no oil.

    ii)   free fatty acid process.

    iii) alcoholysis process.

    Describe the free fatty acid process.

d) Explain the following in the preparation of polycarbonates by solution method.

    i)   a mixture of pyridine chloroform is used.

    ii)   Phosgene is passed into a solution of bisphenol A in the above solution.

    iii) the resulting mass is washed with HCl then with water.

    iv) after washing methanol is added.

    v)   in the above process pyridine is a solvent, catalyst reagent.

e) In preparation of cellulose triacetate and secondary cellulose comment on the following :

    i)   Use of CH_2Cl_2.

    ii)   Use of CH_3COOH.

    iii) Addition of 50% aq. CH_3COOH.

    iv) Addition of sodium acetate.

    v)   Boiling with very dilute H_2SO_4.

f) i)   Determine the % N in a cellulose nitrate with a DE of 2.4.

   ii)   Determine the DE of cellulose acetate butyrate having acetyl content 3.18 % butyrol content 16.61%.

g) Name the sources of cellulose besides cotton and wood. Indicate which are stem and leaf fibres. Give their use and the property (if any) on which the uses are based.

Q3) Attempt <u>any four</u> of the following :   **[16]**

a) Application of Novolak resin dictates the choice of catalyst in the reaction. Explain.

b) How is the molecular weight of epoxy prepolymer controlled? Why is it important to control molecular weight of the prepolymer?

c) Explain manufacture of MF resins. State their important applications.

d) Describe any one method of manufacturing silicon containing polymer. Explain the applications of the manufactured polymer.

e) Compare crosslinking reactions in phenol formaldehyde urea formaldehyde resins.

f) What are Resol polymers? How does the ratio of phenol to formaldehyde affects the properties of the polymer formed?

Q4) Attempt <u>any two</u> of the following : [16]

a) Give a synthetic method to prepare
   i) acrylonitrile.
   ii) vinyl acetate.
   iii) styrene monomer and
   iv) acrylic acid.

b) Describe the manufacture of any methacrylate polymer. State its important applications.

c) Describe variation in the manufacturing of LDPE, LLDPE, HDPE.

Q5) Attempt <u>any two</u> of the following : [16]

a) Describe synthesis of different grades of poly (vinyl alcohol). Describe different chemical modifications yielding different properties leading to different applications.

b) Describe at least three halogen containing polymers. Compare their different properties. State their applications.

c) Describe briefly Ziegler-Natta catalyzed manufacture of polyolefin. What is importance of Z-N catalyst? How it differs from benzoyl peroxide type initiators in polymerizations?

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[4228] - 33
M.Sc. (Polymer Science)
PS - 312 : POLYMER PROCESSING
(2004 Pattern)

Time : 3 Hours]   *[Max. Marks : 80*

Instructions to the candidates :

1) *All questions are compulsory.*
2) *Answers to the two sections should be written in separate answer books.*
3) *Figures to the right indicate full marks.*
4) *Use of logarithmic table/calculator is allowed.*

SECTION - I

Q1) Attempt <u>any four</u> of the following :   **[20]**

a) Discuss importance of compounding in rubber industry.

b) Define vulcanization. Discuss non sulphur mechanism of vulcanization.

c) What are acclerators and activators? Discuss their importance in rubber vulcanization.

d) Explain what are reinforcing and non-reinforcing fillers. Discuss theory of re-inforcement action of carbon black.

e) Draw and explain stress strain curves for unvulcanized and vulcanized rubber. Justify the change in the stress strain behaviour after vulcanization.

f) Write an account of oxidative aging of rubbers.

Q2) Attempt <u>any four</u> of the following :   **[20]**

a) Explain the terms with suitable examples.
   i) Continuous fibre.
   ii) Staple fiber.
   iii) Deniere.
   iv) Tenacity.
   v) Crimp.

b) Compare the processes of wet spinning and dry spinning.

c) Which fiber properties are important in textile uses? Write their significance.

d) Write short note on Fiber after treatment. Why such treatment is necessary?

e) Draw and explain stress strain curve for Silk like and Wool like fibers.

f) Describe preparation and applications of non woven fibers.

SECTION - II

Q3) Attempt <u>any four</u> of the following : **[20]**

a) Enlist different additives used in polymer processing and describe role of each of them.

b) Discuss the criteria for selecting a polymeric process for obtaining a polymeric object.

c) Describe typical processing parameters for compression molding.

d) Explain different defects occurring in transfer molding. Suggest the measures to avoid the defects.

e) Comment on the importance of flight angle, root diameter and pitch in designing a screw in extrusion.

f) Write a note on corotating twin screw extruder.

Q4) Attempt <u>any four</u> of the following : **[20]**

a) Describe reciprocating screw injection molding with the help of suitable diagram.

b) With the help of neat diagram, explain injection blow molding.

c) Write an account of pultrusion.

d) Describe the process of rotational molding.

e) Explain the variation in number of rollers and their arrangement in the process of calendering.

f) Describe design peculiarities of pressure forming.

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[4228] - 34
M.Sc.
POLYMER SCIENCE
PS - 313 : Polymer Chains and their Characterisation
(2004 Pattern)

Time : 3 Hours]   *[Max. Marks : 80*

Instructions to the candidates :

    1)   *All questions are compulsory.*

    2)   *Answers to the two sections should be written in separate answer books.*

    3)   *Figures to the right indicate full marks.*

    4)   *Use of logarithmic table/calculator is allowed.*

SECTION - I

Q1) Attempt <u>any four</u> of the following :   **[20]**

    a)   In predicting polymeric solubility.

        i)   polarity.

        ii)   'like dissolves like' and

        iii) solubility parameters are used.

        Explain their usefulness and limitations.

    b)   How does the chain entanglement and molecular weight distribution affects solution properties of polymer?

    c)   What are athermal solutions? Explain free energy of solubilisation in athermal solutions.

    d)   What is second virial coefficient in solutions? How does it affect the solubilisation of a solute in a solvent?

    e)   Explain Hildebrand's theory of solubilisation.

    f)   Describe Flory Huggins interaction parameter its relation with poor, ideal and good solvent.

Q2) Attempt <u>any four</u> of the following :   **[20]**

    a)   Explain the concept of theta temperature.

    b)   How does free energy of polymeric solution and second virial coefficient of polymeric solution change with temperature? How does it explain phase separation in polymeric solution with change in temperature?

    c)   Describe LCST and UCST behaviours of polymeric solution.

    d)   Predict, giving reasons, whether each of the following polymers will undergo degradation or crosslinking on exposure to radiation : poly (alpha methyl styrene), PVC, Poly (vinylidene chloride) and PVA.

e) Discuss the application of radiation induced polymerisation in
    i)   grafting.
    ii) polymer modification and
    iii) removal of monomer.

f) A relatively small does of radiation causes appreciable change in the physical properties of a polymer, though the chemical change produced is negligible. Explain.

SECTION - II

Q3) Attempt any four of the following :   [20]

a) Explain the terms :
    i)   stress tensor.
    ii) shear modulus.
    iii) deborah number.
    iv) normal stress.
    v)   shear thickening.

b) Explains Hooke's law and Newton's law and their relevance to rheology.

c) Describe different stress strain behaviours exhibited by polymeric materials.

d) Compare the processes of creep and stress relaxation in polymeric materials.

e) Compare Maxwell and Voigt model for explaining viscoelastic behaviour.

f) Explain the rheological properties of a solid and that of a polymeric melt.

Q4) Attempt any four of the following :   [20]

a) Given a rheological data at varying temperature and shear for polyethylene of varying mol. wt. and MWD, is it possible to predict the rheological properties of another polymer? Explain.

b) Explain stress strain behaviour of different material such as Newtonian, shear thickening, shear thinning, bingham plastic and St. Venon body.

c) Describe cone and plate viscometer. Explain its scope and limitation in the study of rheological behaviour of polymeric melt.

d) Describe the effect of molecular weight and molecular weight distribution on the viscocity and zero shear viscosity.

e) What are storage and loss modulii? Describe with respect to polymeric material.

f) Explain the relevance of die swell and shark skin effect to the rheological behaviour.

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[4228] - 41
M.Sc. - II
POLYMER SCIENCE
PS - 410 : Analysis and Testing of Polymers
(2004 Pattern) (Semester - IV)

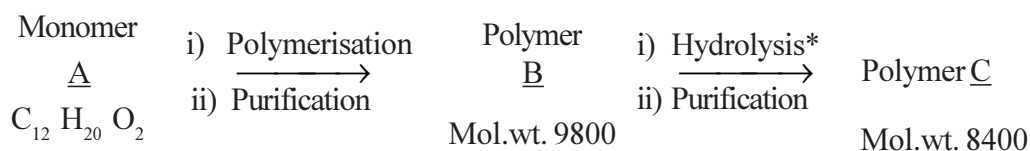*Time : 3 Hours]*   *[Max. Marks : 80*

Instructions to the candidates :

1) *All questions are compulsory.*
2) *Answers to the two sections must be written in separate answer books.*
3) *Figures to the right indicate full marks.*
4) *Use of logarithmic tables/calculators is allowed.*

SECTION - I

Q1) a) Determine the structure of the monomer $\underline{A}$ and the polymers $\underline{B}$ and $\underline{C}$, from the given data. Explain your answer **[5]**

Monomer
$\underline{A}$
$C_{12} H_{20} O_2$
$\xrightarrow[\text{ii) Purification}]{\text{i) Polymerisation}}$
Polymer
$\underline{B}$
Mol.wt. 9800
$\xrightarrow[\text{ii) Purification}]{\text{i) Hydrolysis*}}$
Polymer $\underline{C}$
Mol.wt. 8400

* hydrolysis without backbone degradation.

$\underline{A}$ contains a cyclohexane ring and has IR bands at 1745, 1635 and 960 cm^{-1}. $\underline{B}$ IR - 1740, $\underline{C}$ IR - 3300 to 2500 (broad), 1735 cm^{-1}.

b) Answer <u>any one</u> of the following : **[5]**

i) Explain the carbonyl frequencies given below :

RCOCl - 1780, RCO OCH = CHR' - 1760, RCOOR 1740, RCO CH$_3$ 1720, RCO NHR' 1660, RCOO$^-$ 1580, 1350 cm^{-1}.

ii) Deduce the structure of $\underline{E}$ and $\underline{F}$ from the given data. Use this to assign the spectral data reported for $\underline{D}$. Deduce the structure of $\underline{D}$. Explain your answer.

$\underline{D}\ (C_{14} H_{12} O_3) \xrightarrow[H_2O]{H^+} \underline{E}\ (C_5 H_8 O_2) + \underline{F}\ (C_9 H_6 O_2)$
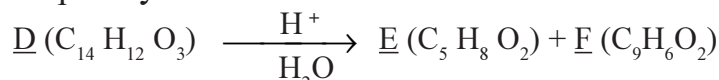
$\underline{D}$ IR - 2720, 2200, 1695, 1680, 1630, 1600, 1480, 890, 750, 680 cm^{-1}
  uv - 207 ($\in\ >8000$), 250 ($\in\ >14,000$) nm

$\underline{E}$ IR 3300, 2720, 1695, 1630, 890 cm^{-1}.

  uv 207 nm ($\in\ >7000$)

$\underline{F}$ IR 3200 - 2500 (broad), 2200, 1680, 1600, 1480, 750, 680 cm^{-1}., uv : 250 ($\in\ 14,000$) nm.

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*Q2)* Answer <u>any two</u> of the following :   **[10]**

a) Make a neat sketch of the ^1H - NMR of the important polymer intermediate <u>1</u>. Consider chemical shifts, multiplicity, coupling constant, integration, intensity of lines with in a multiplet, and intensity of lines of different multiplets.
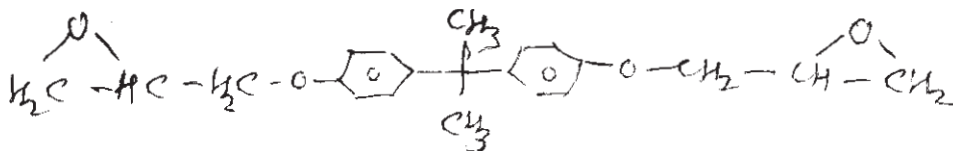
b) Identify the different isomers of $C_5 H_{10} Br_2$ from the ^1H - NMR data given below :
i)   1.0 (s, 6H), 3.4 (s, 4H),
ii)   1.0 (t, 6H), 2.4 (q, 4H)
iii) 0.9 (d, 6H), 1.5 (m, 1H), 1.8 (t, 2H), 5.8 (t, 1H),
iv)   1.0 (s, 9H), 5.3 (s, 1H),
v)   1.3 (quintet, 2H), 1.8 (m, 4H), 3.35 (t, 4H),
vi)   1.0 (d, 6H), 1.75 (m, 1H), 3.95 (m, 2H), 4.7 (m, 1H)

c) Deduce the structure of a compound $C_{10}H_{15}N$, from it's ^1H-NMR spectrum (300 MHz). 1.85 (quintet, J = 6Hz, 12 mm), 2.45 (s, 18 mm), 2.68, (t, J = 6Hz, 12 mm), 2.73 (t, J = 6Hz, 12 mm), 4.35 (s, 6 mm, exchanges), 7.15 (m, 30 mm).

Q3) Answer <u>any two</u> of the following :   **[12]**

a) Indicate how the number and nature of signals can be used to differentiate the given isomers (all $C_{10}H_8$) given below. For each isomer clearly indicate those carbons which are identical.
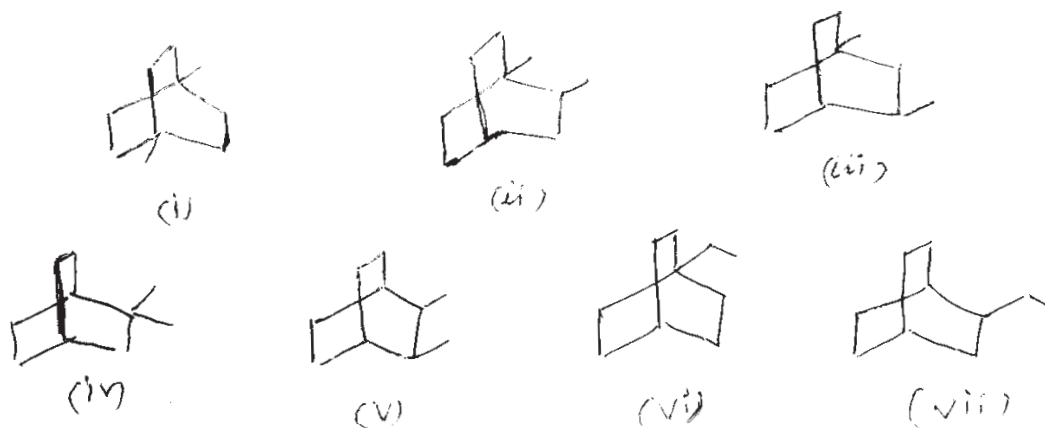
b) Deduce the structure of a compound $C_9H_8O_3$ from the CMR data given below :
115.4, 115.9 (strong), 125.4, 130.0 (strong), 144.2, 159.2, 168.1.
<u>DEPT</u> - 1 115.4, 115.9, 130.0, 144.2 all up; 125.4, 159.7, 168.1, absent
<u>DEPT</u> - 2 115.4, 115.9, 130.0, 144.2 up

c) Explain the following features of a CMR spectrum.
    i) The undecoupled spectrum is not useful.
    ii) ^{13}C - ^{13}C coupling is not seen.
    iii) The terms involved in the equation related to the off-resonance experiment $J^r = \dfrac{2\pi J \Delta v}{r B_2}$.
    iv) The change in the nature of signal of methanol when $Dv = +\ 300$ Hz, 0 Hz, $-\ 100$ Hz and $-\ 300$ Hz.

Q4) Deduce the structure of a possible monomer $C_5H_8O_2$ whose spectral data is given below. Assign the spectral signals. Explain your answer. **[8]**
IR - 1773 cm^{-1}
^1H - NMR : 1.33 (d, J = 6Hz, 21mm),
1.77 (m, 7mm), 2.3 (dt, J = 6 and 20 Hz, 7mm), 2.48 (dd; J = 6 and 8 Hz, 14mm), 4.57 (ten lines, 7mm).
CMR : 22, 28, 29, 76, 177
<u>DEPT - 1</u> : 22, 76, up, 28, 29 down, 177 absent
<u>DEPT - 2</u> : 76 up.

SECTION - II

Q5) Attempt <u>any four</u> of the following : **[20]**
a) Sketch and explain the X ray diffraction pattern for oriented and unoriented poly oxymethylene. Define and explain birefringence.
b) What are the dielectric properties of polymers? Give one method for determination of dielectric constant.
c) Why it is relevant to analyse for elements in polymers?
d) What are the difficulties encountered in identifying polymers? Explain how burning test and solubility of polymers are useful?
e) Discuss the analysis of molecular structure of any two polymer samples by X ray diffraction method.
f) Explain in detail principle of SEM analysis of polymers.

Q6) Attempt <u>any four</u> of the following : **[20]**
a) Discuss the principle and the application of thermogravimetric analysis for the study of polymers.
b) How DTA and DSC techniques could be used to supplement the information obtained from TGA of polymer? Explain with examples.
c) Draw a typical DSC curve for a polymer having Tg 65 degrees, Tm 265 degrees, and decomposition temperature of 320 degree centigrade. Comment on the endo/exo transitions.
d) Differentiate between dyanamic and isothermal TG analysis.
e) How will you determine the kinetic parameters from the thermogravimetric curve of the polymer.
f) Describe the determination of crystallinity in polymers using DSC.

TABLE - 1

Some characteristic IR data in cm^{-1}. Only approximate values are listed.

≡C–H	3300	C = C –H	3050
$\overset{}{\underset{O}{C}}$–H	2730	N –H	3300
O–H	3600(free)	C ≡ N	2250
C ≡ C	2200	C = C	1620 – 1680
		C = N	1660
Aromatic	1500 , 1600	Sat·ester	1740
Sat ketone	1720	Sat. aldehyde	1720
Sat acid	1730	– CH = CH$_2$	910, 990
		CH = CH (cis)	690
Sat amide	1650	C = CH	790 - 840
NO$_2$	1530 , 1350	(Trans) – CH = CH –	960
		= CH$_2$	890

Band for aromatic compounds depends on the number of adjacent free aromatic hydrogens

5 free	690 – 710 and 730 – 770
4 free	735 – 770,
3 free	750, 810
2 free	770, 800 – 860
1 free	850 – 900

TABLE 2
PMR CHEMICAL SHIFTS

Approximate δ value, TMS as internal reference :

C – CH$_3$	0.9	$\overset{}{\underset{O}{C}}$–C = $\overset{}{\underset{H}{C}}$	6.2
C = C–CH$_3$	1.7		
Ar – CH$_3$	2.3	O – C – CH$_3$	1.4
$\overset{}{\underset{O}{C}}$–CH$_3$	2.2	N.– CH$_3$	2.3
CH in	0.6	O – CH$_3$	3.3
Cyclopropane		C = CH$_2$ exocyclic	4.6
C = CH$_2$	5.3	C = CH	5.1
C = CH	cyclic 5.3	Ar – H	6.5 to 8
$\overset{}{\underset{O}{C}}$–$\overset{}{\underset{H}{C}}$ = C	5.7	$\overset{}{\underset{O}{C}}$–H	9 to 10
		– COOH	10 to 12

TABLE 3 - CMR CHEMICAL SHIFTS :

R – CHO 182 – 205 Aromatic 110 – 150; Conjugated olefin 140 – 170;

C = C 100 – 130 ; H – CO 62 – 85; H$_2$C–O 57 – 77; H$_3$C– O 53 – 75;

H –C – N 45 – 70; C ≡ C 65 – 95; HC – CO 35 – 52; H$_3$ C – C ≡ 18 – 35

H$_3$ C – C 12 – 30; C = O (ketone) 180 – 205; COOR, CONH$_2$ CONHR 160 – 180

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[4228] - 42
M.Sc.
POLYMER SCIENCE
PS - 411 : Structure and Properties of Bulk Polymers
(2004 Pattern)

Time : 3 Hours]   *[Max. Marks : 80*

Instructions to the candidates :
1)   *All questions are compulsory.*
2)   *Answers to the two sections must be written in separate answer books.*
3)   *Figures to the right indicate full marks.*
4)   *Use of logarithmic tables/calculators is allowed.*

SECTION - I

Q1) Attempt <u>any four</u> of the following :   **[20]**

a)   Explain different crystalline transitions in atactic, isotactic and syndiotactic polystyrene with increasing temperature.

b)   What is Schotzki crankshaft transition? How it can be detected? Give examples of polymers which display this type of transition.

c)   A polymer is heated above Tg, and above Tm respectively and cooled down to room temperatures at the rate of 20 deg per min. and 2 deg per min. What will be the difference in crystallinity of the four different polymer samples obtained?

d)   Explain the terms internal plasticization and external plasticization. What is its effect on the mechanical properties over a long period of time.

e)   Discuss various factors which affect the crystallisability of alphatic-aromatic polyesters with suitable examples.

f)   Describe a method to determine the degree of crystallinity in crystalline polymer.

Q2) Attempt <u>any four</u> of the following :   **[20]**

a)   Compare the Avarami, Keith-Padden and Hoffman theories of crystallisation.

b)   Discuss the phenomenon of chain folding in polymer crystals including evidence in support of chain folding and the conditions under which it occurs.

c)   What is the effect of crystallization temperature on the fold length.

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d) Explain the terms :
   i)   Spherulites.
   ii) Cold drawing.
   iii) Lamella.
   using suitable examples.

e) Explain with a suitable diagram the dilatometric method for the characterization of polymer. What information is obtained using this method?

f) Discuss the effect of crystallinity, crystal size, and crystal size distribution on mechanical properties of polymer.

SECTION - II

Q3) Attempt <u>any four</u> of the following :   **[20]**

a) What are traditional ways of joining materials? What are their disadvantages?

b) Explain the terms such as fracture behaviour, adhesive failure and cohesive failure. Discuss importance of these terms in adhesive applications.

c) What do you mean by the term peel strength of the adhesive? Explain test conducted to determine it.

d) Describe the adhesive used in the field of furniture. Justify the selection.

e) Discuss processing techniques of paints.

f) What role does an additive play in the paint formulation? Enlist various additives used in the paint industries with their appropriate properties.

Q4) Attempt <u>any four</u> of the following :   **[20]**

a) Specify the terms tinting strength and reducing strength of the pigment.

b) What are the different types of resins used in paint formulations? How do these resins get cured?

c) Suggest polymeric materials for 'three layer pack'. Explain the function of each layer.

d) What are advantages of polymers as packaging material over the materials such as glass and metal?

e) Discuss importance of ecofriendly packaging polymeric materials.

f) Write a note on retortable plastic packaging.

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[4228] - 43
M.Sc. - II
POLYMER SCIENCE
PS - 404 : Special Topics in Polymer Science
(2004 Pattern) (Semester - IV)

Time : 3 Hours]   *[Max. Marks : 80*

Instructions to the candidates :

1) *All questions are compulsory.*
2) *Answers to the two sections must be written in separate answer books.*
3) *Figures to the right indicate full marks.*
4) *Use of logarithmic tables/calculators is allowed.*

SECTION - I

Q1) Attempt <u>any four</u> of the following :   **[20]**

   a) What are different types of recycling of polymeric materials? Compare the product obtained from different types of recycling.

   b) Describe measures taken to reduce unwanted usage of polymeric materials to reduce formation of polymeric waste.

   c) Describe different methods for studying biodegradation process of polymers.

   d) Discuss structure property relationship in biodegradation of polymeric materials.

   e) Discuss merits and demerits of using spacer arm technique to obtain functional polymer.

   f) Describe different applications of functional polymers.

Q2) Attempt any four of the following :   **[20]**

   a) Describe stratagies to form LCP from a known low molecular weight mesogen.

   b) Is it possible to observe different liquid crystalline phases in the same polymer? Justify the answer with suitable example.

   c) What is importance of blends in obtaining materials with desired properties?

   d) Compare melt blending, emulsion blending and solution blending.

e) Explain influence of limiting oxygen index, bond dissociation energy and crystallinity on inherent thermal stability of polymers.

f) Discuss heteroaromatic thermally stable polymers.

SECTION - II

Q3) Attempt <u>any four</u> of the following : **[20]**

a) Why polymeric material is a preferred choice for biomedical applications as compared to other materials used traditionally in the past.

b) Suggest the polymers for blood veins and arteries, sutures and adhesives to treat deep wounds.

c) What is the selection criteria for engineering applications of plastics?

d) Discuss preparations and important applications of polyacetals as engineering plastics.

e) What are polymeric membranes? Discuss mechanism of separation of suspended and dissolved lowmolecular weight substances in liquids using polymeric membranes.

f) Discuss the applications of polymeric membranes in gas separations.

Q4) Attempt <u>any four</u> of the following : **[20]**

a) Discuss importance of polymeric materials for various controlled release applications.

b) What are solitons and polarons. How this concept is used for explaining conduction mechanism in inherently conducting polymers.

c) Discuss the applications of inherently conducting polymers.

d) Discuss the use of polymeric materials in the development of engineering composites.

e) Write importance of epoxy resins in composites.

f) Write a note on Fick's law or Ferry's law in separation process.

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