John Wilson Education Society's

Wilson College (Autonomous)

Chowpatty, Mumbai-400007

RE-ACCREDITED 'A' grade by NAAC

Affiliated to the

UNIVERSITY OF MUMBAI

Syllabus for PG Second Year (S.Y.) under New Education Policy (NEP 2020)

Program: M.Sc. (Physical Chemistry)

Program Code: WSCHP (Physical Chemistry)

Choice Based Credit System (CBCS) with effect from Academic year 2024–2025

WILSON COLLEGE (AUTONOMOUS), SYLLABUS FOR CHEMISTRY

PROGRAM OUTLINE 2024-2025

YEAR	COURSE	COURSE CODE	COURSE TITLE	CREDITS
M.Sc-II Sem-III	Mandatory Course-I	WSCHPMT631	Nano chemistry, statistical mechanics & Nuclear chemistry.	04
	Mandatory Course-II	WSCHPMT632	Atomic and Molecular: Structure and Spectroscopy	04
	Mandatory Course-III Practical	WSCHPMP631	Physical Chemistry Practical -I	04
	Mandatory Course-IV	WSCHPMT633	Chemistry: Surface & Photo Chemistry	02
	Elective Theory	WSCHPET631	Advanced Instrumental Techniques-I	02
		OR		
		WSCHPET632	Advanced Instrumental Techniques-II	
	Elective Practical	WSCHPEP631	Instrumental Analysis	02
	Project	WSCHPRP631	Research Project	04
MSc-II Sem-IV	Mandatory Course-I	WSCHPMT641	Material Science, network and irreversible thermodynamics	04
	Mandatory Course-II	WSCHPMT642	Symmetry & Spectroscopy	04
	Mandatory Course-III Practical	WSCHPMP641	Physical Chemistry Practical -II	04
	Elective Theory	WSCHPET641	Intellectual Property Rights	02
		OR		
		WSCHPET642	Chemistry: Polymer, Green, Biophysical and Applied	
	Elective Practical	WSCHPEP641	Spectral Interpretation	02
	Project	WSCHPRP641	Dissertation	06

PROGRAMME SPECIFIC OUTCOME (PSOs)

1. Gain knowledge of the advanced concepts in the branch of chemistry, scrutinize and accomplish a solution to problems encountered in the field of research and analysis.

2. Apply the basic knowledge of chemistry to perform various tasks assigned to them at the workplace in industry and academia to meet the global standards.

3. Deduce qualitative and quantitative information of chemical compounds using advanced spectroscopic methods which can further be analysed using practical skills inculcated in them during the course.

4. Imbibe the attitude as well as aptitude of a scientific approach along with analytical reasoning with respect to the novel techniques actually implemented in the Industry.

5. Use the subject knowledge, communication and ICT skills to become an effective team leader/team member in the interdisciplinary fields.

6. Understand, Manage and contribute to solve basic societal issues and environmental concerns ethically based on principles of scientific knowledge gained.

7. Exhibit professional work ethics and norms of scientific development.

Preamble

Master of Science (M.Sc.) in Chemistry is a postgraduate course of Department of Chemistry, Wilson College, Chowpatty, Mumbai (Autonomous). The Choice Based Credit System to be implemented through this curriculum would allow students to develop a strong footing in the fundamentals and specialize in the disciplines of his/her liking and abilities.

This syllabus is prepared to give the sound knowledge and understanding of chemistry to undergraduate students in the second year of the M.Sc. degree course. The goal of the syllabus is to make the study of Chemistry as stimulating, interesting and relevant as possible. The syllabus is prepared by keeping in mind the aim to make students capable of studying Chemistry in academic and industrial courses. Also, to expose the students and to develop interest in them in various fields of Chemistry.

The new and updated syllabus is based on a interdisciplinary approach with vigour and depth taking care that the syllabus is not heavy at the same time it is comparable to the syllabi of other universities at the same level. The students pursuing this course would have to develop an understanding of various aspects of chemistry. The conceptual understanding, development of experimental skills, developing the aptitude for academic and professional skills, obtaining basic ideas and understanding of hyphenated techniques, understanding the fundamental chemical processes and rationale towards application of knowledge are among such important aspects.

PROGRAM(s): M.Sc.-II	**SEMESTER: III**				
Course: Mandatory Course-1	**Course Code: WSCHPMT631**				
Teaching Scheme					**Evaluation Scheme**
Lectures (hours per week)	**Practical (hours per week)**	**Tutorial (hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks40)**	**Semester End Examination (Marks- 60)**
04	**NA**	**–**	**04**	**40**	**60**

Learning Objective:

1. To describe the nano chemistry of gold, cadmium, and selenide, analyze the optical and magnetic properties of Nanomaterials, and examine how these properties vary with the shape, size, and surface of nanoparticles.
2. To explain learners about the diagnosis and treatment of diseases using nanoparticles
3. To apply the concept of distribution and thermodynamic probability, and assess the most probable distribution state for all types of statistics, including Maxwell-Boltzmann, Fermi-Dirac, and Bose–Einstein statistics.
4. To determine the concept of partition function, explore its physical significance, and compute the molar and atomic partition function.

Course Outcomes:

Learners will be able to:

CO-1. Correlate nanochemistry of gold, cadmium, and selenide, analyze optical and magnetic properties of nanomaterials, and examine variations in these properties with the shape, size, and surface of nanoparticles.

CO-2. Examine the diagnosis and treatment of diseases using nanoparticles.

CO-3. Evaluate the concept of distribution and thermodynamic probability, and assess the most probable distribution state for all types of statistics, including Maxwell-Boltzmann, Fermi-Dirac, and Bose–Einstein statistics.

CO-4. Explain the concept of partition function, interpret its physical significance, and calculate molar and atomic partition functions.

Detailed Syllabus: Mandatory Course- I: Nanochemistry, Statistical mechanics & Nuclear chemistry

Course Code: - WSCHPMT631	**Unit**	**Course/ Unit Title**	**04 Credits/ 60 Lectures**
I		**Nanochemistry of gold, cadmium, selenide.**	**15 L**
	1.1	Variation of optical and magnetic properties of nanomaterials with size, shape, surface characteristics and impurities.	4 L
	1.2	Relationship between size and shape of nanomaterials.	3 L
	1.3	Nanoarchitecture: self-assembly and template methods.	3 L
	1.4	Diagnosis and treatment of diseases using nanoparticles.	3 L
	1.5	Safety and ethics of use of nanoparticles.	2 L
II		**Nanochemistry of silica and polydimethylsiloxane**	**15 L**
	2.1	Variation of optical and magnetic properties of nano materials with size, shape, surface characteristics and impurities.	4 L
	2.2	Relationship between size and shape of nanomaterials.	3 L
	2.3	Nanoarchitecture: self-assembly and template methods	4 L
	2.4	Diagnosis and treatment of diseases using nanoparticles	4 L
III		**Statistical Mechanics**	**15 L**
	3.1	Thermodynamic probability: Combinatorial problems, Stirling approximation, Lagrange's method, macro and microstates, ensembles, Boltzmann distribution law.	3 L
	3.2	Partition functions: Translational, rotational, vibrational, electronic and nuclear partition functions, Expressions for the thermodynamic functions in terms of partition function- Internal energy, heat capacity, the Helmholtz and Gibbs functions, Enthalpy, entropy and	7 L

		equilibrium constants. Sackur–Tetrode equation for the entropy of a monatomic gas. Molecular partition function.	
	3.3	Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics.	3 L
	3.4	Debye and Einstein theory of specific heats of solids.	2 L
IV		**Nuclear Chemistry**	**15 L**
	4.1	Charged particle accelerator-linear accelerator, cyclotron, Betatron, Synchrocyclotron, synchrotron	4 L
	4.2	Nuclear forces-characteristics and Meson field theory of nuclear forces	2 L
	4.3	Nuclear Models-Liquid drop model, Fermi Gas Model, Shell Model, Collective Model, Optical Model	4 L
	4.4	Applications of Nuclear radiations-geological applications of radioactivity, age of minerals and rocks, age of earth and solar system, medical, industrial and agricultural applications of radiochemistry, positron emission tomography, Radioimmunoassay.	5 L

References:

Unit I and II:

1. Ludovico Cademartiri and Geoffrey A. Ozin, Concepts of Nanochemistry, Wiley–VCH Verlag GmbH&co,2009
2. C. Bréchignac, P. Houdy, Marcel Lahmani, Nanomaterials and Nano chemistry, Springer,2007
3. C. N. R. Rao, Achim Müller, Anthony K. Cheetham, Nanomaterials Chemistry, John Wiley& Sons,2007
4.Geoffrey A.Ozin, André C. Arsenault, Ludovico Cademartiri, Nanochemistry: A Chemical Approach to Nanomaterials, Royal Society of Chemistry (Great Britain) 2, illustrated, Royal Society of Chemistry, 2009.

Unit-III

1. Atkins P. W, Physical Chemistry, Oxford University Press, 6th edition, 1998
2. John M. Seddon & Julian D. Gale, Thermodynamics and statistical mechanics, Tutorial Chemistry Texts Series, Vol.10, Royal society of Chemistry, 2001.
3. Silbey RJ & Alberty R A, PhysicalChemistry,3rd edition, John Wiley and sons, Inc.2002.
4. Laidler K.J. and Meiser J.H., Physical Chemistry, 2nd edition, CBS publishers & distributors,1999.
5. B.K. Agarwal and M. Eisner, Statistical Mechanics, (1988) Wiley Eastern, New Delhi.
6. D. A. McQuarrie, Statistical mechanics, (1976) Harper and Row Publishers, New York., Lesley E. Smart, Elaine A. Moore, ISBN 0-203-49635-3, Taylor & Francis Group, LLC.

Unit IV

1. G. Friedlander, J. W. Kennedy. Nuclear and Radiochemistry. Third. John Wileyandsons,1981.
2. H.J. Arnikar, Essentials of Nuclear Chemistry. second. Wiley Eastern Ltd., 1989.

PROGRAM(s): M.Sc.-II		**SEMESTER: III**			
Course: Mandatory Course-II		**Course Code: WSCHPMT632**			
Teaching Scheme					**Evaluation Scheme**
Lectures (hours per week)	**Practical (hours per week)**	**Tutorial (hours per week)**	**Credits**	**Continuous Assessment (CA) (Marks40)**	**Semester End Examination (Marks- 60)**
04	**NA**	**–**	**04**	**40**	**60**

Learning Objectives:

1. To discuss the variation and perturbation theory and its application to Helium atom.
2. To calculate term symbol for multi electron atoms, exchange of interactions and multiplicity of states.
3. To evaluate hydrogen molecules using the valence bond method.
4. To apply molecular spectroscopy on spherical top, symmetrical top and asymmetrical top molecules.

Course Outcomes:

Learners will be able to:

CO-1: Analyze the variation and perturbation theory and apply it to the Helium atom.

CO-2 Calculate term symbols for multi-electron atoms, explore exchange interactions, and examine multiplicity of states.

CO-3: Deduce hydrogen molecules using the valence bond method.

CO-4: Apply molecular spectroscopy on spherical top, symmetrical top, and asymmetrical top molecules.

Detailed Syllabus: Mandatory Course- II: Atomic and Molecular: Structure and Spectroscopy

Course Code:- WSCHPMT632	**Unit**	**Course/ Unit Title**	**04 Credits/ 60 Lectures**
I		**Atomic structure**	**15 L**
	1.1	Introduction to approximate methods in Quantum Mechanics-	2 L
	1.2	Variation Theorem, linear and nonlinear variation functions.	7 L
	1.3	Application of variation and perturbation theory to ground state of Helium Atom. Multi–electron atoms: Antisymmetric and Pauli principle, Slater determinants, Hartree–Fock and configuration interaction wavefunctions, Slater type orbitals, Gaussian orbitals, orbitals plots, Basis sets. Density functional theory.	6 L
II		**Atomic spectroscopy**	**15 L**
	2.1	Angular momentum, orbital and spin, total angular momentum, total angular momentum (J) of many electron atoms, Russell Saunders(L-S) coupling and J-J Coupling.	4 L
	2.2	Term symbols, term symbols for multi electron atoms like He, Li, Be, B etc.	3 L
	2.3	Exchange of interactions and multiplicity of states	4 L
	2.4	Anomalous Zeeman Effect and Paschen Back effect.	4 L
	2.5	Atomic spectra and selection rules, energy level diagram of atomic sodium.	
III		**Molecular Structure**	**15 L**
	3.1	The Born–Oppenheimer approximation	1 L
	3.2	LCAO method-molecular orbital formation	2 L
	3.3	Calculation of energy of hydrogen molecule ion using Valence bond method, Heitler-London treatment Improvements in Heitler-London treatment	3 L

	3.4	Electronic structure of polyatomic molecules Valence bond method for BeH_2, H_2O, NH_3, BH_3, CH_4. Huckel molecular orbital. Theory for–ethylene, Allyl system, cyclopropenyl system and cyclobutadiene.	8 L
IV		**Molecular spectroscopy**	**15 L**
	4.1	Rotational spectroscopy: Einstein coefficients, classification of polyatomic Molecules spherical top, symmetric top and asymmetric top molecules, rotational spectra of polyatomic molecules Stark modulated microwave spectrometer	3 L
	4.2	Raman Spectroscopy-Classical theory of molecular polarizability, pure rotational, vibrational and vibration-rotation spectra of diatomic and polyatomic molecules polarization and depolarization of Raman lines correlation between IR and Raman spectroscopy instrumentation.	5 L
	4.3	Electronic Spectra of molecules: Term symbols for linear molecules, selection rules characteristics of electronic transitions-Franck-Condon principle, types of electronic transitions-d-d, vibronic, charge transfer, π-π^*, n-π^* transitions, fate of electronically excited states, fluorescence, phosphorescence, dissociation and predissociation.	7 L

References:

Unit: - I, II and III

1. Laidler and Miser, Physical Chemistry, 2nd edition, CBS publishers, New Delhi. (chapters 11-14).
2. Silbey and Alberty, Physical Chemistry, 3rd edition, John Wiley and sons, 2000. (Part Two Quantum Chemistry).
3. Atkins P.W, Physical Chemistry, Oxford University Press, 6th edition,1998.
4. William Kemp, Organic spectroscopy, 3rd Edition, ELBS,1996.
5. I.N. Levine, Quantum Chemistry,5th Edition (2000).
6. D.A. McQuarrie and J. D. Simon, Physical Chemistry: A Molecular Approach (1998).
7.J.N. Murrell, S. F. A. Kettle and J. M. Tedder, Valence Theory, 2(1965), John Viley, New York.
8. A. K. Chandra, Introductory Quantum Chemistry,4th edition (1994),Tata Mc Graw Hill, New Delhi.
9. D.A. Mc Quarrie, Quantum Chemistry, Viva Books Private Limited, New Delhi, first Indian ed.,2003.
10. R. K. Prasad, Quantum Chemistry,3rd Ed., New Age International Publishers,2006.
11. James E. House, Fundamentals of Quantum Chemistry, Second Ed, Academic Press,2005.
12.T.A. Littlefield and N. Thorley, Atomic and Nuclear Physics– An Introduction, Van Nostrand,1979.

Unit-IV

1. C.N. Banwell and E.M. McCash, Fundamentals of Molecular Spectroscopy, 4th Ed, Tata-McGraw-Hill,1994.
2. M. L. Gupta, Atomic and Molecular Spectroscopy, New Age International Publishers, 2001.
3. H.S. Randhawa, Modern Molecular Spectroscopy, Macmillan India Ltd.,2003.
4. G. Aruldhas, Molecular Structure and Spectroscopy, Prentice-Hall of India, 2001.
5. J. Michael Hollas, Modern Spectroscopy, 4thEd., John Wiley and Sons,2004.

PROGRAM(s): M.Sc.-II	**SEMESTER: III**				
Course: Mandatory Course-III (Practical)	**Course Code: WSCHPMP631**				
Teaching Scheme					**Evaluation Scheme**
Lectures (hours per week)	**Practical (hours per week)**	**Tutorial (hours per week)**	**Credits**	**Continuous Assessment (CA) (Marks 40)**	**Semester End Examination (Marks- 60)**
NA	**08**	**NA**	**04**	**40**	**60**

Learning Objectives:

1. To collect knowledge of the advanced concepts in pH metry, quantum mechanics, potentiometry and conductometry experiments.
2. To recall advanced concepts of thermodynamics and chemical kinetics in the chemical reactions.
3. To construct scientific temper and research-based skills encountered in the field of research.

Course Outcomes:

CO-1: Apply fundamental principles and practical knowledge to design experiments, analyze data, and interpret results to draw appropriate conclusions.
CO-2: Apply the knowledge handling equipment such as potentiometer, conductivity meter, colorimeter, and spectrophotometer.
CO-3: Practice scientific temper and research-based skills in the field of research.

Course code: WSCHPMP631	**Practical**	**04 Credits**
	PAPER 1 **MAJOR EXPERIMENTS:** 1. To determine the formula of the copper (II) ammonia complex by partition method. 2. To determine the transport no. of copper (II)ions by Hittorf's method. 3. To determine the mean ionic activity coefficient of zinc chloride by emf method. 4. To construct the phase diagram for a two-component system forming a simple eutectic. **MINOR EXPERIMENTS:** 1. To determine the equilibrium constant for the reaction $CaSO_4$ (s) + $2Ag^{+1}$ (aq) $\rightleftharpoons$ Ag_2SO_4(s) + Ca^{-2} (aq) 2. To determine the isoelectric point of gelatin by viscosity measurement.	02 Credits
	PAPER 2 **MAJOR EXPERIMENTS:** 1. Determination of the energy of activation and other thermodynamic parameters of activation for the acid catalyzed hydrolysis of methyl acetate. 2. To determine the proton ligand stability constant of an organic acid and metal ligand stability constant of its complex by pH measurement. 3. Colorimeter & Spectrophotometry: To determine the ionization constant of bromophenol blue. **MINOR EXPERIMENTS:** 4. To Study Complex Formation Between Nickel (II)with o-phenanthroline. 5. To determine the rate constant and the order of the reaction between persulfate and iodide ions. 6. To determine the partial molar volume of ethanol. 7. To determine the molar mass of a non-volatile solute by cryoscopic method.	02 Credits

References:

1. Advanced experiments in Inorganic Chemistry, G. N. Mukherjee,1st Edn, 2010, U. N. Dhur & Sons Pvt Ltd
2. The Synthesis and Characterization of Inorganic Compounds by William L. Jolly
3. Inorganic Chemistry Practical Under UGC Syllabus for M.Sc. in all India Universities By: Dr. Deepak Pant.

PROGRAM(s): M.Sc.-II	**SEMESTER: III**				
Course: Mandatory Course IV	**Course Code: WSCHPMT633**				
Teaching Scheme					**Evaluation Scheme**
Lectures (hours per week)	**Practical (hours per week)**	**Tutorial (per week)**	**Credit**	**Continuous Assessment (CA) (Marks 20)**	**Semester End Examination (Marks- 30)**
02	**NA**	**–**	**02**	**40**	**60**

Learning Objectives:

1. To analyze the properties and importance of surface-active agents, micelles and emulsion and to learn the applications of surface chemistry for the storage of graphene, fullerenes and nanomaterials.
2. To discuss the principles of photophysical processes in electronically excited molecules and mechanism of the relaxation by fluorescence and phosphorescence.
3. To explain the application of photochemical reactions and their quenching mechanisms.

Course Outcomes:

Learners will be able to:

CO-1: Illustrate the properties and importance of surface-active agents, micelles, and emulsion and analyze the applications of surface chemistry for the storage of graphene, fullerenes, and nanomaterials.
CO-2: Apply the principles of photophysical processes in electronically excited molecules. Examine the mechanism of relaxation by fluorescence and phosphorescence.
CO-3: Identify the applications of photochemical reactions.

Detailed Syllabus- Mandatory Course – IV Chemistry: Surface and Photo Chemistry

Course Code: WSCHPMT633	**Unit**	**Course/ Unit Title**	**02 Credits/ 30 Lectures**
I		**Modern Applications of Surface Chemistry**	**15 L**
	1.1	Surface active agents and micelles: Surface active agents and their classification, hydrophile-lipophile balance Micellization: shape and structure of micelles, hydrophobic interaction, critical Micelles concentration (CMC), factors affecting CMC of surfactants, counter ion binding to micelles, micelle catalysis, reverse micelles. Emulsions: Solubilization, micro emulsions, characterization of microemulsions	9 L
	1.2	Hydrogen storage by Adsorption: Hydrogen storage: fundamentals physisorption, temperature and pressure influence, chemisorption, adsorption energy, ‘Electrochemical Adsorption. Practical adsorption: storage of hydrogen with carbon materials, activated carbon, graphite graphene, carbon nanostructures, fullerene. Carbon nanofibers (CNF) and graphite nanofibers electrochemical storage of hydrogen in carbon materials.	6 L
II		**Applications of Fluorescence Phenomena**	**15 L**
	3.1	Fluorescence sensing: Mechanism of sensing; sensing techniques based on Collisional quenching, energy transfer, electron transfer; examples of pH sensors, glucose sensors and protein sensors	5 L
	3.2	Novel fluorophores: Quantum dots, lanthanides and long-lifetime Metal-ligand complexes Radiative decay engineering: metal enhanced fluorescence	8 L
	3.3	DNA technology–sequencing.	2 L

References:

Unit I

1. M. J. Rosen. Surfactants and Interfacial Phenomena (3rd edn.), John Wiley (2004).
2. Y. Moroi, Micelles: Theoretical and Applied Aspects, (1992) Plenum Press, New York
3. Arun K. Chattopadhyay, Kashmiri Lal Mittal, Surfactants in Solution, Volume 64 of Surfactant Science Series, Volume 64 of Lecture Notes in Pure and Applied Mathematics, illustrated, Marcel Dekker,1996
4. K.L. Mittal, American Chemical Society, Micellization, solubilization, and micro emulsions, Volume1 Micellization, Solubilization, and Microemulsions, American Chemical Society, illustrated, Plenum Press,1977

5. Deepak Thassu, Michel Deleers, Yashwant Pathak, Nanoparticle Drug Delivery Systems Volume166 of Drugs and the Pharmaceutical Sciences Series illustrated, CRC Press, 2007

Unit II

1.B. Valeur, Molecular Fluorescence: Principles and Applications, Wiley-VCH (2001).
2.J.R. Lakowicz ,Principles of Fluorescence Spectroscopy, Springer(2006)

Elective I

PROGRAM(s): M.Sc.-II	SEMESTER: III				
Course: Elective I	Course Code: WSCHPET631				
Teaching Scheme					Evaluation Scheme
Lectures (hours per week)	Practical (hours per week)	Tutorial (hours per week)	Credit	Continuous Assessment (CA) (Marks 20)	Semester End Examination (Marks- 30)
02	NA	–	02	40	60

Learning Objectives:

1. Recall the principles of electron spectroscopy techniques such as ESCA (XPS), AUGER, and UPS.
2. To apply the principles of electron spectroscopy to analyze different types of samples.
3. Analyze data obtained from electron spectroscopy experiments to draw meaningful conclusions.
4. Compare and contrast different electron microscopy techniques in terms of their capabilities and limitations.

Course Outcomes:

Learners will be able to:

CO-1: Explain the principles underlying electron spectroscopy techniques including ESCA (XPS), AUGER, and UPS.

CO-2 Apply the principles of electron spectroscopy to conduct analysis on various sample types.

CO-3 Interpret data gathered from electron spectroscopy experiments to derive significant insights.

CO-4: Differentiate electron microscopy techniques by evaluating their respective strengths and limitations.

Detailed Syllabus- Elective-I Advanced Instrumental Techniques-I

Course Code: WSCHPET631	Unit	Course/ Unit Title	02 Credits/ 30 Lectures
I		**Electron Spectroscopy and Microscopy**	**15 L**
	1.1	Electron Spectroscopy: principles, instrumentation and applications of the following ESCA (XPS), AUGER, UPS.	9 L
	1.2	Electron instrumentation and applications of the following: Scanning Probe Microscopes, Scanning Electron Microscope (SEM), Scanning Tunneling electron Microscope (STEM) Atomic Force Microscope (AFM)	6 L
II		**Hyphenated Techniques**	**15 L**
	3.1	Introduction, need for hyphenation, possible hyphenation.	2 L
	3.2	Interfacing devices and applications of the following: GC-MS, GC-IR, MS-MS, HPLC-MS, ICP-MS, spectro-electro chemistry and radio-chromatography.	13 L

References:

Unit I

1. Skoog DA, West DM,Fundamentals of Analytical Chemistry, Thomson Asia Pvt ltd.,8th Ed,(2004).
2. Skoog, Holler, Nieman, Principles of Instrumental Analysis, Thomson Asia Pvt ltd.,5th Ed(2003).
3. Willard Merrit and Settle, Instrumental Methods of Analysis.
4. Douglas A.Skoog, Holler & Crouch, Instrumental analysis India edition CENGAGE Learning (Eighth Indian Reprint 2011)

Unit II

1. R. P. W. Scott, Tandem Techniques, Wiley India Pvt. Ltd. Reprint 2009
2. J. Barker, Analytical chemistry for open learning, Mass spectrometry, Wiley India ED.

Elective II

PROGRAM(s): M.Sc. II		**SEMESTER: III**			
Course: **Elective II**		**Course Code: WSCHPET632**			
Teaching Scheme		**Evaluation Scheme**			
Lectures (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks20)**	**Semester End Examination (Marks-30)**
02	**NA**	**–**	**02**	**40**	**60**

Learning Objectives:

1. Describe the quantum mechanical methods applicable to the analysis of light-matter interactions.
2. Establish fundamental knowledge of radioanalytical methods to address existing problems in basic science.
3. Explain the principles of ORD, CD, ENDOR, ELDOR, EWDOR, Nuclear quadrupole resonance spectroscopy.
4. Analyze the strengths and limitations of each resonance technique in molecular analysis.

Course Outcomes:

Learners will be able to:

CO-1: Understand the basic principles of light-matter interactions and learn quantum mechanical methods to analyze the interactions.

CO-2: Apply the fundamental knowledge of radioanalytical methods to existing and an emerging problem in basic science

CO-3: Describe the principles of ORD, CD, ENDOR, ELDOR, EWDOR, Nuclear quadrupole resonance spectroscopy.

CO-4: Differentiate various resonance techniques used in the analysis of molecules.

CO-5: Apply the fundamental knowledge of electro-analytical methods to existing and an emerging problem in basic science.

Detailed Syllabus-Elective- II Advanced Instrumental Techniques-II

Course Code: WSCHPET632	Unit	Course/ Unit Title	02 Credits/ 30 Lectures
I		**Spectral Methods**	**15 L**
	1.1	Spectral Methods Principle, instrumentation and applications of the following: Reflectance spectroscopy	3 L
	1.2	Photo-acoustic spectroscopy	3 L
	1.3	Polarimetry: ORD, CD	04 L
	1.4	Chemiluminescence method	02 L
	1.5	Nuclear quadrupole resonance spectroscopy, ENDOR, ELDOR, EWDOR	03 L
II		**Radio-analytical Methods**	**15 L**
	3.1	Activation analysis-basic principles, fast neutron activation analysis, radiochemical method inactivation analysis	04 L
	3.2	Isotopic dilution method-principle and applications.	02 L
	3.3	Auto, x-ray and gamma radiography	04 L
	3.4	Radiometric Titrations	03 L
	3.5	Applications of radio-analytical techniques.	02 L

Reference books:

Unit:- I

1. A. J. Bardand L. R. Faulkner, Electrochemical Methods, 2nd Ed, John Wiley and sons, Asia Pvt, Ltd, (2004).
2. J. J. Lingane, Electro-analytical Chemistry, 2nd Ed, Inter science Publishers, Inc., New York (1958)
3. A.M. Bond, Modern Polarographic Methods in Analytical Chemistry, Marcel Dekker Publishers, Inc., New York, (1980)
4. A.J. Bard (Ed), Electro-analytical Chemistry, Marcel Dekkre Inc., New York (A series of volumes)

Unit-II

1. J. Ruticka and J. Stary, Sub stoichiometry in Radiochemical Analysis, Pergamon Press (1968).
2. R.A. Faires and G. G. J. Boswell, Radioisotope Laboratory Technique,4th Ed, Rutterworths; London, (1981)
3. D. Brune, B. Forkman, B. Person, Nuclear Analytical Chemistry, Chartwell- Bratt Ltd., (1984)
4. Maheshwar Sharon and Madhuri Sharon, Nuclear Chemistry, Ane Books Pvt. Ltd (2009)
Nuclear Chemistry by Arnikar

Elective Practical

PROGRAM(s): M.Sc.-II		**SEMESTER: III**			
Course: Elective Practical		**Course Code: WSCHPEP631**			
Teaching Scheme					**Evaluation Scheme**
Lectures (hours per week)	**Practical (hours per week)**	**Tutorial (hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks 20)**	**Semester End Examination (Marks- 30)**
NA	**04**	**NA**	**02**	**40**	**60**

Learning Objectives:

1. To Understand the concept of molar conductance, its significance in determining the degree of dissociation of weak electrolytes and to comprehend the behaviour of weak electrolytes at infinite dilution.
2. To learn to utilize the experimental data to calculate the dissociation constant of the weak electrolyte.
3. To understand the concept of standard electrode potential and its significance in determining redox reactions.

Course Outcomes:

Learner will be able to

CO-1 Recall fundamental principles and concepts related to conductometry, potentiometry, and pH metry.

CO-2 Apply these techniques to perform experiments accurately, analyze data, and draw conclusions.

CO-3 Analyze experimental results to interpret the behaviour of electrolytes, redox reactions, and acid-base systems.

Detailed Syllabus-Elective Practical- Instrumental Analysis

Course code: WSCHPEP631	Practical	02 Credits
	Non-Instrumental: 1. To determine instability constant & stoichiometry of silver ammonia complex potentiometrically. **Instrumental:** **Conductometry** 2. To determine the molar conductance of a weak electrolyte at infinite dilution hence to determine its dissociation constant. 3. To titrate potassium ferrocyanide with zinc sulphate and hence to determine the formula of the complex. **Potentiometry:** 4. To determine the E0 of the quinhydrone electrode. 5. To determine the formula of the zinc(II)ferrocyanide complex by titration of Zn(II) sulphate with potassium ferrocyanide. **pH metry:** 6. To estimate the amount of hydrochloric acid and acetic acid in a mixture by titration with an alkali using a pH meter. 7. To determine hydrolysis constant and degree of hydrolysis of ammonium chloride and hence to estimate the dissociation constant of the base.	

References:

1. B. Vishwanathan and P. S. Raghavan, Practical Physical Chemistry, Viva Books Private Limited, 2005.
2. A.M. James and F.E. Prichard, Practical Physical Chemistry,3rd ed., Longman,1974.
3. B.P. Lewitt(ed.), Findlay's Practical Physical Chemistry, 9th ed.,1973.
4. C.D. Brennan and C. F. H. Tipper, A Laboratory Manual of Experiments in Physical Chemistry, McGraw-Hill, 1967.
5. F. Daniel & Others, Experimental Physical chemistry, 19665, Kogakasha Co Ltd., Tokyo.

PROGRAM(s): M.Sc.-II	**SEMESTER: III**					
Course: Training/ Field Project	**Course Code: WSCHPRP631**					
Teaching Scheme				**Evaluation Scheme**		
Lectures (hours per week)	**Practical (hours per week)**	**Tutorial (hours per week)**	**Credit**	**Log book (Marks- 30%)**	**Report (Marks- 30%)**	**Via-Voce (Marks- 40%)**
NA	08	NA	04	30	30	40

Learning Objectives:

To provide students the opportunity to test their interest in a particular career before permanent commitments are made.

2. To develop skills in the application of theory to practical work situations. To develop skills and techniques directly applicable to their careers.

Course Outcomes:

Learners will be able to:

CO-1. Analyze the organizational structure of a company to identify its key components and relationships.

CO-2. Develop work habits and attitudes necessary for job success (technical competence, professional attitude, organization skills etc.)

CO-3. Demonstrate written communication proficiency and technical report writing skills.

Course Code	**Research Project**	**04 Credits**
WSCHPRP631	1. Students should carry out a detailed research project. 2. This should make them familiar with i. Literature survey, research methodologies ii. Data Analysis iii. characterization techniques 3. Project report must be written and submitted in a proper format as follows; i)Certificate (Signed by Project guide and Head of the Department)	

	ii) Certificates for Poster/Paper presented in conferences (if any) iii) Self declaration certificate for plagiarism iv) Introduction (not more than 6 pages) v) Experimental Section vi) Results and Discussions vii) Conclusion viii) References (Use ACS format) ix) Spectroscopic or other relevant supporting data x) Acknowledgement 4. Interdisciplinary projects shall be encouraged 5. Students should spend enough time for the project works (at least 8 hours per week) 6. If a student is performing a project in another institute, for such a student, an internal mentor must be allotted and he will be responsible for internal assessment of a student. In this case a student has to obtain a certificate from both external and internal mentors. 7. Systematic record of attendance of project students must be maintained by a mentor. 8.Project will be evaluated jointly by three examiners. 9. Astudent has to present his practical work, discuss results and conclusions in detail which will be followed by a question-answer session . 10. It is an open type of examination.	

PROGRAM(s): M.Sc.-II		**SEMESTER: IV**			
Course: Mandatory Course-1		**Course Code: WSCHPMT641**			
Teaching Scheme					**Evaluation Scheme**
Lectures (hours per week)	**Practical (hours per week)**	**Tutorial (hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks 40)**	**Semester End Examination (Marks 60)**
04	**NA**	**–**	**04**	**40**	**60**

Learning Objectives:

1. To understand the laws of thermodynamics and their applications.
2. To interpret the information and applications of material Sciences.
3. To explain the applications of statistical thermodynamics.
4. To analyze how irreversible thermodynamics is more effective than reversible thermodynamics.
5. Know the information and applications of irreversible thermodynamics and networking.

Course Outcomes:

Learners will be able to:

CO-1: Recall the laws of thermodynamics and their applications.

CO-2: Deduce the information and applications of material Sciences.

CO-3: Evaluate the applications of statistical thermodynamics.

CO-4: Compare how irreversible thermodynamics is more effective than reversible thermodynamics.

CO-5: Recall the information and applications of irreversible thermodynamics and networking.

Detailed Syllabus: Mandatory Course- I: Material Science, network and irreversible thermodynamics

Course Code:- WSCHPMT641	Unit	Course/ Unit Title	04 Credits/ 60 Lectures
I		**Metals and alloys**	**15 L**
	1.1	Solidification of metals and alloys-homogeneous and heterogeneous nucleation Growth of crystals, growth of silicon single crystal.	4 L
	1.2	Metallic solid solutions-substitutional and interstitial solid solutions.	3 L
	1.3	Crystalline imperfections-point ,line and boundary defects	4 L
	1.4	Atomic diffusions in solids-diffusion mechanisms, steady state and non-steady state diffusions,-impurity diffusion into silicon wafers for integrated circuits.	4 L
II		**Mechanical properties of solid materials**	**15 L**
	2.1	Stress and strain in metals- Engineering stress and engineering strain, shear stress and shear strain, the tensile test and engineering stress -strain diagram, modulus of elasticity, yield strength.	5 L
	2.2	Hardness and hardness testing plastic deformations of metals in single crystals plastic deformation of polycrystalline metals, solid solution strengthening of metals.	5 L
	2.3	Fracture of metals-ductile and brittle fracture ,toughness and impact testing, fatigue of metals, the creep test ,creep-rupture test.	5 L
III		**Lasers and superconductors**	**15 L**
	3.1	Lasers in chemistry General principles of LASER action-Population Inversion, cavity and mode characteristics, Q-switching, Modelocking. Practical lasers- Solid state lasers-Ruby, neodymium, gas lasers-HeNe, Ar, Kr, Carbon dioxide, Chemical and exciplex Lasers,Dye lasers LED and Semiconductor Lasers.	10 L

		Applications of Lasers in chemistry: Spectroscopy at high photon fluxes, collimated beams, Precision specified transitions, Isotope separation, Study of fast reactions using pulsed techniques	
	3.2	Super conducting solid materials Band theory of electrical conductivity, Bardeen-Cooper-Schriffer Theory of superconductivity,the superconducting state, High critical temperature superconductors, magnetic properties of superconductors.	5 L
IV		**Non-equilibrium thermodynamic**	**15 L**
	4.1	Non-equilibrium thermodynamics: Features of non-equilibrium thermodynamics, second law of thermodynamics, uncompensated heat and its relation to thermodynamics function.	2 L
	4.2	Entropy production and its rate. Entropy production in heat transfer process and during mixing of gases. Entropy production and efficiency of galvanic cell.	4 L
	4.3	Onsagers theory: Reciprocal relation, principle of microscopic reversibility. Coupled and uncoupled reactions and their condition.	5 L
	4.4	Transport phenomena across membranes. Electro kinetic effect and thermo mechanical effects	4 L

References:

Unit I and II:

1. William F. Smith, Principles of Material Science and Engineering, 3 rd edition, McGraw–HillInc.1996.
2. Keer H.V, Principles of the Solid State, first reprint, Wiley Eastern Limited, 1994.
3. Principles of Material science and engineering, 3rd edition, McGraw– Hill Inc.1996.

List of Books for further reading:

1. A.R. West, Solid State Chemistry and its Applications, John Wiley and Sons (Asia) Pvt. Ltd.,
2. L. E. Smart and E.A. Moore, Solid State Chemistry–An Introduction,3rdEd., Taylor and Francis, 2005.
3. V.Raghavan,Materials Science and Engineering, Fifth Ed., Prentice-Hall of India Pvt. Ltd.,NewDelhi,2004.
4. WilliamD.Callister,Jr.,Materials Science and Engineering, An Introduction, Fifth Ed.,John Wiley and Sons (Asia)Pvt.Ltd.,2001.
5. S.O.Pillai, Solid State Physics, Fifth Ed., New Age International Publishers, 2002.
6. Leonid V.Azaroff, Introduction to Solids, Tata-McGraw-Hill Publishing Co.Ltd., New Delhi, 1977.
7. Sandra E.Dann, Reactions and Characterization of Solids, Royal Society of Chemistry, 2000.
8. C.N.R.RaoandJ.Gopalakrishnan, New Directions in Solid State Chemistry, Seconded.,Cambridge University Press,1997.

9. N. B. Hannay, Solid State Chemistry, Prentice Hall of India, New Delhi,1976. 10 M. Ali Omer, Elementary Solid-state Physics,5th Indian Reprint, Pearson Education, Inc., 1999.

Unit-III

1. Atkins P.W, Physical Chemistry, Oxford University Press, 6th edition, 1998

Unit IV

1. D.A. McQuarrie and J. D. Simon, Molecular Thermodynamics, Viva Books Private Limited, First Indian Ed.,2004.
2. D. A. McQuarrie and J. D. Simon, Physical Chemistry, A Molecular Approach, Viva Books Private Limited, First South Asian Ed.,1998.
3. E. D. Kaufmann, Advanced Concepts in Physical Chemistry, McGraw-Hill,1966. 4. Robert P. H. Gasser and W. Graham Richards, An Introduction to Statistical Thermodynamics, World Scientific Publishing Co.Pte.Ltd.,1995.

PROGRAM(s): M.Sc.-II	**SEMESTER: IV**				
Course: Mandatory Course-II	**Course Code: WSCHPMT642**				
Teaching Scheme					**Evaluation Scheme**
Lectures (hours per week)	**Practical (hours per week)**	**Tutorial (hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks 40)**	**Semester End Examination (Marks- 60)**
04	**NA**	**–**	**04**	**40**	**60**

Learning Objectives:

1. To Gain knowledge of the Fundamental concepts and expertise in the field of NMR spectroscopy, ESR spectroscopy and Mossbauer Spectroscopy.
2. To Gain knowledge of the Fundamental concepts and detail applications of symmetry in Inorganic complexes.

Course Outcomes:

Learners will be able to:

CO-1: Apply these mathematical notations into objects and molecules.

CO-2: Analyze infrared, Raman, and electronic spectra of simple molecules.

CO-3: Apply the principles of NMR, 13CNMR, EPR/ESR, Mossbauer spectroscopy.

CO-4: Differentiate various resonance techniques used in the analysis of molecules

Detailed Syllabus: Mandatory Course- II: Symmetry & Spectroscopy

Course Code:- WSCHPMT642	Unit	Course/ Unit Title	04 Credits/ 60 Lectures
I		**Symmetry in Chemistry**	15 L
	1.1	Recapitulation: point groups, character tables	2 L
	1.2	Reduction formula, application of reduction formula to vibrational modes of water molecule.	2 L
	1.3	Application in vibrational spectroscopy, selection rules for IR spectroscopy for molecules such as H2O, CO2, HF, H2	3 L
	1.4	Application to Raman spectra, selection rules, comparison of IR and Raman selection rules, general approach to vibrational spectroscopy.	2 L
	1.5	Symmetry in chemical bonding: symmetry adapted linear combination of _molecular orbitals, H2 + ,H2, LiH, BeH2, BH3, CH4, molecular orbital energy, and bond order.	6 L
II		**N.M.R.Spectroscopy-I**	15 L
	2.1	A review of one dimensional NMR spectroscopy.	1 L
	2.2	Spin-relaxation. Nuclear Overhauser Effect (NOE).polarization transfer.	3 L
	2.3	Two-dimensional NMR.Correlated spectroscopy(COSY)	3 L
	2.4	Nuclear Overhauser effect Spectroscopy(NOESY)	2 L
	2.5	Hetero nuclear correlation Spectroscopy(HETCOR)	2 L
	2.6	Solid-state NMR	2 L
	2.7	Magnetic Resonance Imaging(MRI)	2 L

III		**ESR and Mossbauer Spectroscopy**	**15 L**
	3.1	Electron spin Resonance Spectroscopy-	10 L
	3.2	Basic principle, hyperfine splitting (isotropic systems)	2 L
	3.3	G-value and the factors affecting thereof; interactions affecting electron energies in paramagnetic complexes (Zero-field splitting and Kramer's degeneracy);	3 L
	3.4	An isotropic effect (the g-value and the hyperfine couplings);The EPR of triplet states; Structural applications to transition metal complexes.	2 L
	3.5	Fundamentals and hyperfine splitting, application to study of free radicals spin densities McConnell relationship Zero field splitting	3 L
	3.6	Mossbauer Spectroscopy:Principles, Recoilless emission and absorption of γ-rays, experimental methods, isomer shift, hyperfine structure (quadrupole interaction), magnetic hyperfine interaction, applications.	5L
IV		**13C-N.M.R. Spectroscopy**	**15 L**
	4.1	Elementary ideas, instrumental difficulties, FT technique advantages and disadvantages. proton noise decoupling technique advantages and disadvantages, off-resonance technique.	5 L
	4.2	Chemical shifts of solvents, factors affecting chemical shifts, analogy with 1H NMR.	3 L
	4.3	Calculations of chemical shift of hydrocarbons, effect of substituents on chemical shifts, different types of carbons (alkene, alkyne and allene).	3 L
	4.4	Chemical shift of aromatic carbons and effect of substituent.	2 L
	4.5	Chemical shifts of carbonyl, nitrile, and oxime carbons.	2 L

References:

Unit-I

1. K.Veera Reddy, Symmetry and Spectroscopy of molecules,2nded,new age International publishers.

2. U.C.Agarwala,H/L/Nigam,S.Agarwal, S.S.Kalra, Molecular symmetry in Chemistry via group theory, 2013, Ane Books Pvt.ltd.
3. H.N.Dass,symmetry and group theory for chemists,2004 Asian Books Pvt.Ltd. K.V.Raman, group theory and its applications to Chemistry,1980,Tata McGraw hill Pub.Co.Pvt.Ltd.
4. P.K.Bhattacharya, Group theory and its chemical applications,1999,Himalaya, Pub.House.
5. F.A.Cotton, Chemical applications ofGroup Theory, Wiley Student Ed., 2006, JohnWiley and Sons,(Asia) Pvt.Ltd.
6. R.L.Carter, Molecular symmetry and Group theory, Wiley Student Ed.,1996,John Wiley and Sons, (Asia) Pvt.Ltd.
7. S.Swarnalakshmi, T.saroja, R.M.Ezhilarisi, A simple approach to Group theory in chemistry, 2008, Universities Press (India) Pvt. Ltd.

Unit-II and III

1. C.N.Banwell and E.M.McCash, Fundamentals of Molecular Spectroscopy, 4thEd., Tata-McGraw-Hill,1994.
2. M. L. Gupta, Atomic and Molecular Spectroscopy, New Age International Publishers,2001.
3. H.S.Randhawa, Modern Molecular Spectroscopy, McMillan India Ltd.,2003
4. G.Aruldas, Molecular Structure and Spectroscopy, Prentice-HallofIndia,2001.
5. J.MichaelHollas, Modern Spectroscopy ,4thEd.,John Wiley and Sons,2004. List of Books for further reading:
6. R.Drago,Physical Methods for Chemists, Saunders ,Philadelphia,1992.
7. B. P. Straughan and S. Walker (Eds.), Spectroscopy – Vol 1-3, Chapman and Hall, New York,1976.
8. R. K. Harris, Nuclear Magnetic Resonance Spectroscopy, Pitman, London,1983.
9. Donald L. Pavia, Gary M. Lampman and George S. Kriz, Introduction to Spectroscopy,3rded.,Thomson,Brooks/Cole,2001.

Unit-IV

1. A.E. Derome, Modern NMR Techniques for Chemistry Research, Pergamon,Oxford(1987) 2. J.K.M. Sanders and B.K. Hunter, Modern NMR Spectroscopy, 2nd edition (1993), Oxford University Press, Oxford.
2. R.K.Harris,Nuclear Magnetic Resonance Spectroscopy,(1986) Addison-Wesley, Longman Ltd.,London
3. Organic spectroscopy by William Kemp,3rdEdition, ELBS, 1996.

PROGRAM(s): M.Sc.-II		**SEMESTER: IV**			
Course: Mandatory Course-III (Practical)		**Course Code: WSCHPMP641**			
Teaching Scheme					**Evaluation Scheme**
Lectures (hours per week)	**Practical (hours per week)**	**Tutorial (hours per week)**	**Credits**	**Continuous Assessment (CA) (Marks 40)**	**Semester End Examination (Marks- 60)**
NA	**04**	**NA**	**04**	**40**	**60**

Learning Objectives:

1. To apply experimental techniques to determine phase boundaries and compound formation temperatures.
2. Comprehending the determination of activation energy and other thermodynamic parameters from experimental data.
3. To understand the experimental techniques to vary ionic strength and measure its effect on reaction rates.
4. To apply conductometric techniques to measure conductivity changes during the dissolution of a sparingly soluble salt.
5. To apply analytical techniques to interpret vibrational-rotational, electronic, NMR, ESR, Mössbauer, XRD, DTA, TG, and DTG spectra and data.

Course Outcomes:

Learners will be able to:

CO-1 Apply experimental techniques to determine phase boundaries and compound formation temperatures.
CO-2 Determine the activation energy and other thermodynamic parameters from experimental data.
CO-3 Show the experimental techniques to vary ionic strength and measure its effect on reaction rates.
CO-4 Apply conductometric techniques to measure conductivity changes during the dissolution of a sparingly soluble salt.
CO-4 Interpret vibrational-rotational, electronic, NMR, ESR, Mössbauer, XRD, DTA, TG, and DTG spectra and data.

<table>
<tr><td>Course code:
WSCHPMP641</td><td>Practical</td><td>04 Credits</td></tr>
<tr><td></td><td>Major Experiments:
1. To construct the phase diagram for a two component system forming a compound
2. To determine the energy of activation and other thermodynamic parameters of activation for the reaction between persulphate and potassium iodide.
3. To determine the effect of ionic strength of a solution on the reaction between potassium persulphate and potassium iodide.

Minor Experiments:
Conductometry.
1. To study the order of the reaction between bromate and bromide.
2. To determine the composition of a mixture of hydrochloric acid, potassium chloride and ammonium chloride by titration with sodium hydroxide and silver nitrate.
3. To determine ΔG, ΔH and ΔS of dissolution of a sparingly soluble salt by conductometry.</td><td>02 Credits</td></tr>
<tr><td></td><td>Non–Instrumental:
1. To determine the formula of the zinc(II) ammonia complex by partition method.
2. Determination of the transport no. of silver(I) ions by Hittorf's method.
3. To determine the van't Hoff's factor by cryoscopic method.

Instrumental:
pH metry
1. To determine K1 and K2 of a dibasic acid by titration with base.
2. To determine the dissociation constant of p-nitrophenol.

Potentiometry
1. To determine the liquid junction potential with a concentration cell with and without transference.</td><td>02 Credits</td></tr>
</table>

References:

1.B. Vishwanathan and P. S. Raghavan, Practical Physical Chemistry, Viva BooksPrivateLimited,2005.
2.A.M. James and F.E. Prichard, Practical Physical Chemistry,3rd Ed, Longman,1974.
3.B.P. Lewitt(ed.) Findlay's Practical PhysicalChemistry,9th Ed,1973.

4.C.D. Brennan and C. F. H. Tipper, A Laboratory Manual of Experiments Physical Chemistry, McGraw-Hill,1967.
5.F. Daniel & Others, Experimental Physical chemistry,1966,5, Kogakasha Co Ltd.,Tokyo.

Elective I

<table>
<tr><td colspan="2">PROGRAM(s): M.Sc.-II</td><td colspan="4">SEMESTER: IV</td></tr>
<tr><td colspan="2">Course: Elective I</td><td colspan="4">Course Code: WSCHPET641</td></tr>
<tr><td colspan="5">Teaching Scheme</td><td>Evaluation Scheme</td></tr>
<tr><td>Lectures (hours per week)</td><td>Practical (hours per week)</td><td>Tutorial (hours per week)</td><td>Credit</td><td>Continuous Assessment (CA) (Marks20)</td><td>Semester End Examination (Marks- 30)</td></tr>
<tr><td>02</td><td>NA</td><td>–</td><td>02</td><td>40</td><td>60</td></tr>
<tr><td colspan="6">Learning Objectives:
1. To create awareness and understanding of terms like intellectual property, patents, copyright, industrial designs, trademarks, geographical indications etc.

2. To know trade secrets, IP infringement issues, economic value of intellectual property and study of various related international agreements.</td></tr>
<tr><td colspan="6">Course Outcomes:

Learners will be able to-

CO-1 Describe the terms with their meaning such as intellectual property, patents, copyright, industrial designs, trademarks, geographical indications etc.

CO-2 Interpret various trades and their trade secrets.

CO-3 Summarize the different IP infringement issues, economic value of intellectual property.</td></tr>
</table>

Detailed Syllabus- Elective-I Intellectual Property Rights

Course Code: WSCHPET641	**Unit**	**Course/ Unit Title**	**02 Credits/ 30 Lectures**
	I	**Introduction to Intellectual Property-I**	**15 L**
		Historical Perspective, Different types of IP, Importance of protecting IP. 1.2 Patents: [5L] Historical Perspective, Basic and associated right, WIPO, PCT system, Traditional Knowledge, Patents and Health care-balancing promoting innovation with public health, Software patents and their importance for India. 1.3 Industrial Designs: [2L] Definition, How to obtain, features, International design registration. 1.4 Copyrights: [2L] Introduction, How to obtain, Differences from Patents. 1.5 Trade Marks: [2L] Introduction, How to obtain, Different types of marks – Collective marks, certification marks, service marks, trade names etc. 1.6 Geographical Indications: [2L] Definition, rules for registration, prevention of illegal exploitation, importance to India.	
	II	**Intellectual Property Rights-II**	**15 L**
		2.1Trade Secrets: [2L] Introduction and Historical Perspectives, Scope of Protection, Risks involved and legal aspects of Trade Secret Protection. 2.2 IP Infringement issue and enforcement: [2L] Role of Judiciary, Role of law enforcement agencies – Police, Customs etc.	

		2.3 Economic Value of Intellectual Property: [5L] Intangible assets and their valuation, Intellectual Property in the Indian context – Various Laws in India Licensing and Technology transfer. 2.4 Different International Agreements: [6L] (a) World Trade Organization (WTO): [5L] ● General Agreement on Tariffs and Trade (GATT), ● Trade Related Intellectual Property Rights (TRIPS) agreement ● General Agreement on Trade-Related Services (GATS) ● Madrid Protocol. ● Berne Convention ● Budapest Treaty (b) Paris Convention [6L] WIPO and TRIPS, IPR and Plant Breeders Rights, IPR and Biodiversity	

References:

1. Andrew R. Leach & Valerie J. Gillet (2007) *An Introduction to Cheminformatics.* Springer: The Netherlands.
2. Gasteiger, J. & Engel, T. (2003) *Cheminformatics: A textbook*. Wiley–VCH
3. Gupta, S. P. *QSAR and Molecular Modeling.* Springer-Anamaya Pub.: New Delhi.

Elective II

PROGRAM(s): M.Sc. II		**SEMESTER: IV**			
Course: **Elective II**		**Course Code: WSCHPET642**			
Teaching Scheme		**Evaluation Scheme**			
Lectures (Hours per week)	**Practical (Hours per week)**	**Tutorial (Hours per week)**	**Credit**	**Continuous Assessment (CA) (Marks 20)**	**Semester End Examination (Marks-30)**
02	**NA**	**–**	**02**	**40**	**60**

Learning Objectives:

1. Understand the behavior of polymers in the solid state, including crystalline behavior and the significance of transitions.
2. Understand the theoretical basis and application of each characterization method in polymer analysis.
3. Understand the mechanisms underlying polymer properties and their relationship to molecular structure and processing conditions.
4. Understand the functions and applications of polymer auxiliaries in enhancing material properties and processing.

Course Outcomes:

Learners will be able to:

CO-1 Explain the behaviour of polymers in the solid state, including crystalline behaviour and the significance of transitions.

CO-2 Evaluate the theoretical basis and application of each characterization method in polymer analysis.

CO-3 Identify the mechanisms underlying polymer properties and their relationship to molecular structure and processing conditions.

CO-4 Analyze the functions and applications of polymer auxiliaries in enhancing material properties and processing.

Detailed Syllabus-Elective- II Chemistry: Polymer and Applied.

Course Code: WSCHPET642	**Unit**	**Course/ Unit Title**	**02 Credits/ 30 Lectures**
I		**Polymer Chemistry-II**	**15 L**
	1.1	Polymers in solid state–Transitions (glass transition and crystalline melting temperature), crystalline behavior, factors affecting crystallinity,polymer blends and Alloys.	3 L
	1.2	Identification And Characterization Of Polymers: Chemical analysis-End Group Analysis;Physical analysis bySpectral methods: IR, UV, Ramam, NMR, X-ray diffraction analysis, Microscopic methods: SEM, TEM, Thermal analysis-TGA, DTA, DSC.	6 L
	1.3	Properties of polymers: Thermal (glass transition temperature, and its determination),mechanical (deformation and fracture) effects polymers, viscoelasticity surface (surface tension, hardness, friction, abrasion), physical (Impact Strength, Tensile Strength, solubility) of polymers, weatherability, rheology and mechanical models, mechanical behaviour, Rubber Elasticity	4 L
	1.4	Polymer degradation and stabilization: Oxidative, thermal, radiation, Biodegradation	2 L
II		**Polymer Chemistry-III**	**15 L**
	3.1	Techniques Of Polymerization: Bulk Polymerization, solution polymerization, suspension polymerization, emulsion polymerization.	3 L
	3.2	Thermodynamics Of Polymer Solutions: Solubility parameter, thermodynamics of mixing, theta temperature	2 L
	3.3	Polymer technology: Polymer Auxiliaries, plasticizers, heat Stabilizers, colorants, flame retardants. Fillers, reinforcements. Elastomers: Introduction, Processing, Rubber Types, Vulcanization, Properties. Reclaiming. Fibers: Introduction, production, Fiber spinning, Textile fibers, Industrial fibers, recycling	5 L

	3.4	Films sheets: Introduction and processing techniques (injection and blow moulding extrusion), Recycling of plastics.	2 L
	3.5	Properties and applications of some commercially important polymers. Carbon chain polymers- Polyolefins, ABS group, elastomers, vinyl polymers, acrylic polymers, heterochain polymers- polyethers, polycarbonates, polysaccharides, polyamides fluoropolymers, Resins (epoxy, alkyd, phenol-formaldehyde and urea formaldehyde), Silicones, polyphosphazenes, Sulfur containing polymers.	3 L

Reference books:

Unit:- I and Unit-II

1. P. Bahadur and N. V. Sastry, Principles of Polymer Science, second edition, Narosa Publishing House,2005.

2. C. E. Carraher, Jr., Carraher's Polymer Chemistry, 8th edition, CRC Press, New York,2010.

3. Joel R. Fried, Polymer Science and Technology, Prentice-Hall of India Pvt Ltd., 2000.

4. V.R. Gowarikar, H. V. Viswanathan and J. Sreedhar, Polymer Science. New Age International Pvt. Ltd., New Delhi,1990.

5. F. W. Billmeyer Jr., Text Book of Polymer Science, 3rd edition, John Wiley and Sons,1984.

6 V. K. Ahluwalia & A. Mishra, Polymer Science, A textbook, Ane Books Pvt. Ltd,2008.

7 R. Sinha, Outline of Polymer Technology manufacture of Polymers, Prentice Hall of India Pvt. Ltd. 2000

8 F. J. Davis, Polymer Chemistry, Oxford university Press,2000.

9 D. Walton & P. lotimer, Polymer, Oxford university Press,2000.

10 R. Young, Introduction to Polymers, Chapman & Hall, reprint,1989.

11 V. Jain. Organic Polymer Chemistry, I V Y Publishing House,2003.

12 A. Singh, Polymer Chemistry, Campus BookInternational,2003.

Elective Practical

<table>
<tr><td colspan="3">PROGRAM(s): M.Sc.-II</td><td colspan="3">SEMESTER: IV</td></tr>
<tr><td colspan="3">Course: Elective Practical</td><td colspan="3">Course Code: WSCHPEP641</td></tr>
<tr><td colspan="5">Teaching Scheme</td><td>Evaluation Scheme</td></tr>
<tr><td>Lectures (hours per week)</td><td>Practical (hours per week)</td><td>Tutorial (hours per week)</td><td>Credit</td><td>Continuous Assessment (CA) (Marks 20)</td><td>Semester End Examination (Marks- 30)</td></tr>
<tr><td>NA</td><td>04</td><td>NA</td><td>02</td><td>40</td><td>60</td></tr>
</table>

Learning Objectives:

1. Understand the concept of partitioning between two immiscible phases and its application in determining complex formulas.
2. Understand the concept of migration of ions in an electrolyte solution under the influence of an electric field.
3. Explain Hittorf's method techniques to determine the transport number of silver(I) ions.
4. Discuss potentiometric techniques to determine the liquid junction potential in concentration cells

Course Outcomes:

Learner will be able to:

CO-1 Determine the concept of partitioning between two immiscible phases and its application in determining complex formulas.

CO-2 Illustrate the concept of migration of ions in an electrolyte solution under the influence of an electric field.

CO-3 Apply Hittorf's method techniques to determine the transport number of silver(I) ions.

CO-4 Determine the liquid junction potential in concentration cells.

Detailed Syllabus-Elective Practical- Spectral Interpretation.

Course code: WSCHPEP641	Practical	02 Credits
	Interpretation of spectra/data: 1. Interpretation of vibrational-rotational spectra of rigid non-rigid diatomic molecules 2. Interpretation of electronic spectra of diatomic molecules. 3. Interpretation of electronic spectra of simple polyatomic molecules. 4.Interpretation of NMR, ESR spectra. 5.Interpretation of Mössbauer spectra. 6.Analysis of XRD pattern of cubic system 7. Interpretation of DTA, TG and DTG curves	

References:

1. B. Vishwanathan and P. S. Raghavan, Practical Physical Chemistry, Viva BooksPrivateLimited,2005.
2. A. M. James and F.E. Prichard, Practical Physical Chemistry,3rd Ed, Longman,1974.
3. B. P . Lewitt(ed.) Findlay's Practical PhysicalChemistry,9th Ed,1973.
4. C.D. Brennan and C. F. H. Tipper, A Laboratory Manual of Experiments Physical Chemistry, McGraw-Hill,1967.
5. F. Daniel & Others, Experimental Physical chemistry,1966,5, Kogakasha Co Ltd.,Tokyo.

PROGRAM(s): M.Sc. II			SEMESTER: IV			
Course: Project			Course Code: WSCHPRP641 Course Title: Research Project			
Teaching Scheme				Evaluation Scheme		
Lectures (Hours per week)	Practical (Hours per week)	Tutorial (Hours per week)	Credit	Log book (Marks-30%)	Report (Marks-30%)	Via-Voce (Marks-40%)
-	12	–	06	45	45	60

Learning Objectives:

1. To understand and discuss the new research topics in the field of chemistry.
2. To display, organize and represent correlation between different types of data.
3. To summarize and provide a concise summary of research projects carried out.
4. Demonstrate a capacity to communicate research results clearly and comprehensively.
5. Ability to demonstrate oral/poster presentation.

Course Outcomes:

Learners will able to

CO-1 Work and explain key research concepts and issues.

CO-2 Develop different experimental skills required for research.

CO-3 Read, comprehend and anticipate the solution of research problems in their project work.

CO-4 Analyze data critically and validate its applications.

CO-5 Equip themselves with ethical issues related to Research and Publication.

CO-6 Communicate research findings in written and verbal forms.

CO-7 Develop a strong foundation for future research work in a systematic manner by applying notions of Research Methodology.

Detailed Syllabus:

Course Code	Research Project	06 Credits
WSCHPRP641	1. Students should carry out a detailed research project. 2. This should make them familiar with i. Literature survey, research methodologies ii. Data Analysis iii. characterization techniques 3. Project report must be written and submitted in a proper format as follows;	

	i)Certificate (Signed by Project guide and Head of the Department) ii) Certificates for Poster/Paper presented in conferences (if any) iii) Self declaration certificate for plagiarism iv) Introduction (not more than 6 pages) v) Experimental Section vi) Results and Discussions vii) Conclusion viii) References (Use ACS format) ix) Spectroscopic or other relevant supporting data x) Acknowledgement 4. Interdisciplinary projects shall be encouraged 5. Students should spend enough time for the project works (at least 12 hours per week) 6. If a student is performing a project in another institute, for such a student, an internal mentor must be allotted and he will be responsible for internal assessment of a student. In this case a student has to obtain a certificate from both external and internal mentors. 7. Systematic record of attendance of project students must be maintained by a mentor. 8.Project will be evaluated jointly by three examiners. 9. Astudent has to present his practical work, discuss results and conclusions in detail which will be followed by a question-answer session . 10. It is an open type of examination.	

Modality of Assessment (4 credit)

Theory Examination Pattern:

A. Internal Assessment- 40%- 40 Marks per paper

Sr. No.	Evaluation Type	Marks
1	**Written Objective Examination**	**20**
2	**Assignment/ Case study/ field visit report/ presentation/ project**	**20**
	Total	**40**

B. External Examination- 60%- 60 Marks per paper Semester End Theory Examination:

1. Duration - These examinations shall be of **two hours** duration.
2. Theory question paper pattern:
   a. There shall be 05 questions each of 15 marks on each unit.
   b. All questions shall be compulsory with internal choice within the questions.

Paper Pattern:

Question	Options	Marks	Questions Based on
Q.1	Sub Questions: 1A. 2 out of 4 1B. 1 out of 2	12	Unit I
Q.2	Sub Questions: 2A. 2 out of 4 2B. 1 out of 2	12	Unit II
Q.3	Sub Questions: 3A. 2 out of 4 3B. 1 out of 2	12	Unit III
Q.4	Sub Questions: 4A. 2 out of 4 4B. 1 out of 2	12	Unit IV
Q.5	4 out of 8	12	Units (I+II+III+IV)

	TOTAL	**60**	

Modality of Assessment (2 credit)

Theory Examination Pattern:

C. **Internal Assessment- 40%- 20 Marks per paper**

Sr. No.	Evaluation Type	Marks
1	**Written Objective Examination**	**10**
2	**Assignment/ Case study/ field visit report/ presentation/ project**	**10**
	Total	**20**

D. **External Examination- 60%- 30 marks per paper Semester End Theory Examination:**

1. Duration - These examinations shall be of **One hour** duration.
2. Theory question paper pattern:
   a. There shall be 03 questions each of 15 marks on each unit.
   b. All questions shall be compulsory with internal choice within the questions.

Paper Pattern:

Question	Options	Marks	Questions Based on
Q.1	Sub Questions: 1A. 2 out of 4 1B. 1 out of 2	12	Unit I
Q.2	Sub Questions: 2A. 2 out of 4 2B. 1 out of 2	12	Unit II
Q.3	2 out of 4	06	Units (I+II)
	TOTAL	**30**	

Practical Examination Pattern:

A. **Internal Examination: 40%**

Particulars	**Mandatory Practical (4 credit)**	**Elective Practical (2 credit)**
Journal	10	05
Experimental tasks	20	10
Participation	10	05
Total	**40**	**20**

B. **External Examination: 60%**
Semester End Practical Examination:

Particulars	**Mandatory Practical (4 credit)**	**Elective Practical (2 credit)**
Laboratory work	50	25
Viva	10	05
Total	**60**	**30**

Research Project Evaluation

Semester III (4 Credit)			**Semester IV (6 Credit)**		
Log book (Marks- 30%)	**Report (Marks- 30%)**	**Via-Voce (Marks- 40%)**	**Log book (Marks- 30%)**	**Report (Marks- 30%)**	**Via-Voce (Marks- 40%)**
30 Marks	30 Marks	40 Marks	45 Marks	45 Marks	60 Marks

PRACTICAL BOOK/JOURNAL

The students are required to perform 75% of the Practical for the journal to be duly certified. The students are required to present a duly certified journal for appearing at the practical examination, failing which they will not be allowed to appear for the examination.