SARDAR PATEL UNIVERSITY
VALLABH VIDYANAGAR

SYLLABUS EFFECTIVE FROM: 2018-19
M.Sc. CHEMISTRY
SEMESTER-III
INDUSTRIAL POLYMER CHEMISTRY
(Total 650 marks)

Course Code	Course Title	Hours per week	Internal Marks	External Marks	Total Marks
PS03CIPC21	Spectroscopy of Polymers	4 hrs	30	70	100
PS03CIPC22	Manufacture Properties and Applications of Thermosets	4 hrs	30	70	100
PS03CIPC23	Polymer Structure & Properties	4 hrs	30	70	100
PS03EIPC21-22	Any One	4 hrs	30	70	100
PS03CIPC24	Practicals	8 hrs	30	70	100
PS03CIPC25	Project Work	8 hrs	30	70	100
PS03CIPC26	Practicals	8 hrs	30	70	100
PS03CIPC27	Project Work	8 hrs	30	70	100
PS03CIPC28	Comprehensive Viva	1 hrs	-	50	50
				Total Marks	650

Paper Code: PS03CIPC21	**Total Credit: 4**
Title of Paper: Spectroscopy of Polymers	

Unit	Description in detail	Weightage (%)
I	UV Spectroscopy: Theory and Principles of electronic transition and UV absorption, Chromophores and Auxochromes, Woodward-Fieser rules for dienes and enones, Characteristic absorptions in alkenes and alkynes, alcohols, ethers, amines, carbonyl compounds. Effects of conjugation. Characteristic absorptions in aromatic compounds. UV spectroscopy of Polymeric materials.	25%
II	Infrared Spectroscopy: Theory and Principles, Molecular vibrations, Characteristic group absorptions in hydrocarbons, Aromatic compounds, alcohol and phenols, ethers, carbonyl compounds, amines, nitriles, nitro compounds, carboxylic acids and halide. Polymer structrure analysis by different IR techniques.	25%
III	PMR Spectroscopy: Proton resonance condition, Aspects of PMR spectra – number of signals, chemical shifts, shielding and deshielding, diamagnetic anisotropy, factors affecting chemical shifts, peak area and integration, splitting of the signals – spin-spin coupling, coupling constants – vicinal, geminal, long range and virtual couplings, Pople notation and spin assignments, chemical shift	25%

	equivalence and magnetic equivalence, simplification of the PMR spectra – high resolution spectra, use of shift reagents, spin-spin decoupling-double resonance, proton exchange, deuterium exchange, Examples of PMR characterization of simple organic and polymer compound. Solid-State NMR of Polymers: Introduction, Fundamentals of Soldi-State NMR, Polymer Applications of Solid-State NMR	
IV	^{13}C-NMR Spectroscopy: Difficulties and solution for recording 13C-NMR spectra, recording of 13CNMR spectra – scale, solvents, solvent signals and their positions, multiplicity, 13C-1H coupling constant – proton coupled and decoupled 13C spectra, broad band decoupling, off resonance technique. Chemical shifts in 13C spectra – chemical shift calculation for alkanes, alkenes and alkynes, chemical shift calculation in internal and terminal substituted compounds, aromatic compounds. 13C - DEPT spectra – differentiation in primary, secondary and tertiary carbons by DEPT – 45, DEPT – 90, DEPT – 135 spectra. Applications of ^{13}CNMR spectroscopy for characterization of simple organic and polymer compound. 2D NMR Spectroscopy: Theory and principles of 2D NMR spectroscopy, interpretation of 1H-1H COSY, 1H-13C HETCOR,	25%

Reference Books:

1. Spectroscopic Identification of Organic Compounds R. M. Silverstein and F. X. Webster, 6th edition (John Wiley & Sons)
2. Introduction to Spectroscopy D. L. Pavia, G. M. Lampman and G. S. Kriz, 3rd edition (Thomson Brooks/Cole)
3. Organic Spectroscopy – Principles and Applications Jag Mohan, 2nd edition (Narosa Publishing House)
4. Polymer Characterization, E. Schroder, G.Muller et al, Hanser Publ., New York
5. Characterization and analysis of polymers, John Wiley & sons Inc., New York, 2008
6. NMR spectroscopy of polymers in solution and in the solid state, H. N. Cheng and D. English, ACS

Paper Code: PS03CIPC22		Total Credit: 4
Title of Paper: Manufacture Properties and Applications of Thermosets		
Unit	**Description in detail**	**Weightage (%)**
I	Introduction of thermosets, General properties and Uses of Thermosets, Cross-linking reactions, Viscosity and Thermal control during crosslinking. Polyesters: Linear unsaturated polyester, Linear saturated polyesters of low molecular weight, Linear saturated polyesters of high molecular weight, Network polyesters	25%
II	Phenol Formaldehyde Polymers: Raw materials of Phenolics, Various phenol processes, Other Phenols and Aldehydes, Novolacs and Resol (effect of the ratio of phenol to aldehyde on the nature and the property of the polymer, theory of resinification and effect of pH on the reaction mechanism and the reaction product), Curing of phenolics, Applications of phenolics Amino Polymers: Urea-formaldehyde Resins, Melamine-formaldehyde Resins (Raw Materials, Effect of the ratio of phenol to aldehyde on the nature and the property of the polymer, Theory of resinification and effect of pH on the reaction mechanism and the reaction product, Process of conversion of low molecular weight to high molecular weight, Applications), Aniline-formaldehyde Polymers	25%
III	Epoxy resins: Basic raw materials like 2,2-bis(4'-hydroxyphenyl)propane) and 1-chloro-2,3,-epoxy-propane, Resin preparations, Different cross-linking agents used for curing, Modified epoxides & epoxy resins for advanced applications, Resin-modified epoxies (phenol-formaldehyde resins, amino resins, esterified epoxies), Epoxies based on glycidyl ethers and non-glycidyl ethers	25%
IV	Polyurethanes: Basic components: diisocyanates and diols, different diisocyanates and diols used for making resin, Resinficaton, Isocyanate reactions involving active hydrogen compounds, Preparation and Properties of Flexible Foams, Preparation and Properties of Rigid Foams, Solid polyurethane elastomers (Cast elastomers, Millable elastomers and Thermoplastic elastomers) and Polyimides	25%

Reference Books:

1. Polymer Chemistry, Seymour and Carraher, Marcel Dekker, 2003.
2. Polymer Science and Technology, R. O. Ebewel, CRC Press, Boca Raton, New York
3. Thermosets: Structure, Properties and Applications (2^{nd} Edition), Q. Guo(Woodhead Publishing in Materials), Elsevier
4. Handbook of Thermoset Resins, D. Ratna, ISmithers Publ., UK
5. Handbook of Thermoset Plastics (2^{nd} Edition), S. Goodman, Noyes Publication, USA

Paper Code: PS03CIPC23	
Title of Paper: Polymer Structure & Properties	Total Credit: 4

Unit	Description in detail	Weightage (%)
I	Fundamentals of polymer science: Polymerization, Chain polymerization, Radical, Ionic, Stereo specific polymerization, Polycondensation, Polymer solutions: Criteria and thermodynamics of solubility, fractionation of polymers by solubility, Methods of determining molecular mass: End group analysis, colligative properties and Osmometry,	25%
II	Methods for determination of molecular mass: Light scattering, Viscometry, Gel permeation chromatography (GPC). Molecular size and shape: Effect of molecular weight on, Processibility, Mechanical properties, Thermal properties, Electrical properties and Chemical properties,	25%
III	Intermolecular order: Crystallinity: Factors determining crystallinity, effect of crystallinity on properties, Orientation; Processing effect on orientation,effect of orientation on properties, Intermolecular bonding	25%
IV	Polymer chain flexibility: General fundamental concepts,Restriction of rotation, Internal rotations in macromolecules, Configuration and conformations, Thermodynamics of factors affecting chain flexibility.	25%

Reference Books:-

1. Plastic Materials, J.A.Brydson, NewmensButterworths London, 1975
2. Textbook of Polymer Science, F.W. Billmeyer, Interscience Publ., New York
3. Properties of Polymers, D. W. Van Krevelen, Elsevier Publ., 1976
4. Polymer, Structure, Properties & Applications, R.D Deanin, Cohne Books, 1972
5. Macromolecules-I, Hans-Georg Elias, Plenum Press, New York, 1984
6. Polymer Characterization, E. Schroder, G.Muller et al, Hanser Publ., New York

Paper Code: PS03EIPC21	Total Credit: 4
Title of Paper: Selected Topics in Polymers-I	

Unit	Description in detail	Weightage (%)
I	Natural Polymers**:** Polysaccharides and Lignin, Reaction of Cellulose, Glycogen, Proteins, Nucleic acids Water soluble polymers: Importance of water soluble polymers, Classification of water soluble polymers, Functions and Propoerties of water soluble polymers, Starch, Manufacturing process of corn starch, Structure, Composition and Properties of Starch, Degradation processes of Starch, Starch derivatives, Cellulose and its properties, Cellulose derivatives, Polyethylene oxide, Polyvinyl alcohol, Polyvinyl pryrrolidone	25%
II	Fibre Forming Polymers: Introduction, Fibres (Semisynthetic Fibres, Synthetic Fibres, Structure and Properties of Fibres, Applications), Rayon or artificial silk, Nitrocellulose rayon, Cuprammonium rayon and properties of cuprammonium rayon, Viscose rayon and properties of viscous rayon, Kapron Fibre, Terylene or Dacron Fibre, Orlon Fibre, Saran Fibre, Fabric Defects, Fiber Spinning Operations (Dry spinning, Melt spinning and Wet spinning)	25%
III	Rubber General Purpose: History and Importance of Rubber, Polymer Repeating groups of rubber, Natural Rubber and Balta, Types of Natural Rubber, Raw Materials, Production of Rubber, Latex and its compositions, Concentration and Stabilization methods of Latex, Taping of Rubber Latex, Refining of Crude Rubber, Technically Classified Rubber, Various forms of Natural Rubber, Vulcanization of Natural Rubber, Non-sulphur vulcanization, Peroxide vulcanization, Factors affecting the process of vulcanization, Vulcanization Techniques and Properties, Reclaimed Rubber Non-Diene Elastomers: Polyisobutylene, Polysiloxanes, Fluoroelastomers, Chlorinated rubber, Rubber Hydrochloride, Cyclized Rubber, Oxidized Rubber, Ebonite	25%
IV	Rubber Special Purpose: Styrene Butadiene Rubber, Polybutadiene Rubber, Polyisoprene Rubber, Ethylene Propylene Rubber, Butyl Rubber, Nitrile Rubber, Neoprene Rubber. Fluoroelastomers, Thiokol Rubber, and Thermoplastic Elastomers	25%

Reference Books:

1. Polymer Chemistry An Introduction (3rd Indian Edition), Malcolm P. Stevens, Oxford University Press
2. Elastomer and Rubber Compounding Materials, I.Franta, Elsevier Publication
3. Polymer Science and Technology, J. Fried, Prentice-Hall of India Private Limited
4. Rubber Technology, Maurice Morton, Van Nostrand Reinhold Publication, New York
5. Handbook of Textile Fibre Structure, Fundamentals and Manufactured Polymer Fibres, S. J. Eichhorn, J. W.S. Hearle, M. Jaffie and T.Kikutani, Elsevier

Paper Code: PS03EIPC22	Total Credit: 4
Title of Paper: Mechanical and Electrical Properties of Polymers	

Unit	Description in detail	Weightage (%)
I	Mechanical properties of polymer: introduction, general considerations, objectives, different types of mechanicalbehavior, elastic solids and polymer, state of stress and strain, generalized Hook's law. Behavior of polymers in rubber like state; finite strain elasticity, generalized definition of strain and stress, strain-stress relationship, use of strain energy function, experimental studies of finite elastic behaviors in rubbers.	25%
II	Statistical molecular theories of the rubber like state, thermodynamic considerations, statistical considerations. Linear viscoelastic behavior; viscoelastic behavior, mathematical treatment of linear viscoelastic behavior, dynamical measurements, the complex modulus and complex compliance, the relationship between the complex modulii and the stress relaxation modulus, the relaxation strength	25%
III	The glassy state and the glass transaction, Experimental studies of the linear viscoelastic behaviors of polymers: general introduction, time-temperature equivalence and superposition, transition state theories, WLF equation. Relaxation transition and their relationship to molecular structure: relaxation transitions in amorphous polymers, Dynamic mechanical testing.	25%
IV	Electrical properties of polymer: volume resistively dielectric break down, dialectical constant, dielectric loss dissipation factor, electrostatic charging, dielectric behaviors of polar and non polar polymers in an alternating filled varying frequency and temperature, relaxation time and temperature dependence, conductivity and temperature dependence, factor affecting dielectric behavior polymers. Conducting polymers: chronology, synthesis, characterization, doping, mechanism of conduction, Electrochemical Impedance Spectroscopy (EIS).	25%

Reference Books:-

1. Polymer science and material science H.B. Vol. I & II by Jenkins, A.D. North Holland publishing co., Amsterdam London.
2. Mechanical properties of solid polymers, I.M. WardWiley-lnterscience, john-Wiley and sons Ltd. New York
3. Mechnical properties of polymers, L.E. Nielson Reinhold publishing co., Chapman and hall Ltd. London
4. Electrical properties of polymers, A.R.Blythe Cambridge University press, Cambridge
5. "Electrical properties" in encyclopedia of polymer science and technology, John Wiley and sons. Inc. New York
6. Physical chemistry of polymers, A. Tager Mir publishers, Moscow.
7. Impedance Spectroscopy, VadimF.Lvovich, John Wiley & Sons Inc. 2012.

Paper Code: PS03CIPC24	
Title of Paper: Practical	Total Credit: 4

Description	Weightage (%)
Synthesis of Polymers • Phenol-formaldehyde resin (Ammonia catalyst) • Phenol-formaldehyde resin (Acid catalyst) • Urea-formaldehydr resin • Melamine-formaldehyde resin • Epoxy resin (Solid) • Epoxy resin (Liquid) • Poly(ethylene tetrasulfide) • Emulsion polymerization of Methyl Acryalte • Suspension polymerization of Methyl Methacrylate • Slurry polymerization of Acrylonitrile • Emulsion polymerization of Styrene • Solution polymerization of Vinyl Acetate • Unsaturated Polyester resin (Wet process) • Unsatureate Polyester resin (Dry process)	100%

Reference Books:

1. Rubber and Plastics Testing, P. Kluckow, Champman& Hall Publ., UK
2. Handbook of Analysis of Synthetic Polymers and Plastics, J. Urbanski, Ellis Horwood Ltd.(Publ.)
3. Introduction of Chemical Analysis of Plastics, A Krause and A. Lenge, Lliffe books Ltd. London
4. Polymer Characterization, E. Shroder et al., Hanser Publ.
5. Experiments in Polymer Science, D. G. Hundiwale, V. D. Athawale, U. R. Kapadi and V. V. Gite, New Age International Publsihers
6. Macromolecules: Vol. 2: Synthesis, Materials and Technology, H. G. Elias, Springer

Paper Code: PS03CIPC26	Total Credit: 4
Title of Paper: Practical	

Description	Weightage (%)
Characterization of Polymers • Determination of total formaldehyde content in urea resin by Levenson's method. • To determine free formaldehyde in the given urea-formaldehyde or phenol-formaldehyde resin by sodium sulfite method. • To determine free phenol by Koppeschaar's method in PF resin. • Determination of hydroxyl value of polyvinyl alcohol. • To determine epoxy equivalent of epoxy resin using dioxane as neutral solvent. • Determination of the Acid value of polyester resin. • Determination of iodine value of polyester resin. • To determine unreacted styrene in polystyrene. • To determine saponification value of polyvinyl acetate.	50%
Purity of Monomers Determination of percentage purity of - epichlorohydrin using dioxane as netrual solvent - maleic anhydride - phthalic anhydride - styrene - hexamine - phenol	50%

Reference Books:

1. Handbook of Analysis of Synthetic Polymers and Plastics, J. Urbanski, Ellis Horwood Ltd.(Publ.)
2. Introduction of Chemical Analysis of Plastics, A Krause and A. Lenge, Lliffe books Ltd. London
3. Polymer Characterization, E. Shroder et al., Hanser Publ.
4. Experiments in Polymer Science, D. G. Hundiwale, V. D. Athawale, U. R. Kapadi and V. V. Gite, New Age International Publsihers

OR

PS03CIPC25 and PS03IPC27 :

Project work (as optional) in place of practicals; to be offered to some of the students, based on their merit, interest and placement with the teachers (Marks : 200). The project shall have to be carried out under the allotted teacher(s) and a dissertation shall

be submitted and will be assessed for internal (60 marks) and external (140 marks), in the usual manner.

Paper Code: PS03CIPC28	**Total Credit: 1**
Title of Paper: Comprehensive Viva	

Description in detail	**Weightage (%)**
Viva Voce From the Subjects Studied in Semester - III	100%