Dr. Homi Bhabha State University, Mumbai

Syllabus for M.Sc. Physical Chemistry

Semester III and IV

(Choice Based Credit System)

(To be implemented from the academic year - 2021-2022)

	M.Sc. Semester III : Physical Chemistry		
	Course Code: **MSCHCC301T**	Course Title: **Atomic and Molecular: Structure and Spectroscopy**	
	Course Credit: **4**	Total contact hours: **60 Hrs**	
Sr.No.	**Course Contents (Topics and subtopics)**		**Reqd. hours.**
	UNIT I:Atomic structure		**15 Hrs**
1.1	Introduction to approximate methods in Quantum Mechanics 1.1.1 Variation theorem, linear and nonlinear variation functions. 1.1.2Perturbation theory, non degenerate perturbation theory, first order wave function correction, first order and second order energy correction. 1.1.3 Application of variation and perturbation theory to ground state of Helium Atom.		
1.2	Multi –electron atoms: Antisymmetry and Pauli Principle, Slater determinants, Hartree-Fock and configuration interaction wave functions, Slater type orbitals, Gaussian orbitals, orbitals plots, basis sets, density functional theory.		
	UNIT II : Atomic spectroscopy		**15 Hrs**
2.1	Angular momentum, orbital, spin and total angular momentum, total angular momentum (J) of many electron atoms, Russell Saunders (L-S) coupling and J-J coupling,.		
2.2	Term symbols, term symbols for multi electron atoms like He, Li, Be, B,C etc.		
2.3	Exchange of interactions and multiplicity of states.		
2.4	Anomalous Zeeman Effect and Paschen Back effect.		
2.5	Atomic spectra and selection rules, energy level diagram of atomic sodium		
	UNIT III: Molecular Structure		**15 Hrs**
3.1	The Born–Oppenheimer approximation		
3.2	LCAO method-molecular orbital formation		
3.3	Calculation of energy of hydrogen molecule ion using 3.3.1 Valence bond method 3.3.2 Heitler-London treatment 3.3.3 Improvements in Heitler-London treatment		
3.4	Electronic structure of polyatomic molecules 3.4.1 Valence bond method for BeH_2, H_2O, NH_3, BH_3 ,CH_4. 3.4.2 Huckel molecular orbital's Theory for–ethylene, Allyl system, cyclopropenyl system and cyclobutadiene.		
	UNIT IV: Molecular spectroscopy		**15 Hrs**
4.1	Rotational spectroscopy**:** Einstein coefficients, classification of poly atomic molecules- spherical top, symmetric top and asymmetric top molecules, rotational spectra of polyatomic molecules Stark modulated microwave spectrometer.		
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.		
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 pre-dissociation	
	Reference Books 1. Laidler and Miser, Physical Chemistry, 2nd edition, CBS publishers, New Delhi. (Chapters11-14). 2. Silbey and Alberty, Physical Chemistry, 3rd edition, John Wiley and Sons, 2000. 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), Pearson Educ. Inc., New Delhi 6. D. A. McQuarrie and J. D. Simon, Physical Chemistry : A Molecular Approach, (1998) Viva Books, New Delhi. 7. J. N. Murrell, S.F.A. Kettleand, J.M.Tedder, Valence Theory, 2nd Edition (1965), John Viley, NewYork. 8. A. K. Chandra, Introductory Quantum Chemistry, 4th edition(1994), Tata Mc Graw Hill, New Delhi 9. D. A. McQuarrie, 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. C. N. Banwell and E. M. Mc Cash, Fundamentals of Molecular Spectroscopy, 4th Ed., Tata-Mc Graw-Hill, 1994. 13. M. L. Gupta, Atomic and Molecular Spectroscopy, New Age International Publishers, 2001. 14. H. S. Randhawa, Modern Molecular Spectroscopy, Mc Millan India Ltd., 2003 15. G. Aruldas, Molecular Structure and Spectroscopy, Prentice-Hall of India, 2001. 16. J. Michael Hollas, Modern Spectroscopy, 4thEd., John Wiley and Sons, 2004. **Books for further reading** 1. R Drago, Physical Methods for Chemists, Saunders, Philadelphia, 1992. 2. B. P. Straughan and S. Walker (Eds.),S pectroscopy–Vol1-3, Chapman and Hall, NewYork,1976. 3. Donald L. Pavia, Gary M. Lampman and George S. Kriz, Introduction to Spectroscopy, 3rd ed., Thomson, Brooks/Cole,2001. 4. John P. Lowe, Quantum Chemistry, 3rd ed., Academic Press, NewYork, 2006. 5. R. Anantharaman, Fundamentals of Quantum Chemistry, McMillan India Limited, 2001. 6. Mahendra R. Awode, Quantum Chemistry, S. Chand and Co. Ltd., New Delhi, 2002. 7. David O. Hayward, Quantum Mechanics for Chemists, Royal Society for Chemistry, 2002.	

	8. Jack Simons, An Introduction to Theoretical Chemistry, Cambridge University Press,2003. 9. Victor M. S. Gil, Orbitals in Chemistry, A Modern Guide to Students, Cambridge University Press, 2000. 10. A. K. Chandra, Introduction to Quantum Chemistry, 4th Ed.,Tata-McGraw-Hill, 1994. 11. S. N. Datta, Lectures on Chemical Bonding and Quantum Chemistry, Prism Books Pvt. Ltd., 1998. 12. R. Mc Weeny, Coulson's Valence,3rd. Ed., Oxford University Press, 1979. 13. J. N. Murell, S. F. A. Kettle and J. M. Tedder, The Chemical Bond, Wiley, 1985.	

	Course outcomes (Students will ……)
1.	Learn the variation and perturbation methods and different types of orbitals.
2.	Learn the angular momentum and coupling of angular momenta, term symbols and atomic spectra
3	Get idea about LCAO method, calculation of energy of hydrogen molecule ion and electronic structure of polyatomic molecules.
4.	Learn rotational, Raman and electronic spectroscopy. Get idea about different types of transitions.

2	Course Code: **MSCHCC302T**	Course Title: **Solid State and Nanochemistry**	
	Course Credit: **4**	Total contact hours: **60 Hrs**	
Sr.No.	**Course Contents (Topics and subtopics)**		**Reqd. hours.**
	UNITI : Metals and alloys:		**15 Hrs**
1.1	Solidification of metals and alloys-homogeneous and heterogeneous nucleation growth of crystals, growth of silicon single crystal.		
1.2	Metallic solid solutions-substitutional and interstitial solid solutions.		
1.3	Crystalline imperfections-point, line and boundary defects		
1.4	Atomic diffusions in solids-diffusion mechanisms, steady state and non-steady state diffusions,-impurity diffusion into silicon wafers for integrated circuits.		
	UNIT II : Mechanical properties of solid materials		**15 Hrs**
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.		
2.2	Hardness and hardness testing plastic deformations of metals in single crystals plastic deformation of polycrystalline metals, solid solution strengthening of metals.		
2.3	Fracture of metals-ductile and brittle fracture , toughness and impact testing, fatigue of metals, the creep test ,creep-rupture test.		
	UNIT III : **Nano chemistry of gold, cadmium, selenide**		**15 Hrs**
3.1	Variation of optical and magnetic properties of non material with size, shape, surface characteristics and impurities		
3.2	Relationship between size and shape of nano materials		
3.3	Nano architecture: self assembly and template methods		
3.4	Diagnosis and treatment of diseases using nano particles		
3.5	Safety and ethics of use of nano particles		
	UNIT IV : Nano chemistry of silica and poly dimethyl siloxane		**15 Hrs**
4.1	Variation of optical and magnetic properties of non material with size, shape, surface characteristics and impurities		
4.2	Relationship between size and shape of nano materials		
4.3	Nano architecture: self assembly and template methods		
4.4	Diagnosis and treatment of diseases using nano particles		
	Reference Books 1. William F. Smith, Principles of Material Science and Engineering, 3rd 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. 4. Ludovico Cademartiri and Geoffrey A. Ozin, Concepts of Nano Chemistry, Wiley– VCH Verlag GmbH & Co,2009 5. C. Bréchignac, P. Houdy, Marcel Lahmani, Nano Materials and Nano Chemistry, Springer, 2007 6. C. N. R. Rao, Achim Müller, Anthony K. Cheetham, Nano Materials		

	Chemistry, John Wiley & Sons, 2007 7. Geoffrey A. Ozin, André C. Arsenault, Ludovico Cademartiri, Nano Chemistry: A Chemical Approach to Nano materials, Royal Society of Chemistry (Great Britain),09 **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,3rd Ed., Taylor and Francis, 2005. 3. V. Raghavan, Materials Science and Engineering, Fifth Ed., Prentice-Hall Of India Pvt. Ltd., NewDelhi,2004. 4. William D. 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. Rao and J.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, 5thIndian Reprint, Pearson Education, Inc., 1999.	

	Course outcomes (Students will ……)
1.	Learn the solidification of metals and alloys, defects in solids and diffusion in solids.
2.	Get knowledge about mechanical properties of solid - stress and strain, hardness and fracture of metals etc.
3	Understand optical and magnetic properties of nano particles, nano architecture, diagnosis and treatment using nano particles.
4.	Learn nano chemistry of silica and poly dimethyl siloxane

	Course Code: **MSCHDE301T**	Course Title: **Advanced Instrumental Techniques 1**	
	Course Credit: **4**	Total contact hours: **60 Hrs**	
Sr. No.	**Course Contents (Topics and subtopics)**		**Reqd. hours.**
	UNIT I : Electron Spectroscopy and Microscopy		**15 Hrs**
1.1	Electron Spectroscopy: principles, instrumentation and applications of the ESCA (XPS), AUGER, UPS		
1.2	Electron Microscopy: Principles, instrumentation and applications of the following: Scanning Probe Microscopes, Scanning Electron Microscope(SEM), Scanning Tunneling Electron Microscope(STEM) and Atomic Force Microscope(AFM)		
	UNIT II : Thermal Methods		**15 Hrs**
2.1	Thermogravimetry (TG): Principle and Instrumentation, factors affecting thermogravimetric curves, Interpretation of thermo gravimetric curves. applications of thermogravimetry		
2.2	Differential thermal analysis(DTA)and Differential scanning calorimetry (DSC), Principle and instrumentation, heat flux and power compensated DSC Interpretation of DTA and DSC curves applications of DTA and DSC.		
2.3	Enthalpimetric methods		
2.4	Thermometric titrations: Principle instrumentation and applications		
2.5	Evolved gas analysis (EGA): Principle and applications		
	UNIT-III Hyphenated Techniques		**15 Hrs**
3.1	Introduction, need for hyphenation, possible hyphenation.		
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.		
	UNIT IV: Electro-Analytical Methods		**15 Hrs**
4.1	4.1 Over view of electrode process: Electro-capillary curve and electro-capillary maximum potential.		
4.2	Micro electrodes: Mercury electrodes: Stationary mercury drop electrode (SMDE), Hanging mercury drop electrode (HMDE), Mercury film electrode (MFE), Carbon paste electrode and chemically modified electrodes.		
4.3	Introduction to three electrode system: Modern polarography and voltammetry necessity and development of new voltammetric techniques and their comparison with classical DC polarography		
4.4	Voltammetric methods: Sampled DC polarography (TAST), Linear sweep voltammetry (LSV), Cyclic voltammetry (CV), diagnostic criteria of cyclic voltammetry		
	Reference Books 1. Skoog D A, West D M, 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. Sharma B. K., Instrumental Methods of Chemical Analysis, Goel Publishing House. 4. Wendlandt., Thermal Methods, WW John Wiley,(1986).		

5. Willard Merrit and Settle, Instrumental Methods of Analysis.
6. Douglas A. Skoog, Holler & Crouch, Instrumental analysis India edition CENGAGE Learning (Eighth Indian Reprint 2011)
7. Robert D.Braun. Introduction to Instrumental Analysis (Indian Reprint 2006)
8 Pavia, Lapman, Kriz, Introduction to Spectroscopy, Thomson Pub.
9. H. Straw, & K. Walker, Spectroscopy Vol .I& II, Science Paper Backs.
10. M. Mahindersingh, Analytical Chemistry, Instrumental Techniques, Dominant Pub. Delhi.
11. F. W. Fiefield, & D. Kealey, Principles and Practice of Analytical Chemistry, Blackwell Pub.
12. G. W. Ewing, Instrumental Methods of Chemical Analysis, MacGraw Hill.
1 3. R. P. W. Scott, Tandem Techniques, Wiley India Pvt. Ltd.Reprint , 2009
14. J. Barker, Analytical chemistry for open learning, Mass Spectrometry, Wiiley India ED.
15. A. J. BardandL. R. Faulkner, Electrochemical Methods, 2nd Ed, John Wiley and Sons, Asia Pvt. Ltd,(2004)
16. J. J. Lingane , Electro-analytical Chemistry, 2nd Ed, Interscience Publishers, Inc., New York (1958)
17. A. M. Bond, Modern Polarographic Methods in Analytical Chemistry, Marcel Dekker Publishers, Inc., New York,(1980)
18. A. J. Bard(Ed), Electro-analytical Chemistry, Marcel Dekkre Inc., New York (A series of volumes)..
19. Donald T. Sawyer, A. Sobkowiak and J. L. Roberts, Jr., Electro chemistry For Chemists, 2ndEd., John Wiley and Sons, Inc., New York.,(1995).
20. D. A. Skoog, F. J. Holler, J. A. Nieman, Principles of Instrumental analysis, 6thEd.
21. R. D. Braun, .Introduction to Instrumental Analysis, Mac Graw Hill,1987.
22. H.A. Willard, L. L.Merritt, J. A. Dean &F .A. Settle, Instrumnetal methods of Analysis,5thEd.CBS,1986.
23. M. Noel, K. J. Vasu, Cyclic Voltammetry and Frontiers of electro chemistry, IBH, NewDelhi,1990.

	Course outcomes (Students will ……)
1.	Understand the basic principle, instrumentation and applications of ESCA (XPS), AUGER, UPS, Scanning Probe Microscopes, Scanning Electron Microscope(SEM), ScanningTunneling Electron Microscope(STEM) and Atomic Force Microscope(AFM)
2.	Get information about thermal methods like TG, DTA, DSC, EGA and enthlpimetric methods.
3	Learn hyphenated techniques like GC-MS, GC-IR, MS-MS, HPLC-MS, ICP-MS, spectro-electro chemistry and radio-chromatography.
4.	Get the overview of electrode processes, learn about microelectrode, three electrode system and voltametric methods.

	Course Code: **MSCHDE302T**	Course Title: **Polymer Chemistry**	
	Course Credit: **4**	Total contact hours: **60 Hrs**	
Sr. No.	**Course Contents (Topics and subtopics)**		**Reqd. hours.**
	UNIT I: Polymer Chemistry-I		**15 Hrs**
1.1	**Introduction**: Polymer Science, fundamental terms, historical outline, classification based on: the origin (natural, semi-synthetic, synthetic etc.), the structure (linear,branched, network, hyper branched, dendrimer, ladder, cross linked, IPN), the type of atom in the main chain (homo chain, hetero chain), the formation (condensation, addition), homo polymers, copolymers(random, alternate, block, graft), the behavior on application of heat(thermoplastic and thermosetting), the form and application (plastics, fibre, elastomers and resins).		
1.2	**Molar Mass**: Molecular weight averages, fractionation, molecular weight determination by GPC/SEC, end group analysis, viscometry, vapour phase osmometry, gradient elution, and molecular weight distribution curve**.**		
1.3	**Types of polymerization**: condensation, addition (cationic andanionic)and Copolymerization (with kinetics),chain transfer reactions.		
	Unit II: Polymer Chemistry-II		**15 Hrs**
2.1	**Polymers in solid state :** Transitions (glass transition and crystalline melting temperature), crystalline behaviour, factors affecting crystallinity, polymer blends and Alloys.		
2.2	**Identification and characterization of polymers**: Chemical analysis- End group analysis; Physical analysis by Spectral methods: IR, UV, Ramam, NMR, X-ray Diffraction Analysis, Microscopic methods: SEM, TEM, Thermal analysis-TGA, DTA, DSC.		
2.3	**Properties of polymers**: Thermal (glass transition temperature, and its determination), mechanical (deformation and fracture) effects in polymers, visco elasticity surface (surface tension, hardness, friction, abrasion), physical (Impact strength, Tensile strength, solubility) of polymers, weather ability, rheology and mechanical models, mechanical behavior, Rubber elasticity.		
	Unit III: Polymer Chemistry-III		**15 Hrs**
3.1	**Techniques of polymerization**: Bulk polymerization, solution polymerization, suspension polymerization, emulsion polymerizations		
3.2	**Thermodynamics of polymer solutions** : Solubility parameter, thermodynamics of mixing**,** theta temperature		
3.3	**Polymer technology**: **3.3.1** Polymer auxiliaries, plasticizers, heat Stabilizers, colorants, flame retardants. Fillers, reinforcements. **3.3.2** Elastomers: Introduction, Processing, Rubber Types, Vulcanization, Properties. Reclaiming. **3.3.3** Fibers: Introduction, production, Fiber spinning, Textile fibers, Industrial fibers, recycling. **3.3.4** Films sheets: Introduction and processing techniques (injection and blow moulding extrusion), Recyling of plastics		

3.4	**Properties and applications of some commercially important polymers** : Carbon chain polymers- Polyolefins, ABS group, elastomers, vinyl polymers, acrylic polymers, hetero chain polymers- polyethers, polycarbonates, polysaccharides, polyamides fluoropolymers, Resins (epoxy, alkyd, phenol-formaldehyde and urea formaldehyde),Silicones, polyphosphazenes, sulphur containing polymers	
	Unit IV: Polymer Chemistry-IV	**15 Hrs**
4.1	Engineering and Speciality Polymers: engineering resins, high performance polymers, heat resistant polymers, high impact resistance polymers, speciality polymers, Liquid crystalline polymers, Conducting polymers, Polyelectrolytes, polymers in nonlinear optics	
4.2	Applications of polymers in separations, biotechnology and electronics-Membrane Separations, Biomedical Applications, photonic polymers nano-wires, Encapsulation, Electronic shielding., Drag reduction, smart materials, construction and building optical fibres	
4.3	Polymer degradation and stabilization: Oxidative, thermal, radiation, Biodegradation	
	Reference Books 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 Text Book, 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. Ypung, Introduction to Polymers, Chapman & Hall, reprint, 1989. 11. V. Jain. Organic Polymer Chemistry, IVY Publishing House, 2003. 12. A. Singh, Polymer Chemistry, Campus Book International, 2003. **Books for further reading** **1.** J. M. G. Cowie, Polymers: Chemistry and Physics of Modern Materials, 2nd ed. (first Indian Reprint 2004), Replika Press Pvt. Ltd. 2. G. S. Misra, Introductory Polymer Chemistry, New Age International (P) Limited, Publishers, 1993. 3. L. H. Sperling, Introduction to Physical Polymer Science. 2nd Edition, John Wiley and Sons. Inc. 4. Hans-Georg Elias, An Introduction to Polymer Science, VCH 1997. 5. Charles E. Seymour, Jr., Seymour/Carraher's Polymer Chemistry, 6th ed., Marcel Dekker, Inc, 2003. 6. A. Ravve, Principles of Polymer Science, 2nd ed., Kluwer Academic/ Plenum Publishers, New York, 2000.	

	7. Vidyagauri Lele, Chemical modification of starch by green process, Techno World Press, 2015. 8. Vidyagauri Lele, Graft copolymers of starch-Synthesis & Characterization, Neeraj Publishing House, 2015	

	Course outcomes (Students will ……)
1.	Learn basics of polymer science, molecular weight determination and types of polymerization.
2.	Get idea about solid state polymers and characterization of polymers using various techniques, learn the properties of polymers.
3	Understand the polymer technology and properties of commercially important polymers.
4.	Learn about the engineering and speciality polymers and their applications in various fields, degradation and stability of polymers.

	Course Code: **MSCHGE301T**	Course Title : **Research Methodology**	
	Course Credit:**2**	Total contact hours: **30 Hrs**	
Sr. No.	**Course Contents(Topics and subtopics)**		**Reqd. hours.**
	UNITI: Sources of Information		**15Hrs**
1.1	**Primary, Secondary and Tertiary sources.**		05Hrs
1.2	**Journals:** Journal abbreviations, abstracts, current titles, reviews, monographs, dictionaries, text- books, current contents, Introduction to Chemical Abstracts and Beilstein, Subject Index, Substance Index, Author Index, Formula Index, and other Indices with examples.		05Hrs
1.3	**Digital:** Web sources, E-journals, Journal access, TO Calerts, Hot articles, Citation Index, Impact factor, H-index, E-consortium, UGC infonet, E-books, Internet discussion groups and communities, Blogs, preprint servers, Search engines, Scirus, Google Scholar, Chem Industry, Wiki-databases, Chem Spider, Science Direct, Sci Finder, Scopus.		05Hrs
	UNIT II: Methods Of Scientific Research and Writing Scientific Papers		**15hrs**
2.1	Information Technology and Library Resources: The Internet and World wide web, Internet resources for Chemistry, finding and citing published information. Shodhganga -a reservoir of Indian theses : Directory of open Access Journals.		**5hrs**
2.2	Reporting practical and project work, Writing literature surveys and reviews, organizing a poster display, giving an oral presentation.		**5hrs**
2.3	**Writing Scientific Papers:** Justification for scientific contributions, bibliography, description of methods, conclusions, the need for illustration, style, publications of scientific work, writing ethics. **Plagiarism:** Definition of Plagiarism, Types of Plagiarism with examples, strategies to a void plagiarism, case studies (any one)		**5hrs**
	Course Outcome: 1) Students will learn communication related to Science. 2) Awareness in terminology related to Research. 3) Students will learn, to write and present experimental/research results.		
	REFERENCES 1. Dean, J. R., Jones, A.M., Holmes, D., Reed,R., Weyers, J., & Jones, A.,(2011),*Practical skills in Chemistry*,2nd Ed., Prentice Hall, Harlow. 2. Hibbert, D. B. & Gooding,J. J.(2006) *Data Analysis for Chemistry* 3. Topping, J.,(1984) *Errors of Observation and their Treatment* 4th Ed., Chapman Hill, London. 4. Harris, D. C. (2007) *Quantative Chemical Analysis* 6th Ed., Freeman Chapters 3-5 5. Levie, R. De. (2001) *Howtouse Excelin Analytical Chemistry and in general scientific data analysis* Cambridge Universty Press. 6. Research methodology techniques and methods, C. L. Kothari, New age International Publishers		

5	Course Code: **MSCHAE301T**	Course Title: Pharmaceutical Development and Management	
	Course Credit: **2**	Total contact hours: 30Hrs	
Sr. No.	**Course Contents (Topics & subtopics)**		**Reqd. hours**
	UNIT I		**7 Hrs**
1.1	Understanding of Pharmaceutical Industry: What drives the pharmaceutical industry, Subsections of Pharmaceutical industry		
1.2	The Pharmaceutical Products: Drug Development and the Marketing Research Interface; Diversification and Specialisation; Marketing Generic Drugs; Non-prescription drugs.		
1.2	Competitive Practices: Economic and Competitive Aspects of the Pharmaceutical Industry. Advertising; Detailing and other forms of Promotion; Retail Competition – The Community Level; International Marketing.		
1.3	Validation Process: Selectivity , Linearity, Accuracy, Precision		
	UNIT II		**7 Hrs**
2.1	Six sigma in Pharmaceutical Manufacturing Industry • How does Six Sigma work? • Six Sigma Customer Benefits • Build quality in Pharmaceutical Manufacturing Process through Six Sigma Introduction to Kaizen Concept		
2.2	Quality by Design (QbD) : Why QbD, The characteristics of a successful QbD program, The Role of Quality Risk Management in QbD .		
2.3	Review of GLP and GMP and their regulations for analytical labs		
	Suggested readings		
1	Fundamentals of Analytical Chemistry, D.A. Skoog and D. M. West and F. J. Holler Holt- Saunders 6th Edition (1992)		
2	Principles of Instrumental Analysis, D. A. Skoog, F. J. Holler and J.A. Niemann,5th Edition (1998)		
3	Instrumental Methods of Analysis, H. H. Willard, L. L. Merritt, Jr. J. A. Dean and F. A. Settle Jr 6thEd CBS (1986)		
4	Fundamentals of Analytical Chemistry, D. A. Skoog and D. M. West, Saonders, College publication.		
	Course Outcome :		
1	Students will get insight of the management terms used in Pharma industry.		
2	Students will get introduced to Pharmaceutical Legislation		

	M. Sc. Semester III : PHYSICAL CHEMISTRY **Practical Papers**		
1	Course Code: **MSCHLB301P**	Course Title:	
	Course Credit: **2**	Total contact hours: **120 Hrs**	
	Course Contents (Topics and subtopics)		**Reqd. hours.**
	1. To determine of 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 isoelectric point of gelatin by viscosity measurement. 4.To determine the formula of the zinc(II) ammonia complex by partition method 5. To determine the energy of activation and other thermodynamic parameters of activation for the reaction between persulphate and potassium iodide. 6. To study the order of the reaction between bromate and bromide. 7.To determine the mean ionic activity coefficient of zinc chloride by emf method. 8. To construct the phase diagram for a two component system forming a simple eutectic.. 9. To determine the equilibrium constant for the reaction $CaSO_4$ (s) + $2Ag^{+1}$ (aq) = Ag_2SO_4(s) + Ca^{+2} (aq) 10.To determine the composition of a mixture of hydrochloric acid, potassium chloride and ammonium chloride by titration with sodium hydroxide and silver nitrate. 11.To determine ΔG, $\Delta H$and ΔS of dissolution of a sparingly soluble salt by Conductometry 12. To determine K_1 and K_2 of a dibasic acid by titration with a base 13. To determine dissociation constant of p-nitro phenol.		

	Course Code: **MSCHLB302P**	Course Title:	
	Course Credit: **2**	Total contact hours: **120 Hrs**	
	Course Contents (Topics and subtopics)		**Reqd. hours.**
	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 molar mass of a nonvolatile solute by cryoscopic method. 3. To determine the effect of ionic strength of a solution on the reaction between potassium persulphate and potassium iodide. **Conductometry** 4. To determine the molar conductance of a weak electrolyte at infinite dilution hence to determine its dissociation constant. 5.To titrate potassium ferrocyanide with zinc sulphate and hence to determine the formula of the complex. **Potentiometry** 6.To determine the E^0 of the quinhydrone electrode. 7. To determine the formula of the zinc(II) ferrocyanide complex by titration of Zn(II) sulphate with potassium ferrocyanide 8.To determine the liquid junction potential with a concentration cell with and without transference. **pH metry** 9.To estimate the amount of hydrochloric acid and acetic acid in a mixture by titration with an alkali using a pH meter. 10. To determine hydrolysis constant and degree of hydrolysis of ammonium chloride and hence to estimate the dissociation constant of the base. 11. To determine the proton ligand stability constant of an organic acid and metal ligand stability constant of its complex by pH measurement. **Colorimetry& spectrophotometry** 12.To determine the ionization constant of bromophenol blue 13. To study complex formation between nickel(II)with o-phenanthroline. 14. To determine the rate constant and the order of the reaction between persulphate and iodide ions.		
	Reference Books 1.B.Vishwanathan and P. S. Raghavan, Practical Physical Chemistry,Viva Books Private Limited, 2005. 2. A.M. Jamesand, F. E. Prichard, Practical Physical Chemistry, 3rd ed., Longman,1974. 3. B. P. Lewitt(ed.), Findlay's Practical Physical Chemistry, 9thed.,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 Lt d., Tokyo**.**		

	M.Sc. Semester IV: Physical Chemistry		
1	Course Code: **MSCHCC401T**	Course Title: **Symmetry &Spectroscopy**	
	Course Credit: **4**	Total contact hours: **60 Hrs**	
Sr. No.	**Course Contents (Topics and subtopics)**		**Reqd. hours.**
	UNIT I : Symmetry in Chemistry		**15 Hrs**
1.1	Recapitulation: point groups, character tables		
1.2	Reduction formula, application of reduction formula to vibrational modes of water molecule.		
1.3	Application in vibrational spectroscopy, selection rules for IR spectroscopy for molecules such as H_2O, CO_2, HF, H_2		
1.4	Application to Raman spectra, selection rules, comparison of IR and Raman selection rules, general approach to vibrational spectroscopy.		
1.5	Symmetry in chemical bonding: symmetry adapted linear combination of molecular orbitals, H_2, H_2^+, LiH, BeH_2, BH_3, CH_4, molecular orbital energy, and bond order.		
	UNIT II : NMR spectroscopy		**15 Hrs**
2.1	A review of one dimensional NMR spectroscopy.		
2.2	Spin-relaxation. Nuclear Overhauser Effect (NOE).polarization transfer		
2.3	Two-dimensional NMR. : Correlation spectroscopy(COSY)		
2.4	Nuclear Overhauser effect Spectroscopy(NOESY)		
2.5	Hetero nuclear correlation Spectroscopy (HETCOR)		
2.6	Solid-state NMR		
2.7	Magnetic Resonance Imaging (MRI)		
	UNIT III : ^{13}C NMR spectroscopy		**15 Hrs**
3.1	Elementary ideas, instrumental difficulties, FT technique advantages and disadvantages. proton noise decoupling technique advantages and disadvantages, off-resonance technique.		
3.2	Chemical shifts of solvents, factors affecting chemical shifts, analogy with ^{1}HNMR.		
3.3	Calculations of chemical shift of hydrocarbons, effect of substituent's on chemical shifts, different types of carbons (alkene, alkyne and allene).		
3.4	Chemical shift of aromatic carbons and effect of substituent.		
3.5	Chemical shifts of carbonyl, nitrile, and oxime carbons.		
	UNIT IV: ESR and Mossbauer Spectroscopy		**15 Hrs**
4.1	Electron spin Resonance Spectroscopy 4.1.1 Basic principle, hyperfine splitting (isotropic systems) 4.1.2 G-value and the factors affecting thereof; interactions affecting electron energies in paramagnetic complexes (Zero-field splitting and Kramer's degeneracy) 4.1.3 An isotropic effects (the g-value and the hyperfine couplings) ; The EPR of triplet states; Structural applications to transition metal complexes. 4.1.4 Fundamentals and hyper fine splitting, application to study of free radicals spin densities McConnell relationship Zero field splitting.		

4.2	Mossbauer Spectroscopy: Principles, Recoil free emission and absorption of γ-rays, experimental methods, isomer shift, hyperfine structure (quadrupole interaction)	
	Reference Books 1.K.Veera Reddy, Symmetry and Spectroscopy of Molecules, 2nded, New Age International Publishers. 2. U. C. Agarwal, 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. 4. K.V.Raman, Group Theory and its Applications to Chemistry,1980,Tata Mac Graw Hill Pub. Co. Pvt. Ltd. 5. P. K. Bhattacharya, Group Theoryand its Chemical Applications,1999, Himalaya Pub.House. 6. F. A. Cotton, Chemical Applications of Group Theory, Wiley Student Ed., 2006, John Wiley and Sons,(Asia) Pvt. Ltd. 7. R. L. Carter, Molecular Symmetry and Group Theory, Wiley Student Ed., 1996, John Wiley and Sons, (Asia) Pvt.Ltd. 8. S. Swarnalakshmi, T. Saroja, R. M. Ezhilarisi, A Simple Approach to Group Theory in Chemistry, 2008, Universities Press (India) Pvt. Ltd. 9. A.E. Derome, Modern NMR Techniques for Chemistry Research, Pergamon, Oxford (1987) 10. J. K. M. Sanders and B.K. Hunter, Modern NMR Spectroscopy, Oxford University Press, Oxford. edition (1993), 11. R. K. Harris, Nuclear Magnetic Resonance Spectroscopy,(1986) Addison-Wesley, Longman Ltd, London 12. Organic Spectroscopy by William Kemp, 3rdEdition, ELBS, 1996. 13. .J. Michael Hollas, Modern Spectroscopy ,4th Ed., John Wiley and Sons, 2004. 14. C. N. Banwell and E. M. McCash, Fundamentals of Molecular Spectroscopy, 4thEd., Tata-McGraw-Hill,1994. 15. M. L. Gupta, Atomic and Molecular Spectroscopy, New Age International Publishers, 2001. 16. H. S. Randhawa, Modern Molecular Spectroscopy, McMillan India Ltd., 2003 17. G. Aruldas, Molecular Structure and Spectroscopy, Prentice-Hall of India, 2001. 18. Donald L. Pavia, Gary M. Lampman and George S. Kriz, Introduction to Spectroscopy,3rd ed., Thomson Brooks, Cole,2001.	

	Course outcomes (Students will ……)
1.	Learn symmetry, point groups and application of symmetry in vibrational spectroscopy Raman spectroscopy and chemical bonding.
2.	Get information about two dimensional NMR. Solid state NMR and Magnetic Resonance imaging.
3	Understand basic principle and applications of ^{13}C NMR spectroscopy.
4.	Learn basic principles and applications of ESR and Mossbauer spectroscopy.

	Course Code: **MSCHCC402T**	Course Title: **Statistical Thermodynamics, Irreversible Thermodynamics and Catalysis**	
	Course Credit: **4**	Total contact hours: **60 Hrs**	
Sr. No.	**Course Contents (Topics and subtopics)**		**Reqd. hours.**
	UNIT I: Statistical Mechanics		**15 Hrs**
1.1	Thermodynamic probability: Combinatral problems, Sterling apporoximation, Lagranges method, macro and microstates, ensembles, Boltzmann distribution law.		
1.2	Partition functions: Translational, rotational, vibrational, electronic and nuclear partition functions, Expressions for the thermodynamic functions interms of partition function -Internal energy, heat capacity, the Helmholtz and Gibbs functions, Enthalpy, entropy and equilibrium constants. Sackur – Tetrode equation for the entropy of a mono atomic gas. Molecular partition function.		
1.3	Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics.		
1.4	Debye and Einstein theory of specific heats of solids.		
	UNIT II: Irreversible Thermodynamics		**15 Hrs**
2.1	Non-equilibrium thermodynamics : 2.1.1 Features of non-equilibrium thermodynamics, second law of thermodynamics, uncompensated heat and its relation to thermodynamics function. 2.1.2 Entropy production and its rate. Entropy production in heat transfer process and during mixing of gases. Entropy production and efficiency of galvanic cell. 2.1.3 Onsagers theory: Reciprocal relation, principle of microscopic reversibility. Coupled and uncoupled reactions and their condition. 2.1.4 Transport phenomena across membranes. Electro kinetic effect and thermo mechanical effects		
	UNIT III:Catalysis 1		**15 Hrs**
3.1	3.1.1 Theories of catalysis- intermediate compound formation theory and adsorption theory. 3.1.2 Catalysis: bio catalysis, autocatalysis, negative catalysis, characteristics of catalytic reactions concept of activity, selectivity, poisoning, promotion and deactivation. 3.1.3 Types of catalysis: homogeneous, heterogeneous. Enzyme catalysis, effect of temperature and pH on enzyme catalysis. 3.1.4 Heterogeneous catalysis and catalytic kinetics: concept of Langmuir-Hinshelwood		
3.2	Preparation of catalysts: 3.2.1 General methods for preparation of catalysts: precipitation, sol-gel, hydrothermal, impregnation, hydrolysis, vapour deposition. 3.2.2 Activation of catalysts: calcinations, reduction.		
	UNIT IV: Catalysis 2		**15 Hrs**
4.1	Catalyst characterization: surface area, pore size distribution, particle size determination, XPS, AES, UV-Vis, FT-IR and thermal methods		

4.2	Catalysis in green chemistry and environmental applications: Purification of exhaust gases from different sources: auto-exhaust catalysts (petrol vehicles, diesel vehicles), VOC removal; ozone decomposition.	
4.1	Photo-catalysis: Photo processes at metals, oxides and semiconductors: concepts and mechanism. Photocatalysis application in organic pollutant degradation present in water and air. Photocatalytic water splitting, photocatalysis in the field of energy and environment.	
	Reference Books 1. Atkins P.W,PhysicalChemistry,Oxford UniversityPress,6th edition,1998 2. JohnM.Seddon&JulianD.Gale,Thermodynamics and Statistical Mechanics, Tutorial Chemistry Texts Series,Vol.10,Royal Society of Chemistry,2001. 3. Silbey RJ & Alberty RA,Physical Chemistry,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. 7. Physical Chemistry of Surfaces, W. Adamson, Wiley Intersciences,(5th edition) 1990. 8. Heterogeneous Catalysis: Principles and Applications. Bond, G C, Oxford University Press 1987 9. Heterogeneous Catalysis, D.K. Chakrabarty and B. Viswanathan, New Age Publishers 10. Principles of Physical Chemistry by Puri, Sharma, Pathania , 45th edition 11. Catalytic Chemistry, B.C. Gates, John Wiley and Sons Inc. (1992) 12. Solid State Physics – N.W. Aschocruts& N.D. Mermin, Saunders College. 13. Material Science & Engineering, An Introduction - W.D. Callister, Willey. 8. Principles of solid state – H.V. Keer, Willey. 14. Materials Science – Anderson, Leaver, Alexander, & Rawlings, ELBS 15. Theromotropic liquid crystals Gray, Willey 16. Text Book of liquid crystals – Kelkar&Halz, ChemieVerlag	

	Course outcomes (Students will ……)
1.	Get knowledge about probability, distribution, partition function, Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics and theory of specific heat of solids.
2.	Understand the concepts of irreversible thermodynamics.
3	Learn theories and different types of catalysis. Synthesis and activation of catalyst.
4.	Learn characterization of catalyst, use of catalyst in green chemistry and environmental applications. Get information of photocatalysis.

4	Course Code: **MSCHDE401T**	Course Title : **Surface and Electrochemistry**	
	Course Credit: **4**	Total contact hours: **60 Hrs**	
Sr. No.	**Course Contents (Topics and subtopics)**		**Reqd. hours.**
	UNIT I : Surface Chemistry		**15Hrs**
1.1	Adsorption at liquid surfaces, Gibbs equation and its verification, Gibbs Monolayers, insoluble films on liquid substrates, states of monomolecular Films, Wetting, flotation, detergency.		
1.2	Adsorption forces, thermodynamics of physical adsorption, heat of adsorption and its determination, measurement of adsorption by different methods, chemisorption and its mechanism.		
1.3	Multilayer adsorption – critical comparison of various multilayer models- BET, Potential and Polanyi models (no derivation). Measurement of surface area of solids by different methods. Harkins and Jura equation.		
	UNIT II :Modern Applications of Surface Chemistry		**15Hrs**
2.1	Surface active agents and micelle: 2.1.1 Surface active agents and their classification, hydrophile-lipophile balance 2.1.2 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. 2.1.3 Emulsions: Solubilization, micro emulsions, characterization of microemulsions,		
2.2	Hydrogen storage by Adsorption: 2.2.1 Hydrogen storage: fundamentals physisorption , temperature and Pressure influence, chemisorption, adsorption energy, 'Electrochemical' adsorption. 2.2.2. Practical adsorption: storage of hydrogen with carbon materials, activated carbon, graphite graphene, carbon nano structures, fullerene. Carbon nano fibres(CNF) and graphite nano fibers electrochemical storage of hydrogen in carbon materials.		
	UNIT III : Electrochemistry I		**15Hrs**
3.1	Ionics - Ion-ion interaction: Activity and activity coefficients, Debye-Huckel Theory, limited and extended law. Ion transport in solution: Fick's laws of diffusion, Einstein relation between diffusion coefficient and ionic mobilities, The Nernst-Einstein equation, relation between absolute and conventional mobilities.		
	UNIT IV: Electrochemistry II		**15Hrs**
4.1	Electrodics – Standard electrode potentials, Liquid junction potential, Zeta potential, electro kinetic phenomena, electrode-electrolyte interface, double layer theories, Butler- Volmer equation, and Tafel equation.		
4.2	Applications -Fuel cells and batteries – primary and secondary power cells, Fuel cells, Li ion battery		
4.3	Solar Cells: photovoltaic and photogalvanic cells; photoelectron chemistry; prospects of solar energy conversion and storage,organic solar cells		
	Reference Books 1. Physical Chemistry of Surfaces – A. W. Adamson, Interscience Publishers Inc New York, 1967.		

2. Surface Chemistry – Theory and applications, J. J. Bikerman, Academic Press, New York 1972.
3. Adsorption, Surface Area and Porosity – S. J. Gregg and K. S. W. Sing, Academic Press Ltd., London 1967.
4. Zeolites and Clay Minerals as Adsorbents and Molecular Sieves, R. M. Barrar, Academic Press London.
5. Physical Adsorption of Gases, D. M. Young and A. D. Crowell, Butterworths, London, 1962.
6. Adsorption, J. Oscik, John Wiley and Sons. New York.
7. Physical Chemistry - Peter Atkins, Julio de Paula, 7th Edition Oxford University Press.
8. M. J. Rosen. Surfactants and Interfacial Phenomena (3rd edn.), John Wiley (2004).
9. Y. Moroi, Micelles: Theoretical and Applied Aspects, (1992) Plenum Press, New York
10.ArunK.Chattopadhyay,KashmiriLalMittal,SurfactantsinSolution, Volume64of Surfactant Science Series, Volume 64 of Lecture Notes in Pure and Applied Mathematics,illustrated,MarcelDekker,1996
11. K. L. Mittal, American Chemical Society, Micellization, solubilisation and microemulsions,Volume1, American Chemical Society, illustrated, PlenumPress,1977
12.Deepak Thassu, Michel Deleers,Yashwant Pathak, Nano particle Drug Delivery Systems, Volume 166 of Drugs and the Pharmaceutical Sciences Series illustrated, CRC Press, 2007
13. K. R. Lange. Surfactants, Hanser Pub.(1999).
14. R.Zana(ed.).Dynamics of Surfactant Self-Assemblies, CRC Press(2005).
15. M. Abe & J. F. Scamehorn. Mixed Surfactant Systems, CRC Press(2004).
16.Tushar K. Ghosh, Energy Resources and Systems: Volume 2: Renewable Resources,Volume2, Springer Link:Bücher,Springer,2011
17.R. Strobel , J. Garche , P.T. Moseley , L. J¨ Orissen, G. Wolfd. "Review Hydrogen storage by carbon materials." Journal of Power Sources (www.sciencedirect.com) 159 (June 2006): 781–801.
18. Agata Godula-Jopek, Walter Jehle, Joerg Wellnitz, Hydrogen Storage Technologies: New Materials Transport and Infrastructure, John Wiley& Sons, 2012
19. Modern Electrochemistry - Vol I & II J O'M Bockris and AKN Eddy, Plenum Press, N.Y.
20. Fuel cells - heir Electrochemistry, J O'M Bockris and S Srinivasan, McGraw Hill, NY (1969)
21. Fuel cell systems L.I. M Blomen and M.N. Mugerwa, Plenum Press NY (1993)

	Course outcomes (Students will ……)
1.	Get basic knowledge and modern applications of surface chemistry.
2.	Learn basics and applications of electrochemistry.

	Course Code: **MSCHDE402T**	Course Title: **Advanced Instrumental Techniques II**	
	Course Credit: **4**	Total contact hours: **60 Hrs**	
Sr. No.	**Course Contents (Topics and subtopics)**		**Reqd. hours.**
	UNIT I : Spectral Methods		**15 Hrs**
	Principle, instrumentation and applications of the following:		
1.1	Reflectance spectroscopy		
1.2	Photo-acoustic spectroscopy		
1.3	Polarimetry : ORD, CD		
1.4	Chemiluminescence method		
1.5	Nuclear quadruple resonance spectroscopy, ENDOR, ELDOR, EWDOR		
	UNIT II: Electro-analytical Methods – I		**15Hrs**
	Principles, instrumentation and applications of the following :		
2.1	Ion selective field effect transistors, bio-catalytic membrane electrodes, disposable multi layer p-Ion systems, screen–printed electrodes.		
2.2	Chrono potentiometry and chrono amperometry		
2.3	Fused salt electrolysis		
	UNIT III : Radio-analytical Methods		**15Hrs**
3.1	Activation analysis-basic principles, fast neutron activation analysis, radiochemical method inactivation analysis		
3.2	Isotopic dilution method-principle and applications.		
3.3	Auto, x-ray and gamma radiography		
3.4	Radiometric Titrations		
3.5	Applications of radio-analytical techniques		
	UNIT IV : Pulse polarography		**15Hrs**
4.1	Normal pulse polarography (NPP), Differential pulse polarography (DPP) , Double differential pulse polarography (DDPP)		
4.2	Sinusoidal AC polarography, Square wave polarography		
4.3	Applications of electrochemical methods in Organic synthesis.		
	Reference Books 1. A. J. BardandL. 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). 5. Donald T. Sawyer , A. Sobkowiakand , J. L. Roberts, Jr. ,Electro Chemistry For Chemists, 2nd Ed., John Wiley and Sons, Inc., New York.,(1995). 6. D. A. Skoog, F. J. Holler, J. A. Nieman, Principles of Instrumental Analysis, 6th Ed. 7. R. D. Braun, Introduction to Instrumental Analysis, Mac Graw Hill,1987 8. H.A. Willard, L. L. Merritt, J. A. Dean &F. A. Settle, Instrumnetal methods of analysis, 5th Ed.CBS,1986. 9. M. Noel, K. J. Vasu, Cyclic Voltammetry and Frontiers of Electro		

	chemistry, IBH, New Delhi,1990. 10. P. T. Kissinger, W. R. Heinman, Laboratoty Techniques in Electro analytical Chemistry, Dekkar, NY.1984. 11. J. Ruticka and J. Stary, Sub Stoichiometry in Radio Chemical Analysis, Pergamon Press,(1968) 12. R. A. Faires and G. G .J. Boswell, Radio Isotope Laboratory Technique,4th, Ed, Rutterworths; London, (1981) 13. D. Brune, B. Forkman, B.Person, Nuclear Analytical Chemistry, Chartwell- Bratt Ltd.,(1984) 14. Maheshwar Sharon and Madhuri Sharon, Nuclear Chemistry, Ane Books Pvt. Ltd.(2009) 15.Essentials of Nuclear Chemistry, H. J Arnikar, Wiley Eastern Limited, 4th Edition.(1995)	

	Course outcomes (Students will ……)
1.	Get knowledge of various spectral methods .
2.	Learn - Ion selective field effect transistors, bio-catalytic membrane electrodes, disposable multi layer p-Ion systems, screen–printed electrodes, Chrono potentiometry and chrono amperometry.
3	Understand the principles and applications of radioanalytical techniques.
4.	Learn different types of polarography.

	Course Code: **MSCHSE401T**	Course Title: **Recent Trends in Chemistry**	
	CourseCredit:**4**	Total contact hours: 60Hrs	
Sr. No.	**Course Contents (Topics & subtopics)**		**Reqd. hours**
	UNIT I Molecular Interaction		**15 Hrs**
1.1	Electric dipole moments, Polarizabilities and Polarization, Relative permittivity's		
1.2	I**nteraction between molecules** Interaction between dipoles, Impact on medicine: Molecular recognition and drug design Repulsive and total interaction. Impact on material science. Hydrogen storage in molecular clathrates.		
1.3	**Gases and Liquids** Molecular interaction in gases and liquid surface interface, Surface film, Condensation.		
	UNIT II Organic Solid-State Chemistry		**15 Hrs**
2.1	Topochemical control of solid-state organic reactions: a) Intramolecular reactions b) Intermolecular reactions c) Asymmetric synthesis d) Role of crystal defects e) Role of molecular packing arrangements Organic reactions within Inorganic host structures		
2.2	Electrically conducting organic solids : Organic metals		
2.3	Organic charge transfer complexes : New superconductors		
	UNIT III Nanoscience		**15 Hrs**
3.1	Introductions of nanomaterials, Classification of nanomaterials and Properties, Methods of synthesis of nanomaterials.		
3.2	Applications of Nanomaterials : A) Biomedical B) Fuel cell C) Next-Generation device Chips D) Catalysis. Disadvantages of nanomaterials		
3.3	Characterization of nanomaterials by XRD, EXAFS, XPS, SEM, TEM, AFM		

	UNIT IV	**15 Hrs**
4.1	Selection of Analytical Method for Analysis	
	Sampling and Sample Preparation of Environmental/Food samples	
	Stoichiometric calculations, Evaluation and Processing of Analytical data	
	Suggested readings	
1)	G. Schmid, Nanoparticle : From Theory to Applications, Wiley-VCH Verlag GmbH & Co. KGaA, 2004.	
2)	P. Dutta, S. Gupta (Ed), Understanding of Nanoscience and Technology, Global Vision Publishing House, 2006.	
3)	C.C.Koch, Nanostructured Materials: Processing, Properties and Applications, Jaico Publishing House, 2006.	
4)	ChallaS.S.R.Kumar(Ed) Biological and Pharmaceutical Nanomaterials, John Wiley Verlog Cmbh & Co., KgaA, 2006.	
6)	Green Synthesis of Nanomaterials Giovanni Benelli www.mdpi.com/journal/nanomaterials Edited by Printed Edition of the Special Issue Published in Nanomaterial	
6)	J. M. Thomas, S. E. Morsi and J.P. Desvergne, Topochemical phenomenon in organic solid state Chemistry, Adv Physical. Org. Chem, 15,64-151, 1977	
7)	A. R. West, Solid state Chemistry and its applications, John Wiley and Sons,2003	
8)	l. Smart and E. Moore, Solid State Chemistry an introduction, Viva books pvt. Ltd,2004	
9)	Atkins, Physical chemistry 10 th edition	
10)	Analytical Instrumentation , Ewing., Fourth edition	
	Course Outcome	
	This Paper is Interdisciplinary. Students will get knowledge of Recent development in all the branches of Chemistry	

MSCHSE402T: MS(Masters), CH(Chemistry), SE(Skill Enhancement), 402(SEM IV),T(Theory)

	Course Code: **MSCHPR401P**	Course Title: **Research Project**	
	Course Credit: **8**	Total contact hours: **60 Hrs**	
Sr. No.	**Course Contents (Topics and subtopics)**		**Reqd. hours.**
			120
	Objective: Every post graduate (M.Sc.) student is required to prepare the project subject related – based on the guidelines of his / her project guide. **The following are the guidelines to be adhered to** The project should be an individual one The language for the project is **English** The Minimum number of pages should be **60** Project observations, suggestions and conclusion shall form part of the project. The Projects will be evaluated both by the Internal as well as External Examiner each The Division of marks for the Project Report is as mentioned below: Wording of Title 10M Objectives/ Formulation including Hypothesis 20M Review of Literature 20M Relevance of Project to Social Needs 40M Methodology/ Technique/ Procedure Adopted 70M Summary/ Findings/ Conclusion 30M Bibliography/ Annexure/ Foot notes 10M **Total 200M**		