Dr. Homi Bhabha State University, Mumbai

The Institute of Science

Syllabus for M. Sc (Semester I)

CHEMISTRY

Choice based Credit System

(To be Implemented from Academic year 2023-2024)

	Course Code: **MSCHDC101T/ MSCHDE101T**	Course Title: Physical Chemistry	
	Course Credit: **4**	Total contact hours: 60 Hrs	
Sr. No.	**Course Contents (Topics & subtopics)**		**Reqd. hours**
	UNIT I Thermodynamics-I		**15 Hrs**
	State function and exact differentials. Maxwell equations, Maxwell thermodynamic Relations; it's significance and applications to ideal gases, Joule Thomson experiment, Joule Thomson coefficient, inversion temperature, Joule Thomson coefficient in terms of van der Waals constants.		**8**
	Third law of Thermodynamics, Entropy change for a phase transition, absolute entropies, determination of absolute entropies in terms ofheat capacity, standard molar entropies and their dependence on molecular mass and molecular structure, residual entropy. [Ref 2 and 1,10,11,12 17]		**7**
	UNIT II Quantum Chemistry		**15 Hrs**
	Classical Mechanics, failure of classical mechanics: Need for Quantum Mechanics.		
	Particle waves and Schrödinger wave equation, wave functions,properties of wave functions, Normalization of wave functions, orthogonality of wave functions.		
	Operators and its algebra, linear and Hermitian operators, operators for thermodynamic variables of a system such as, position, linear momentum, angular momentum, total energy, eigenfunctions, eigenvalues and eigenvalue equation, Schrödinger wave equation as the eigen value equation of the Hamiltonian operator, average value and the expectation value of a dynamic variable of the system,Postulates of Quantum Mechanics, Schrodinger's Time independent wave equation from Schrodinger's time dependent wave equation.		
	Application of quantum mechanics to the following systems: Free particle, wave function and energy of a free particle. b) Particle in a one-, two- and three-dimensional box, separation of variables, Expression for the wave function of the system, expression for the energy of the system, concept of quantization, introduction of quantum number, degeneracy of the energy levels. c) Harmonic oscillator, approximate solution of the equation, Hermite polynomials, expression for wave function, expression for energy, use of the recursion formula.[Ref 7, 8 and 9]		
	UNIT III Chemical Dynamics-I		**15 Hrs**
	Composite Reactions: Recapitulation: Rate laws, Differential rate equationsConsecutive reactions, Steady state Approximation, rate determining steps, Microscopic Reversibility and Detailed Balanced Chain reactions-chain initiation processes. Some inorganic mechanisms: formation and		

	decomposition of phosgene, decomposition of ozone, Reactionbetween Hydrogen and Bromine and some general examples of Organic Decompositions: Decomposition of ethane, decomposition of acetaldehyde Gas phase combustion: Reaction between hydrogen and oxygen, Semenov–Hinshelwood and Thompson mechanism, Explosion limits and factors affecting explosion limits.	
	Polymerization reactions: Kinetics of stepwise polymerization, Calculation of degree of polymerization for stepwise reaction. Kinetics of free radical chain polymerization, Kinetic chain lengthand estimation of average no. of monomer units in the polymer produced by chain polymerization.	
	Reaction in Gas Phase Unimolecular Reactions: Lindeman-Hinshelwood theory, Rice-Ramsperger- Kasssel (RRK) theory, Rice-Ramsperger-Kassel Marcus (RRKM) theory. [Ref. 2 and 15, 17,18]	
	UNIT IV **Electrochemistry Recapitulation – basics of electrochemistry**	**15 Hrs**
	Debye-Hückel theory of activity coefficient, Debye-Hückel limiting law and it's extension to higher concentrations (derivations are expected).	
	Electrolytic conductance and ionic interaction, relaxation effect, Debye-Hückel- Onsager equation(derivation expected). Validity of this equation for aqueous and non-aqueous solution, deviations from Onsager equation, Debye-Falkenhagen effect (dispersion of conductance at high frequencies),Wien effect.	
	Batteries: Alkaline fuel cells, Phosphoric acid fuel cells, High temperature fuel cells [Solid –Oxide Fuel Cells (SOFC) and Molten Carbonate Fuel Cells]	
	Bio-electrochemistry: Introduction, cells and membranes, membrane potentials, theory of membrane potentials, interfacial electron transfer in biological systems, adsorption of proteins on to metals from solution, electron transfer from modified metals to dissolved protein in solution, enzymes as electrodes, electrochemical enzyme-catalysed oxidation of styrene.Goldmann equation. (derivations are expected) [Ref: 14 and16, 17, 18] **[Note: Numerical and theoretical problems from each unit are expected]**	
	Suggested readings	
	1. Peter Atkins and Julio de Paula, Atkin's *Physical Chemistry*, 7th Edn., Oxford University Press, 2002.	

	2. K.J. Laidler and J.H. Meiser, *Physical Chemistry*, 2nd Ed., CBS Publishers and Distributors, New Delhi, 1999. 3. Robert J. Silby and Robert A. Alberty, *PhysicalChemistry*,3rdEdn., John Wiley and Sons (Asia) Pvt. Ltd., 2002. 4. Ira R. Levine, *Physical Chemistry*, 5thEdn., Tata McGraw-Hill New Delhi, 2002. 5. G.W.Castellan, *Physical Chemistry*,3rdEdn., Narosa Publishing House, NewDelhi, 1983. 6. S.Glasstone, *Text Book of PhysicalChemistry*, 2ndEdn., McMillan and Co.Ltd., London, 1962 7. B.K. Sen, *Quantum Chemistry including Spectroscopy*, Kalyani Publishers, 2003. 8. A.K. Chandra, *Introductory Quantum Chemistry*, Tata McGraw – Hill, 1994. 9. R.K. Prasad, *Quantum Chemistry*, 2ndEdn., New Age International Publishers, 2000. 10. S.Glasstone,*Thermodynamics for Chemists*, Affiliated East-WestPress, New Delhi, 1964. *11*. W.G. Davis, *Introduction to Chemical Thermodynamics – A Non – Calculus Approach*, Saunders, Philadelphia, 19772. 12. Peter A. Rock, *Chemical Thermodynamics*, University Science Books, Oxford University Press, 1983. 13. IraN.Levine,*QuantumChemistry*,5thEdn., Pearson Education (Singapore) Pvt. Ltd., Indian Branch, New Delhi, 2000. 14. Thomas Engeland Philip Reid, PhysicalChemistry,3rd Edn.,Pearson Education Limited 2013. 15. D.N. Bajpai, Advanced Physical Chemistry, S. Chand 1stEdn., 1992. 16. ***Bockris***, John O'M., ***Reddy***, Amulya K.N., Gamboa-Aldeco, Maria E., Modern Electrochemistry, 2A, Plenum Publishers, 1998. 17. Physical Chemistry by Gurtu and Gurtu 18. A Text book of Physical Chemistryby K L kapoor Vol 5 , 2ndEdn	
	Course outcomes (Students will be able to……)	
1.	Understand the basic concepts of thermodynamics and learn the state functions, entropy and entropy change during the reactions.	
2.	Get the basic idea about quantum chemistry and its use to solve the simple problems.	
3	Learn the chemical dynamics of Composite, chain, Polymerization and gas phase reactions.	

4.	Get the basic idea about electrochemistry, batteries and bioelectrochemistry	

MS(MSc), CH(Chemistry), DC(Core Course),101(SEM I), T(Theory)

	Course Code: **MSCHLB101P/ MSCHDE101P**	Course Title: Physical Chemistry LAB	
	Course Credit: **2**	Total contact hours: 60 Hrs	
Sr. No.	**Course Contents (Topics & subtopics)**		
	Non – Instrumental: 1. To determine the heat of solution (ΔH) of a sparingly soluble acid (benzoic/salicylic acid) from solubility measurement at three different temperatures. 2. To investigate the reaction between acetone and iodine. 3. To study the variation in the solubility of $Ca(OH)_2$ in presence of NaOH and hence to determine the solubility product of $Ca(OH)_2$at room temperature. 4. Graph Plotting of mathematical functions–linear, exponential and trigonometry and identify whether functions are acceptable or non-acceptable. **Instrumental:** 1. To determine the mean ionic activity coefficient of an electrolyte by e.m.f. measurement. 2. To determine pKa values of phosphoric acid by potentiometric titration with sodium hydroxide using glass electrode. 3. To verify Ostwald's dilution law and to determine the dissociation constant of a weak mono-basic acid conductometrically.	**60 Hrs**
	Suggested readings	
	1. Practical Physical Chemistry, B. Viswanathan and P.S. Raghavan, Viva Books Private Limited, 2005. 2. Practical Physical Chemistry, A.M. James and F. E. Prichard, 3rd Edn., Longman Group Ltd., 1974. 3. Experimental Physical Chemistry, V.D. Athawale and P. Mathur, New Age International Publishers, 2001.	
	Course outcomes (Students will be able to……)	
	1. Learn to determine the thermodynamic parameters such as entropy enthalpy, solubility, solubility products etc.	
	2. Draw the graphs of various types of mathematical functions.	
	3. Understand the kinetics of reaction/	
	4. Learn principles and applications of various types of Instrumental techniques .	

	Course Code: **MSCHDC102T/ MSCHDE102T**	**Course Title: Inorganic Chemistry**	
	Course Credit: **4**	Total contact hours: 60 Hrs	
Sr. No.	**Course Contents (Topics & subtopics)**		**Reqd. hours**
	UNIT I Solid State Chemistry		**15 Hrs**
	i) Structures of Inorganic Compounds of the type: a) AB [Halite(NaCl) and Nicolite(NiAs)]. b) AB_2 [fluorite(CaF_2), antifluorite(Na_2O) and rutile(TiO_2). c) Layer structures [cadmium chloride($CdCl_2$) and iodide(CdI_2)].		
	(ii) Methods of preparation for Inorganic solids by: a) Ceramic method, b) Precursor method, c) Sol-gel method and d) Microwave synthesis (discussion on principles, examples, merits and demerits are expected).		
	iii) Preparative methods Nanomaterials: a) Coprecipitation method, b) Langmuir Blodgett (L-B) method and c) Biological methods : synthesis using microorganisms		
	iv) Band theory and applications of Nanomaterials in the field of semiconductors.		
	UNIT II Inorganic Reaction Mechanisms		**15 Hrs**
	Rate of reactions, factors affecting the rate of reactions, techniques for determination of rate of reaction(Direct Chemical Analysis, Electrochemical and Flow methods).		
	Ligand substitution reactions of: (a) Octahedral complexes without breaking of metal- ligand bond. (b) Square planar complexes – trans-effect, its theories and applications. Mechanism and factors affecting these substitution reactions.		
	Redox reactions: Introduction of electron and atom transfer reactions, inner and outer sphere mechanisms, Marcus theory, complimentary and non-complimentary reactions.		
	Stereochemistry of reactions of octahedral complexes (Isomerisation and Racemisation reactions)		
	UNIT III Organometallic Chemistry		**15 Hrs**

	(i) Electron counting of organometallic compounds. Application of MOT for the counting of electrons. Eighteen electron rule and sixteen electron rule and with examples.	
	(ii) Preparation and properties of the following compounds a) Alkyl and aryl derivatives of Pd and Pt complexes b) Carbenes and carbynes of Cr, Mo and W c) Alkene derivatives of Pd and Pt d) Alkyne derivatives of Pd and Pt e) Allyl derivatives of nickel f) Sandwich compounds of Fe, Cr and Half Sandwich compounds of Cr, Mo.	
	Structure and bonding on the basis of VBT and MOT in the following organometallic compounds: a) Zeise"s salt b) Bis(triphenylphosphine)diphenylacetylene platinum(0) $[Pt(PPh_3)_2(HC{\equiv}CPh)_2]$,	
	Structure and bonding on the basis of VBT and MOT in the sandwiched and half sandwiched organometallic compounds: a) Diallylnickel(II), ferrocene and bis(arene)chromium(0), b) Tricarbonyl (η^2-butadiene) iron(0).	
	UNIT IV Characterisation of Coordination compounds	**15 Hrs**
	Formation, Conductivity measurements, thermal studies and magnetic measurements.	
	Spectroscopic methods: IR, NMR, ESR, UV-Visible and electronic spectral calculations using Orgel and Tanabe-Sugano diagram, calculation of electronic parameters such as Δ, B, C, Nephelauxetic ratio.	
	Determination of formation constants of metal complexes (Overall and Stepwise): Comparative studies of Potentiometric and spectral methods.	
	Suggested readings	
	Unit I 1. Solid State Chemistry Introduction, Lesley E. Smart, Elaine A. Moore, ISBN 0-203- 49635-3, Taylor & Francis Group, LLC.	

2. Nanomaterials & Nanochemistry, 2007, Catherine Brechignac, Philippe Houdy, Marcel Lahmani, ISBN 978-3-540-72992-1 Springer Berlin Heidelberg New York.

3. Nanomaterials Chemistry, Recent Developments and New Directions C.N.R. Rao, A. Muller, and A.K. Cheetham, ISBN 978-3-527-31664-9, 2007 WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim.

4. Nano-Surface Chemistry, 2001, Morton Rosoff, ISBN: 0-8247-0254-9, Marcel Dekker Inc. New York.

5. The Chemistry of Nanomaterials, CNR Rao, Muller Cheetham, WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, 2004.

6. Semiconductor Nanomaterials, Challa S.S.R. Kumar, ISBN: 978-3-527-32166-7, WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, 2010.

7. Principles of Nano-technology, Sulbha Kulkarni.

Unit II

1. P. Atkins, T. Overton, J. Rourke, M. Weller and F. Armstrong, Inorganic Chemistry, 5th Ed., Oxford University Press, 2010.

2. D. Banerjea, Coordination Chemistry, Tata McGraw Hill, 1993.

3. W. H. Malik, G. D./ Tuli and R. D. Madan, Selected Topics in Inorganic Chemistry, 8th Ed., S. Chand & Company ltd.

4. M. L. Tobe and J. Burgess, Inorganic Reaction Mechanism, Longman, 1999.

5. S. Asperger, Chemical kinetics and Inorganic Reaction Mechanism, 2nd Ed., Kluwer Academic/ Plenum Publishers, 2002

6. Gurdeep Raj, Advanced Inorganic Chemistry-Vol.II, 12th Edition, Goel publishing house, 2012.

7. B. R. Puri, L. R. Sharma and K. C. Kalia, Principles of Inorganic Chemistry, Milestone Publishers, 2013-2014.

8. F. Basalo and R. G. Pearson, Mechanism of Inorganic Reactions, 2nd Ed., Wiley, 1967.

9. R. Gopalan and V. Ramlingam, Concise Coordination chemistry, Vikas Publishing house Pvt Ltd., 2001.

10. Robert B. Jordan, Reaction Mechanisms of Inorganic and Organometallic Systems, 3rd Ed., Oxford University Press 2008.

	Unit III 1. D. Banerjea, Coordination chemistry. Tata McGrew Hill, New Delhi,1993. 2. R.C Mehrotra and A.Singh, Organometallic Chemistry- A unified Approach, 2nded, New Age International Pvt Ltd, 2000. 3. R.H Crabtree, The Organometallic Chemistry of the Transition Metals, 5th edition, Wiley International Pvt, Ltd 2000. 4. B.Doughlas, D.H McDaniel and J.J Alexander. Concepts and Models of Inorganic Chemistry, 2nd edition, John Wiley and Sons. 1983. 5. Organometallic Chemistry by G.S Sodhi. Ane Books Pvt Ltd. **Unit IV** 1. J. E. Huheey, E. A. Keiter and R. L. Keiter; Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Education, 2006. 2. D. Banerjea ,Coordination Chemistry 3. Geary Coordination reviews 4. P.W. Atkins, T. Overton, J. Rourke, M. Weller and F. Armstrong; Shriver & Atkins: Inorganic Chemistry, 4th ed. Oxford University Press, 2006. 5. F. A. Cotton, G. Wilkinson, C. A. Murillo and M. Bochmann; Advanced Inorganic Chemistry, 6th ed. Wiley, 1999, 6. B. Douglas, D. McDaniel and J. Alexander. *Concepts and Models of Inorganic Chemistry*(3rd edn.), John Wiley & Sons (1994).	
	Course outcomes (Students will be able to know…)	
1	Basics of Solid-State Chemistry and Nanomaterials. To draw crystal structures and some preparative methods for Inorganic Compounds and nanomaterials. Band theory for electronic structures of solids and its applications in the field of semiconductors.	
2	Electron counting with the help of MOT for 18 electron rule and sixteen electron rule. Synthesis and chemical properties of organometallics of Pt, Pd, Cr, W, Fe, Mo and Ni. Structure and bonding of organometallics by VBT and MOT. Study of sandwiched and half sandwiched complexes	
3	Rate of reaction, factors affecting rate of reaction and methods used for determination of rate of reaction. Effect of stereochemistry of coordination compounds on its biological properties and how to synthesize coordination compounds which is used for medicinal purposes.	

4	The formation of complexes, their electrolytic nature, thermal stability and magnetic properties. Various spectroscopic methods and electronic parameters for the study of complexes. The determination of stability constant and its signification.	

MS(Masters), CH(Chemistry), DSC (Core Course), (SEM I, DSC-1-1), T(Theory)

	Course Code: **MSCHLB102P/ MSCHDE102P**	Course Title: Inorganic Chemistry LAB	
	Course Credit: **2**	Total contact hours: 60 Hrs	
Sr. No.	**Course Contents (Topics & subtopics)**		
	(i) Ores and Alloys a) Analysis of Devarda‟s alloy b) Analysis of Tin Solder alloy c) Analysis of Limestone **(ii) Instrumentation** a) Estimation of Cu^{2+} using Iodometric method Potentiometrically b) Estimation of Cl^- using $AgNO_3$ using conductometrically c) Estimation of Ti^{4+} using peroxide method Colorimetrically		
	Suggested readings		
	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		

MS(Masters), CH(Chemistry), LB(Laboratory), 102(SEM I, CC2), P(Practical)

	Course Code MSCHDC103T/ MSCHDE103T	**Course Title: Organic Chemistry**	
	Course Credit: 4	**Total hours: 60 Hrs**	
Sr. No.	**Course Contents (Topics & subtopics)**		**Reqd. hours**
1	**UNIT I Kinetics and mechanisms of Organic Reactions**		**15 Hrs**
	Mechanism of Organic Reactions: Activation Energy and Activated Complex, Reaction Energetics, Structure of Activated Complex, Hammond's Postulates, Isotope Effect, Detection and trapping of intermediates, crossover experiments and stereo chemical evidence, Kinetic vs Thermodynamic control of organic reactions **Electronic Effect and Reactivity:** Electronic Effect, The Hammett equation, substituent constants, theories of substituent effects, interpretation of σ-values, reaction constants ρ, Uses of Hammett equation, deviations from Hammett equation, Curtin-Hammett Principle, Taft Equation, Using the Hammett rho values to uncover mechanisms, Non Linear Hammett Plots, Correlation of structure and reactivity		
2	**UNIT II Introduction to Molecular Orbital Theory for Organic Chemistry**		**15 Hrs**
	Introduction to Molecular Orbital Theory for Organic Chemistry: Molecular orbitals: Formation of π-MOs by using LCAO method.Concept of nodal planes and energies of π-MOs, Formation of π MOs of ethylene, butadiene, allyl cation, anion and radical. Introduction to FMOs: HOMO and LUMO and significance of HOMO-LUMO gap in absorption spectra as well as chemical reactions. HOMO and LUMO (π and π*orbitals) of formaldehyde. Concept of 'donor-acceptor' interactions in nucleophilic addition reactions on formaldehyde. The concept of hardness and softness and its application to electrophiles and nucleophiles. Identificationof hard and soft reactive sites on the basis of MOs with examples. Application of FMO concepts: SN2 reaction, Ethylene dimerization to cyclobutane, Diels-Alder cycloaddition, addition of hydride to formaldehyde. **Aromaticity:** Huckel's (4n+2) and 4n rules. Structural, thermochemical, and magnetic criteria for aromaticity, including NMR characteristics of aromatic systems. Application of HMO theory to monocyclic conjugated systems. Frost-Musulin diagrams. Aromatic, antiaromatic and Homoaromatic compounds. Aromaticity of all benzenoid systems, heterocycles, metallocenes, azulenes, annulenes, aromatic ions and Fullerene (C 60).		

3	**UNIT III Fundamentals of Stereochemistry**	**15 Hrs**
	Concept of Chirality: Isomerism (Structural isomerism, Stereoisomerism, Enantiomerism, Distereoisomerism), Constitutionally symmetrical molecules with odd and even number of chiral centers: Enantiomeric and Meso forms, Concept of Stereo genic, Chirotopic, and Pseudo asymmetric centers**,** Chirality Centers other than carbon, Configurational Nomenclature of compounds with a Stereo cente**r** (D and L system, Threo and Erythro System, E-Z system), The Cahn-Ingold-Prelog(CIP) Convention R and S system. **Element of Symmetry:** Symmetry elements, Operations, Point Group and Stereo chemical properties, Resolution of Racemic mixture, Stereo selective and Stereospecific Reactions **Axial and planar chirality:** Principles of axial and planar chirality, Stereo chemical features and configurational descriptors (R, S) for the following classes of compounds: allenes, alkylidene cycloalkanes, spirans, biaryls, (including BINOLs and BINAPs), ansa compounds, cyclophanes **Prochirality:** Chiral and Prochiral centers, Homotopic and Heterotopic Ligands and Faces, Identification using substitution and symmetry criteria Nomenclature of Heterotopic Ligands and Face	
4	**UNIT IV Basics in Synthetic Organic Chemistry**	**15 Hrs**
	Elementary ideas of electronic effects: Inductive effect, Mesomeric effect, Electromeric effects, Hyperconjugation, Steric effect, ortho **effect** **Organic reactive intermediates:** Generation, stability, reactivity and examples of carbocations, carbanions, free radicals, carbenes, benzynes and nitrenes **Enolates and Enamines:** Kinetic and thermodynamic enolate formation, Regioselectivity in enolate formation, alkylation of enolates. Enamines and imines formation, Alkylation and acylation of enamines **Reaction,Mechanism and applications :** Acid/Base catalyzed aldol condensation reaction, Mixed aldol condensation reactions. Intramolecular Aldol condensation reaction, Michael addition reaction, Robbinson Annulation reaction, Mannich Reaction, Knoevenagel reaction.	
	Suggested readings	
	1. Physical Organic Chemistry, Neil Isaacs 2. Modern Physical Organic Chemistry, Eric V. Anslyn and Dennis A.Dougherty 3. Comprehensive Organic chemistry, Barton and Ollis, Vol 1 4. Organic Chemistry, J. Claydens, N. Greeves, S. Warren and P.Wothers, Oxford University Press. 5. Advanced Organic Chemistry, F.A. Carey and R.J. Sundberg, Part Aand B, Plenum Press. 6. Stereochemistry: Conformation and mechamism, P.S. Kalsi, NewAge International, New Delhi.	

	7. Stereochemistry of carbon compounds, E.L Eliel, S.H Wilen and L.NManden, Wiley. 8. Stereochemistry of Organic Compounds-Principles and Applications, D. Nasipuri. New International Publishers Ltd. 9. March's Advanced Organic Chemistry: Reactions, Mechanisms andStructure, Michael B. Smith, Jerry March, Wiley. 10. Advanced Organic Chemistry: Reactions and mechanism, B. Millerand R. Prasad, Pearson Education. 11. Advanced Organic Chemistry: Reaction mechanisms, R. Bruckner, Academic Press. 12. Understanding Organic Reaction Mechanisms, Adams Jacobs, Cambridge University Press. 13. Writing Reaction Mechanism in organic chemistry, A. Miller, P.H. Solomons, Academic Press. 14. Principles of Organic Synthesis, R.O.C. Norman and J.M Coxon, Nelson Thornes. 15. Advanced Organic Chemistry: Reactions and mechanism, L.G. Wade, Jr., Maya Shankar Singh, Pearson Education. 16. Mechanism in Organic Chemistry, Peter sykes, 6th edition onwards. 17. Modern Methods of Organic Synthesis, W. Carruthers and Iain Coldham, Cambridge University Press. 18. Organic Synthesis, Jagdamba Singh, L.D.S. Yadav, Pragati Prakashan.	
	Course Outcome:	
	Students will able to understand ➢ Fundamentals of organic reaction mechanisms and its kinetics ➢ Molecular Orbital Theory for Organic Chemistry ➢ Basics in stereochemistry of organic compounds ➢ Fundamentals of synthetic organic chemistry	

	Course Code MSCHLB103P/ MSCHDE103P	**Course Title: Organic ChemistryLAB**	
	Course Credit : 2	**Total hours: 60 Hrs**	
Sr. No.	**Course Contents (Topics & Subtopics)**		
	One step preparations (1.0 g scale) any ten of the following: **I. Nitration:** 1. Bromobenzene to p-nitrobromobenzene 2. Salicylic acid to 5-nitrosalicylic acid 3. Acetanilide to 4-nitroacetanlide 4. Nitrobenzene to m-dinitrobenzene **II. Oxidation:** 1. Anthracene to anthraquinone 2. Benzoin to benzil 3. P-nitrotoluene to p-nitrobenzoic acid 4. Benzaldehyde to benzoic acid **III. Diels-Alder reaction:** 1. Anthracene to Anthracene maleic anhydride adduct **IV. Halogenation:** 1. Acetanilide to p-bromoacetanlide **V. Synthesis of Heterocycles:** 1. Ethyl acetoacetate to 3-methyl-1-phenylpyrazol-5-one 2. o-Phenylenediamine to 2-methylbenzimidazole 3. *o*-Phenylenediamine to 2,3-diphenylqunooxaline 4. Urea and benzil to 5,5-diphenylhydantoin **VI. Base Catalysed aldol type reaction:** 1. Green synthesis of chalcones condensation of benzaldehyde with :- a) Acetone Or b)Acetophenone		
	Course outcomes (Students will be able to……) ➢ Planning of synthesis, effect of reaction parameters including stoichiometry, and safety aspects including MSDS should be learnt. ➢ Purify the product by crystallization. Formation and purity of the product should be checked by TLC ➢ Report mass and melting point of the purified product		
	MS(Masters), CH(Chemistry), LB(Laboratory), 103(SEM I, CC3), P(Practical)		

	Course Code: MSCHDC104T/ MSCHDE104T	Course Title: An**alytical Chemistry**	
	Course Credit: 4	Total contact hours: 60 Hrs	
Sr. No.	**Course Contents (Topics & subtopics)**		**Reqd.**
1.	**UNIT I Unit Operations and Quality Control in Chemical Analysis**		**15 Hrs**
1.1	Chemical analysis concept, Defining the analytical problem, **Sampling**-sample definition and types, sampling plan, and sampling techniques of Solid, liquid and gaseous samples. Selection of Analytical methods-Performance criterions		
1.2	Sample preparation-Acid Dissolution and digestion, fusion, Principles of Chemical separation- Solvent extraction, Solid phase extraction, Solid phase micro extraction, Dispersive solid phase extraction (QuCEhERS)		
1.3	Quality measurement concept, Quality control and Quality assurance. Quality Management systems- ISO 9001 and ISO17025 GLP, ICH guidelines		
1.4	Validation of Analytical method , Instrument qualification, system suitability, ICH guidelines , Robustness and Ruggedness		
2.	**UNIT II Chemical Stoichiometry and Data Handling**		**15 Hrs**
2.1	Stoichiometric calculations in analytical chemistry- Concentration expressions,		
2.2	Evaluation of analytical data-Errors and distribution of errors Statistical treatment of data-Mean deviation, Standard deviation, coefficient of variance, normal distribution, confidence intervals F test, T-test, rejection of results, Rounding Data, Regression analysis-Method of Least Squares		
2.3	Control Charts.1 The Shewhart Chart .2 Moving Average Chart .3 CUSUM Charts .4 Range Charts Measurement Uncertainty. The Measurement Process. Definition of Uncertainty. Evaluating Uncertainty, Expanded Uncertainty, Putting Uncertainty to Use		
3.	**UNIT III Optical Methods of Analysis**		**15 Hrs**
3.1	Basic Concept of Spectroscopic Instrumentation, Sources, Wavelength Selectors, Detectors, Signal, Processors		
3.2	Ultraviolet-Visible spectroscopy – Instrument Design for Molecular UV/Visible Absorption-Single beam, double beam spectrophotometers, Qualitative and Quantitative analysis Beer's Law, Multicomponent analysis, Limitations of Beer's Law		

3.3	Infrared absorption spectroscopy-Principle, Sample handling in IR spectroscopy, Instrumentation- Sources, Sampling devices, detectors Dispersive and nondispersive instruments FTIR	
3.4	Application of IR- Mid, Far, Near IR.Qualitative and Quantitative analysis by IR. Advantages and limitations of IR	
	UNIT IV Thermal Methods and Spectroscopy	**15 Hrs**
4.1	**Thermal Methods**	
4.1.1	Principal of thermal method, Classification of Thermal methods, Comparison between TGA and DTA, DTA and DSC	
4.1.2	Differential Scanning calorimeter- Principle, Instrumentation, Block diagram Nature of DSC curves, Factor affecting DSC curve(Sample size, Sample shape and Pressure)	
4.1.3	Applications of Thermal methods- Heat of reaction, Specific heat, Drug analysis, Analysis of polyethylene for its crystallinity. Oxidative stability	
4.2	**NMR Spectroscopy**	
4.2.1	Recapitulation, Relaxation Processes, Magic angle spinning, FTNMR, Instrumentation- Sample holder, sample probe, Rf generation and detection.	
	REFERENCE BOOKS	
1)	Introduction to instrumental analysis by R. D. Broun, Mc Graw Hill (1987) Dean and F.A. settle. Sixth edition CBS (1986)	
2)	Instrumental methods of chemical analysis by H. Willard, L. Merrit, J.A. settle. Sixth edition CBS (1986)	
3)	Fundamentals of analytical chemistry by D. A. Skoog, D. M. West and H. J. Holler sixth edition (1992)	
4)	Principles of Instrumental Analysis Skoog, West, Niemann.	
5)	Thermal analysis by W.W. Wendlandt, John Wiley, (1986)	
6)	Vogel Text Book of quantitative analysis 6th Ed.	
7)	Preparative chromatography Chrome Ed. book series, Raymond P. W. Scott (free e-book available on internet)	
8)	Extraction technique in analytical science, John R. Dean, Wiley (2009)	
	Course Outcome	
1)	Recall and describe the basic concepts of electro analytical, thermal, atomic spectroscopic techniques.	
2)	Illustrate the applications of advanced analytical techniques for various types of chemical analysis. Interpret experimental/spectral data and apply knowledge to solve simple to advance numerical.	
3)	Identify and explain the given scientific problems based on an advanced analytical approach.	

Course Code: MSCHLB104P/ MSCHDE104P	Course Title: Analytical Chemistry LAB
Course Credit : 2	**Total hours: 60 Hrs**
1)	To carry out assay of the sodium chloride injection by Volhard's method.
2)	Determine the amount of Potassium in the given sample by Flame photometry
3)	To determine amount of Cr (III) and Fe (II) individually in a mixture of the two by titration with EDTA.
4)	Determine the amount of Cr(VI) and Mn(VII) in the given solution by simultaneous spectrophotometric
5)	To determine amount of Cu(II) present in the given solution containing a mixture of Cu(II) and Fe(II).
6)	To determine percentage purity of sodium Carbonate in washing soda pH metrically.
	Suggested reading
1.	Quantitative Inorganic analysis including elementary Instrumental analysis by A.I.Vogel. Third edition. ELBS 1964
2.	Analytical Chemistry by Gary D. Christian, 6th edition, John Wiley and sons Publication
3.	Ewings Analytical Instrumental Handbook, Third Edition. Edited by Jack Cazes
	Course outcomes
	Students will be able to understand, acquire knowledge on Basic concepts of Analytical Chemistry, Stoichiometric Calculations, Safety in laboratory, spectroscopy and Thermal methods.

	Course Code MSCHMN101T	Course Title: Research Methodology	
	Course Credit: 4	Total contact hours: 60 Hrs	
Sr. No.	Course Contents (Topics & Subtopics)		Reqd. hours
	UNIT I		15 Hrs
1.1	Research-Definition, Characteristics, Objectives, Research and Scientific method Types of Research Descriptive vs. Analytical Research Applied vs. Fundamental Research Quantitative vs. Qualitative Research Conceptual vs. Empirical Research Research Methodology: An Introduction Research Process: Basic Overview, Formulating the Research Problem. Defining the Research Problem, Research Questions		
1.2	Research Methods versus Methodology, Research and Scientific Method, Importance of Knowing How Research is Done, Criteria of Good Research Problems Encountered by Researchers in India		
1.3	Defining the Research Problem What is a Research Problem? Selecting the Problem The Necessity of Defining the Problem Technique Involved in Defining a Problem		
1.4	Research Design Meaning of Research Design Need for Research Design Features of a Good Design Important Concepts Relating to Research Design Different Research Designs Basic Principles of Experimental Designs		
	UNIT II		15 Hrs
2.1	Research Design, Formulation of Hypothesis, Sources of Hypothesis, Characteristics of Hypothesis, Role of Hypothesis, Tests of Hypothesis		
2.2	Sampling Design, Census and Sample Survey, Implications of a Sample Design, Steps in Sampling Design, Criteria of Selecting a Sampling Procedure, Characteristics of a Good Sample Design, Different Types of Sample Designs, How to Select a Random Sample, Random Sample from an Infinite Universe, Complex Random Sampling Designs		

2.3	Methods of Data Collection, Collection of Primary Data, Observation Method , Interview Method, Collection of Data through Questionnaires, Collection of Data through Schedules, Difference between Questionnaires and Schedules Some Other Methods of Data Collection, Collection of Secondary Data	
	UNIT III	15 Hrs
3.1	DESCRIPTIVE DATA ANALYSIS (a) Measures of central tendency. (b) Variability (c) Measures of Divergence from Normality • Skewness • Kurtosis (d) Estimation of Population Parameters of Mean and SD. (e) Graphical Presentation of Data. Regression analysis. Parametric Techniques (a) Conditions to be satisfied for using parametric techniques (b) Pearson's Coefficient of Correlation (c) t-test for comparison of Mean Scores. (d) z-test for comparison of r's. (e) ANOVA (f) Hotelling's t-test (g) Biserial and Point-Biserial r	
3.2	Interpretation and Report Writing. Meaning of Interpretation Why Interpretation? The technique of Interpretation: Precaution in Interpretation Significance of Report Writing Different Steps in Writing Report Layout of the Research Report Types of Reports Oral Presentation Mechanics of Writing a Research Report	
	UNIT IV Scientific Communications	
4.1	concept of information organization and dissemination (IOD), Need For IOD, Role Of IOD, Definition Of Documentation, IOD Activities, and Information Sources.	
4.2	Discovering scientific information, Chemical Abstracts Service (CAS), Introduction to Chemical Abstracts and Beilstein, Subject Index, Author Index, Formula Index, citation indices Indices with examples,	
4.3	Web sources, E-journals, E-books, open access, Internet Search engines, Scirus, Google Scholar, ChemIndustry, Wiki-databases, Sci Finder, Scopus, Plagiarism UGC Infonet, Shodhganga	

4.4	publications of scientific work- Scholarly article, Research Paper, Research Project, Legislation Drafting, Judgment Writing, Thesis, Dissertation, Book, Citation Methods- Foot Note, Text Note, End Note, Bibliography, Citation Rules, Blue Book, OSCOLA, MLA, APA, Chicago writing ethics, plagiarism	

Course Outcomes-

1. Familiarisation and building competence with the Concept of Research, its importance and its role in advancing society.
2. Ability to select an appropriate research method, experimental design.
3. Ability to collect, analyse and interpret the data, prepare the research project report, and make Conclusions.
4. Effective dissemination of scientific information through scientific writing in different filed, such as scholarly articles, reviews, and technical reports.
5. Understand the importance of ethical writing.

Reference books

1. Research Methodology, Methods and Techniques, By C. R. Kothari, New Age International (P) Limited
2. Elements of Information Organization and Dissemination. Amitabha Chatterjee, Chandos Publishing.
3. Managing Scientific Information and Research Data, Svetla Baykoucheva, Elsevier Publisher
4. Driving Science Information Discovery in the Digital Age, Svetla Baykoucheva, Elsevier publisher
5. Scientists Must Write, A Guide to better writing for Scientists, engineers and Students
6. Second edition, Robert Barrass, Routledge-Taylor & Francis Group
7. Guide to Publishing a Scientific Paper, Ann M. Körner, Routledge- Taylor & Francis Group
8. McGraw Hill's concise guide to Writing Research Papers, Carol Ellison McGraw *Hill Publisher*

Dr. Homi Bhabha State University

The Institute of Science

M Sc Syllabus SEM II

(To be Implemented from 2023-2024)

	Course Code: **MSCHDC201T/ MSCHDE201T**	**Course Title: Physical Chemistry**	
	Course Credit: **4**	Total contact hours: 60 Hrs	
Sr. No.	**Course Contents (Topics & subtopics)**		**Reqd. hours**
	UNIT I		**15 Hrs**
	Chemical Thermodynamics II		
1.1	**Fugacity of real gases**, Determination of fugacity of real gases using graphical method and from equation of state. Equilibrium constant for real gases in terms of fugacity. Gibbs energy of mixing, entropy and enthalpy of mixing.		
1.2	**Real solutions:** Chemical potential in non-ideal solutions excess functions of non ideal solutions calculation of partial molar volume and partial molar enthalpy, Gibbs Duhem Margules equation.		
1.3	**Thermodynamics of surfaces,** Pressure difference across curved surface (Laplace equation), vapour pressure of droplets (Kelvin equation), Gibbs adsorption isotherm, BET isotherm (derivations expected).		
1.4	**Bioenergetics :** standard free energy change in biochemical reactions, exergonic, endergonic. Hydrolysis of ATP, synthesis of ATP from ADP.		
	UNIT II		**15 Hrs**
	Quantum Chemistry II		
2.1	Rigid rotor, spherical coordinates, Schrödinger wave equation in spherical coordinates, separation of the variables, wave function, quantization of rotational energy, spherical harmonics.		
2.2	Hydrogen atom, the two particle problem, separation of the energy as translational and potential, separation of variables, R, θ and φ equations, solution of the R equation, introduction of the four quantum numbers and their interdependence on the basis of the solutions of the three equations, total wave function, expression for the energy, probability density function, distances and energies in atomic units, radial and angular plots, points of maximum probability, expressions for the total wave function for 1s, 2s, 2p and 3d orbitals of hydrogen.		
2.3	Application of the Schrödinger equation to two electron system,limitations of the equation, need for the approximate solutions, methods of obtaining the approximate solution of the Schrödinger wave equation.		
2.4	Hückel Molecular Orbitals theory for ethylene , 1,3-butadiene and benzene. (Derivation expected)		
	UNIT III		**15 Hrs**
	Chemical Kinetics and Molecular Reaction Dynamics		
3.1	**Elementary Reactions in Solution:-** Solvent Effects on reaction rates, Reactions between ions- influence of solvent Dielectric constant, influence of ionic strength, Linear free energy relationships Enzyme action		
3.2	**Kinetics of reactions catalyzed by enzymes** -Michaelis-Menten analysis, Lineweaver-Burk and Eadie Analyses.		

3.3	**Inhibition of Enzyme action:** Competitive, Non competitive and Uncompetitive Inhibition. Effect of pH, Enzyme activation by metal ions, Regulatory enzymes.	
3.4	**Kinetics of reactions in the Solid State:-** Factors affecting reactions in solids, Rate laws for reactions in solid: The parabolic rate law, The first order rate law, the contracting sphere rate law, Contracting area rate law, some examples of kinetic studies. (Ref: 7 and 2)	
	UNIT IV	**15 Hrs**
	Solid State Chemistry and Phase Equilibria	
4.1	**Solid State Chemistry**	
	4.1.1. Recapitulation: Structures and Defects in solids.	
	Types of Defects and Stoichiometry a) Zero dimensional (point) Defects b) One dimensional (line) Defects c) Two dimensional (Planar) Defects d) Thermodynamics of formation of defects (Mathematical derivation to find concentration of defects and numerical problems based on it) (Ref: 17, 18 and19)	
4.2	**Phase equilibria**	
	4.2.1. **Recapitulation:** Introduction and definition of terms involved in phase rule. Thermodynamic derivation of Gibbs Phase rule.	
	4.2.2. **Two component system:** a) **Solid –Gas System :** Hydrate formation, Amino compound formation b) **Solid – Liquid System:** Formation of a compound with congruent melting point, Formation of a compound with incongruent melting point . (with suitable examples	
	4.2.3. **Three component system** Type-I : Formation of one pair of partially miscible liquids Type-II: Formation of two pairs of partially miscible liquids Type-III: Formation of three pairs of partially miscible liquids (Ref: 4, 6, 11, 12 ,13,16, 24)	
Sr.No.	**References**	
1.	Peter Atkins and Julio de Paula, Atkin's Physical Chemistry, 7th Edn., Oxford University Press, 2002.	
2.	K.J. Laidler and J.H. Meiser, Physical Chemistry, 2nd Ed., CBS Publishers and Distributors, New Delhi, 1999.	
3	Robert J. Silby and Robert A. Alberty, Physical Chemistry, 3rd Edn., John Wiley and Sons (Asia) Pvt. Ltd., 2002.	
4	Ira R. Levine, Physical Chemistry, 5th Edn., Tata McGraw-Hill New Delhi, 2002.	

5	G.W. Castellan, Physical Chemistry, 3rdEdn., Narosa Publishing House, New Delhi, 1983.	
6	S. Glasstone, Text Book of Physical Chemistry, 2nd Edn., McMillan and Co. Ltd., London, 1962.	
7	Principles of Chemical Kinetics, 2nd Ed., James E. House, ELSEVIER, 2007.	
8	B.K. Sen, Quantum Chemistry including Spectroscopy, Kalyani Publishers, 2003.	
9	A.K. Chandra, Introductory Quantum Chemistry, Tata McGraw – Hill, 1994.	
10	R.K. Prasad, Quantum Chemistry, 2ndEdn., New Age International Publishers, 2000.	
11	S. Glasstone, Thermodynamics for Chemists, Affiliated East-West Press, New Delhi, 1964.	
12	W.G. Davis, Introduction to Chemical Thermodynamics – A Non – Calculus Approach, Saunders, Philadelphia, 19772.	
13	Peter A. Rock, Chemical Thermodynamics, University Science Books, Oxford University Press, 1983.	
14	Ira N. Levine, Quantum Chemistry, 5thEdn., Pearson Education (Singapore) Pvt. Ltd., Indian Branch, New Delhi, 2000.	
15	Thomas Engel and Philip Reid, Physical Chemistry, 3rdEdn., Pearson Education Limited 2013.	
16	D.N. Bajpai, Advanced Physical Chemistry, S. Chand 1stEdn., 1992.	
17	Solid State Chemistry [An Introduction], 3rd Ed., Lesley E. Smart & Elaine A. Moore, Taylor & Francis, 2010.	
18	The Physics and 'Chemistry of Solids, Stephen Elliott, Willey India, 2010	
19	Principles of the Solid State, H.V. Keer, New Age International Publishers, 2011.	
20	Solid State Chemistry, D.K. Chakrabarty, New Age International Publishers, 1996.	
21	Principles of physical Chemistry , Marrown and Prutton 5th edition	
22	Essentials of Physical Chemistry , Arun Bahl, B. S Bahl, G. D.Tulli , S Chand and Co. Ltd , 2012 Edition.	
23	Introduction of Solids, L.V Azaroff , Tata McGraw Hill .	
24	A Text book of Physical Chemistry ; Applications of thermodynamics vol III, Mac Millan Publishers India Ltd ,2011	
25	New directions in solid state Chemistry, C.N.R. Rao and J Gopalkrishnan , Cambridge University Press.	
	Course outcomes (Students will be able to……)	
1.	Learn the concept of fugacity, real solutions and bioenergetics	
2.	Get the basic idea about rigid rotor, learn the hydrogen atom system and approximation methods, Applications of Huckel MO theory .	

3.	Understand the chemical kinetics and molecular reaction dynamics	
1.	Learn various types of defects in solid state chemistry, phase rule, two component system , three component system .	

MSCHDC201T ; M (Masters)CH(Chemistry)DC(Core Course) 201(SEM II)T (Theory)

	Course Code: **MSCHLB201P/ MSCHDE201P**	**Course Title: Physical Chemistry LAB**	
	Course Credit: **2**	Total contact hours: 60 Hrs	
Sr. No.	**Non – instrumental**		
1.	Polar plots of atomic orbitals such as 1s, 2Px and $3dz^2$orbitals by using angular part of hydrogen atom wave functions.		
2	To study the influence of ionic strength on the base catalysed hydrolysis of ethyl acetate.		
3.	To study phase diagram of three component system water – chloroform /Toluene - acetic acid.		
	Instrumental		
1.	To determine the formula of silver ammonia complex by potentiometric method.		
2.	To determine CMC of sodium Lauryl Sulphate from measurement of conductivities at different concentrations.		
3.	To determine Hammette constant of m- and p- amino benzoic acid/nitro benzoic acid by pH measurement.		
	References		
1.	Practical Physical Chemistry, B. Viswanathan and P.S. Raghavan, Viva Books Private Limited, 2005.		
2.	Practical Physical Chemistry, A.M. James and F.E. Prichard, 3rd Edn., Longman Group Ltd., 1974.		
3.	Experimental Physical Chemistry, V.D. Athawale and P. Mathur, New Age International Publishers, 2001.		
	Course outcomes (Students will be able to……)		
	1. Draw the polar plots of atomic orbitals and phase diagram of three component system .		
	2. Understand the kinetics of hydrolysis of ethyl acetate.		
	3. Understand the basic principles of various instrumental techniques and their utility to find out physical/thermodynamic parameters.		

MSCHLB201P ; MS (Masters) CH (Chemistry) LB(Laboratory)201(SEM II) P(Practical)

	Course Code: **MSCHDC201T/ MSCHDE201T**	**Course Title: Inorganic Chemistry**	
	Course Credit: **4**	Total contact hours: 60 Hrs	
Sr. No.	**Course Contents (Topics & subtopics)**		**Reqd. hours**
	UNIT I Bioinorganic Chemistry		**15 Hrs**
(i)	Role of Essential elements in biological systems.		
(ii)	Biological oxygen carriers: hemoglobin, myoglobine, hemerythrene and hemocyanine. Hill equation, Bohr effect and their implications.		
(iii)	Reactions of dioxygen in biological system with examples of peroxidase, mono-oxygenase, superoxide dismutase and oxidase reactions.		
(iv)	Nitrogen fixation-nitrogenase, Hydrogenases.		
(v)	Metal ion transport and storage: Ionophores, Transferrin and Ferritin.		
(vi)	Metal ions in medicines, Cis-platin and related compounds.		
	UNIT II Chemical Bonding and Magnetism		**15 Hrs**
(i)	Hydrogen bonding – Concept, Types, Properties, Methods of detection and importance. Van der Waal's forces, Ion-dipole, Dipole-dipole, London forces.		
(ii)	Hybridisation: Derivation of wave functions for the following orbital hybridisation types: sp (BeH_2); sp^2 (BF_3); sp^3 (CH_4) considering only sigma bonding.		
(iii)	Molecular Orbital Theory (LCAO-MO approach) for (a) Electron deficient species (B_2H_6) and (b) Electron rich species (triodide ion, I_3^-).		
(iv)	Theory of magnetism: Diamagnetism, Paramagnetism, Ferromagnetism and Anti-ferromagnetism, Curie and Curie-Weiss laws, Gouy's Method and Faraday's method for determination of magnetic susceptibility. Diamagnetic Corrections.		
	UNIT III Molecular Symmetry and Group theory		**15 Hrs**
(i)	**Molecular Symmetry:** Definition, Symmetry operations and symmetry elements, Concepts of Groups and Sub-groups, Definition of Class, Group Multiplication Tables, Abelian and non-Abelian point groups, symmetry restrictions on dipole moment, Symmetry criterion of optical activity.		
(ii)	**Representations of Groups:**,- Matrix Representation: Reducible and Irreducible Representations, Reduction of Reducible Representation by reduction formula.		

(iii)	**Character tables:-** Great Orthogonality Theorem (its three types and five rules), Mulliken's notations for Irreducible Representations, Character of element, Character Table, definition and construction of Character table for C_{2v} and C_{3v} point groups.	
(iv)	**Applications of Group Theory:-** 1) Normal Modes of Analysis: IR active modes and Raman active modes of molecules for C_{2v}, C_{3v} and C_{2h} point groups (Determination of symmetry species in terms of normal modes for translations, rotations and vibrations). 2) Group-subgroup relationships: Descent and ascent in symmetry and correlation diagrams showing relationship between different groups. 3) Symmetry adapted linear combinations (SALC), symmetry aspects of MO theory, sigma bonding in AB_4 (Ammonia, CH_4) molecules.	
	UNIT IV Environmental Chemistry	**15 Hrs**
(i)	**Standard water quality parameters.**	
(ii)	**Water pollution**: Heavy metal pollutants like mercury, lead, cadmium, arsenic, copper and chromium, with respect to their sources, distribution, speciation, toxic effects, control and treatment.	
(iii)	**Radiation pollution**: Sources and biological implication of radioactive pollutants. Effects of radioactivity on cell proliferation and cancer.	
	Suggested readings	
	Unit I Bioinorganic Chemistry 1. R. W. Hay, *Bioinorganic Chemistry*, Ellis Harwood, England, 1984. 2. I. Bertini, H.B. Gray, S.J Lippard and J.S. Valentine, *Bioinorganic Chemistry*, First South Indian Edition, Viva Books Private ltd, (1998). 3. J.A. Cowan, *Inorganic Biochemistry - An introduction*, VCH Publication, 1993. *4.* S.J Lippard and J.M. Berg, *Principles of Bioinorganic Chemistry*, University Science Publications, Mill Valley, Caligronic, 1994. 5. G.N. Mukherjee and A. Das, *Elements of Bioinorganic Chemistry*, Dhuri and Sons, Calcutta, 1988. 6. J.Chem Educ. (Special issue), Nov, 1985. 7. E. Frienden, J. Chem. Educ., 1985, 62. 8. Robert R. Crechton, *Biological Inorganic Chemistry- An Introduction*, Elsevier.	

Unit II Chemical Bonding and Magnetism

1. *Elements Of Magnetochemistry*- R.L. Datta and Shamal.

2. *Magnetochemistry* by Selwood.

3. P. Atkins, T. Overton, J. Rourke, M. Weller and F. Armstrong, *Inorganic Chemistry*, 5th Ed., Oxford University Press, 2010.

4. J. E. Huheey, E. A. Keiter and R. L. Keiter; *Inorganic Chemistry: Principles of Structure and Reactivity*, Pearson Education, (2006).

5. Gary Miessler and Donald Tarr, *Inorganic Chemistry- Principles of Structure and Reactivity*, 4th Edition, Harper Collins,1993.

6. W. H. Malik, G. D./ Tuli and R. D. Madan, *Selected Topics in Inorganic Chemistry*, 8th Ed., S. Chand & Company ltd.

7. Earnshaw, *Introduction to Magnetochemistry*, Academic Press, New York, 1968.

8. J. Crangle, *The Magnetic Properties of Solids*, Edward Arnold, 1977.

9. Durrant and Durrant, *Introduction to Advanced Inorganic Chemistry*, Oxford University Press, 1967.

10. R.L. Dekock and H.B.Gray, *Chemical Structure and Bonding*, The Benjamin / Cummings Publishing Company, 1989.

11. R. Sarkar, *General and Inorganic Chemistry*, Books & Allied (P) Ltd., Calcutta, 2001.

12. J.N. Murrell, S.F. A. Kettle and J.M. Tedder, *The Chemical Bond*,Wiley, New York, 1978.

13. George A. Jeffrey, *An Introduction to Hydrogen Bonding*, Oxford University Press, Inc., New York, 1997.

14. B. R. Puri, L. R. Sharma and K. C. Kalia, *Principles of Inorganic Chemistry*, Milestone Publishers, 2013-2014.

15. Gurdeep Raj, *Advanced Inorganic Chemistry*-Vol. II, 12th Edition, Goel publishing house, 2012.

16. B.Doughlas, D.H McDaniel and J.J Alexander. *Concepts and Models of Inorganic Chemistry*, 2nd edition, John Wiley and Sons. 1983.

17. F. A. Cotton, G. Wilkinson, C. A. Murillo and M. Bochmann; *Advanced Inorganic Chemistry*, 6th ed. Wiley, (1999).

18. P.W. Atkins, T. Overton, J. Rourke, M. Weller and F. Armstrong;*Shriver & Atkins: Inorganic Chemistry*, 4th ed. Oxford University Press,(2006).

Unit III Molecular Symmetry and Group theory

1. *Chemical Applications of Group Theory*, 3rd Edn., Author - F. A. Cotton (Wiley, New York)
2. *Symmetry and spectroscopy of molecules*, 2nd Ed. 2009; K. Veera Reddy, (New Age International Publication)
3. *Group theory and its chemical applications*: P.K Bhattacharya, 2nd edn, Himalaya, pub. India,(1989).
4. *Symmetry and Group Theory In Chemistry*, Mark Ladd, Harwood Publishers, London, (2000)
5. *Symmetry Through the Eyes of a Chemist*, I. Hargittai and M. Hargittai, 2nd Edition,Plenum Press, NY (1995)
6. *Molecular Symmetry and Group Theory*, Robert L. Carter, John Wiley & Sons (1998).
7. *Group Theory for Chemists*, G. Davidson, Macmillan Physical Science Series (1991).
8. *Molecular symmetry and group theory* -A. Vincent.
9. *Symmetry in Chemistry*: H.H. Jaffe' and M. Orchin, Dover Publications Inc, NewYork,(2002).
10. *Symmetry in Inorganic Chemistry*: J.P.Fackler.
11. *Molecular Symmetry Groups and Chemistry*, Rakshit, S.C., The New Book Stall (1988).
12. *Symmetry and Group Theory for Chemists*, Dass, N.N., Asian Books Pvt. Ltd (2004).
13. *Group Theory in Chemistry*, Gopinathan, M.S., and Ramakrishnan, V., Vishal Publishers (2006).
14. *Symmetry in Chemistry* Jaffe, H. H. &Orchin, M.,Dover Publications (2002).
15. *Symmetry in Chemical Bonding & Structure* Hatfield, W. E. & Parker, W. E.,C. E. Merrill Publishing Co.USA (1974).
16. *Group Theory and Chemistry*, Bishop, D. M.,Clarendon Press: Oxford, U.K. (1973).

	Unit IV Environmental Chemistry 1. A. K. De, *Environmental Chemistry*, 7th Edition, New Age International Publishers. 2. G. S. Sodhi, *Fundamental Concepts of Environmental Chemistry*, Narosa Publishing House. 3. S. S. Dara, *A Textbook of Environmental Chemistry and Pollution Control*, S. Chand & Company Ltd., New Delhi.	
	Course outcomes	
	Students will be able to understand:	
1.	Basics of Bio-inorganic Chemistry and Role of essential elements. Importance of metallobiomolecules. Medical applications of metal ions and complexes.	
2.	Concept of hydrogen bonding and its Types. The hybridisation using wave functions for the sp, sp^2 and sp^3 – hybridisation. The Molecular Orbital Theory for electron deficient species and electron rich species. The theory of diamagnetism, paramagnetism, Ferromagnetism and Anti-ferromagnetism, determination of magnetic susceptibility.	
3.	The symmetry operations, symmetry elements and point group of chemical compounds. Students can check dipole moment and optical activity of given compounds using point group. It will be very easy to discuss the normal modes of analysis for IR and Raman modes using character table. Students will learn about group-subgroup relationship by transfer of properties in terms of irreducible representations and Mulliken's symbols. They also will get an idea of symmetry adopted linear combination of tetrahedral compounds.	
4.	Students will understand standard quality parameters for drinking and industrial purpose and also water pollution by heavy metals and radiation pollution.	

	Course Code: **MSCHLB202P / MSCHDE202P**	**Course Title: InorganicChemistry LAB**	
	Course Credit: **2**	Total contact hours: 60 Hrs	
Sr. No.	**Course Contents (Topics & subtopics)**		
	(i) Synthesis and Characterization of complexes a) Bis(ethylenediammine) Copper(II) Sulphate, $[Cu(en)_2]SO_4$ b) Bis(tetramethylammonium) tetrachloro Cobaltate(II) $(Me_4N)_2[CoCl_4]$ c) Hexaamine Nickel(II) Sulphate $[Ni(NH_3)_6]SO_4$ **(ii) Instrumentation** a) Estimation of Cu^{+2} solution using EDTA Spectrophotometrically. b) Estimation of Fe^{+2} solution using Ce(IV) Potentiometrically. c) Determine the nature of electrolyte by conductometrically.		
	Suggested readings		
	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.		
	Course outcomes		
	Students will be able to understand: 1. Synthesis and Characterization of complexes by different methods. 2. Spectrophotometric estimation of Cu by using EDTA. 3. Potentiometric determination of Fe^{+2} using Ce(IV) ions. 4. Determine the nature of electrolyte by conductometrically.		

MSCHLB202P ; M (Masters) CH (Chemistry) DSC-1-3 (SEM II) P (Practical)

	Course Code MSCHDC203T/ MSCHDE203T	Course Title: OrganicChemistry	
	Course Credit : 4	**Total hours: 60 Hrs**	
Sr. No.	**Course Contents (Topics & Subtopics)**		**Reqd. hours**
1	**UNIT –I Oxidation and Reduction**		**15 Hrs**
	Oxidation: General mechanism, selectivity and important applicationsof the following: Oxidation of alcohols to aldehydes and ketones: Chromium reagents such as $K_2Cr_2O_7/H_2SO_4$ (Jones reagent), CrO_3-pyridine (Collin's reagent), PCC (Corey's reagent), hypervalent iodine reagents (IBX, Dess-Martin periodinane). DMSO based reagents (Swern oxidation), Pfitzner-Moffatt oxidation-DCC and DMSO, Oppenauer oxidation, Swern Oxidation Oxidation involving C-C bonds cleavage: Glycols using HIO_4; cycloalkanones using CrO_3; carbon-carbon double bond using ozone, $KMnO_4$,CrO_3, $NaIO_4$ and OsO_4; aromatic rings using RuO_4 and $NaIO_4$. Oxidation involving replacement of hydrogen by oxygen: oxidation ofCH_2 to CO by SeO_2, oxidation of arylmethanes by CrO_2Cl_2 (Etard oxidation). Oxidation of aldehydes and ketones: with H_2O_2 (Dakin reaction), with peroxy acid (Baeyer-Villiger oxidation) **Reduction: General mechanism, selectivity and important applicationsof the following reducing reagents:** Reduction of CO to CH_2 in aldehydes and ketones- Clemmensen reduction, Wolff-Kishner reduction and Huang-Minlon modification. Metal hydride reduction: Boron reagents ($NaBH_4$, $NaCNBH_3$, diborane,9-BBN, $Na(OAc)_3BH$, aluminium reagents ($LiAlH_4$, DIBAL-H, Red Al,). NH_2NH_2 (diimide reduction) and other non-metal based agents includingorganic reducing agents (Hantzsch dihydropyridine). Dissolving metal reductions: using Zn, Li, Na, and Mg under neutral andacidic conditions, Li/Na-liquid NH_3 mediated reduction (Birch reduction) of aromatic compounds and acetylenes.		
2	**UNIT II Name Reactions and Rearrangements**		**15 Hrs**
	Mechanisms, stereochemistry (if applicable) and applications of the following reactions: **Reactions:** Baylis-Hilman reaction, McMurry Coupling, Corey-Fuchs reaction, Nef reaction, Passerini reaction. **Concerted rearrangements:** Hofmann, Curtius, Lossen, Schmidt,Wolff **Cationic rearrangements:** Tiffeneau-Demjanov, Pummerer,Dienone-phenol, Rupe, Wagner-Meerwein. **Anionic rearrangements:** Brook, Neber, Von Richter, Wittig.		

3	UNIT III Nucleophilic and Electrophilic substitution	15 Hrs
	Nucleophilic substitution reactions (8L) **Aliphatic nucleophilic substitution:** S_N1, S_N2, $S_N i$ reactions, mixed S_N1 and S_N2 and SET mechanisms. S_N reactions involving NGP - participation by aryl rings, α-and pi-bonds. Factors affecting these reactions: substrate, nucleophilicity, solvent, steric effect, hard-soft interaction, leaving group. Ambident nucleophiles. S_NcA, S_N1' and S_N2' reactions. S_N at sp (vinylic) carbon. **Aromatic nucleophilic substitution:** S_NAr, S_N1, benzyne mechanisms. Ipso, cine, tele and vicarious substitution. **Ester hydrolysis:** Classification, nomenclature and study of all eight mechanisms of acid and base catalyzed hydrolysis with suitable examples. **Electrophilic substitution reactions (7L)** **Aliphatic electrophilic substitution:** Unimolecular mechanism SE1 with evidence, Factors affecting on reactivity of SE reactions, SE2 mechanism (Hydrogen exchange), Halogenation of Aldehydes, Ketones and sulphoxides, aliphatic diazonium coupling. Nitrosation at carbon and nitogen. **Aromatic electrophilic substitution:** Arenium ion mechanism with evidence, Mechanisms of Aromatic electrophilic substitution reactions: Nitration, Sulphonation, Halogenation, Friedel Craft Alkylation and acylation Orientation and reactivity of mono substituted benzene based on charge distribution and intermediate stability. Introduction of third group in benzene ring, IPSO attack.	
4	**UNIT IV Fundamentals of Organic spectroscopy**	**15 Hrs**
	Introduction of Spectroscopy of Organic Compounds **Ultraviolet spectroscopy:** Basic Theory**,** Chromophore Auxochrome concept, Bathochromic and Hypsochromic shifts**,** Factors affecting the position of UV bands**,** Calculation of absorption maxima for dienes and conjugated polyenes (cyclic and acyclic) **Infrared spectroscopy:** Basic Theory**,** the modes of stretching and bending, Correlation charts and Tables for alkanes, alkenes, alkynes, aromatics, alcohols, ethers, phenols, amines, nitriles and nitrocompounds, aldehydes, ketones, esters, amides, acids, acid halides, anhydrides and conjugated carbonyl compounds. **NMR spectroscopy:** Basic Theory and Principles of NMR Spectroscopy**,** Chemical shift and Shielding, Factors affecting chemical shift (Electronegativity, H-bonding, Anisotropy effects), Chemical equivalence- A Brief Overview, Peak Area and Proton Counting**,** Spin- Spin Splitting (n+1) Rule**,** Spin-Spin Coupling Coupling Constant, Geminal Coupling, Vicinal Coupling, Long Range Coupling **Mass spectrometry:** Basic Theory and Principles of Mass Spectroscopy**,** Importance of Molecular ion peak, base peak, metastable ions, isotopic abundance and Nitrogen Rule**,** Fragmentation patterns and Fragmentation Modes in various classes of organic compounds**,** Homolytic Cleavage, Heterolytic Cleavage, Retro-Diel's Alder reaction**,** Ortho Elimination, McLafferty Rearrangement**,** Molecular	

	Formula and Index of Hydrogen Deficiency**,** Interpretation of Mass Spectra **4.6 Structure Elucidation of Organic Compounds involving individual or combined use of UV, IR, NMR and Mass spectroscopic techniques**	
	Suggested readings	
	1. Organic Chemistry, J. Claydens, N. Greeves, S. Warren and P. Wothers, Oxford University Press. 2. Advanced Organic Chemistry, F.A. Carey and R.J. Sundberg, Part A, page no. 713-769, and B, Plenum Press. 3. March's Advanced Organic Chemistry: Reactions, Mechanisms and Structure, Michael B. Smith, Jerry March, Wiley. 4. Organic Chemistry, R.T. Morrison, R.N. Boyd and S.K. Bhattacharjee, Pearson Publication (7 Edition) 5. Advanced Organic Chemistry: Reactions and mechanism, B. Miller and R. Prasad, Pearson Education. 6. Advanced Organic Chemistry: Reaction mechanisms, R. Bruckner, Academic Press. 7. Understanding Organic Reaction Mechanisms, Adams Jacobs, Cambridge University Press. 8. Writing Reaction Mechanism in organic chemistry, A. Miller, P.H. Solomons, Academic Press. 9. Principles of Organic Synthesis, R.O.C. Norman and J.M Coxon, Nelson Thornes. 10. Advanced Organic Chemistry: Reactions and mechanism, L.G. Wade, Jr., Maya Shankar Singh, Pearson Education. 11. Mechanism in Organic Chemistry, Peter Sykes, 6^{th} Edition 12. Molecular Orbital and Organic chemical reactions, Ian Fleming Reference Edition, Wiley 13. Reactions, Rearrangements and Reagents by S. N. Sanyal 14. Name Reactions, Jie Jack Li, Springer 15. Name Reactions and Reagents in Organic Synthesis, Bradford P. Mundy 16. Organic Reaction Mechanisms, V.K. Ahluwalia, R.K. Parasher, Alpha Science International, 2011. 17. Introduction to Spectroscopy, Donald L. Pavia, Gary M. Lampman, George S. Kriz, Thomson Brooks. 18. Spectrometric Identification of Organic Compounds, R. Silverstein, G.C Bassler and T.C. Morrill, John Wiley and Sons. 19. Organic Spectroscopy, William Kemp, W.H. Freeman & Compan. 20. Organic Spectroscopy-Principles and Applications, Jagmohan, Narosa Publication. 21. Organic Spectroscopy, V.R. Dani, Tata McGraw Hill Publishing Co. 22. Spectroscopy of Organic Compounds, P.S. Kalsi, New Age International Ltd.	
	Course outcomes:	

	Students will be able to understand: ➢ Important oxidation and reduction reactions with various reagents. Alkylation ➢ Mechanisms, stereochemistry and applications of the different reactions and Rearrangements ➢ Detail study of Nucleophilic and Electrophilic substitution reactions and its mechanisms ➢ Applications of UV, IR spectroscopy, NMR spectroscopy and Mass spectrometry and Structure determination involving individual or combined use of the above spectral techniques	

	Course Code: MSCHLB203P/ MSCHDE203P	**Course Title: Organic Chemistry LAB**	
	Course Credit: 2	**Total hours: 60 Hrs**	
Sr. No.	**Course Contents (Topics & subtopics)**		
	Separation of Binary mixture using micro-scale technique 1. Separation of binary mixture using physical and chemical methods. 2. Characterization of one of the components with the help of chemical analysis and confirmation of the structure with the help of derivative preparation and its physical constant. 3. Purification and determination of mass and physical constant of the second component. The following types are expected: (i) Water soluble/water insoluble solid and water insoluble solid, (ii) Non-volatile Liquid-Non-volatile liquid (chemical separation) (iii) Water-insoluble Solid-Non-volatile liquid. **Minimum three mixtures from each type and a total of ten mixtures are expected.**		
	Suggested readings		
	1. Systematic Qualitative organic analysis, H. Middleton (Orient Longman) 2. A Handbook of Organic Analysis, H.T. Clark (Orient Longman) 3. Systematic Identification of organic compounds, R.L. Shriner (John Wiley, New York) 4. Practical Organic Chemistry by Mann and Saunders. 5. Advance Practical Organic Chemistry, N.K. Vishnoi, Vikas Publication		
	Course outcomes:		

	Students will be able to understand: ➢ Separation of binary mixture using physical and chemical methods. ➢ Characterization of the components with the help of chemical analysis and confirmation of the structures with the help of derivative preparationand their physical constants. ➢ Purification and determination of mass and physical constant of the components.	

	Course Code: MSCHDC204T/ MSCHDE204T	**Course Title: Analytical Chemistry**	
	Course Credit: 4	**Total contact hours: 60 Hrs**	
Sr. No.	Course Contents (Topics & subtopics)		Req d.
	UNIT I		15 Hrs
	Chromatography		
1.1	Recapitulation of Basic Concepts in Chromatography Concept of plate and rate theories in chromatography: efficiency, resolution, selectivity and separation capability, Van Deemar equation and broadening of chromatographic peaks, Optimization of chromatographic conditions.		
1.2	**Gas Chromatography**: Principle –GSC and GLC, Column and Stationary Phases, column oven, packed columns, stationary phases for packed columns, micro packed columns, capillary columns, Optimum Practical Gas velocity, stationary phases for wall-coated open tubular columns, Adsorbents in GSC-alumina, silica gel, molecular sieves, carbon materials,		
1.3	Gas Chromatography Instrumentation- Carrier gas and controls, Sample introduction/injection system, column and oven, detectors, applications		
1.4	**High-Performance Liquid Chromatography (HPLC):** Separation modes in HPLC-Adsorption, Bonded phase chromatography, Normal phase and reversed phase, Ion exchange, Ion pair formation, Gel permeation. HPLC Instrumentation – Overview, Sample introduction- valve injection and autosampler, pumps, Solvent systems- Isocratic and gradient elution Columns—column packing for different modes and stationary phases, Detectors- Solute property detectors, Bulk property detectors, Chiral chromatography		
	UNIT II		15 Hrs
2.1	X-ray Spectroscopy: Principle, Instrumentation and Application of X-Ray fluorescence, Absorption, and Diffraction Spectroscopy.		
2.2	Mass Spectrometry: Recapitulation, Instrumentation, Ion sources for molecular studies, Electron impact, Field ionization, Field absorption, Chemical ionization and fast atom bombardment sources. Mass analyzers: Quadrupole, Time of flight and Ion trap. Applications.		
2.3	Radioanalytical Methods- Recapitulation, Isotope dilution, Introduction, principle, single dilution, double dilution, and applications.		
	UNIT III		15 Hrs
3.1	**Ion beams in Chemical analysis**		
	Ion beams types- Proton, Noble gas ions other ions, Liquid metal ion sources, Properties, Ion beam specimen interaction- Kinematics, impact parameter, distance of closest approach, stopping power, cross-sections low energy interactions high energy interactions		
3.2	**Atomic Spectroscopy**		
	Recapitulation of AAS, Atomic spectroscopy based on Plasma, Arc and Spark Sources- Introduction, Principle, Instrumentation and Application.		

	UNIT IV	15 Hrs
	Electroanalytical Methods (Numerical are Expected)	
4.1	Polarography: Recapitulation of classical DC Polarography limitations sensitivity optimization Advances In DC Polarography –Rapid DC, TAST, Pulse-Normal Pulse and Differential pulse	
4.2	Voltammetry –Basic principle, Methodology and Applications of Linear sweep voltammetry, Cyclic voltammetry and Stripping voltammetry	
4.3	Coulometry: Introduction, Principle, Instrumentation, Coulometry at controlled potential and controlled current, Coulometric titrations, applications	
4.4	Electrochemical Biosensors- Potentiometric and amperometrc biosensors enzyme-based biosensors, Biocatalytic membrane electrode	
	REFERENCE BOOKS	
1	Introduction to instrumental analysis by R. D. Broun, Mc Graw Hill (1987) Dean	
2	Instrumental methods of chemical analysis by H. Willard, L. Merrit, J.A. settle.	
3	Fundamentals of analytical chemistry by D. A. Skoog, D. M. West and H. J.	
4	Principles of Instrumental Analysis Skoog, West, Niemann.	
5	Thermal analysis by W.W. Wendlandt, John Wiley, (1986)	
6	Vogel Text Book of quantitative analysis 6th Ed.	
7	Preparative chromatography Chrome Ed. book series, Raymond P. W. Scott	
8	Cyclic Voltammetry and frontiers of electrochemistry by N.Noel and K.I. Vasu IBH, New Delhi (1990)	
9	Electrochemical Methods: Fundamentals and Applications by Allen J. Bard and Larry R. Faulkner.	
10	Practical HPLC method Development, Snyder, Kirki and Glajch, Wiley India Pvt.	
11	Skoog, West, Holler and Crouch. Fundamentals of analytical chemistry, 8 th Ed.,	
	Course Outcome	
1	To study the separation techniques, optical methods of chemical analysis, electro analytical techniques and thermal methods of analysis	
2	To give introduction to students about different spectroscopy techniques.	
3	To learn the basics of electro analytical techniques.	
4	To introduce the concept Ion beams as a source in chemical analysis.	

Course Code: MSCHLB204P/ MSCHDE204P	Course Title: Analytical Chemistry LAB
Course Credit : 2	Total contact hours: 60 Hrs
1)	Determine the amount of Ti(III) and Fe(II) in the given solution by titrating with Ce(IV) potentiometrically.
2)	Determine the percentage purity of a sample of sodium benzoate /Glycine/Orth or Para nitro aniline by using perchloric acid in a non-aqueous medium by using Combined glass electrode potentiometrically.
3)	Determine the amount of Nitrite present in the given water sample calorimetrically.
4)	Determine the amount of Fe(II) and Fe(III) present in the given solution by spectrophotometric method using 1-10 phenanthroline.
5)	Determine the ion exchange capacity and exchange efficiency of the given cation exchange resin.
6)	Determine the break through capacity of a given cation exchange resin.
	Suggested reading
1.	Quantitative Inorganic analysis including elementary Instrumental analysis by A.I.Vogel. Third edition. ELBS 1964
2.	Analytical Chemistry by Gary D. Christian, 6th edition, John Wiley and sons Publication
3.	Ewings Analytical Instrumental Handbook, Third Edition. Edited by Jack Cazes
	Course outcomes
	Students will be able to understand, acquire knowledge on Basic concepts of Analytical Chemistry, Stoichiometric Calculations, Safety in laboratory, spectroscopy and Thermal methods.

Course Code: MSCHOJ201P/ MSCHFP201P	Course Title: On Job Training / Field Project (Course Credit : 4)
	Students have to complete On Job training/ Field Project in summer vacation.