Total No. of Questions : 4] **[Total No. of Pages : 3**

P1205

[3731]-31

M.Sc.

POLYMER SCIENCE

PS-310 : Kinetics and Mechanism of Polymerization Processes

(Old Syllabus)

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

Instructions to 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) Compare and contrast addition, condensation and ring opening polymerization reactions with respect to the kinetics and molecular weights obtainable.

b) How do X_w and X_n depend upon conversion in a typical polycondensation reaction? Explain with the help of suitable graph.

c) Generally a low molecular by-product is continuously removed in a condensation polymerization. Why? Under which condition the reaction is possible in a closed system, where no material exchange is allowed during the course of polymerization reaction.

d) Discuss the effect of by-product removal on the molecular weight built up of the polymer formed in step reaction polymerization with a suitable example.

e) 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.

f) Write short note on gel point.

P.T.O.

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

a) Write a detailed note on the different termination processes in radical polymerizations.

b) What are the actions of retardants, inhibitors and chain transfer agents in free radical polymerizations?

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) Explain the effect of temperature and pressure on chain polymerization.

SECTION - II

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

a) Compare and contrast 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 both the reactions.

c) Discuss the influence of ion pair on polymerization by ionic mechanism.

d) Under what conditions does cyclization take place in a polycondensation reaction? What is importance of such reaction?

e) What are the 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 any four of the following. **[20]**

a) Derive copolymer composition equation. Explain the assumption under which it is derived.

b) Write a short note on any one method for estimation of reactivity ratios.

c) Discuss the importance of reactivities of monomers and reactivities of radicals in explaining mechanism of copolymer formation.

d) Describe 'Q-e' scheme. Discuss its advantages and limitations.

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

(i) r_2 and $r_1 = 1$;

(ii) $r_1 >>> 0$, $r_2 = 1$;

(iii) r_1 = infinity, $r_2 = 0$.

Justify your answer.

f) Write a note on alternate copolymer formation tendency in certain monomer pairs.

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Total No. of Questions : 4] **[Total No. of Pages : 4**

P1206

[3731]-32

M.Sc.

POLYMER SCIENCE

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

(Old Syllabus)

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

Instructions to 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) In the 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/ H_3COOH (iv) no addition of sodium acetate (v) boiling with very dilute H_2SO_4.

b) In the process of making cellulose nitrate, explain the following. (i) dried cellulose is stirred with an acid mixture containing HNO_3 (25%), H_2SO_4 (55%) and water (20%) at 30 - 40 ^oC for 20-60 minutes (ii) the product is then centrifuged and dropped in drowning tank (iii) washed with water (iv) product is boiled with water for several hours (v) Then treated with NaOCl and washed with water.

c) Give arguments to establish the structure of cellulose.

d) Explain the following regarding alkyd resins (i) Though semi-drying oils are still tacky after air drying for seven days, the resins prepared from these oils undergo effective air drying; (ii) Such resins are preferred to those from drying oil resins for obtaining high gloss white finishes; (iii) In the free fatty acid process the solvent process is preferred to the fusion process; and (iv) Alkyd resins can not be prepared by heating a mixture of oil, polyol and dibasic acid.

P.T.O.

e) With respect to polyurethanes, please comment and explain the following:

(i) Reactions of polyols with diisocyanates are more widely used than reactions of diols with polyisocyanates.

(ii) Hydroxyl terminated polyethers are preferred to hydroxyl terminated polyesters.

(iii) The structural difference when diols or polyols react with diisocyanates.

f) Give chemical equations for the preparation of terephthalic acid. Explain the steps and the interchange reaction involved in the conversion of dimethyl terephthalate to poly (ethylene terephthalate). What is the role of the intermediate "esteralcohol"?

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

a) The composition of four typical hydroxyl terminate polyesters are shown. Based on these indicate the structural change and use of the resulting polyurethanes for each of the compositions. Comment on the molar proportion of the components in the composition. Explain your answer.

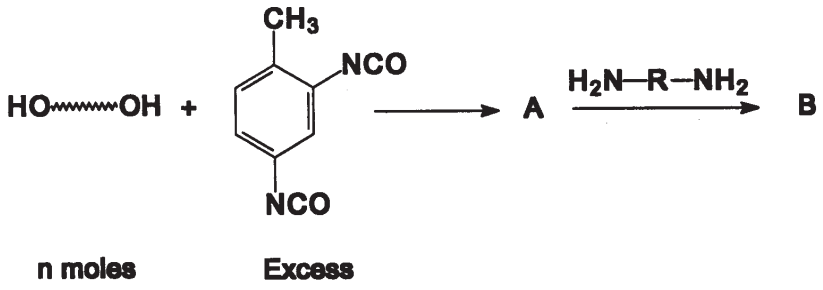
Composition (i) Adipic acid (AA) 1.0; ethylene glycol 0.75, propylene glycol 0.35;

Composition (ii) AA 1.5, sebacic acid 1.5, diethylene glycol DEG 3.25, glycerine (Gl) 0.5;

Composition (iii) AA 3.0, 1, 3 butanediol 3.0, Glycerine 1.0;

Composition (iv) AA 3.0, DEG 2.0, trimethylol propane 3.0.

b) Give the structures of the polymers A and B. What are the terminal groups in A? What types of links are formed in conversion of A to B? In the polymer B, what are the hard and soft segments? Why are these characteristics observed? What happens when this polymer is stretched and when the stretching force is withdrawn? What class of fiber is B?



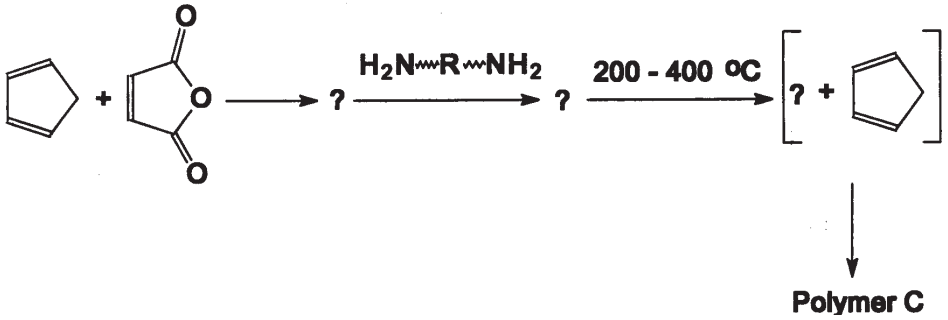
c) A typical formulation for flexible foam is given below. Comment on the role of different components and their quantities. What are the reactions leading to cross linking? Draw a structure indicating crosslinking.

Polyether triol 100 (parts by weight), 80:20 TDI 40, water 3.0 DABCO 0.5, stannous octoate 0.3, silicone block copolymer 1.0.

d) Describe the Japanese process involving photonitrosation for conversion of cyclohexane to caprolactam. What are its advantages as compared to the usual process? Give the mechanism of photonitrosation.

e) How are the aromatic polyamides Nomex and Kevlar prepared? What are their advantages? Where are these used? What are their drawbacks?

f) Complete the reactions shown below. The polymer C obtained is called PMR. Explain.



SECTION - II

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

a) In the manufacture of epoxy resins, how is the molecular weight of epoxy prepolymers controlled? Why should the molecular weight of the prepolymer be controlled?

b) Write a short note on the preparation and chemical modifications of melamine formaldehyde resin. Write its important applications.

c) Write a short note on Resol and Novolak polymers.

d) Bring out the similarities and differences in the crosslinking reactions in phenol-formaldehyde and urea-formaldehyde resins.

e) Write a short note on the preparation and applications of silicone containing polymers.

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

a) Give a synthetic method for the preparation of (i) acrylic acid, (ii) methyl methacrylate, (iii) styrene, and (iv) vinyl chloride.

b) Citing advantages and limitations, describe the bulk polymerization of styrene.

c) How are copolymers of styrene prepared? Enlist their applications.

d) How can one prepare different grades of poly(vinyl alcohol)? What is the role of chemical modification in tuning polymer properties?

e) How is 2-chloro-1, 3-butadiene synthesized? Explain its crosslinking reaction. Illustrate the applications of this rubber in view of its properties.

f) Explain briefly the formation of stereoregular polypropylenes in the polymerization of propylene. Explain the role of tacticity on the properties of polypropylenes.

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Total No. of Questions : 4] **[Total No. of Pages : 2**

P1207

[3731]-33
M.Sc.
POLYMER SCIENCE
PS-312 : Polymer Processing
(Old Syllabus)

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

Instructions to 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 importance of compounding and a compounder's job in rubber industry.

b) What is meant by vulcanization? Write the mechanism of vulcanization?

c) Define the role of accelerators and activators in rubber vulcanization on a non-sulfur system.

d) Differentiate between re-enforcing and non-reinforcing fillers. Discuss theory of re-enforcement action of carbon black.

e) With the help of suitable diagrams, explain stress-strain behaviour exhibited by (i) unvulcanized rubber, (ii) vulcanized rubber and (iii) vulcanized rubber with filler.

f) Describe the process of Branbury mixing.

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

a) Enlist the fiber properties that are important in textile uses.

b) Enumerate the different methods of spinning synthetic fibers. Describe any one method in details.

P.T.O.

c) Define the following : Denier, tenacity, moisture contents and moisture regain, and crimp.

d) Describe preparation and applications of non woven fiber.

e) Give three examples polymers used for synthetic fibers. Describe preparation of any one of them.

f) Write a short note on spinning of inorganic fibers.

SECTION - II

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

a) Discuss the role of thermal stabilizers and UV stabilizers in polymers.

b) Explain what criteria are important in choosing a polymeric material for desired application.

c) Write design characteristics of object obtained by compression molding. Discuss advantages and disadvantages of compression molding.

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

e) Extrusion process is a versatile process. Explain.

f) Screw design for processing different types of polymers is of utmost importance. Explain.

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

a) Explain reciprocating screw injection molding. What are its advantages over ram based injection molding?

b) Explain injection blow molding process with the help of a neat diagram.

c) What is pultrusion? What are their specific applications?

d) Write a short note on processes of blow molding and rotamolding.

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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Total No. of Questions : 4] **[Total No. of Pages : 3**

P1208

[3731]-34

M.Sc.

POLYMER SCIENCE

PS-313 : Polymer Chains and Their Characteristics

(Old Syllabus)

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

Instructions to 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) What is solubility? Enlist the factors on which solubility of polymers depend.

b) Write a note on determination of solubility parameter of polymers.

c) Explain in short (i) size of linear and branched polymer of identical molecular weight, and (ii) solubility of crystalline and amorphous polymers.

d) Write a note on theta temperature and virial coefficients.

e) Explain in short polymer electrolytes.

f) Discuss the cases of LCST > UCST and UCST > LCST.

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

a) Discuss the dissolution of crystalline and amorphous polymers.

b) Relate Flory Huggins interaction parameter with cohesive energy density.

c) How does high energy radiation bring out chemical changes in polymers? How does it affect the properties of polymers?

d) Describe applications of radiation induced modification of polymers.

P.T.O.

e) Predict the effect of high energy radiation on polystyrene, PVC and PMMA.

f) Estimate solubility parameter of poly-n-ethyl methacrylate.

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-ethylmethacrylate is 1.05.

SECTION - II

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

a) What are material functions? Explain any three material functions useful in understanding rheological behaviour.

b) Explain the terms (i) viscosity, (ii) shear rate, (iii) deformation, (iv) shear flow, and (v) elongational flow.

c) Describe different stress stain behaviour 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 polymeric melt.

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

a) Given a rheological data at varying temperature and shear for polyethylene of varying molecular weight 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 and Bingham plastic.

c) Elaborate the relevance of visco-elastic behaviour of a polymer in polymeric processes.

d) Write a short note on kinetic theory of rubber elasticity.

e) Describe dynamic mechanical model for testing of polymeric material.

f) Describe theory of visco-elasticity for amorphous polymeric materials. Can it be extended to crystalline polymeric materials? Explain.

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Total No. of Questions : 4] **[Total No. of Pages : 2**

P1209

[3731]-41

M.Sc.

POLYMER SCIENCE

PS-404 : Special Topics in Polymer Science

(Old Syllabus)

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 recycling of post consumer polymer is carried out. Enlist the types of plastic containers that should not be recycled.

b) Suggest the polymers for bone replacement, dental application and substitute for blood.

c) Explain essential features of biodegradation. Why are polymers generally difficult to biodegrade?

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

e) Describe different methods to obtain functional polymers.

f) Discuss the applications of polymeric membranes in pollution control.

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

a) What are liquid crystalline polymers? How is liquid crystallinity detected?

b) Describe different methods of obtaining polymer blends.

c) Describe synthesis of any one thermally stable polymer.

P.T.O.

d) "Polymers are the most suitable materials for biomedical applications". Discuss.

e) What are engineering plastics? Discuss importance of HDT in selecting engineering applications of plastics.

f) What are polymeric membranes? Discuss mechanism of separation of gases using polymeric membranes.

SECTION - II

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

a) Describe different factors affecting liquid crystallinity in polymers.

b) What are polymer blends? Describe role of compatibilizers in blending.

c) Explain thermally stable polymers, flame retardant polymers and polymers with high HDT. Compare their properties.

d) Suggest and explain polymers for i) burnt skin replacement, ii) artificial kidneys and iii) lens / contact lens.

e) Enlist the laboratory tests conducted for the evaluation of polymers for biomedical applications.

f) Describe the importance of various molding process option while selecting engineering plastic for various applications.

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

a) Explain and suggest polymer membranes for each of the following :

i) separation of suspended solid in water,

ii) dissolved salts from water,

iii) separation of N_2 and O_2 from air.

b) Explain the phenomenon of controlled release of drugs using polymers.

c) Enlist and discuss the different applications of piezoelectric PVDF.

d) What are electroactive polymers? Describe the mechanism of conduction using solitons and polarons.

e) Discuss applications of polymeric membranes in food processing.

f) Describe the mechanism and applications of polymers that are filled with conducting fillers.

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Total No. of Questions : 4] **[Total No. of Pages : 5**

P1210

[3731]-42
M.Sc.
POLYMER SCIENCE
PS-410 : Analysis and Testing of Polymers
(Old Syllabus)

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

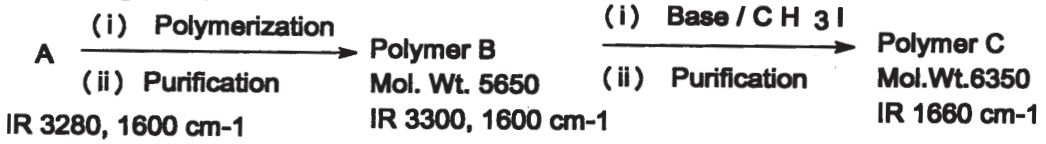
Instructions to candidates:

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) A monomer A ($C_6H_{11}NO$), with no methyl group, shows the reactions given below. Identify monomer A and polymers B and C from the given data. Explain your answer.



* Assume no degradation during reaction. Hydrolysis of A and B gives a product soluble in aq. HCl and aq. NaOH.

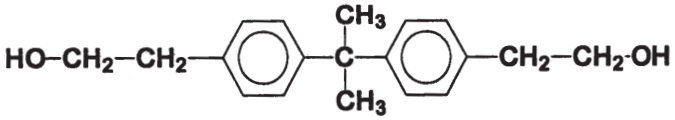
b) Answer any one of the following :

(i) Explain the term localized group frequency. Why is the X-H frequency localized? Why are the non-hydrogen bonded stretching frequencies OH > NH > CH > SH.

(ii) Suggest two possible structures for a compound C_5H_8O which gives positive iodoform test and shows IR bands at 3300 (broad) and 2150 cm^{-1}. Explain your answer.

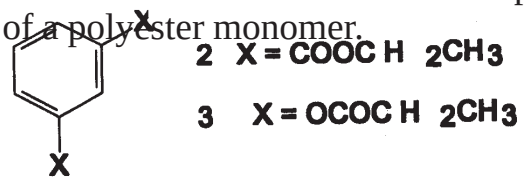
c) Make a neat sketch of the ^{1}H-NMR of the following monomer shown below.

Consider chemical shifts, multiplicity, integration, coupling constants, intensity of lines within a multiplet and comparative intensity of different lines of different multiplets. Assume no coupling of OH proton with CH_2.



P.T.O.

d) The ^{1}H-NMR spectra of 2 and 3 are given below. Identify which spectrum corresponds to which compound. Assign the signals. Clearly explain the differences in chemical shifts in the two compounds. Note that 2 is the ethyl ester of a polyester monomer.



(i) 1.4 (t, J = 6 Hz, 24 mm); 4.4 (q, J = 6 Hz, 16 mm); 7.58 (t, J = 8 Hz, 4 mm); 8.2 (dd, J = 2 and 8 Hz, 8 mm); 8.67 (t, J = 2 Hz, 4 mm).

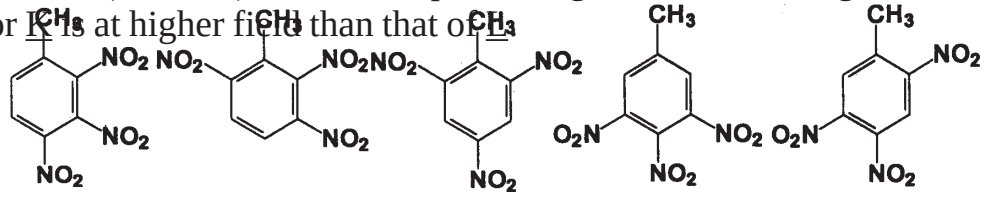
(ii) 1.1 (t, J = 6 Hz, 24 mm); 2.4 (q, J = 6 Hz, 16 mm); 6.8 (m, 24 mm), 7.28(t, J = 8 Hz, 8 mm).

e) Identify four aldehydes all with the formula $C_5H_{10}O$ from their ^{1}H-NMR spectra. Explain your answer. D shows only two singlets. E shows four sets of signals both F and G show five sets of signals, F shows 9.7(t) while G shows 9.7(d). For isomers E, F and G indicate maximum number of lines expected and integration for each set of signals. (Assume for each compound 1H = 4 mm).

f) The CMR spectrum of cycloheptanone shows signals at 24.4(t*), 30.6(t*), 43.9(t*) and 215.* Strong signals.
Assign these signals. On reaction with base and D_2O it gives a mixture of two products mol. wt. 115 and 116. The Proton noise decoupled spectrum around 44 showed signals with intensities 9:18:9:27:9:18:9:9 from high field to low field. Deduce the percentage of the two isomers. Explain your answers.

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

a) Identify the five isomers of the trinitrotoluenes 4 to 8 from the CMR and ^{1}H-NMR data, giving reasons. Isomers H and I both show five signals while J, K, and L all show seven signals in the proton noise decoupled spectrum. In the ^{1}H-NMR both H and I show in aromatic region 2H singlet, the singlet of H is more downfield than that of I. while J shows two different singlet each 1H. Isomer K and L both show two doublet J = 8 Hz (each 1H). The most upfield singlet in aromatic region of CMR for K is at higher field than that of L.



b) The major compound M ($C_{14}H_9Cl_5$) obtained by the reaction of C_6H_5Cl and CCl_3CHO has the CMR given below. Deduce its structure, giving reasons. Two other minor products are isolated in the same reaction both $C_{14}H_9Cl_5$. How can the number of signals seen in the minor products establish their structure? Note that chlorine in C_6H_5Cl is ortho and para directing.

CMR : 68(d), 103(s), 128(d, strong), 132(d, strong), 134(s), 137(s).

c) Assign a structure to a possible monomer based on the spectral data. Explain your answer. Assign the signals seen in CMR and ^{1}H-NMR.

Mol formula $C_7H_{12}O_4$ UV : Featureless above 220 nm,

IR 3400 to 2500 (broad), 1680 cm^{-1}.

CMR : 28*, 32, 44*, 180*, * strong signal.

DEPT 1 : 28 up; 44 down; 32, 180 absent

DEPT 2 : no signal

^{1}H-NMR : 1.2 (s, 24 mm), 2.4 (s, 16 mm), 11.5 (s, exchanges, 8 mm)

TABLE 1 - Some characteristics IR data in cm^{-1}. Values are approximate.		
O-H 3600 (free)	NH 3300	C-H 3000
C≡N 2250	C≡C 2200	C=C 1620
Vinyl ester 1760	Saturated ester 1740	Saturated ketone 1720

Saturated amide 1650.

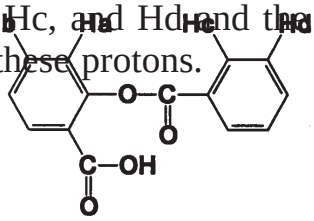
TABLE 2 - Approximate chemical shifts of protons (δ values)

CH_3-C 0.9	C=C-CH_3 1.6	O=C-CH_3 2.0
ROCH_3 3.8	-CO-CH_3 3.8	H_2C=C 4.6
C=C-H 5.1	HC=C-CO 6.3	C=CH-CO 5.7

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, RCOCH_2, RCOOH 165-180	RCOR, RCHO, 190-210	

d) In the conversion of toluene to phenol, the compound I is an intermediate. Indicate giving reasons, the appropriate chemical shift of the protons

Ha, Hb, Hc, and Hd and the maximum number of lines expected for each of these protons.



e) The following compound shows the PMR signals given below. Assign these signals giving reasons.

PMR :

1.05 (t, J = 6.5 Hz, 15 mm);

1.3 (t, J = 6 Hz, 14.8 mm);

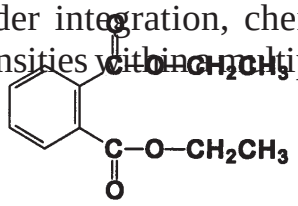
2.1(m, 9.8 min);

4.05 (t, J = 5.5 Hz, 5 mm);

4.22 (q, J = 6 Hz, 10 mm).

$$H_3C–CH_2–O–\overset{\overset{O}{\|}}{C}–\overset{\overset{Br}{|}}{CH}–CH_2–CH_3$$

f) Phthalic acid esters are widely used as plasticizers. With the help of a neat sketch of the PMR explain the structure of the diethyl ester given below. Consider integration, chemical shift, multiplicities, coupling constants, intensities within a multiplet and intensities of lines in different multiplets.



SECTION - II

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

a) Write a note on dichroism and birefringence and its use in characterization of polymers.

b) With the help of a neatly labeled diagram explain scanning electron microscope. Mention important applications.

c) Define acid number in the analysis of polymers. Describe the method for the analysis of acetyl number of polymers.

d) How is iodine number of unsaturated polymers? What is its significance?

e) How are density, refractive index and color tests important in testing and analysis of polymers?

f) Write a short note on semiconductor detector used in x-ray analysis.

Q4) Attempt <u>any four</u> 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 transition of 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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Total No. of Questions : 4] **[Total No. of Pages : 3**

P1211

[3731]-43
M.Sc.
POLYMER SCIENCE
PS-411 : Structure and Properties of Bulk Polymers
(Old Syllabus)

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

Instructions to 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) What is glass transition temperature? Do highly crystalline polymers exhibit glass transition temperature? Explain your answer.

b) What is the difference between primary and secondary glass transition temperature?

c) Explain what happens during quenching of polymers. Comment on the thermal and mechanical properties of melt and solution crystallized polymers.

d) Consider the following facts: nylon 6 is crystalline, poly (vinyl carbazole) is amorphous and polyvinyl alcohol is crystalline. With the help of structures explain the reasons for this.

e) What are plasticizers? Explain with suitable examples the role of plasticizers employed in polymers.

f) Explain the features of semicrystalline and amorphous polymers. With a suitable diagram explain Tg, Tm and Tc.

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

a) Arrange the polymers in order of increasing Tg.

Polyethylene, polystyrene and polypropylene

Poly(methylacrylate) and poly(methyl methacrylate)

Poly(vinyl chloride) and poly(vinylidene chloride)

Poly(methyl acrylate), poly(ethylacrylate) and poly(butylacrylate).

P.T.O.

b) Differentiate between crystalline and crystallizability. It is possible to obtain a polymer with 100% crystallinity. Comment on its Tg, Tm and Tc.

c) What are spherulites? Comment on the mechanical properties of a rapidly crystallized polymer sample and slowly crystallized polymer sample.

d) What are plasticizers? What does plasticization depend on? Give suitable examples of plasticized polymers.

e) Explain the term degree of crystallinity. What are X_v, X_m and X_{cal}.

f) Differentiate between plasticization and copolymerization on Tg of polymers. Give examples.

SECTION - II

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

a) Differentiate between adhesion and cohesion. Describe the mechanism of adhesion of a substrate to a metal, wood and paper surface.

b) What are the different classes of adhesives that are based on bonding temperature and method of bonding?

c) Describe the various polymer used in packaging industries. Discuss the process of production of thermocol as a packing material.

d) Discuss the importance of design aspects in the selection of type of polymer in packaging system.

e) Enlist the property requirement for food packaging system.

f) Describe the FDA and other regulations related to polymer properties for packaging the perishable food and drugs.

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

a) Define the role and importance of pigment to binder ratio in a paint formulation.

b) Differentiate between obliterating power or hiding power of a pigment. How is it important in surface coating?

c) Discuss briefly the UV curable coatings on the plastics.

d) Discuss the significance of polylactic acid as packaging material in various applications.

e) Enlist the machinery employed in paint production. Explain the working of a ball mill.

f) What polymeric materials are normally used for packaging electronic gadgets? List reasons.

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Total No. of Questions : 4] **[Total No. of Pages : 2**

P1212

[3731]-301

M.Sc.

POLYMER SCIENCE

PS-310 : Chain Polymerization

(New Syllabus)

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) With suitable examples discuss the mechanism of vinyl polymerization.

b) Define inhibitors and retarders. Explain the requirements. Draw diagrams where necessary.

c) What are chain transfer agents? Describe their role and effect on molecular weight obtained in their presence.

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

e) Derive the expression for the over all rate of polymerization as a function of conversion.

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

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

a) Write a short note on ring opening polymerization.

b) Write a short note on living free radical polymerization.

c) Derive the expression for $\overline{Xn}$ in free radical polymerization.

d) Write a short note on nitroxide mediated polymerization (NMP).

e) Write a short note on atom transfer radical polymerization.

f) Derive an expression for the overall rate of polymerization for cationic polymerization.

P.T.O.

SECTION - II

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) $r_2 >> 0$, $r_2 >> 1$, (iii) r_1 infinity, r_2 infinity. Justify your answer.

c) Why do monomers show different reacting tendencies in binary copolymerization? Which factors influence their relative reactivities?

d) During binary copolymerization, some times one monomer is consumed faster than the other. What could be the reasons for such preferential consumption? Elaborate the answer with suitable examples.

e) How is polypropylene prepared? Explain the formation of stereoregular polypropylenes. Explain the variation of properties due to stereoregularity in polypropylenes.

f) Give synthetic methods to prepare following monomers (i) acrylonitrile, (ii) vinylidene fluoride, (iii) butadiene, (iv) isoprene and (v) styrene.

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

a) Describe the polymerization of acrylamide. State the important applications of acrylamide and its copolymers.

b) Describe briefly Ziegler-Natta catalyzed manufacture of polyolefins. How is it different from benzoyl peroxide type initiators in polymerizations?

c) Describe the manufacture of any one styrene copolymer that can be used as elastomer. Describe their special properties and applications.

d) Enlist the distinguishing features between LDPE and HDPE.

e) Write a note on the preparation of butadiene acrylonitrile copolymer. Give its application.

f) Discuss chemistry, technology and importance of fluoropolymers.

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Total No. of Questions : 4] **[Total No. of Pages : 3**

P1213

[3731]-302
M.Sc.
POLYMER SCIENCE
PS-311 : Condensation Polymerization
(New Syllabus)

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

Instructions to 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 rate of polymerization is independent of molecular size in step growth polymerization.

b) Describe briefly 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) A polyester made with equivalent quantities of a dibasic acid and a glycol is stabilized in molecular weight at $\overline{X}n=100$ by adding methanol. Calculate $\overline{X}w$ and the weight number fraction of monomers in the resulting polymer.

e) What is gel point? How is it experimentally determined?

f) Write in detail how stoichiometric balance affects the DP in step growth polymerization.

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

a) Explain the concept of generation in hyperbranched polymers. How many generations are practically possible in hyperbranched polymers? Explain why?

b) Write a note on divergent, convergent and accelerated convergent approaches for preparing hyperbranched polymers.

P.T.O.

c) Write a short note on the synthesis of star polymers via controlled sol gel process.

d) Give two examples of step growth polymerization reaction where in there is no formation of by product.

e) 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.

f) How do addition and condensation polymerizations differ from each other?

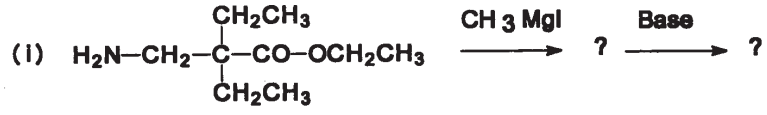
SECTION - II

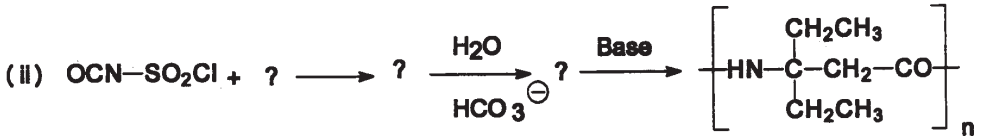
Q3) Attempt any four of the following: **[20]**

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

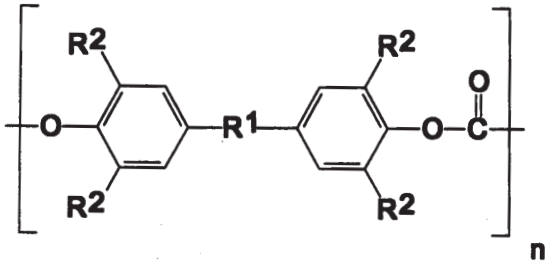
b) Give the structure of the polymers formed by the reaction of Cl-CO-R-CO-Cl with (i) NH_2-NH_2 and (ii) H_2N-NH-CO-R'-$CONHNH_2$. Why is the reaction with (ii) preferred over that with (i)? When the reaction is carried out with NH_2-NH_2 the first reaction is faster than the second. Explain why?

c) Complete the syntheses of differently substituted nylon-3 in the reaction shown below. Why is it more difficult to prepare unsubstituted nylon-3?



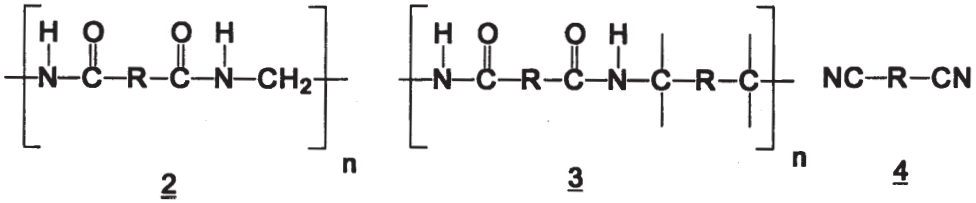


d) Comment on the Tg of the polycarbonates shown below.



R^1	R^2	Tg, ^oC
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

e) Explain the following regarding the synthesis of polyamides (i) the use of picrylchloride in the synthesis starting from p-aminobenzoic acids (ii) the formation of nylon 2 from α-amino acids using $COCl_2$ (iii) the formation of 2 and 3 from 4.



2 3 4

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

(i) a mixture of pyridine and chloroform is used,

(ii) phosgene is passed into a solution of Bisphenol A in the above,

(iii) the resulting mass is washed with HCl and then with water,

(iv) in the above proces pyridine is used as solvent, catalyst and reagent.

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

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

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

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

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

e) Describe different reactions involved in the MF resins. State their important applications.

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

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Total No. of Questions : 4] **[Total No. of Pages : 3**

P1214

[3731]-303
M.Sc.
POLYMER SCIENCE
PS-312 : Physical Chemistry of Polymers
(New Syllabus)

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

Instructions to 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 crystallinity and crystallizability. Are 100% crystalline and 100% amorphous polymers obtainable? Explain your answer.

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

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

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

e) Define heat capacity. Explain the construction and method of a suitable instrument to determine glass transition temperature of polymers.

f) Explain why nylon 6 is highly crystalline, poly(vinyl carbazole) is amorphous and polyvinyl alcohol is crystalline.

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?

P.T.O.

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) What is solubility? Enlist the factors on which solubility of a polymer depends.

b) Write a note on determination of solubility parameter of polymers.

c) Explain in short i) size of linear and branched polymer of identical molecular weight and ii) solubility of crystalline and amorphous polymers.

d) Write a note on theta temperature and virial coefficients.

e) Explain in short polymer electrolytes.

f) Discuss the cases of LCST > UCST and UCST > LCST.

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

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

b) What is hydrodynamic volume and excluded volume? What is the origin of excluded volume?

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

d) Describe applications of radiation induced modification of polymers.

e) Write a short note on radiation induced polymerization.

f) Determine the solubility parameter of poly-n-butyl 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-butyl acrylate is 1.05.

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Total No. of Questions : 4] **[Total No. of Pages : 4**

P1215

[3731]-304

M.Sc.

POLYMER SCIENCE

PS-313 : Analytical Chemistry of Polymers

(New Syllabus)

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

Instructions to 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) A monomer A ($C_6H_{11}NO$), with no methyl group) shows the reactions given below. Identify the monomer A and the polymers B and C from the given data. Explain your answer :

$$\text{A} \xrightarrow[\text{(ii) Purification}]{\text{(i) Polymerization}} \begin{matrix}\text{Polymer B} \\ \text{Mol. Wt.5650} \\ \text{3300, 1660 cm}^{-1}\end{matrix}$$

3280, 1660 cm^{-1}

$$\xrightarrow[\text{(ii) Purification}]{\text{(i) Base/CH}_3\text{I}} \begin{matrix}\text{Polymer C} \\ \text{Mol.Wt. 6350} \\ \text{1660 cm}^{-1}\end{matrix}$$

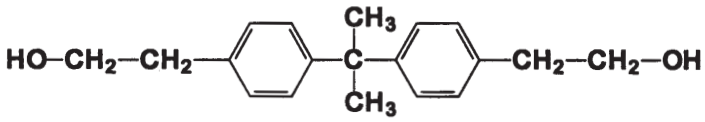
*Assume no degradation during reaction, hydrolysis of A and B gives a product soluble in aq. HCl and aq.NaOH.

b) Explain the term localized group frequency. Why is the X-H frequency localized? Why are the non-hydrogen bonded stretching frequencies OH > NH > CH > SH.

c) Suggest two possible structures for a compound C_5H_8O which gives positive iodoform test and shows IR bands at 3300 (broad) and 2150 cm^{-1}. Explain your answer.

P.T.O.

d) Make a neat sketch of the ^{1}H-NMR of a possible monomer 1 shown below. Consider chemical shifts, multiplicity, integration, coupling constants, intensity of lines within a multiplet and comparative intensity of different lines of different multiplets. Assume no coupling of OH proton with CH_2.



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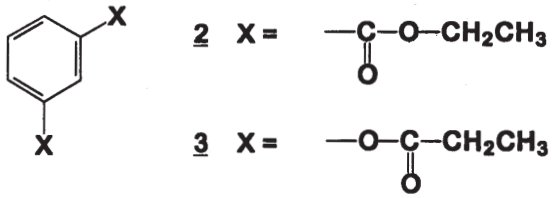
e) The ^{1}H-NMR spectra of 2 and 3 are given below. Identify which spectrum corresponds to which compound. Assign the signals. Clearly explain the differences in chemical shifts in the two compounds. Note that 2 is the ethyl ester of a polyester monomer.



(i) 1.4(t, J = 6 Hz, 24 mm); 4.4(q, J = 6 Hz, 16 mm); 7.58(t, J = 8 Hz, 4 mm); 8.2(dd, J = 2 and 8 Hz, 8 mm); 8.67(t, J = 2 Hz, 4 mm).

(ii) 1.1(t, J = 6 Hz, 24 mm); 2.4(q, J = 6 Hz, 16 mm); 6.8(m, 24 mm), 7.28(t, J = 8 Hz, 8 mm).

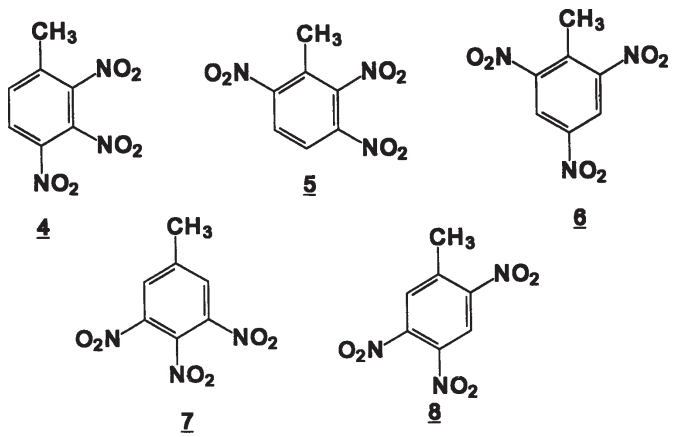
f) Identify four aldehydes all with the formula $C_5H_{10}O$ from their ^{1}H-NMR spectra. Explain your answer. D shows only two singlets. E shows four sets of signals both F and G show five sets of signals, F shows 9.7 (t) while G shows 9.7 (d) . For isomers E, F and G indicate maximum number of lines expected and integration for each set of signals. (Assume for each compound 1H = 4 mm).

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

a) The CMR spectrum of cycloheptanone shows signals at 24.4(t*, 30.6(t*), 43.9(t*) and 215. *Strong signals.

Assign these signals. On reaction with base and D_2O it gives a mixture of two products mol. wt. 115 and 116. The Proton noise decoupled spectrum around 44 showed signals with intensities 9:18:9:27:9:18:9:9 from high field to low field. Deduce the percentage of the two isomers. Explain your answers.

b) Identify the five isomers of the trinitrotoluenes 4 to 8 from the CMR and ^{1}H NMR data, giving reasons. Isomers H and I both show five signals while J, K and L all show seven signals in the proton noise decoupled spectrum. In the ^{1}H-NMR both H and I show in aromatic region 2H singlet, the singlet of H is more downfield than that of I. While J shows two different singlet each 1H. Isomer K and L both show two doublet J = 8 Hz (each 1H). The most upfield singlet in aromatic region of CMR for K is at higher field than that of L.



c) The major compound M($C_{14}H_9Cl_5$) obtained by the reaction of C_6H_5Cl and CCl_3CHO has the CMR given below. Deduce its structure, giving reasons. Two other minor products are isolated in the same reaction both $C_{14}H_9Cl_5$. How can the number of signals seen in the minor products establish their structure. Note that chlorine in C_6H_5Cl is ortho and para directing.

CMR: 68(d), 103(s), 128(d, strong), 132(d, strong), 134(s), 137(s).

SECTION - II

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

a) How is DTA useful in the study of first order and second order transitions in polymers?

b) Write a note on small angle scattering of X-rays by polymers.

c) Explain with reference to a simple example the analysis of molecular structure of a simple polymer using XRD technique.

d) Describe the different detectors used for detecting X-rays.

e) Find the interplanar spacing from the following data for the crystal obtained in a powder camera method:

λ rays used = 154 nm.

Order of reflection = 1.

Length of blackened arc on the camera = 58.88 mm.

Camera radius = 57.3 mm.

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

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

a) How is thermal stability of a polymer elucidated from TGA studies?

b) Discuss the maximization method used in TGA.

c) Explain the behaviour of PTFE during TGA studies.

d) Write a short note on DTG for polymer characterization.

e) What phenomenon governs the glass transition temperature in polymers?

f) What is refractive index and abbe number? How are these useful in getting information about transparency, mechanical properties and moisture resistance of the polymeric material?

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Total No. of Questions : 4] **[Total No. of Pages : 2**

P1216

[3731]-401

M.Sc.

POLYMER SCIENCE

PS-410 : Polymer Processing

(New Syllabus)

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) Write the important features of injection molding.

b) Explain various defects and their causes in injection molding.

c) Describe process of RIM and RRIM.

d) Compare the processes of blow molding and rotamolding.

e) Describe the process of calendering. Explain the variation in roller arrangement with variation in the nature of the polymer processed.

f) Explain the variation in thickness in the product formed by thermoforming.

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

a) Why are the additives needed for polymers? Explain plasticizers with their role. Give examples of different plasticizers.

b) Explain the 'role of design of object' in deciding the suitable polymeric process.

c) Describe typical processing parameters for compression molding.

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

P.T.O.

e) Describe different zones in the barrel of an extruder. Explain variation in the screw in each zone.

f) Write a note on co-rotating twin screw extruder with a neat diagram.

SECTION - II

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

a) What fiber properties are important in textile uses?

b) What are different methods of spinning synthetic fibers, describe any one in details?

c) Define Denier, tenacity, moisture contents and moisture regain and crimp.

d) Describe preparation and applications of non woven fiber.

e) Give examples of any three synthetic fibers. Describe preparation of any one of them.

f) Write a short note on spinning of inorganic fibers.

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

a) Discuss importance of compounder's job in rubber industry.

b) Define vulcanization. Write the mechanism of vulcanization.

c) Discuss importance of accelerators and activators in rubber vulcanization on a non-sulphur system.

d) Compare the concept of re-enforcing and non-reinforcing fillers. Discuss theory of re-enforcement action of carbon black.

e) With the help of suitable diagram, explain (i) unvulcanized rubber, (ii) vulcanized rubber and (iii) vulcanized rubber with filler.

f) Explain the process of Branbury mixing.

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Total No. of Questions : 4] **[Total No. of Pages : 2**

P1217

[3731]-402

M.Sc.

POLYMER SCIENCE

PS-411 : Rheology and Mechanical Properties of Polymers

(New Syllabus)

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

Instructions to 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) What is power law model? Explain.

b) Draw stress strain curve for (i) hard and brittle, (ii) hard and strong, (iii) hard and tough, (iv) soft and weak, and (v) soft and tough polymers. Explain their behaviour.

c) Write short note on kinetic theory of rubber elasticity.

d) Describe dynamic mechanical model for testing of polymeric material.

e) Describe theory of visco-elasticity for amorphous polymeric material. Why it can not be extended to crystalline polymeric materials?

f) Explain shear thickening and shear thinning with respect to polymers.

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

a) Explain Hook's equation and Newton's equation.

b) Explain using dashpot and spring analogy Maxwell and Voigt viscoelasticity model.

c) Compare the process of creep and stress relaxation in polymers.

d) Describe the effect of branching and stereo-regularity of polymers on rheological properties.

P.T.O.

e) Define the terms : (i) rheology, (ii) Deborah number, (iii) normal stress, (iv) deformation, and (v) shear thinning.

f) Explain the principle of time-temperature super position.

SECTION - II

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

a) Describe mechanism of adhesion of a substrate to metal, wood and paper surface.

b) Describe the classification of adhesives.

c) Describe different methods of applying an adhesive onto the substrate.

d) Describe different tests to control the quality of adhesives during manufacturing.

e) What is the difference between paint and varnish?

f) Discuss tinting resistance of white pigment and tinting power of dye pigment.

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

a) Discuss importance of selecting pigment to binder ratio in paint formulation.

b) Discuss the property of polymeric material as the film former in surface coating. Enlist various commercial polymers / resins used in surface coating applications.

c) Discuss the importance of barrier properties of packaging materials in the packaging of biological air sensitive materials.

d) Discuss the important property requirements of polymer for packaging applications.

e) Compare special purpose and general purpose packaging techniques.

f) Describe the preparation of thermocol from styrene monomer.

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Total No. of Questions : 4] **[Total No. of Pages : 2**

P1218

[3731]-403

M.Sc.

POLYMER SCIENCE

PS-404 : Special Topics

(New Syllabus)

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

Instructions to 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) What are functional polymers? Enlist applications of functional polymers.

b) Discuss the applications of polymeric membranes in pollution control.

c) Suggest the polymers for bone replacement, dental application and substitute for blood.

d) What are liquid crystalline polymers? How is liquid crystallinity detected?

e) What are electroactive polymers? Discuss the mechanism of conduction in inherently conducting polymers.

f) What are water soluble polymers? Give examples of water soluble polymers.

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

a) Write and discuss the principles of Green Chemistry and its relevance to polymers.

b) What are polymer gels? Give examples and applications of polymer gels.

c) Write a note on polymer nanocomposites and their applications.

P.T.O.

d) What are biodegradable polymers? Give examples and applications of biodegradable polymers.

e) Explain how recycling of post consumer polymer is carried out. Enlist the types of plastic containers that should not be recycled.

f) What are polymer blends? Describe role of compatibilisers in blending.

SECTION - II

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

a) Write a note on chemical modification of polymers to obtain functional polymers.

b) What are polymeric membranes? Discuss mechanism of separation of gases using polymeric membranes.

c) Suggest and explain polymers for (i) burnt skin replacement, (ii) artificial kidneys, and (iii) lens / contact lens.

d) Describe different factors affecting liquid crystallinity in polymers.

e) Describe applications of polymeric materials filled with conducting fillers. What are the property requirements of conducting filler?

f) Give two methods of synthesis of water soluble polymers.

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

a) Write and describe two examples chemical reactions carried out under green conditions.

b) Write and describe the synthesis of two polymer gels and list their uses.

c) Write a note on polymer nanocomposites in medicine.

d) Enlist the accepted mechanisms of biodegradation. Explain essential features of biodegradation.

e) Write a note on different methods of recycling of poly (ethylene terephthalate) (PET).

f) Write a note on LCST and UCST with reference to polymer blends.

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