SARDAR 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 (Physical 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	PS03CPHC51	Spectroscopy and Molecular Structure	EM & EN	T	4	4	3	30/10	70/28	100/40
	PS03CPHC52	Electro-analytical Methods	EM	T	4	4	3	30/10	70/28	100/40
	PS03CPHC53	Selected Topics in Physical Chemistry – I	EM& EN	T	4	4	3	30/10	70/28	100/40
Core Course (Any One)	PS03CPHC54	Practicals **OR**	EM&SD	P	4	8	6	30/10	70/28	100/40
	PS03CPHC55	Project Work	EM&SD	P	4	8		30/10	70/28	100/40
Core Course (Any One)	PS03CPHC56	Practicals **OR**	EM&SD	P	4	8	6	30/10	70/28	100/40
	PS03CPHC57	Project Work	EM&SD	P	4	8		30/10	70/28	100/40
Core Course	PS03CPHC58	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 in Science, Physical Chemistry
M. Sc. Physical Chemistry, Semester – III

Course Code	**PS03CPHC51**	Title of the Course	Spectroscopy and Molecular Structure
Total Credits of the Course	**04**	Hours per Week	**04**

Course Objectives:	The student will acquire basic knowledge of the interaction of radiation with matter and will be able to use various molecular spectroscopic techniques for structure determination. From this study, different functional groups as well as plausible structure can be determined.

Course Content

Unit	**Description**	**Weightage* (%)**
I	Interaction of radiation with matter, semi-classical treatment, time dependent perturbation theory and transition rates. **UV-spectroscopy :** Theory and principles of electronic transition, chromophores and auxochromes, Woodward-Fieser rules, Effect of conjugation, Characteristic absorptions in organic compounds. **Infra-red spectroscopy :** Principle, Theory of Molecular Vibrations, Rotation and vibration of diatomic molecules : frequency, force constant, energy and selection rules based on spectroscopy and symmetry. Vibrations of polyatomic molecules, classical and quantum mechanical approach, Local and normal modes of analysis and structure with suitable examples, Applications	25
II	**Raman Spectroscopy :** Raman effect, theory of Raman spectra, Characteristics of Raman lines, Raman spectra of diatomic molecules, selection rules, instrumentation, applications. **Microwave spectroscopy :** Introduction, Differences between Microwave spectroscopy and IR Spectroscopy, Theory of Microwave Spectroscopy, Diatomic molecules as a Rigid rotator, Selection Rules for Rotational Spectra, Instrument for Microwave spectroscopy, Applications.	25
III	**^{1}H-Nuclear Magnetic Resonance :** Origin of Chemical shift and spin-spin coupling, Fourier Transform technique, Pulse sequence, relaxation processes, Use of integration in the quantative determination of isomers, Factors affecting chemical shifts (inductive, resonance and anisotropic effect with examples), chemical shift of different types of protons (alkane, alkene, alkyne and allene etc.), different spin systems (AB, AM, AX, AB2, AX2, A2B2, A2X2,….). Factors affecting coupling constants (dihedral angle, Karplus equation-graph, electronegativity, bond order, hybridization, bond angle with examples). Double resonance, spin-spin decoupling, Nuclear Overhauser effect with examples.	25
IV	**Mass spectroscopy :** Theory, instrumentation, method of ionization (field ionization, FAB, MALDI, californium plasma), different detectors [magnetic analyser, ion cyclotron analyser, quandruple mass filter], time of flight	25

	(TOF). Importance of HRMS, Rules of fragmentation of different functional groups, factors controlling fragmentation examples such as drugs, ionic liquids etc.	

Teaching-Learning Methodology	Chalk and board method along with ICT tools Model demonstration as per the demand of the topic

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.	To learn the basic Principle, instrumentation, theory, application and problems of molecular spectroscopy (UV-vis, IR, Raman, Microwave etc).
2.	To identify the various functional groups from the UV-vis as well IR spectroscopy by determining maximum absorption as well as vibrational frequencies.
3.	To gain insight in proton and carbon environment in the organic molecules using Nuclear magnetic resonance (NMR) spectroscopy.
4.	To realize the various fragment of molecules through mass spectroscopic techniques that helps to study the molecular structure.

Suggested References:	
Sr. No.	**References**
1.	Introduction to Spectroscopy, Donald L. Pavia, Gary M. Lampman, George S. Kriz, 3rd Edition, Thomson Brooks/Cole publisher.
2.	Physical Chemistry, Ira N. Levine, 4th Edition, Tata-McGraw Hill Edition
3.	Spectroscopy, Donald L. Pavia, Gary M. Lampman, George S. Kriz, James R. Vyvyan, 1st Indian Edition, Brooks/Cole Cengage Learning, 4th Edition

4.	Molecular Spectroscopy : Theory and Applications, Raman Patel & Raman Patel, University Press, 1st Edition
5.	Atomic and Molecular Spectroscopy: Basic concepts and Applications. Rita Kakkal, Cambridge Publication, 1st Edition
6.	Molecular Spectroscopy, I. N. Levine, Wiley-Interscience Publication
7.	Atomic and Molecular Spectroscopy, Mool Chand Gupta, New Age International Publisher
8.	Modern Spectroscopy, J. M. Hollas, John Wiley & Sons
9.	High Resolution Spectroscopy, J. M. Hollas, Butterworths
10.	Fundamentals of Molecular Spectroscopy, C. N. Banwell and E. M. McCash, Tata McGraw Hill publishing
11.	Physical Chemistry: A Molecular Approach, Donald A. McQuarrie, John D. Simon, Viva Books, Viva Student Edition, Reprint Edn

On-line resources to be used if available as reference material
On-line Resources
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www.swayam.gov.in
www.epgp.inflibnet.ac.in (e-PG pathshala)
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Master in Science, Physical Chemistry
M. Sc. Physical Chemistry, Semester – III

Course Code	**PS03CPHC52**	Title of the Course	**Electro-analytical Methods**
Total Credits of the Course	**04**	Hours per Week	**04**

Course Objectives:	The course is design to apply the measurements based on electrochemical properties as tools for qualitative and quantitative analysis of simple to complex systems. The basic theory, principle, instrumental methods and application parts are very useful in the analysis of industrial products for quality control and assurance.

Course Content

Unit	Description	Weightage* (%)
I	**pH metry & its applications :** Introduction, Construction and working of different electrodes, Ion selective electrodes, applications of pHmeasurements, Acid-base titrations, Polybasic acid-base titrations, Determination of dissociation constant of weak acids and weak bases, Determination of hydrolysis constant and degree of hydrolysis	25
II	**Potentiometry :** Introduction, Principle, Types of electrodes and its classifications, Chemical cell with and without transference, concentration cell with and without transference, EMF and thermodynamics of cell reactions, Measurements of single electrodes, Determination of activity coefficient from EMF measurements, Potentiometric titration methods, oxidation – reduction titration, argentometric titration, applications	25
III	**Conductometry and High Frequency Conductometry :** Introduction, Definition of basic terms and their interrelationship, factors affecting conductance, types of cell, conductometric titrations, Applications – different types of acid-base titrations, complex formation titration, Determination of degree of dissociation, dissociation constant, basicity of organic acids, solubility and solubility product of sparingly soluble salts, degree of hydrolysis and hydrolysis constant, Advantages of conductometry titration. **High Frequency Conductometry :** Introduction, Types of cells, Instrumentation, Importance of relationship between conventional conductance measurement and capacitance, advantages and disadvantages, applications.	25
IV	**Voltammetric Techniques :** Introduction, Principle, Instrument, Electrode system, advantages and disadvantages, components of limiting currents, polarography – polarography maxima, half-wave potential, Determination of relationship between half wave potential & diffusion coefficient, Factors governing diffusion current, calibration curve method. Voltammetric methods and its applications, **Amperometry** – Principle, Apparatus, Different types of amperometric titration, advantages and disadvantages, applications.	25

Teaching-Learning Methodology	Chalk and board method along with ICT tools Model demonstration as per the demand of the topic

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.	Student will understand the detailed measurements of electrochemical properties, the instrumentation, measuring tools and aids such as electrode system, their construction and development.
2.	The methods of analysis under direct as well as alternate currents streams are taught.
3.	Complex systems based on real samples can be handled for qualitative and quantitative determination of chemical species in pure aqueous solutions and also in complex samples which also have other interfering species.

Suggested References:

Sr. No.	**References**
1.	Principles of Instrumental Analysis, Douglas A. Skoog, F. James Hooer, Timothy A. Nieman.
2.	Instrumental Methods of Analysis, Willard, Merritt, Dean, Settle, CBS Publishers & Distributors
3.	Contemporary Chemical Analysis, J. F. Rubinson and K. A. Rubinson, Princtice-Hall International Inc..
4.	Introduction to Instrumental Analysis, Robert D. Braun, McGraw-Hill Book company, New Delhi.
5.	The Principles of Electrochemistry, Duncan A. Maclnnes, Dover Publications Inc., N.Y

6.	Instrumental Methods of Chemical Analysis, B. K. Sharma, Goel Publishing House, Meerut.
7.	Instrumental methods of Chemical Analysis, V. K. Ahluwalia, Ane Books Pvt. Ltd.

On-line resources to be used if available as reference material
On-line Resources
www.nptel.ac.in
www.swayam.gov.in
www.epgp.inflibnet.ac.in (e-PG pathshala)
www.ndl.iitkgp.ac.in (National Digital Library)

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Master in Science, Physical Chemistry
M. Sc. Physical Chemistry, Semester – III

Course Code	**PS03CPHC53**	Title of the Course	**Selected Topics in Physical Chemistry – I**
Total Credits of the Course	**04**	Hours per Week	**04**

Course Objectives:	The course aims to introduce the students to the concepts of statistical Thermodynamics and electrochemistry and their industrial applications. The statistical treatment is a tool for understanding concepts used in other subjects related to Solid State Physics, Pharmaceutical sci., Optical, Electrical and Magnetic Properties, Semiconductors, Magnetic Materials, Superconducting, Materials, Phase Diagrams, Physical Metallurgy etc. Electrochemistry is useful to provide inside knowledge of advanced devices like sensors, solar cells, fuel cells, batteries etc.

Course Content

Unit	Description	Weightage* (%)
I	**Statistical Thermodynamics - I :** Introduction, Frequency distribution, Binomial, Poisson and normal distribution, Energy states and energy levels, macro states and microstates, thermodynamics probability, the Bose – Einstein statistics, the Fermi – Dirac statistics, the Maxwell – Bolzmann statistics	25
II	**Statistical Thermodynamics – II :** The statistical interpretation of entropy, the Bose – Einstein distribution function, The Fermi-Dirac distribution function, the classical distribution, comparison of distribution functions for indistinguishable particles, the Maxwell – Boltzmann distribution function, the partition function, thermodynamics properties of system	25
III	**Electrochemistry – I :** Introduction, Electrolysis, Arrhenius theory of ionization, Ostwald's dilution law, Application of electrolysis, Ionic atmosphere its radius, Relaxation time, DHO equation and its validity and limitation Wein effect, DH effect, Industrial applications of Electrochemistry : Batteries, Fuel cells, Solar cells.	25
IV	**Electrochemistry – II :** Kinetics of Electrode reactions : Essentials of electrode reactions, Butler-Volmmer model for electrode kinetics, one step, one electron process through potential energy diagram, standard rate constants and transfer coefficients, equilibrium condition and exchange current, current-over potential equation. Marcus microscopic model, predictions from Marcus theory, Gerischer model based on distribution of energy states, Tunnelling and extended charge transfer	25

Teaching-Learning Methodology	Chalk and board method along with ICT tools Model demonstration as per the demand of the topic

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.	To understand the concept of probability and its use for understanding of Statistical thermodynamics. The distributions like Binomial, Poisson, Normal are applicable to different types of data.
2.	To get information on various types of statistical approaches and understand its application in the determination of various partition function in the form entropy.
3.	To get inside into the distribution of particles in various energy levels and evaluation of various thermodynamic parameters in terms of partition function.

Suggested References:	
Sr. No.	**References**
1.	Molecular Statistics for Students of Chemistry, L. A. Woodward Clarendon Press, Oxford
2.	Elements of Statistics for Students of Chemistry, L. K. Nash, Wesley Publishing Co., London.
3.	Thermodynamics, Kinetic Theory and Statistical Thermodynamics, Francis W. Sears, Gerhard L. Salinger, Narosa Publishing House, New Delhi.
4.	Industrial Electrochemistry, Derek Pletche, Chapmann & Hall, New York.
5.	Modern Electrochemistry, Vol. 1 &2., J. M. Bockrisand A. K. N. Reddy, Plenum Press, New York.
6.	Electrochemical Methods, A. J. Bard and L. R. Faulkner, John Wiley & Sons, 2nd Edition

7.	The Principles of Electrochemistry, Duncan A. MacInnes, Dover Publications Inc., New York.
8.	Electrolytic Solutions, R. A. Robinson and R. H. Stokes, Butterworths, London.

On-line resources to be used if available as reference material
On-line Resources
www.nptel.ac.in
www.swayam.gov.in
www.epgp.inflibnet.ac.in (e-PG pathshala)
www.ndl.iitkgp.ac.in (National Digital Library)

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Master in Science, Physical Chemistry
M. Sc. Physical Chemistry, Semester – III

Course Code	**PS03CPHC54**	Title of the Course	**Practicals - Instrumental methods**
Total Credits of the Course	**04**	Hours per Week	**08**

Course Objectives:	The Physical Chemistry laboratory experiments illustrating some instrumental methods based exercises dealing with quantative measurements of chemical substances in general.

Course Content	
1.	To carry out the following conductometric titrations at room temperature. (a) Solution of a strong acid (hydrochloric acid) with a solution of strong alkali (sodium hydroxide). (b) Solution of a weak acid (acetic acid) with a solution of strong alkali (sodium hydroxide). (c) Solution of a strong acid (hydrochloric acid) with a solution of weak alkali (ammonium hydroxide).
2.	To determine the stability constant of co-ordination compound (copper-5-sulfosalicyclic acid) by pH-metry.
3.	To titrate pH metrically a phosphoric acid solution against alkali and calculate the first, second and third neutralization or ionization constants of the acid.
4.	To study the rate equation for the mutarotation of D-glucose in water.
5.	To study the variation of refractive index with composition of mixtures of carbon tetrachloride and ethyl acetate.
6.	To find out the amount of Borax in given solution by titrating it against hydrochloric acid pH metrically.
7.	To determine the standard redox potential and thermodynamics parameters of the Fe^{2+} ion by potentiometry technique.
8.	To determine the concentrations of KI by potentiometry.
9.	To determine the amounts of aspirin content in a given tablet by conductometry.
10.	To determine the amount of Paracetamol in a given tablet by spectrophotometer.
11.	To determine the concentrations of Fe(III) solutions by spectrophotometric titrations with EDTA.
12.	To study the effect of electrolytes on water structure by Viscosity/conductometry.
	Other practicals related to instruments like spectrophotometer, conductometer, potentiometer, refractometer, pH-meter, polarimeter etc. can also be given.

Teaching-Learning Methodology	Practical demonstration with the explanation of theory/mechanism involved in the experiment

Evaluation Pattern		
Sr. No.	**Details of the Evaluation**	**Weightage**
1.	Internal Written / 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.	Know the various instrumental based methods for determination of dissociation constant, concentration of an unknown materials, std. electrode potential, rate constant etc. by performing various type of titrations and instruments.

Suggested References:	
Sr. No.	**References**
1.	Experiments in Physical Chemistry, J. M. Wilson, R. J. Newcombe, A. R. Denaro, R. M. W. Rickett, Pergamon Press, Oxford.
2.	Findlay's Practical Physical Chemistry, B. P. Levitt, Longman Group Limited, 9th Edition.
3.	A Laboratory Manual of Experiments in Physical Chemistry, D. Brennan, C. F. H. Tipper, McGraw-Hill Publishing Company Ltd., London.
4.	Advanced Physico-Chemical Experiments : A Textbook of Practical Physical Chemistry and Calculations. J. Rose, Sir Isaac Pitman & Sons Ltd., London.
5.	Experimental Physical Chemistry, R. C. Das, B. Behera, Tata McGraw-Hill Publishing Company Ltd., New Delhi.
6.	Advanced Physical Chemistry Experiments, J. N. Gurtu, A. Gurtu, Pragati Prakashan, Meerut, 5th Ed., 2011.

On-line resources to be used if available as reference material
On-line Resources (for theory/mechanism involve in the experiments)
www.nptel.ac.in
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Master in Science, Physical Chemistry
M. Sc. Physical Chemistry, Semester – III

Course Code	**PS03CPHC55**	Title of the Course	**Project Work**
Total Credits of the Course	**04**	Hours per Week	**08**

Course Objectives:	To provide exposure to research problem and carry out research in the novel and fascinating topics of research in chemistry.

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Master in Science, Physical Chemistry
M. Sc. Physical Chemistry, Semester – III

Course Code	**PS03CPHC56**	Title of the Course	**Practicals – Physico-chemical Exercises**
Total Credits of the Course	**04**	Hours per Week	**08**

Course Objectives:	The Physical Chemistry laboratory experiments dealing with the interrelation between the composition and properties of matter such as autocatalysis reaction, distribution method, hydrolysis method, solubility product, partial molal volume.

Course Content	
1.	To investigate the autocatalysis reaction between Potassium permanganate and Oxalic acid.
2.	To determine the distribution coefficient of benzoic acid between benzene and water.
3.	To determine the formula of the complex ion formed between the curperic ion and ammonia (cupramonium ion) by distribution method.
4.	To determine the rate constant of the oxidation of Iodide ion by hydrogen peroxide in aqueous solutions.
5.	To determine the relative strength of HCl and H_2SO_4 by studying the hydrolysis of methyl acetate.
6.	To study the variation in the solubility of calcium hydroxide in the presence of sodium hydroxide and determine the solubility product of calcium hydroxide at room temperature.
7.	To study the phase diagram of the ternary system, HAc, H_2O and $CHCl_3$.
8.	To determine the molar volume and partial molal volume of given liquid at 25 ^oC.
9.	Kinetics of the reaction of ferric and iodide ions – use of initial rates.
10.	To study oscillations chemical reaction (Briggs-Raucher reactions).
11.	To investigate the adsorption isotherm of oxalic acid or acetic acid from aqueous solutions by activated charcoal and examine the validity of classical and Langmuir's adsorptions isotherm.
12.	To determine Cl^- ion concentration in a given sample of water.
	Depending on availability of time, some experiments may be added/exchange during the semester.

Teaching-Learning Methodology	Practical demonstration with the explanation of theory/mechanism involved in the experiment

Evaluation Pattern		
Sr. No.	**Details of the Evaluation**	**Weightage**
1.	Internal Written / 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.	To investigate the autocatalysis reaction, to determine the distribution coefficient, the formula of the complex ion formed between metal and ligand, determination of the rate constant, relative strength, the solubility product. To study the phase diagram of the ternary system, determine the molar volume and partial molal volume of given liquid.

Suggested References:	
Sr. No.	**References**
1.	Experiments in Physical Chemistry, J. M. Wilson, R. J. Newcombe, A. R. Denaro, R. M. W. Rickett, Pergamon Press, Oxford.
2.	Findlay's Practical Physical Chemistry, B. P. Levitt, Longman Group Limited, 9th Edition.
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Master in Science, Physical Chemistry
M. Sc. Physical Chemistry, Semester – III

Course Code	**PS03CPHC57**	Title of the Course	**Project Work**
Total Credits of the Course	**04**	Hours per Week	**08**

Course Objectives:	To provide exposure to research problem and carry out research in the novel and fascinating topics of research in chemistry.

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Master in Science, Physical Chemistry
M. Sc. Physical Chemistry, Semester – III

Course Code	**PS03CPHC58**	Title of the Course	**Comprehensive Viva**
Total Credits of the Course	**01**	Hours per Week	**02**

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

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Vallabh Vidyanagar, Gujarat
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Syllabus with effect from the Academic Year 2022-2023

PROGRAMME STRUCTURE
Master of Science in Chemistry
MSc (Physical Chemistry) Semester: IV

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 - IV	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**		
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								Total/ Passing	**Total/ Passing**	**Total/ Passing**
Core Course	PS04CPHC51	Atomic Spectroscopy and Microscopic Techniques	EM & EN	T	4	4	3	30/10	70/28	100/40
	PS04CPHC52	Chemistry of Solid Materials	EM	T	4	4	3	30/10	70/28	100/40
	PS04CPHC53	Nuclear Reactions and Photochemistry	EM& EN	T	4	4	3	30/10	70/28	100/40
Core Course (Any One)	PS04CPHC54	Practicals **OR**	EM&SD	P	4	8	6	30/10	70/28	100/40
	PS04CPHC55	Project work*	EM&SD	P	4	8		30/10	70/28	100/40
Core Course (Any One)	PS04CPHC56	Practicals **OR**	EM&SD	P	4	8	6	30/10	70/28	100/40
	PS04CPHC57	Project work*	EM&SD	P	4	8		30/10	70/28	100/40
Core Course	PS04CPHC58	Comprehensive Viva		-	1	1			50/20	50/20
Elective Course (Any one)	PS04ECHE51	Environmental Chemistry and analysis	EM& EN	T	4	4	3	30/10	70/28	100/40
	PS04ECHE52	Analysis of Pharmaceuticals drugs	EM& EN	T	4	4	3	30/10	70/28	100/40

	PS04ECHE53	Selected Topics in Advanced Inorganic Chemistry-II	EM& EN	T	4	4	3	30/10	70/28	100/40
	PS04ECHE54	Inorganic Polymers and Inorganic Materials	EM& EN	T	4	4	3	30/10	70/28	100/40
	PS04ECHE55	Selected Topics in Polymers-III	EM& EN	T	4	4	3	30/10	70/28	100/40
	PS04ECHE56	Selected Topics in Polymers- II	EM& EN	T	4	4	3	30/10	70/28	100/40
	PS04ECHE57	Surface Chemistry and Catalysis	EM& EN	T	4	4	3	30/10	70/28	100/40
	PS04ECHE58	Introduction to Different Materials	EM& EN	T	4	4	3	30/10	70/28	100/40
	PS04ECHE59	Topics in Organic Chemistry	EM& EN	T	4	4	3	30/10	70/28	100/40
	PS04ECHE60	Applied Organic Chemistry	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 in Science, Physical Chemistry
M. Sc. Physical Chemistry, Semester – IV

Course Code	**PS04CPHC51**	Title of the Course	**Atomic Spectroscopy and Microscopic Techniques**
Total Credits of the Course	**04**	Hours per Week	**04**

Course Objectives:	The students will be exposed to the atomic spectroscopy and microscopic techniques which include-principles and theories used to determine the elemental composition of a sample (it can be gas, liquid, or solid) by observing its electromagnetic spectrum or its spectra. By applying various atomic spectroscopy and microscopic techniques, element concentrations of a millionth (ppm) or one billionth part (ppb) of the sample can be detected will be studied.

Course Content

Unit	Description	Weightage* (%)
I	**Electron Spectroscopy :** Introduction of electronic spectroscopy (PES, UPS, XPS, ESCA); Principle and theory, Instrumentation, application and problems. **Mossbauer Spectroscopy :** Principles, Origin of isomer shifts, quadrupole splitting and h. f. s.	25
II	**Atomic absorption and Flame Emission Spectroscopy :** Absorption of radiation by atoms, equipment, radiation sources, atomizers, detectors, interferences in atomic absorption spectroscopy, applications. Introduction to plasma, various type of emission spectroscopy, instrumentation, inductively coupled plasma spectrometer, flame photometer, applications.	25
III	**Luminescence Spectroscopy :** Atomic Fluorescence, Introduction to molecular luminescence (fluorescence, phosphorescence and chemiluminescence); Theory of luminescence, instrumentation (spectrofluorometer), applications. **Microscopic techniques - I :** Introduction to TEM and SEM : Electron gun, electron acceleration, Condenser lenses, specimen stage, vacuum system, Operating principle, Penetration of electrons into a solid, TEM image, secondary electron images, Backscattered electron images.	25
IV	**Microscopic techniques - II :** AEM (Analytical Electron Microscopy) : The Bohr model of the atom, X-ray emission spectroscopy, X-ray energy dispersive spectroscopy, Quantitative analysis in TEM and SEM. **Scanning Tunneling Microscopy (SEM) and Atomic Force Microscopy (AFM):** Basic principles and theory, instrumentation, operating parameters and applications.	25

Teaching-Learning Methodology	Chalk and board method along with ICT tools Model demonstration as per the demand of the topic

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.	To learn the basic fundamentals, Principle and theory, instrumentation, application and problems of electronic spectroscopy (PES, UPS, XPS, ESCA).
2.	To identify the atomic absorption and flame emission spectroscopy including inductively coupled plasma spectrometer for the analysis of the chemical and biological analytes.
3.	To gain insight in atomic Fluorescence, Introduction to molecular luminescence (fluorescence, phosphorescence and chemiluminescence); theory of luminescence, instrumentation spectrofluorometer, applications, introduce the students the techniques - TEM and SEM.
4.	To realize the microscopic techniques Analytical Electron Microscopy, X-ray emission spectroscopy, X-ray energy dispersive spectroscopy, Quantitative analysis in TEM, SEM and Atomic Force Microscopy (AFM) through Basic principles and theory, instrumentation, operating parameters and applications.

Suggested References:	
Sr. No.	**References**
1.	Introduction to Instrumental Analysis, Robert D. Braun. Pharma Med Press.
2.	Principles of Instrumental Analysis, Douglas A. Skoog, F. James Holler, Timonthy A. Nieman, Harcourt Asia – Harcourt College Publishers.

3.	Undergraduate Instrumental Analysis, James W. Robinson, Marcel Dekker Inc.
4.	Microscopic and Spectroscopic Imaging of the Chemical State, Michael D. Morris, Marcel Dekker, Inc.
5.	Instrumental Methods for Chemical Analysis, B. K. Sharma, Goel Publishing House
6.	Instrumental Methods for Chemical Analysis, V. K. Ahluwalia, Ane Books Pvt. Ltd.
7.	Physical Principles of Electron Microscopy : An Introduction to TEM, SEM and AEM, Ray F. Egerton, Springer Publication.

On-line resources to be used if available as reference material
On-line Resources
www.nptel.ac.in
www.swayam.gov.in
www.epgp.inflibnet.ac.in (e-PG pathshala)
www.ndl.iitkgp.ac.in (National Digital Library)

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Master in Science, Physical Chemistry

M. Sc. Physical Chemistry, Semester – IV

Course Code	**PS04CPHC52**	Title of the Course	**Chemistry of Solid Materials**
Total Credits of the Course	**04**	Hours per Week	**04**

Course Objectives:	The knowledge on design and development of materials with desired properties based on understanding the structure of solids in its influence on physical-chemical properties, understanding of phase relations, chemical synthesis, reaction kinetics etc. can be obtained. This will help to explore the novel applications of the solid materials.

Course Content

Unit	Description	Weightage* (%)
I	**Geometrical Crystallography :** Periodicity in Crystals – Representation of a pattern, translational periodicity, representation of a lattice, notation of planes in lattice. Symmetry Element, screw axes, glide plane. Symmetry groups – Point groups. **Crystal Structure :** Forms of solids, law of constancy of interfacial angles, crystal systems, crystal classes, lattice structure, unit cell, designation of crystal faces, law of rational indices, planes of cubic lattice, types of lattices.	25
II	**Crystal Defects and Non-Stoichiometry :** Perfect and imperfect crystals, instrinsic and extrinsic defects – point defects, line and plane defects, Vacancies – Schottky defects and Frenkel defects. Thermodynamics of Schottky and Frenkel defect formation. **Solid State Reactions :** Types of solid state reactions, experimental procedures, co-precipitation as a precursor to solid state reactions, sol-gel method, kinetics of solid state reactions.	25
III	**Mechanism of Diffusion:** Ficks first law and second law of diffusion in solids; Wagner mechanism of solid state reactions, Kirkendal effects in solids. **Diffraction Methods for Crystal Structure :** X-ray diffraction – Diffraction and Intensities of diffracted beam, Laue and Bragg methods, Debye-Scherer method of X-ray structure analysis, Structure of simple lattices, structure factor and its relation to intensity and electron density, Electron Diffraction, Neutron Diffraction.	25
IV	**Electronic Properties and Band Theory :** Electric structure of solids – band theory, Free electron theory, band structure of metals, insulators and semi conductors, intrinsic and extrinsic semi conductors, p- and n- type semiconductors and their applications, **Optical Properties :** Optical reflectance, Lasers, Organic solids – electrically conducting solids, organic charge transfer complex, organic metals. **Magnetic properties** :	25

	Classification of materials: Quantum theory of paramagnetics - cooperative phenomena - magnetic domains, **Thermal Properties :** Lattice vibrations - phonon spectrum; Lattice heat capacity; Thermal expansion; Thermal conductivity.	

Teaching-Learning Methodology	Chalk and board method along with ICT tools Model demonstration as per the demand of the topic

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.	To understand the detailed crystallographic structure of the solids with various symmetry and points present in them.
2.	To get information on various types of solid state reactions and understand the detail mechanism involve in it.
3.	To appropriate experimental methods, analysis of structural characterization of solid materials using different diffraction methods like XRD, Electron and neutron diffraction.
4.	To understand various electrical, thermal, magnetic and optical properties of solids and their applications in advance fields like solar cells, supercapacitor, sensors etc.

Suggested References:	
Sr. No.	**References**
1.	Crystallography and Crystal Chemistry, F. B. Bloss, Halt Reinhold & Winston Inc.
2.	Introduction to Solids, L. V. Azaroff, Mc-Graw Hill Co., New York.

3.	Principles of the Solid State H. V. Kheer Wiley Eastern.
4.	Solid State Chemistry and Its Applications, Anthony R. West, John Willey & Sons.
5.	Crystal – Structural Analysis M. J. Buerger John Wiley and Sons, New York.
6.	Solid State Chemistry : An introduction, Lesley Smart, Elaine Moore, Nelson Thornes.
7.	Solid State Chemistr D. K. Chakrabarthy New Age International.
8.	Elements of X-ray Diffraction, B. D. Cullity, Addision – Wesley Publication Co.

On-line resources to be used if available as reference material
On-line Resources
www.nptel.ac.in
www.swayam.gov.in
www.epgp.inflibnet.ac.in (e-PG pathshala)
www.ndl.iitkgp.ac.in (National Digital Library)

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Master in Science, Physical Chemistry
M. Sc. Physical Chemistry, Semester – IV

Course Code	**PS04CPHC53**	Title of the Course	**Nuclear Reactions and Photochemistry**
Total Credits of the Course	**04**	Hours per Week	**04**

Course Objectives:	The subject of nuclear reactions along with their specific is taught in detail: The importance of nuclear fission and nuclear fusions in harnessing the energy is explained. The applications of radioactive tracer techniques will be taught and explained. The current era is "the age of light" because science and technology involving light is expected to play central roles in important fields such as energy, environment and sustainable technology. The course design for understanding the various photochemical process and mechanism involved behind them.

Course Content

Unit	Description	Weightage* (%)
I	**Nuclear Reaction :** Introductions, Bathe's notations, magic numbers, types of nuclear reactions: Elastic Scattering, Photonuclear reactions, radiative capture, Special nuclear reactions, Evaporation, Fragmentation, Transfer reactions. **Nuclear Fission:** Nuclear shape distortion following excitation, Relation between fission Energy & Fission barrier, Fission parameter.	25
II	**Nuclear Reaction & Tracer Technique :** **Nuclear Fusion:** Fusion reactions, Basic requirement for controlled thermo nuclear reaction, Threshold conditions, Lawson's criterion, Q-Values & reactions thresholds, Barrier for charged particles, **Tracer Techniques:** Reaction mechanism, Structure determination, Isotope dilution analysis: (i) Direct Isotope dilution analysis (DIDA), (ii) Inverse Isotope Dilution Analysis (IIDA), Dating by tritium content, Dating by 14C, medical applications, Radiometric titrations	25
III	**Photochemistry -I** Introduction of photochemistry, laws of photochemistry, Electronics energy levels, atomic and molecular term symbol, mechanism of Absorption and emission of radiations, Type of electronic transitions in organic molecules photochemical pathways, Selection rules of electronics transitions, Jablonski diagram and photophysical processes, florescence, Phosphorescence, Franck -Condon principle.	25
IV	**Photochemistry -II** Florescence emissions, Factors affecting florescence, via structure, solvent, pH, temperature etc., Triplet state and phosphorescence, environmental effects on absorptions and emission spectra, Stern-Volmer equation, quenching by added substances charge transfer mechanism, life times excited states of atoms and molecules, steady state and time resolved	25

	emission, different type of photochemical organic reactions like [2+2],[4+2] cycloaddition reactions, Paterno-Buechi Reaction, Norrish type 1 & 2 reaction, etc.	

Teaching-Learning Methodology	Chalk and board method along with ICT tools Model demonstration as per the demand of the topic

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.	To understand unique features of various nuclear reactions in terms of producing isotopes, energy and radiations in general.
2.	To grasp the mechanistic aspects of fusion and fissions, methods and techniques for producing energy in controlled manner
3.	To apply the principles of radiation in terms of analytic techniques of qualitative and quantative determination of physiological and geological samples.
4.	To understand the fabrication of counting techniques for radiation monitoring and measurement.
5.	To get detail about mechanism of photochemical process and other optical phenomena like luminescence, fluorescence, variation of potential energy as a function of measurements of electrochemical properties, the instrumentation, measuring tools and aids such as electrode system, their construction and development.

Suggested References:	
Sr. No.	**References**
1.	Essential of Nuclear Chemistry, H. J. Arnikar, Wiley Eastern Limited, New Delhi
2.	Elements of Nuclear Chemistry, R. Gopalan, Vikas Publishing House Pvt. Ltd.
3.	Nuclear Chemistry, Bernard G. Harvey, Prentice – Hall, Inc., Englewood Cliffs, N. J.
4.	Radiochemistry and Nuclear Methods of Analysis, W. D. Ehman and D. E. Vance, John Wiley
5.	Source book on Atomic Energy. S. Glasstone, Van nostrand Company
6.	Fundamentals of Photochemistry, K. K. Rohatgi-Mukherjee, Age International Publishers.
7.	Principles of Molecular Photochemistry : An introduction, Nicholas J. Turro, V. Ramamurthy, J. C. Scaiano, Viva Publications.
8.	Principles and Applications of Photochemistry, Brian Wardle, John Wiley & Sons.
9.	Principles of Fluorescence Spectroscopy, J. R. Lakowicz, Springer, Int. Ed.

On-line resources to be used if available as reference material
On-line Resources
www.nptel.ac.in
www.swayam.gov.in
www.epgp.inflibnet.ac.in (e-PG pathshala)
www.ndl.iitkgp.ac.in (National Digital Library)

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Master in Science, Physical Chemistry
M. Sc. Physical Chemistry, Semester – IV

Course Code	**PS04CPHC54**	Title of the Course	**Practicals – Polymer Synthesis & Characterization**
Total Credits of the Course	**04**	Hours per Week	**08**

Course Objectives:	Hands on training for synthesis and characterization of polymers by using different methods of polymerization as well as characterization technique.

Course Content	
1.	Carry out emulsion polymerization of methyl acrylate.
2.	Preparation of Polyvinyl Alcohol (PVA).
3.	Preparation of polysulphide rubber (Thiokol)
4.	Preparation of polystyrene by free radical polymerization
5.	To synthesis epoxide resin (Liquid).
6.	Preparation of Epoxy Resin (solid).
7.	To synthesis Urea-Formaldehyde resin.
8.	To determine the epoxy equivalent weight of given epoxy resin. (doixan) (solid)
9.	To determine the epoxy equivalent weight of given epoxy resin. (doixan) (liquid)
10.	To determine free formaldehyde in the given Phenol-Formaldehyde resin.
11.	To determine free formaldehyde in the given Urea-Formaldehyde resin.
12.	Determination of viscosity average molecular weight of polystyrene in toluene by dilute solution.
13.	Determination of radius of a molecule by viscosity measurements (glycerol).
	Depending on availability of time, some experiments related to synthesis and characterization of the polymers can be given.

Teaching-Learning Methodology	Demonstration of practicals / set up along with theoretical knowledge.

Evaluation Pattern		
Sr. No.	**Details of the Evaluation**	**Weightage**
1.	Internal Written / 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
The students are familiar, in general terms at least, with the established methods of polymer synthesis by free radical, suspension polymerization, anionic, cationic and coordination addition polymerization, and stepwise condensation and rearrangement polymerization. The practical lab will expose the students in few polymer synthesis methods. Students will able to gain knowledge of different methods used for characterization of polymers along with hands on training to operate such instruments.

Suggested References:	
Sr. No.	**References**
1.	Experimental Plastics Technology, J.A. Brydson and K.J. Saunders
2.	Techniques of polymer synthesis and characterization, Braun, Cherdron and Kern
3.	Handbook of Epoxy Resins, McGraw-Hill, New York, H. Lee and K. Neville
4.	Encyclopedia of Industrial Chemical Analysis, Volume-5
5.	Principles of polymer Systems, F. Rodriguez, Mc. Graw-Hill Book Co., New York
6.	Experimental Plastics Technology, J. A. Brydson and K. J. Saunders
7.	Principles of Polymer Science by P. Bahadur and N.V.Sastry

On-line resources to be used if available as reference material
On-line Resources (Theory/mechanism of practicals)
www.nptel.ac.in
www.swayam.gov.in
www.epgp.inflibnet.ac.in (e-PG pathshala)
www.ndl.iitkgp.ac.in (National Digital Library)

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Master in Science, Physical Chemistry
M. Sc. Physical Chemistry, Semester – IV

Course Code	**PS04CPHC55**	Title of the Course	**Project Work**
Total Credits of the Course	**04**	Hours per Week	**08**

Course Objectives:	To provide exposure to research problem and carry out research in the novel and fascinating topics of research in chemistry.

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Master in Science, Physical Chemistry
M. Sc. Physical Chemistry, Semester – IV

Course Code	**PS04CPHC56**	Title of the Course	**Practicals – Advanced Characterization Techniques**
Total Credits of the Course	**04**	Hours per Week	**08**

Course Objectives:	Hands on training for synthesis of polymers by using different methods of polymerization.

Course Content	
1.	Determination of conductivity of different types of solid/liquid materials using Impedance spectroscopy (EIS). [2 – 3 experiments]
2.	Measure the electrochemical impedance spectroscopy (EIS) of electrochemical cell and find best equivalent circuit models as well as extract electrochemical parameters like Diffusion, Charge transfer resistance, capacitors etc.
3.	To investigate effect of applied voltage and frequency on conductivity of an electrolyte. [2 experiments]
4.	Determination of an unknown concentration of metal salts in aqueous mixture of salts using cyclic voltammetry.
5.	Study the effect of scan rate as well as concentration of salts on cyclic voltammogram of aqueous solution of metal salts.
6.	Determination of diffusion coefficient of metal ions/ferrocene using cyclic voltammetry. (Randles-Sevcik equation).
7.	Determine the strength of acid (HCl and H_2SO_4) using acid catalyzed inversion of cane sugar using polarimetery.
8.	Study the photochemical decomposition reactions of cyclohexanone pH-metrically and conductometrically.
9.	Synthesis of Ag nanoparticles and their spectroscopic characterization.
10.	Preparations of CdS nanoparticles and record their UV/Visible spectra.
11.	Determination of various electrochemical parameters using Amperometric titration.
	Dry Experiments
1.	Interpretation of TGA curve.
2.	To determine the order of reaction – decomposition and Activation Energy with the help of TGA Technique.
3.	To determine Important thermal transitions, include the glass transition temperature (T_g),

	crystallization temperature (T_c), melting temperature (T_m) and enthalpy change of given sample by Differential scanning calorimetry (DCS) analysis.
4.	Interpretation of X-ray diffractogram.
5.	Determination of crystalline size and identification type of cubic crystal from X-ray diffraction pattern.
6.	Geometry optimization, calculation of minimum energy, surface energy density of organic molecules through computation software.
	Depending on availability of time, some experiments may be added/exchange during the semester based on availability of instrument/equipment.

Teaching-Learning Methodology	Demonstration of instruments/methods used for characterization of polymers

Evaluation Pattern

Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / 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

To gain knowledge of different advanced characterization methods like EIS, cyclic voltammetry, amperometry etc. Also get experience in interpretation of data obtained from TGA/DSC, EIS, X-ray diffraction etc.

Suggested References:

Sr. No.	References
1.	Advanced Physical Chemistry Experiments, J N Gurtu and Amita Gurtu, Pragati Prakashan, Meeruth.2012.
2.	Experimental Electrochemistry, A laboratory Textbook, R. Holze, Wiley – VCH GmbH & Co., 2009.
3.	Experiments in Physical Chemistry, J. M. Wilson, R. J. Newcombe, A. R. Denaro, R. M. W. Rickett, Pergamon Press, Oxford.

4.	Findlay's Practical Physical Chemistry, B. P. Levitt, Longman Group Limited, 9th Edition.
5.	A Laboratory Manual of Experiments in Physical Chemistry, D. Brennan, C. F. H. Tipper, McGraw-Hill Publishing Company Ltd., London.
6.	Advanced Physico-Chemical Experiments : A Textbook of Practical Physical Chemistry and Calculations. J. Rose, Sir Isaac Pitman & Sons Ltd., London.
7.	Experimental Physical Chemistry, R. C. Das, B. Behera, Tata McGraw-Hill Publishing Company Ltd., New Delhi.

On-line resources to be used if available as reference material
On-line Resources (Theory/mechanism of practicals)
www.nptel.ac.in
www.swayam.gov.in
www.epgp.inflibnet.ac.in (e-PG pathshala)
www.ndl.iitkgp.ac.in (National Digital Library)

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Master in Science, Physical Chemistry
M. Sc. Physical Chemistry, Semester – IV

Course Code	**PS04CPHC57**	Title of the Course	**Project Work**
Total Credits of the Course	**04**	Hours per Week	**08**

Course Objectives:	To provide exposure to research problem and carry out research in the novel and fascinating topics of research in chemistry.

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Master in Science, Physical Chemistry
M. Sc. Physical Chemistry, Semester – IV

Course Code	**PS04CPHC58**	Title of the Course	**Comprehensive Viva**
Total Credits of the Course	**01**	Hours per Week	**02**

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

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