ARDAR PATEL UNIVERSITY
Vallabh Vidyanagar, Gujarat
(Reaccredited with 'A' Grade by NAAC (CGPA 3.25)
Syllabus with effect from the Academic Year 2022-2023

PROGRAMME STRUCTURE
Master of Science in Chemistry
MSc (Industrial Polymer Chemistry) Semester: III

Programme Outcome (PO) - For MSc Chemistry Programme	Master of Science program provides extended theoretical and practical knowledge of different science subjects. Master of Science programme at Sardar Patel University is designed keeping the overall back ground preparation in mind for the student to either seek a job or to become an entrepreneur. The students, after completion of Bachelor of Science can select the master's programme in the subject they have had at the final year or in a related discipline (depending upon eligibility criteria prescribed by university). **Programme outcomes: At the end of the program, the students will be able to** 1. Have a deep understanding of both the theoretical and practical concepts in the respective subject. 2. Understand laboratory processes and use scientific equipments and work independently. 3. Develop research temperament as a consequence of their theory and practical learning. 4. Communicate scientific information in oral and written form. 5. Understand the issues related to nature and environmental contexts and think rationally for sustainable development. 6. The students are able to handle unexpected situations by critically analyzing the problem.
Programme Specific Outcome (PSO) - For MSc Chemistry Semester - III	Students will have a firm foundation in the fundamentals and application of current chemical and scientific theories including those in Analytical Inorganic Chemistry, Organic Chemistry, Physical Chemistry, Chemistry and Industrial polymer Chemistry. After completing M.Sc. chemistry program, students will be able to: ■ Demonstrate and apply the fundamental knowledge of the basic principles in various fields of Chemistry. ■ Apply knowledge to build up small scale industry for developing endogenous product. ■ Collaborate effectively on team-oriented projects in the field of chemistry or other related fields. ■ Communicate scientific information in a clear and concise manner both orally and in writing. ■ Inculcate logical thinking to address a problem and become result oriented with a positive attitude. ■ Enhance the scientific temperament among the students so as to develop a research culture and implementation of the policies to tackle the burning issues at global and local level. ■ Apply the knowledge to develop the sustainable and eco-friendly technology.

	■ Take up global level research opportunities to pursue Ph.D programme targeted approach and specific competitive exams conducted by service commission ■ Accept enormous job opportunities at all level of chemical industries, pharmaceutical industries and placements in R & D.

To Pass	At least 40% Marks in the University Examination in each paper and 40% Marks in the aggregate of University and Internal examination in each course of Theory, Practical & 40% Marks in Viva-voce.

Course Type	**Course Code**	**Name of Course**	**Type of Course**	**T /P**	**Credit**	Hours per Week	**Exam Duration in hrs**	**Component of Marks**		
								Internal	**External**	**Total**
								Total/ Passing	**Total/ Passing**	**Total/ Passing**
Core Course	PS03CIPC51	Spectroscopy of Polymers	EM & EN	T	4	4	3	30/10	70/28	100/40
	PS03CIPC52	Manufacture Properties and Applications of Thermosets	EM& EN	T	4	4	3	30/10	70/28	100/40
	PS03CIPC53	Polymer Structure & Properties	EM	T	4	4	3	30/10	70/28	100/40
Core Course (Any One)	PS03CIPC54	Practicals **OR**	EM&SD	P	4	8	6	30/10	70/28	100/40
	PS03CIPC55	Project Work	EM&SD	P	4	8		30/10	70/28	100/40
Core Course (Any One)	PS03CIPC56	Practicals **OR**	EM&SD	P	4	8	6	30/10	70/28	100/40
	PS03CIPC57	Project Work	EM&SD	P	4	8		30/10	70/28	100/40
Core Course	PS03CIPC58	Comprehensive Viva		-	1	1			50/20	50/20
Elective Course (Any one)	PS03ECHE51	Separation methods	EM& EN	T	4	4	3	30/10	70/28	100/40
	PS03ECHE52	Analytical techniques in Materials characterization	EM& EN	T	4	4	3	30/10	70/28	100/40
	PS03ECHE53	Applications of Inorganic Chemistry in Industry	EM& EN	T	4	4	3	30/10	70/28	100/40
	PS03ECHE54	Selected Topics in Advanced Inorganic Chemistry-I	EM& EN	T	4	4	3	30/10	70/28	100/40

	PS03ECHE55	Mechanical and Electrical Properties of Polymers	EM& EN	T	4	4	3	30/10	70/28	100/40
	PS03ECHE56	Selected Topics in Polymers-I	EM& EN	T	4	4	3	30/10	70/28	100/40
	PS03ECHE57	Advanced Characterization Techniques	EM& EN	T	4	4	3	30/10	70/28	100/40
	PS03ECHE58	Selected Topics in Physical Chemistry-II	EM& EN	T	4	4	3	30/10	70/28	100/40
	PS03ECHE59	Selected Topics in Organic Chemistry	EM& EN	T	4	4	3	30/10	70/28	100/40
	PS03ECHE60	Occupational Practices	EM& EN	T	4	4	3	30/10	70/28	100/40
					25					650
Add-on Course		MOOCs course from Swayam Portal								

EMPLOYABILITY = EM, ENTREPRENEURSHIP = EN and SKILL DEVELOPMENT = SD

* 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.

Master of Science, Industrial Polymer Chemistry
M. Sc. Industrial Polymer Chemistry, Semester – III

Course Code	PS03CIPC51	Title of the Course	Spectroscopy of Polymers
Total Credits of the Course	4	Hours per Week	4

Course Objectives:	1. To introduce the materials characterization techniques to the students and to help the students to understand the instrumentation aspects 2. To provide a detailed understanding of data interpretation.

Course Content		
Unit	Description	Weightage* (%)
1.	**Infrared Spectroscopy: Fundamentals, Experimental and Applications to Polymers:**-Theory and principles, molecular vibrations and calculations of vibrational frequencies, characteristic group absorptions in various polymeric compounds. Sample preparation. **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 based on polymers. Effects of conjugation. Characteristic absorptions in aromatic polymeric compounds.	25
2.	**PMR Spectroscopy: Fundamentals, Experimental and Applications to Polymers:-**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 equivalence and magnetic equivalence, first order and second order spectra, complex PMR spectra, simplification of the PMR spectra – high resolution spectra, use of shift reagents, spin-spin decoupling-double resonance, proton exchange, deuterium exchange, Nuclear Overhauser Effect. Use of PMR spectra in differentiation of stereo isomers.	25
3.	**NMR Spectroscopy: Fundamentals, Experimental and Applications to Polymers: -**13C- Difficulties and solution for recording 13C-NMR spectra, recording of 13CNMR spectra – scale, solvents, solvent signals and their positions, multiplicity, 13C-1H	25

	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. Use of 13C spectra in differentiating stereoisomers, Nuclear Overhauser Effect. 13C - DEPT spectra – differentiation in primary, secondary and tertiary carbons by DEPT – 45, DEPT – 90, DEPT – 135 spectra. 2D NMR Spectroscopy: Theory and principles of 2D NMR spectroscopy, interpretation of 1H-1H COSY, 1H-13C HETCOR, HMQC, HMBC, INADEQUATE spectra.	
4.	**Mass Spectroscopy, Fundamentals, experimental and applications to polymers:** Theory and principles of mass spectroscopy, Instrumentation, low and high resolution mass spectra, Ionization techniques – Electron Impact (EI) ionization, Chemical Ionization (CI), Field Desorption (FD), 25 Page 3 of 7 Fast Ion Bombardment (FAB), Electronspray Ionization (ESI) and Matrix Assisted 25% Page 2 of 2 Laser Desorption/Ionization (MALDI). Determination of molecular weight and molecular formula, nitrogen rule, detection of molecular ion peak, metastable ion peak. Fragmentations – rules governing the fragmentations, McLafferty rearrangement. Interpretation of mass spectra of different class of POLYMER compounds – saturated and unsaturated hydrocarbons, aromatic hydrocarbons, alcohols, ethers, ketones, aldehydes, carboxylic acids, amines, amides, compounds containing halogens.	25

Teaching-Learning Methodology	The institutional course consists of classroom lessons and video projection of the lessons is also used in classroom. The students are also able to obtain directly the above material from the University Digital Library Service.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to know	
1.	Spectroscopic techniques and applications
2.	Structural elucidation of organic and polymeric compounds by combined application of UV, IR, PMR, NMR and Mass Spectroscopy.
3.	Fundamentals of Solid-State NMR and its application to polymers.
4.	Tacticity analysis of polymers by IR and NMR spectroscopy.

Suggested References:

Sr. No.	References
1.	Polymer Spectroscopy A.H. Faweett. 1st Edition, John Wiley (1996)
2.	NMR of Polymers F. Bovey and P. Miran. First edition, Academic Press (1996)
3.	Spectroscopic Identification of Organic Compounds R. M. Silverstein and F. X. Webster,6th edition (John Wiley & Sons)
4.	Introduction to Polymer Chemistry by R. B. Seymour,Mc – Graw – Hill, New York
5.	Introduction to Spectroscopy D. L. Pavia, G. M. Lampman and G. S. Kriz, 3rd edition (Thomson Brooks/Cole)
6.	NMR of Macromolecules: A practical approach G. C. K. Roberts, 1st Edition, Oxford University Press, (1993)
7.	Organic Spectroscopy William Kemp, 3rd edition (Palgrave)
8.	Organic Spectroscopy – Principles and Applications Jag Mohan, 2nd edition (Narosa Publishing House)
9.	Spectroscopy of Organic Compounds P. S. Kalsi, 5th edition (New Age International Publishers)

On-line resources to be used if available as reference material
On-line Resources
https://www.youtube.com/watch?v=Ra4P0XCBkXs
https://www.youtube.com/watch?v=lD1bEJrJmLk

Master of Science, Industrial Polymer Chemistry
M. Sc. Industrial Polymer Chemistry, Semester – III

Course Code	PS03CIPC52	Title of the Course	Manufacture Properties and Applications of Thermosets
Total Credits of the Course	4	Hours per Week	4

Course Objectives:	To impart basic knowledge on the synthesis of various thermoset resins and its applicability.

Course Content		
Unit	Description	Weightage* (%)
1.	**Introduction of thermosets**: General properties and Uses of Thermosets, Cross-linking reactions, Viscosity and Thermal control during cross-linking. **Polyesters:** Linear unsaturated polyester, Linear saturated polyesters of low molecular weight, Linear saturated polyesters of high molecular weight, Network polyesters	25
2.	**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 and other modified phenolic resins. **Urea 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 and other modified urea formaldehyde resins.	25
3.	**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 and other melamine formaldehyde modified resins **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	25

	epoxies (phenol-formaldehyde resins, amino resins, esterified epoxies), Epoxies based on glycidyl ethers and non-glycidyl ethers	
4.	**Polyurethanes**: Basic components: diisocyanates and diols, different diisocyanates and diols used for making resin, Resinification, 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) **Polyimides**: Basic Components, Synthesis, Properties and Applications.	25

Teaching-Learning Methodology	The institutional course consists of classroom lessons and video projection of the lessons is also used in classroom. The students are also able to obtain directly the above material from the University Digital Library Service.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	Formulation for manufacturing, properties and applications of variety of thermoset materials
2.	Effect of variation in the quantities & type of curing agents & curing condition on the properties of thermoset material

Suggested References:	
Sr. No.	References
1.	Polymer Chemistry, Seymour and Carraher, Marcel Dekker,2003.
2.	Polymer Science and Technology, R.O.Ebewel, CRC Press, BocaRaton, New York

3.	Thermosets: Structure, Properties and Applications (2nd Edition), Q. Guo (Wood head Publishing in Materials),Elsevier
4.	Handbook of Thermoset Resins, D. Ratna, I. Smithers Publ.,UK
5.	Handbook of Thermoset Plastics (2nd Edition), S. Goodman, Noyes Publication, USA

On-line resources to be used if available as reference material
On-line Resources
https://www.youtube.com/watch?v=zPkhdQL2Eos
https://www.youtube.com/watch?v=PSSK5VGcC_0
https://www.youtube.com/watch?v=Nt9jsWEk8aU

Master of Science, Industrial Polymer Chemistry
M. Sc. Industrial Polymer Chemistry, Semester – III

Course Code	PS03CIPC53	Title of the Course	Polymer Structure & Properties
Total Credits of the Course	4	Hours per Week	4

Course Objectives:	To provide the students with basic knowledge of polymer materials, so that they would be able to understand and distinguish between variety of materials based on their structure and properties.

Course Content		
Unit	Description	Weightage* (%)
1.	Polymerization reactions: Chain polymerization, Ionic polymerization, Stereo specific polymerization, Polycondensation, Polymer solutions: Criteria and thermodynamics of solubility, fractionation of polymers by solubility, Methods of determining molecular mass based on coligative properties: End group analysis, VPO,HSMO etc.	25
2.	Methods for determination of molecular mass based on size: 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
3.	Intermolecular order: Crystallinity; Factors determining crystallinity, effect of crystallinity on properties, Orientation; Processing effect on orientation, effect of orientation on properties, Intermolecular bonding	25
4.	Polymer chain flexibility: General fundamental concepts, Restriction of rotation, Internal rotations in macromolecules, Configuration and conformations, Thermodynamics of factors affecting chain flexibility.	25

Teaching-Learning Methodology	The institutional course consists of classroom lessons and video projection of the lessons is also used in classroom. The students are also able to obtain directly the above material from the University Digital Library Service.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	Upon completion of the course, the student will be able to understand various structure of polymers and their effect on different properties of polymers.
2.	They can also able to predict the different properties of polymers using group contribution technique.
3.	Understanding the intermolecular order and chain flexibility of polymers.

Suggested References:	
Sr. No.	References
1.	Plastic Materials, J.A. Brydson, Newmens Butterworths 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

On-line resources to be used if available as reference material
On-line Resources
https://www.youtube.com/watch?v=jUDyjFXOb8s

Master of Science, Industrial Polymer Chemistry
M. Sc. Industrial Polymer Chemistry, Semester – III

Course Code	PS03CIPC54	Title of the Course	Practicals
Total Credits of the Course	4	Hours per Week	8

Course Objectives:	Studies synthesis of polymeric materials, emphasizing interrelationships of chemical pathways, process conditions and micro architecture of molecules produced.

Course Content		
	Description	Weightage* (%)
	Synthesis of Polymers	100

Teaching-Learning Methodology	Laboratory work

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Practical Examination (As per CBCS R.6.8.3)	30%
2.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	Understand the basic concept of chemical reactions and polymerization reactions.

Suggested References:	
Sr.	References

No.	
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., HanserPubl.
5.	Experiments in Polymer Science, D. G. Hundiwale, V. D. Athawale, U.R. Kapadi and V. V. Gite, New Age International Publishers
6.	Macromolecules: Vol. 2: Synthesis, Materials and Technology, H. G.Elias, Springer

On-line resources to be used if available as reference material
On-line Resources

Master of Science, Industrial Polymer Chemistry
M. Sc. Industrial Polymer Chemistry, Semester – III

Course Code	PS03CIPC55	Title of the Course	Project Work
Total Credits of the Course	04	Hours per Week	08

Course Objectives:	To assess the overall knowledge of the student in the relevant subjects covered in core as well as elective courses.

Course Content	
Description	Weightage* (%)
Research work in laboratory on a topic given by the supervisor	100%

Teaching-Learning Methodology	Laboratory exercise and thesis writing

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Presentation and Viva-voce Examination (As per CBCS R.6.8.3)	30%
2.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to proceed for literature survey, synthesis and characterization of compounds/ materials using modern analytical and spectroscopic techniques and their study for various applications. They will be trained in research for pursuing higher studies. They will get training for working in research in academic and industries.

Suggested References: Published research articles on given research topic.

On-line resources to be used if available as reference material
Published papers by reputed publishers like American Chemical Society, Royal Society of Chemistry, Wiley, Elsevier, etc.

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Master of Science, Industrial Polymer Chemistry
M. Sc. Industrial Polymer Chemistry, Semester – III

Course Code	PS03CIPC56	Title of the Course	Practicals
Total Credits of the Course	4	Hours per Week	8

Course Objectives:	Studies synthesis of polymeric materials, emphasizing interrelationships of chemical pathways, process conditions and micro architecture of molecules produced.

Course Content		
	Description	Weightage* (%)
	Characterization of Polymers	50
	Purity of Monomers	50

Teaching-Learning Methodology	Laboratory work

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to	
1.	Understand the basic concept of chemical reactions and polymerization reactions.
2.	Understand the basics of laboratory reagents/solutions and their preparations with respect to percent solution, molar and normal solutions too.

Suggested References:	
Sr. No.	References
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 Publishers, New Delhi

On-line resources to be used if available as reference material
On-line Resources

Master of Science, Industrial Polymer Chemistry
M. Sc. Industrial Polymer Chemistry, Semester – III

Course Code	PS03CIPC57	Title of the Course	Project Work
Total Credits of the Course	04	Hours per Week	08

Course Objectives:	To assess the overall knowledge of the student in the relevant subjects covered in core as well as elective courses.

Course Content	
Description	Weightage* (%)
Research work in laboratory on a topic given by the supervisor	100%

Teaching-Learning Methodology	Laboratory exercise and thesis writing

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Presentation and Viva-voce Examination (As per CBCS R.6.8.3)	30%
2.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to proceed for literature survey, synthesis and characterization of compounds/ materials using modern analytical and spectroscopic techniques and their study for various applications. They will be trained in research for pursuing higher studies. They will get training for working in research in academic and industries.

Suggested References: Published research articles on given research topic.

On-line resources to be used if available as reference material
Published papers by reputed publishers like American Chemical Society, Royal Society of Chemistry, Wiley, Elsevier, etc.

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Master of Science, Industrial Polymer Chemistry
M. Sc. Industrial Polymer Chemistry, Semester – III

Course Code	PS03CIPC58	Title of the Course	Comprehensive Viva
Total Credits of the Course	01	Hours per Week	01

Course Objectives:	To assess the overall knowledge of the student in the relevant subjects covered in core as well as elective courses.