Programme: M. Sc. Part-I (Chemistry)

Course Code: ACC-401 **Title of the Course: Concepts in Analytical Spectroscopy**

Number of Credits: 03 **Effective from AY: 2018-19**

Prerequisites for the course:	Students should have studied the spectroscopic techniques such as UV-Vis, IR at FY B Sc, S Y B Sc or T Y B Sc levels so as to have basic knowledge of spectroscopy and basic principles.	
Course Objectives:	1. Introduction of various concepts in molecular and atomic spectroscopy. 2. Learning data analysis, handling and interpretation of spectra	
Course Outcomes:	1. Students should be in a position to use spectroscopic methods for qualitative and quantitative analysis. 2. Evaluate the utility of UV/Vis spectroscopy as a qualitative and quantitative method. 3. Identification of functional group based on IR spectra 4. Students should be in a position to predict the structure based on IR, NMR, MS data.	
Content:	**1.Introduction to spectrochemical methods** 1.1. Interaction of Electromagnetic Radiation with Matter: electromagnetic spectra, Regions of Spectrum; Numericals. 1.2 Electronic spectra and Molecular structure: kinds of transition, Chromophores and auxochrome; absorption by isolated chromophores, conjugated chromophores, aromatic compounds, inorganic chelates. 1.3. Infrared absorption and molecular structures: IR spectra, overtones and bands-basis of NIR absorption 1.4. Spectral Databases: Identification of unknown; Application of UV-Vis and IR spectroscopy for identification of unknown compounds 1.5. Solvents for spectrometry: Choices and effect of solvents on UV-Vis and IR spectra. 1.6. Quantitative Calculations: The Lambert-Beer's Law; Mixtures of absorbing species-laws of additivity of absorbance; calibration curve for calculation of unknown; Spectrometric errors in measurement; Deviation from Lambert-Beer's law-chemical deviation, instrumental deviation; Quantitative measurement from IR spectra; Numericals for quantitative analysis using UV-VIS spectroscopy. 1.7. Spectrometric Instrumentation of UV-Vis and IR (brief introduction only): Sources, monochromators, sample cells, Types of instruments; detectors; Instrumental wavelength and absorption calibration. (Chapter 16: Analytical Chemistry, G.D. Christian, 6thEd.) **2. Molecular Luminescence: Fluorimetry, Phosphorimetry and Raman Spectroscopy** 2.1. Introduction, 2.2. Fluorimetry : Theory and basic principle; Quenching; Spectrofluorimeters and applications 2.3. Phosphorimetry: Theory and basic principle; phosphorimeters and application 2.4. Raman Spectroscopy: Theory and Structural analysis using Raman Spectra (Chapter 6: Instrumental Methods of Chemical Analysis, G.W. Ewing,5thEd) **3. Atomic Spectroscopy** 3.1. Principles of emission 3.2. Atomic Emission spectroscopy (AES) 3.3. Flame Emission spectroscopy (FES)	12 hr 4 hr 6 hr

	3.4. Atomic absorption Spectroscopy (AAS) 3.5. X-Ray Fluorescence Spectroscopy (XRF) (Introduction, principles and applications of above techniques shall be discussed; Chapter 13: Analytical Chemistry Principles, J.H. Kennedy, 2nd ed) **4.Spectrometric Identification of Organic compounds** **4.1 Ultraviolet and visible Spectroscopy :** Brief Revision of UV/VIS Spectroscopy **;**Instrumentation and Sampling ; Applications of Electronic S pectroscopy:Conjugated Dienes, Trienes, polyenes, a, ßunsaturated carbony l compounds, aromatic hydrocarbons (Assignment based on BSc. Syllabus for calculating λmax) (Kemp – Chap4) **4.2 Infrared Spectroscopy:** Introduction to IR spectroscopy; Basic IR spectra interpretation; Frequencies of functional group. (Kemp – Chap2). **4.3 Proton and Carbon NMR Spectroscopy:** Theory of NMR **;** Chemical shift; factors influencing chemical shift **;** Solvents used in NMR; Theory of spin-spin splitting and simple spin systems;Coupling constant calculation; Factors influencing coupling constant (Assignment based on BSc. Syllabus) (Kemp - Chapter 3) **4.4 Mass Spectrometry :** Basic PrinciplesandInstrumentation: Problem solving in structure elucidation based on MS (Kemp - Chapter 5) **4.5. Conjoint Spectrometry Problems:** Structural elucidation of organic molecules using UV, IR, NMR (^{1}H,^{13}C), MS, (Silverstein) (**Note:**Assignment based on BSc. syllabus for all above spectrometric structure should be given to student. *More weightage of lectures shall be given for solving IR and NMR data for structur elucidation*)	14 hr
Pedagogy:	Mainly lectures and tutorials. Seminars / term papers /assignments / presentations / self-study or a combination of some of these can also be used. Sessions shall be interactive in nature to enable peer group learning.	
Text Books References / Readings	1. G. D. Christian; *Analytical Chemistry*, John Wiley; 6th Edition. 2. J.H. Kennedy, *Analytical Chemistry: Principles*, Saunders College Publishing, 2nd Edition. 3. G. W. Ewing, *Instrumental Methods of Chemical Analysis*, McGraw-Hill Int 5th Ed. 4. W. Kemp; *Organic Spectroscopy*; Palgrave; 3 Ed. 5. D.A. Skoog, D.M. West, F.J. Hollar, S.R. Crouch; *Fundamentals of Analytical Chemistry*, Cengage learning; 9 Ed. 6. J. Mendham, R.C. Denney, J.D. Barnes and M. Thomas; *Vogel's Textbook of Quantitative Inorganic Analysis;* 6th Edition, Pearson Education Asia 2005 7. H. Willard, L.L. Merritt, J.A. Dean, F.A. Settle, *Instrumental methods of Analysis*; HCBS Publishing New Delhi; 2004, 7th Ed. 8. C.N. Banwell and E.M. McCash, *Fundamentals of Molecular Spectroscopy*, Tata McGraw- Hill, New Delhi; 4th Ed. 9. R. M. Silverstein, F.X. Webster; *Spectrometric identification of Organic Compounds*; Wiley- India; 6th Ed. 10. H. Gunzler & A. Williams; *Handbook of Analytical Techniques*, WILEY-VCH Verlag GmbH; 2001, 1st Ed. 11. P.S. Kalsi; *Spectroscopy of Organic Compounds*; New Age Internationa l; 2 Ed. 12. R.T. Morrison, R.N. Boyd; *Organic Chemistry*, Prentice Hall India 4th Edition 13. E. Pretsch, P. Buhlmann, C. Affolter; *Structural Determination of Organic Compounds*, Springer; 2005; 2nd Ed.	

Programme: M. Sc. Part-I (Chemistry)
Course Code: ACC-402
Title of the Course: Laboratory Course in Analytical Chemistry
Number of Credits: 02 **Effective from AY: 2018-19**

Prerequisites for the course:	Should have studied practical chemistry courses at F.Y B.Sc, S.Y. B .Sc & T Y B Sc levels so as to have basic knowledge of quantitative analysis.	
Course Objectives:	Introduction of various experimental techniques for analysis. Learning data analysis, handling and interpretation of spectra	
Course Outcomes:	Students should be in a position to use standardized material to determine an unknown concentration. To gain experience with some statistics to analyse data in laboratory Students should be in position to use different techniques for qualitative and quantitative estimation	
Content:	*This course consists of 6 units of experiments in various areas of Analytical chemistry. Minimum 12 experiments shall be carried out and at least 02 experiment from each unit shall be conducted.* **UNIT 1: STATISTICS** 1.Calibration of apparatus (balance, volumetric flasks, pipettes and burettes) and preparation of standard solutions and standardisation **UNIT 2: COLORIMETRY AND UV-VISIBLE SPECTROPHOTOMETRY** 2.Estimation of Iron from Pharmaceutical sample (capsule) by thiocyanate method 3. Estimation of lead/nitrate in water sample 4. Estimation of KNO_3 by UV spectroscopy and $K_2Cr_2O_7$ by Visible spectroscopy 5. Simultaneous determination and Verification of law of additivity of absorbances ($K_2Cr_2O_7$ and KMnO4) 6.Estimation of phosphoric acid in cola drinks by molybdenum blue method **UNIT 3: FLAME SPECTROPHOTOMETRY** 7.Estimation of Na 8.Estimation of K or Ca **UNIT 4: VOLUMETRY** 9.Estimation of Ca in pharmaceutical tablet. 10.Estimation of Al and/or Mg in antacid tablet **UNIT 5:** **ION EXCHANGE CHROMATOGRAPHY &SOLVENT EXTRACTION** 11.Separation and Estimation of Zn and Cd 12.Separation and Estimation of chloride and bromide 13.Extraction of Cu as copper dithiocarbamate (DTC) using solvent extraction and estimation by spectrophotometry	

	UNIT 6: INTERPRETATION EXERCIES 14.Thermal studies: TGDTA and Isothermal weight loss studies of various hydrated solids like $CuSO_4 \cdot 5H_2O$, $Ca_2C_2O_4 \cdot H_2O$, $Fe_2C_2O_4 \cdot 2H_2O$ 15. X-ray powder diffractometry: Calculation of lattice parameters from X-ray powder pattern of cubic system such as $NiMn_2O_4$, $CoFe_2O_4$ etc.	
Pedagogy:	Prelab exercises / assignments / presentations / lab hand-out or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.	
Text Books/ References / Readings	1. J. H. Kennedy, *Analytical Chemistry Principles*, Saunders College Publishing, Second Edition 1990. 2. G. D. Christian, *Analytical chemistry*, 5th Ed, John Willey and Sons, 1994 3. J. Mendham, R.C. Denney, J.D. Barnes and M. Thomas; *Vogel's Textbook of Quantitative Inorganic Analysis;* 6th Edition, Pearson Education Asia 2005 4. A. J. Elias, *Collection of interesting chemistry experiments*, University press, 2002. 5. R.A. Day & A.L. Underwood, *Quantitative Analysis*, 6th Edition, Prentice Hall, 2001. 6. J. Kenkel, *Analytical Chemistry for Technicians*, 3rd Edition, Lewis publishers, 2002.	

Programme: M. Sc. Part-I (Chemistry)

Course Code: ACO-401 **Title of the Course: Analytical Techniques**
Number of Credits: 03 **Effective from AY: 2018-19**

Prerequisites for the course:	Should have knowledge of basic analytical techniques such as chromatography, electro-analytical techniques and data handling.	
Course Objectives:	1. Introduction of various statistical approach used in analytical data handling 2. Introduction of different analytical techniques used for qualitative, quantitative estimation	
Course Outcomes:	3. Students should be in a position to understand principle behind different analytical techniques 4. With the knowledge basic techniques used for qualitative and quantitative estimation students should be in a position to choose for appropriate technique for particular analysis 5. Students should be in a position to select the separation techniques for purification of analytes.	
Content:	**Section A** **1 Analytical Objectives, Data Handling and Good Laboratory Practice (GLP)** Scope of analytical science and its literature, qualitative and quantitative analysis, ways to express accuracy and precision, types of errors and their causes; significant figures, control charts, confidence limit, test of significance, rejection of a result- the Q-test. Introduction to significant analytical procedure such as GLP- standard operating procedures, quality assurance, quality control and analytical method validation. **2 Sampling and Calibration Methods** Sampling and sample preparation, general steps in chemical analysis, calibration of glass wares. Finding the best straight line-least square regression, correlation coefficient; Calibration curves, standard addition technique and internal standards. Chemical concentrations. **3 Electroanalytical techniques** Introduction to electroanalytical techniques, electrochemical cells, electrode potentials, voltametry and polarography, cyclic voltametry, coulometry, controlled potential coulomety and coulometric titrations, Stripping voltammetry, ion-selective electrodes and sensors; Evaluation and Calculation; Application to Inorganic and Organic Trace analysis **Section B** **1. Extraction Techniques** ***Liquid-liquid extraction/solvent extraction:*** partition coefficient, distribution ratio and percent extraction; choice of solvents; Solvent extraction of metal ions-ion association complexes and metal chelates; multiple batch extraction, Craig's counter-current distribution; Introduction to green analytical extraction methods:Supercritical Fluid Extraction (SFE); Pressurized Liquid Extraction (PLE); Ultrasound Assisted Extraction (UAE); Microwave Assisted Extraction (MAE);	7 hr 5 hr 6 hr 4 hr

	Enzyme Assisted Extraction (EAE); Solid Phase Microextraction (SPME); Solid Phase Extraction (SPE) **2. Basic Principles in Chromatographic Methods** Principles of chromatography, classification of chromatographic techniques based on mechanism of retention, configuration, mobile and stationary phase. Efficiency of separation- plate theory (theoretical plate concept) and rate theory (Van Deemter equation). Principles and applications of Paper chromatography, thin layer chromatography, HPTLC, Size exclusion and Ion exchange chromatography. Counter-current chromatography for isolation of natural products. **3. Gas and Liquid Chromatography** Introduction; Instrumental Modules; The Separation System; Choice of Conditions of Analysis; Sample Inlet Systems; Detectors; Practical Considerations in Qualitative and Quantitative Analysis; Coupled Systems-introduction to GCMS, LCMS; Applicability-interpretation and numerical problems; Recent and Future Developments **4.Radioanalytical techniques** Theory and principles of radio analytical technique, detection of nuclear radiation, radiation detectors, pulse height analysis, counting error, analytical application of radioisotopes, neutron activation analysis and isotope dilution analysis.	4 hr 6 hr 4 hr
Pedagogy:	Mainly lectures & tutorials. Seminars / term papers /assignments / presentations/ self-study or a combination of some of these can also be used to some extent. Sessions shall be interactive in nature to enable peer group learning.	
References/ Readings	1. G.D. Christian, *Analytical Chemistry*, John Wiley New York (2004) 6th Edition 2. D.A. Skoog, D. M. West and F. J. Holler, *Fundamentals of Analytical Chemistry*, Sounders College publishing (2014), 9th Ed. 3. F. J. Holler, D. A. Skoog, S. R. Crouch, *Priniciples of Instrumental Analysis*, Thomson Books/Cole , 6thEd. 4. J. Mendham, R.C. Denney, J.D. Barnes and M. Thomas,*Vogel's Text Book of Quantitative Inorganic Analysis*, Pearson Education Asia 2000, 6th Ed. 6. H.H. Willard, L.L. Merritt, J.A. Dean, F.A. Settle, *Instrumental Methods of Analysis*, CBS Publishing New Delhi, 7th Ed. 7. J.H. Kennedy, *Analytical Chemistry:Principles*, Saunders College Publishing 2ndEd. 8. G.W. Ewing, *Instrumental Methods of Chemical Analysis*, McGraw-Hill (Singapore), 5th Ed. 9. L.G.Hargis, *Analytical Chemistry: Principles and Techniques*, Prentice Hall, New Jersey (1988) 10. R. A. Day, Jr. and A. L. Underwood, *Quantitative Analysis*, Prentice Hall, 2001., 6thEd. 11. T. Rocha-Santos, A.C. Duarte, *Comprehensive Analytical Chemistry*, Elsevier, 2014, 1st Ed.	

Programme: M. Sc. Part-I (Chemistry)
Course Code: ICC-401 **Title of the Course: General Inorganic Chemistry**
Number of Credits: 03 **Effective from AY: 2018-19**

Prerequisites for the course:	Students should have studied the courses in Chemistry at F.Y. B.Sc., S.Y.B.Sc. and T.Y.BSc. levels so as to have basic knowledge of Inorganic Chemistry and basic principles.	No. of lectures
Course Objectives:	1. To introduce atomic / molecular structure and symmetry. 2. To provide fundamental knowledge of solid state chemistry. 3. To introduce basic aspects of coordination / organometallic / bioinorganic chemistry. 4. To provide the concepts of acids and bases.	
Course Outcomes:	1. Students should be in a position to understand atomic and molecular structure and the importance of symmetry. 2. Students should be able to understand molecular shapes. 3. Students should be in a position to understand concepts in i) solid state chemistry, ii) coordination chemistry, iii) organometallic chemistry, iv) bioinorganic chemistry.	
Content:	**1. Atomic structure, molecular structure and bonding** 1.1 Atomic Structure: Structures of hydrogenic atoms: some principles of quantum mechanics. Many electron atoms: penetration & shielding, building up principle, classification of elements. spectroscopic terms. Atomic/ionic radii, ionization energy, electron affinity, electrononegativity, polarizability. 1.2 Molecular Structure & bonding: Lewis structures, VSPER model, the basic shapes. Valence bond theory: the hydrogen molecule, homonuclear diatomic & polyatomic molecules; hybridisation. molecular orbital theory: approximation, boding & antibonding orbitals. Homonuclear diatomic & Heteronuclear diatomic molecules. **2. Molecular Symmetry**: 2.1 Symmetry elements 2.2 Symmetry operations, equivalent symmetry elements and equivalent atoms, symmetry point groups with examples, point groups of higher symmetry, systematic procedure for symmetry classification of molecules and illustrative examples, 2.3 Dipole moment, optical activity and point groups. **3. Solid state chemistry** 3.1 Structures of solids: crystal structures, lattices & unit cells, close packing of spheres, holes in closed-packed structures. 3.2 Structures of metals & alloys: polytypism, nonclosed-packed structures, polymorphism of metals, atomic radii of metals, alloys, substitutional solid solutions, interstitial solid solutions of non-metals, intermetallic compounds. 3.3 Ionic solids: Basic characteristic structures of ionic solids, the rationalization of structures, ionic radii, radius ratio, structure maps, the energetics of ionic bonding, lattice energy.	9 hr 4 hr 6 hr

	4. **Coordination Chemistry** 4.1 Introduction, representative ligands, nomenclature, 4.2 Constitution & geometry, low coordination numbers, intermediate coordination numbers, higher coordination numbers, polymetallic compounds. 4.3 Isomerism & chirality in square planar & octahedral complexes, ligand chirality. 4.4 Thermodynamics of complex formation: formation constants, chelate & macrocyclic effects, steric effects & electron delocalization. 4.5 Electronic properties of metal complexes: CFT applied to octahedral and tetrahedral complexes, magnetic moments/CFSE. Electronic spectroscopy: basic concepts, interpretation of spectra of d^1 & d^2 ions (Orgel diagram for octahedral and tetrahedral complexes).	5 hr
	5. **Organometallic Chemistry** 5.1 Introduction to organometallic chemistry, nomenclature, stability and inert gas rules (neutral atom and donor pair electron count methods). 5.2 Ligands CO & phosphines, homoleptic carbonyls/synthesis/ properties/ oxidation-reduction of carbonyls/ basicity/reactions of CO/spectroscopic properties of metal carbonyls. 5.3 Oxidative addition and reductive elimination.	4 hr
	6. **Basic Bioinorganic Chemistry** 6.1 Macronutrients/micronutrients. Role of elements in biology. Metal ion transport role. 6.2 Definition of metallobiomolecules / metalloporphyrins, structure of porphine and heme group, examples of metalloenzymes of copper and zinc.	3 hr
	7. **Acids and Bases** 7.1 Brönsted Acidity, proton transfer equillibria in water, solvent levelling, solvent system definition if acids & bases, characteristics of Brönsted acids, 7.2 Periodic trends in aqua acid strengths, non-aqeuous solvents, Lewis acidity, hard & soft acids and bases, solvents as acids & bases, superacids & superbases.	5 hr
Pedagogy:	Mainly lectures / tutorials. Seminars / assignments / presentations / self-study or a combination of some of these could also be used to some extent.	

Text Books / Reference Books	1. P. W. Atkins, T. Overton, J. Rourke, M. Weller & F. Armstrong, *Shriver & Atkins Inorganic Chemistry*, Oxford Publications, 2009, 5th Ed. 2. J. E. Huheey, E. A. Kieter, R. L. Kieter & O. K. Medhi, *Inorganic Chemistry: Principles of Structure & Reactivity*, Pearson, 2011, 4th Ed. 3. F. A. Cotton, G. Wilkinson & P. L. Gauss, *Basic Inorganic Chemistry*, Wiley, 2008 (reprint), 3rd Ed. 4. J. D. Lee, *Concise Inorganic Chemistry*, Wiley, 2008, 5th Ed. 5. F. A. Cotton, *Chemical applications of group theory*, Wiley Eastern, New Delhi, 1976, 3rd Ed. 6. L. Pauling, *The Nature of The Chemical Bond*, Cornell University Press, 1960, 3rd Ed. 7. M.C. Day & J. Selbin, *Theoretical Inorganic Chemistry*, Van Nostrand-Reinhold, New York, 1969,2nd Ed. 8. H.V. Keer, *Principles of Solid state Chemistry*, New age Intl. Ltd, New Delhi, 1995. 9. A.R. West, *Solid State Chemistry and Its Applications*, John Wiley & Sons, Singapore, 1987. 10. D.K. Chakrabarty, *Solid State Chemistry*, New Age Publishers, 1996, 2nd Ed. 11. F. A. Cotton & G. Wilkinson, *Advanced Inorganic Chemistry*, Wiley Eastern, New Delhi, 1984, 3rd Ed.	

Programme: M. Sc. Part-I (Chemistry)
Course Code: ICC-402 Title of the Course: Lab Course in Inorganic Chemistry
Number of Credits: 02 Effective from AY: 2018-19

Prerequisites for the course:	Students should have studied the courses in chemistry at F.Y. B.Sc., S.Y.B.Sc. and T.Y.BSc. levels so as to have basic knowledge of experimental chemistry.	No. of lectures
Course Objectives:	Students shall be trained in the preparation of coordination compounds / double salts, understanding of redox chemistry, determination of metal content and degree of hydration, and determination of the formula of synthesized compounds. Students will be given hands-on experience in using colorimeter / UV-Vis spectrophotometer while performing instrumental analysis.	
Course Outcomes:	1. Students should be in a position to: i) set up and perform inorganic synthesis ii) isolate and purify crystalline product. iii) develop skills for compound characterization iv) determine the metal content by titrimetry / gravimetry /colorimetry.	
Content:	**Synthesis of inorganic compounds (any six)** 1. $[Ni(NH_3)_6]Cl_2$ 2. $[Co(en)_3]Cl_3 \cdot xH_2O$ 3. $[Co(NH_3)_3(NO_2)_3]Cl_3$ 4. $K_3[Al(C_2O_4)_3] \cdot 3H_2O$ 5. $K_3[Cr(SCN)_6] \cdot 4H_2O$ 6. $K_3[Cr(C_2O_4)_3] \cdot 3H_2O$ 7. $[Cr(OAc)_2]_2 \cdot 2H_2O$ 8. Potash alum from scrap aluminium 9. Zinc iodide (Redox synthesis) **Quantitative estimations/determinations (any six)** 1. Estimation of Ni in $[Ni(NH_3)_6]Cl_2$ titrimetry/gravimetry 2. Estimation of Co in $[Co(en)_3]Cl_3 \cdot xH_2O$ volumetrically 3. Estimation of oxalate in $K_3[Al(C_2O_4)_3] \cdot xH_2O$ or $K_3[Cr(C_2O_4)_3] \cdot xH_2O$ 4. Estimation of nitrite by redox titration 5. Estimation of calcium in calcite ore 6. Estimation of copper in gun metal alloy or Devarda's alloy iodometrically 7. Estimation of Cr in chrome alum and $K_3[Cr(C_2O_4)_3] \cdot xH_2O$ to determine degree of hydration. 8. Colorimetric determination of Cr or Ni	24 hr 24 hr
Pedagogy:	Students should be given suitable pre-lab and post-lab assignments and explanation revising the theoretical aspects of laboratory experiments prior to the conduct of each experiment. Each experiment should preferably be done individually by the students.	
Text Books / Reference Books	1. J. Mendham, R.C. Denney, J.D. Barnes, M.J. K. Thomas, *Vogel's Text Book of Quantitative Chemical Analysis*, 2002, 6th Ed. 2. G. Brauer, *Handbook of Preparative Inorganic Chemistry*, 1963, Vol . 1 & 2. 3. G. Pass & H. Sutcliffe, *Practical Inorganic Chemistry, Preparations, Reactions and Instrumental Methods*, Chapman & Hall, 1974, 2nd Ed. 4. A. J. Elias, *General Chemistry Experiments*, University Press, 2008, Revised Ed. 5. S. DeMeo, J. Chem. Ed., Vol 80, 2003, Pg. No. 796-798. 6. W. L. Jolly, *The Synthesis & Characterization of InorganicCompounds*, Prentice-Hall, INC, 1970.	

Programme: M. Sc. Part-I (Chemistry)
Course Code: ICO-401
Title of the Course: Topics in Inorganic Chemistry & Environmental Chemistry
Number of Credits: 03 **Effective from AY: 2018-19**

Prerequisites for the course:	Student should have studied the courses in chemistry at F.Y. B.Sc., S.Y.B.Sc. and T.Y.BSc. levels and / or CHIC-401 course so as to have basic knowledge of Inorganic / environmental chemistry.	No. of lectures
Course Objectives:	1. To provide fundamental aspects of transition & inner transition metals & their compounds. 2. To provide knowledge of main group elements of the periodic table & their compounds 3. To introduce various global phenomenon's of atmosphere & environment, follow directive of the Supreme Court in 1993 to introduced environmental education at all levels, have a fair knowledge on the various global activities to justify permissible or adverse, so that future generation are not adversely affected.	
Course Outcomes:	1. Students should be in position to understand fundamentals / usefulness of transition & inner transition metals. 2. Students should be in position to understand chemistry main group elements. 3. Students shall be aware of the maintenance of healthy living atmosphere on the globe.	
Content:	SECTION-I 1. **Chemistry of transition & inner transition elements** 1.1 Transition elements**:** IUPAC definition of transition elements, occurrence, physical & chemical properties, noble character, metal oxides & oxido complexes, examples of metal-metal bonded clusters. 1.2 Inner transition elements: Lanthanides, occurrence, properties, oxidation states, electronic structure, colour and spectra, magnetic properties, lanthanide contraction, compounds of lanthanides. Actinoid chemistry, general trends. 2. **Main group elements and their compounds** 2.1 Boron group: Compounds of boron:- borazine and boron nitride, synthesis, properties, structure & bonding. Borates: classification, structures & examples. 2.2 Carbon group: Allotropes of carbon including C_{60}, intercalation compounds of graphite, carbides. Compounds of silicon: silicates, zeolites & silicones. 2.3 Nitrogen group:- Introduction: oxides & oxyacids of nitrogen. 2.4 Oxygen group: oxyacids & oxohalides of S, S_4N_4 ring compounds: synthesis, properties, structure & bonding.	9 hr 9 hr

	SECTION-II 1. **Atmosphere** Structure and properties of the atmosphere, composition of atmosphere and vertical temperature behaviour, lapse rate and temperature inversion. 2. **Air Pollution** Classification of air pollutants and photochemical reactions in the atmosphere Common air pollutants (e.g. CO, NOx, SO_2, hydrocarbons and particulates) (a) sources (b) physiological and environmental effect (c) monitoring , d) various remedial & technological measures to curb pollution. Air quality standards. 3. **Water pollution** Importance of buffer & buffer index in waste water treatments. C hemical, physical & biological characteristics of water pollution, specific & non-specific characterization of water. DO, BOD, COD, and chlorine demand, typical water treatment & waste water treatment (Municipal). 4. **Treatment of Industrial wastes** Electroplating industry, fertilizer industry and pharmaceuticals industries. 5. **Biogeochemical cycles**: Carbon and Nitrogen cycles nature	2 hr 7 hr 5 hr 2 hr 2 hr
Pedagogy:	Mainly lectures / tutorials. Seminars / assignments / presentations / self-study or a combination of some of these could also be used to some extent.	
Text books / reference books	1. P.W. Atkins, T. Overton, J. Rourke, M. Weller, & F. Armstrong, *Shriver & Atkins Inorganic Chemistry*, Oxford publications, 2009, 5th Ed. 2. J. E. Huheey, E. A. Kieter, R. L. Kieter & O. K. Medhi, *Inorganic Chemistry: Principles of Structure & Reactivity*, Pearson, 2011, 4th Ed. 3. F. A. Cotton, G. Wilkinson & P. L. Gauss, *Basic Inorganic Chemistry*, Wiley, 2008 (reprint), 3rd Ed. 4. N.N. Greenwood and A. Earnshaw, *Chemistry of the Elements*, Pergamon Press, Exetr, Great Britain. 1984. 5. J.D. Lee, *Concise Inorganic Chemistry*, Wiley, 2008, 5th Ed. 6. A.V. Salker, *Environmental Chemistry: Pollution and Remedial Perspective*, Narosa Publication, 2017. 7. A.K. De, *Environmental Chemistry*, New Age, 2006. 8. A.C. Stern, R.W. Boubel, *Fundamentals of Air Pollution*, D. Bruce turner & D.L.Fox, Academic Press, 1984. 9. R.A. Horne, *Chemistry of Our Environment*", John Wiley, N.Y. (1978). 10. C.N. Sawyer & P.J. Macarty, *Chemistry for Environmental Engineering*, Mc Graw Hill, 1978. 12. L.L. Ciaccio, *Water and Water Pollution Hand Book*", Marcel Dekker, 1973. 13. J.C. Lamb, *Water Quality and its Control*, John Wiley & Sons, N.Y., 1985.	

Programme: M. Sc. Part-I (Chemistry)
Course Code: OCC-401
Title of the Course: Structure, reactivity, stereochemistry and reaction mechanism
Number of Credits: 03 **Effective from AY: 2018-19**

Prerequisites for the course:	Should have studied the courses / topics in Organic Chemistry at F Y B Sc, S Y B Sc and T Y B Sc levels so as to have basic knowledge of organic nomenclature and basic principles.	
Course Objectives:	3. Introduction of various concepts based on molecular orbital theory. 4. Introduction of topicity, prostereoisomerism and chemo-, regio- and stereoselectivity in organic reactions. 5. Learning mechanistic aspects of various type of reactions in organic synthesis.	
Course Outcomes:	5. Students should be in a position to evaluate effect of delocalization of electrons & presence or absence of aromaticity in organic compounds. 6. Students should be in a position to apply various concepts in stereochemistry to understand stereochemical output in a reaction. 7. Students shall be in a position to understand/propose plausible mechanism of organic reactions.	
Content:	1. **Molecular orbitals and delocalized chemical bonding**: Qualitative description of Molecular orbitals of simple acyclic and monocyclic Systems, Frontier molecular orbitals, Conjugation, cross conjugation, resonance, hyperconjugation and tautomerism (types and examples), Aromaticity: Origin of Huckel's rule, examples of aromatic, non-aromatic and antiaromatic compounds; concept of Mobius aromaticity. 2. **Structure & Reactivity:** Acidity, basicity and pKa of organic compounds; Acid and base strengths; HSAB concept & Factors affecting it, Effect of structure & medium on acid and base strength, Concept of superacids and superbases, Electrophilicity & Nucleophilicity, Examples of ambident nucleophiles & electrophiles. (Including revision of aromatic electrophilic and nucleophilic substitution) 3. **Stereochemistry**: Brief revision of configurational nomenclature: R & S; D & L; E & Z; cis & trans and *syn* & *anti* nomenclature. Chirality in molecules with two and more chiral centres. Conformational analysis of open chain compounds (Butane, 2, 3-butane diol, 2,3-dibromobutane etc.). *Erythro* and *threo* nomenclature. Topicity and Prostereoisomerism: Topicity of ligands and faces-homotopic, enantiotopic and Cram's rule / diastereotopic ligands and faces. Introduction to chemoselective, regioselective and stereoselective reactions. Stereochemistry of *cis*- and *trans*-decalins, conformation and reactivity of cyclohexane and substituted cyclohexanes, cyclohexene / cyclohexanone. 4. **Reaction Mechanism:** Brief revision of carbocations, carbanions, free radicals, carbenes and nitrenes with reference to generation, structure, stability and reactivity; Types of mechanisms, types of reactions, thermodynamic and kinetic control. The Hammond postulate and principle of microscopic reversibility, Methods of determining reaction mechanisms like- 1) Identification of products,	06 hr 06 hr 08 hr 06 hr

	2) Determination of the presence of intermediates (isolation, detection, trapping and addition of suspected intermediate, 3) Isotopic labelling, 4) Stereochemical evidence, 5) Kinetic evidence and 6) Isotope effect (at least two reactions to exemplify each method be studied) 5. **Aliphatic Nucleophilic substitution:** Brief revision of nucleophilic substitutions with respect to Mechanism, Various factors affecting such reactions; The Neighbouring Group Participation (NGP)/ Anchimeric assistance: General approach to various NGP processes; NGP by unshared/lone pair of electrons; NGP by π-electrons; NGP by aromatic rings (formation of phenonium ion intermediate); NGP by sigma bonds with special reference to bornyl and nor-bornyl system (formation of non-classical carbocation) 6. **Elimination reactions:** The E2, E1 and E1cB mechanisms. Orientation of the double bond, Saytzeff and Hofmann rule. Effects of changes in the substrate, base, leaving group and medium on 1) overall reactivity, 2) E1 vs. E2 vs. E1cB and 3) elimination vs substitution, Mechanism and orientation in pyrolytic *syn* elimination (various examples involving cyclic and acyclic substrates to be studied).	06 hr 04 hr
Pedagogy:	Mainly Lectures & tutorials. Seminars / assignments / presentations / self-study or a combination of some of these could also be used to some extent.	
References/ **Readings**	1. D. Nassipuri, *Stereochemistry of Organic compounds - Principles and Application*, Wiley Eastern Limited, 2013, 4th Ed. Kent, [England]: New Academic Science Limited, 2013. 2. E.L. Eliel, *Stereochemistry of carbon compounds*, Tata MacGraw Hill Publishing Company Ltd. (1990) 3. J. March, *Advanced Organic Chemistry: Reaction, Mechanism and Structure*, Wiley, 2010, 4th Ed. 4. J. Clayden, N. Greeves, S. Warren & Wothers, *Organic Chemistry*, Oxford University Press, 2012, 2nd Ed. 5. I.L. Finar *Stereochemistry and Chemistry of Natural products*, ELBS, Longmans, 1963, Vol. 2, 3rd Ed. 6. V.M. Potapov, *Stereochemistry*, MIR Publishers, Moscow, 1979 7. E.S. Gould *et al*., Mechanism and structure in Organic Chemistry, 1965 8. F. A. Carey, *Organic Chemistry*, 2000, 4th Ed. 9. S.H. Pine, *Organic Chemistry*, McGraw-Hill International Edn. 2010, 5thEd. 10. F.A. Carey and R.J. Sundberg, *Advanced Organic Chemistry*, Vol. I & II. Plenum Press, 1977 11. J. M. Harris & C.C. Wamser, *Fundamentals of Organic Reaction Mechanisms*, John Wiley & Sons. Inc. 1976 12. F.M. Menger, D.J. Goldsmith & L. Mendell, *Organic Chemistry, A concise approach*, 1975, 2nd Ed.	

Programme: M. Sc. Part-I (Chemistry)
Course Code: OCC-402
Title of the Course: Laboratory course in Organic Chemistry
Number of Credits: 02 **Effective from AY: 2018-19**

Prerequisites for the course:	Students should have exposure to common laboratory practices and techniques studied at F Y B Sc, S Y B Sc and T Y B Sc chemistry theory / practical courses.	
Course Objectives:	To translate certain theoretical concepts learnt earlier into experimental knowledge by providing hands on experience of basic laboratory techniques required for organic syntheses.	
Course Outcomes:	Students shall gain the understanding of: 1. Stoichiometric requirements during organic syntheses. 2. Safe and good laboratory practices, handling laboratory glassware, equipment and chemical reagents. 3. Common laboratory techniques including reflux, distillation, steam distillation, vacuum distillation, aqueous extraction, thin layer chromatography (TLC)	
Content:	**1. Introduction to laboratory equipments, apparatus and safety:** a) Use of common laboratory equipments like fume hoods, vacuum pumps, weighing balance etc. to be explained to the students. b) Introduction to various types of quick fit joints and apparatus to the students. c) Discussion of Safety Techniques: i) Disposal of chemicals, ii) Usage of protective equipments, iii) First aid, iv) Fire extinguishers, types of fire, d) Hazards of chemicals. **2. Laboratory Techniques:** a. Simple distillation (any one): Toluene-dichloromethane mixture using water condenser, nitrobenzene and aniline using air condenser. b) Steam distillation (anyone):Separation of *o*-and *p*- nitrophenols, naphthalene from its suspension in water, clove oil from cloves. c) Crystallisation: Concept of induction of crystallization(any one) : i) Crystallisation of phthalic acid from hot water using fluted filter paper and stemless funnel. ii) Acetanilide from boiling water iii) Naphthalene from ethanol . iv) Decolorisation and crystallization of brown sugar (sucrose) with animal charcoal using gravity filtration. d) Sublimation: Simple or vacuum sublimation of camphor, naphthalene, anthracene or succinic acid (any one). e) Vacuum distillation (any one): o-dichlorobenzene, diphenyl ether. Also use of nomograph should be explained. f) Thin layer Chromatography (any one): Separation of *o* and *p*-nitroanilines, Separation of analgesic drugs, Separation of *o* and *p*-nitrophenols,	04 hr 24 hr

	3. Organic synthesis (any four experiments): a) Aliphatic electrophilic substitution: Preparation of iodoform from ethanol & acetone. b) Aromatic electrophilic substitution (anyone): Preparation of p-bromoacet-anilide, bromination of acetophenone to phenacyl bromide, nitration of napthathalene to 1-nitronaphthalene, nitration of benzaldehyde to 3-nitrobenzaldehdye. c) Oxidation of: i) Benzoic acid from toluene ii) Cyclohexanone from cyclohexanol, iii) isoborneol to camphor using Jones reagent (any one). d) Reduction (any one): Reduction of *o*-nitroaniline to *o*-phenylenediamine using Sn/HCl; Reduction of *p*-nitro benzaldehyde to *p*-nitrobenzyl alcohol using $NaBH_4$ e) Bromination of an alcohol using CBr_4/ triphenylphosphine. f) Grignard reaction: Triphenylmethanol from benzoic acid ester or benzophenone. g) Aldol condensation: Dibenzal acetone from benzaldehyde h) Acetoacetic ester condensation : Preparation of ethyl *n*-butylacetoacetate or ethyl acetoacetate. i) Cannizzaro reaction using 4-chlorobenzaldehyde as substrate. j) Friedel Craft's reaction (any one): using toluene and succinic anhydride, resorcinol to resacetophenone, benzene and maleic anhydride to *β*-benzoylacrylic acid k) Solvent free preparation of coumarin by the Knoevenagel condensation under MW irradiation. l) Preparation of oxidizing agent (any one): Pyridinium chlorochromate-silica, pyridinium chlorochromate-alumina, MnO_2. m) Preparation of cuprous chloride. **3**. **Isolation from natural sources :** (any one) Caffeine from tea powder, piperine from pepper, cinnamaldehyde from cinnamon	16 hr 4hr
Pedagogy:	Students should be given suitable pre- and post-lab assignments and explanation revising the theoretical aspects of laboratory experiments prior to the conduct of each experiment. Each of the experiments should be done individually by the students.	
References / Readings	1. A.I. Vogel, A.R. Tatchell , B. S. Furniss, A.J. Hannaford, *Vogel's Textbook of Practical Organic Chemistry*, 5th Ed., Prentice Hall; 2011. 2. D. Pasto, C. Johnson and M. Miller, *Experiments and Techniques in OrganicChemistry*, 1st Ed., Prentice Hall, 1991. 3. L.F. Fieser, K.L. Williamson "*Organic Experiments*" 7th edition D. C. Heath, 1992. 4. K.L. Williamson, K.M. Masters, *Macroscale and Microscale Organic*	

	Experiments, 6th Edition, Cengage Learning, 2010 5. R.K. Bansal, *Laboratory Manual in Organic Chemistry*, New Age International, 5th Edition, 2016. 6. S. Delvin, *Green Chemistry*, Sarup & Sons, 2005. 7. O.R. Rodig, C.E. Bell Jr. and A.K. Clark, *Organic Chemistry Laboratory Standard and Microscale Experiments*, Saunders College Publishing, 3rd edition, 2009. 8. J. Mohan, *Organic Analytical Chemistry*, Narosa Publishing House, 2014.	

Programme: M. Sc. Part-I (Chemistry)
Course Code: OCO-401
Title of the Course: Synthetic Organic Chemistry I
Number of Credits: 03 **Effective from AY: 2018-19**

Prerequisites for the course:	Should have studied the courses / topics in Organic Chemistry at F Y B Sc, S Y B Sc and T Y B Sc levels as well as the course CHOC-401 so as to have basic knowledge of organic nomenclature and basic principles.	
Course Objectives:	1. Introduction to concepts of functional groups and their interconversion 2. Learning mechanistic concepts of carbon-carbon bond making by nucleophilic addition to carbonyl group 3. Learning mechanistic aspects of various oxidation & reductionprocesses used in organic syntheses.	
Course Outcomes:	1. Students should be in a position to choose appropriate oxidizing agent for oxidation of a particular functional group. 2. Students should be in a position to choose appropriate reducing agent for reduction of a particular functional group. 3. Students shall be in a position to understand/propose plausible mechanism of organic reactions. 4. Student should be able to choose appropriate nucleophilic addition reaction for making carbon-carbon bond.	
Content:	**1. Oxidation reactions:** Oxidation of organic compounds using chromium (PCC, PDC) and manganese compounds, Oppenauer oxidation, Swern oxidation, ozonolysis. Other methods of oxidation such as selenium dioxide, $Pb(OAc)_4$, HIO_4, peracids, peroxides, OsO_4,RuO_4, DMSO (Swern) sodium bromated / CAN & NaOCl, DDQ, Prevost's reagent and Woodward Conditions; Catalytic oxidation over Pt, Photosensitised oxidation of alkenes, oxidation with molecular oxygen, aromatization, silver based reagents. 2.**Reduction reactions:** Reduction of organic compounds using hydride-transfer reagents and related reactions : MPV reduction, $NaBH_4$, Trialkylborohydrides, LAH & lithium hydridoalkoxyaluminates, mixed LAH-$AlCl_3$ reagents, DIBAL and reduction with borane and dialkylboranes, Enzymatic reduction involving liver alcohol dehydrogenase/NADH & Bakers' yeast, catalytic hydrogenation, Dissolving metal reductions including acyloin condensation, Clemmensen reduction and Birch reduction,Other methods of reduction: Wolff-Kishner, Raney Ni desulphurisation, di-imide. 3.**Halogenation:** Formation of Carbon Halogen bonds: Substitution in saturated compounds, alcohols, carbonyl compounds, substitution at allylic and benzylic compounds, bromodecarboxylation (Hunsdiecker reaction), Finkelstein reaction, iodolactonisation.	11 hrs 9 hrs 5 hrs

	4. **Esterifiction, amide preparation and hydrolysis:** (study of different mechanisms and reagents) 5. **Name reactions**: Knoevenegel Reaction, Claisen, Darzen, Stobbe, Perkin, Aldol, Benzoin, Pechmann condensation.	6 hrs 5 hrs
Pedagogy:	Mainly Lectures & tutorials. Seminars / assignments / presentations / self-study or a combination of some of these could also be used to some extent.	
References/ Readings	1. H. O. House, *Modern Synthetic Reactions*, 2nd Ed., W. A. Benjamin, Benjamin-Cummings Publishing Co., 1972. 2. W. Caruthers, *Modern Methods of Organic Synthesis*, 4thEd.,Cambridge University Press, 2004. 3. M. B. Smith, Jerry March, *Advanced Organic Chemistry- Reaction, Mechanism and Structure*, 6 Ed, Wiley, 2006. 4. F.A. Carey & R.J. Sundberg, *Advanced Organic Chemistry* (Part A & B) 5th Ed., Springer India Private Limited, 2007. 5. P Sykes, *A guidebook to mechanisms in organic chemistry*, 6th Ed., Pearson Edu., 1996. 6. Clayden, Greeves, Warren and Wothers, *Organic Chemistry*, 2ndEd., Oxford University Press, 2002. 7. E.S. Gould, *Mechanism and structure in Organic Chemistry*, Holt, Reinhart and Winston 1965. 8. F. A. Carey, R. M. Giuliano, *Organic Chemistry*, 8thEd., McGraw-Hill, 2010. 9. S.H. Pine, *Organic Chemistry*, 5th Ed, McGraw-Hill International Edn. McGraw-Hill, 1980.	

Programme: M. Sc. Part-I (Chemistry)
Course Code: PCC-401 **Title of the Course: General Physical Chemistry**
Number of Credits: 03 **Effective from AY: 2018-19**

Prerequisites for the course:	Should have studied the courses in chemistry at F.Y B.Sc, S.Y B.Sc & T.Y B.Sc levels so as to have basic knowledge of Physical Chemistry and basic principles.	
Course Objectives:	6. Introduction of various concepts on thermodynamics. 7. Introduction of electro chemistry and kinetics. 8. Learning quantum chemistry.	
Course Outcomes:	8. Students should be in a position to understand various concepts in physical chemistry. 9. Students should be in a position to apply these concepts during the lab course in physical chemistry. 10. Students shall be in a position to answer the NET/SET examination questions based on these topics.	
Content:	1.**Thermodynamics** 1.1 Thermodynamic properties: Gas laws, Real gasses, Boyle temperature, Critical temperature, State and path properties. Intensive and extensive properties. Exact and inexact differentials. Internal energy, enthalpy, entropy, free energy and their relations and significances. Maxwell relations. Thermodynamic equations of state. 1.2 Joule-Thomson effect. Joule-Thomson coefficient for van der Waals' gas. Joule-Thomson effect and production of low temperature, adiabatic demagnetization, Joule-Thompson coefficient, inversion temperature. 1.3 The third law of thermodynamics. Need for the third law. Apparent exceptions to third law. Application of third law. Use of thermodynamic functions in predicting direction of chemical change. Entropy and third law of thermodynamics. 1.4 Phase equilibria: Phase rule, Discussion of two component systems forming solid solutions with and without maximum or minimum in freezing point curve. Systems with partially miscible solid phases. 1.5 Three component systems: Graphical representation. Three component liquid systems with one pair of partially miscible liquids. Influence of temperature. Systems with two pairs and three pairs of partially miscible liquids. The role of added salts. 2.**Electrochemistry** 2.1 EMF series, decomposition potential and overvoltage, electronegativity, basic principles, completeness of deposition, Separation with controlled potentials, constant current electrolysis, composition of electrolyte, potential buffers, physical characteristics of metal deposits. 2.2 Electroplating and electroless plating, electrosynthesis. 2.3 Concepts of acid-base aqueous and non-aqueous solvents, hard and soft acid-base concept and applications.	10 hrs 06 hrs

	3.**Chemical Kinetics** 3.1 General introduction to various types of order of reaction including fractional order, Molecularity of the reaction. 3.2 Introduction to reversible and irreversible reactions and reactions leading to equilibrium. Van'tHoffs equation and analysis of Gibbs free energy of equilibrium reactions. 3.3 Collision Theory and Maxwell Boltzmann distribution of energies of colliding molecules(derivationnotrequired). The concept of collisional cross section and reactive cross section and its significance. 3.4 Comparative study of transition state and collision state theory (derivation not required). 3.5 Free radical reactions, Complex reactions such as acetaldehyde decomposition and reaction between H_2 and Br_2, Homogeneous reactions and acid-base catalysis. 3.6 Elementary enzyme reactions. 4. **Quantum Chemistry** 4.1 Operators, Functions, Eigen value equations, Postulates. 4.2 Schrodinger equation, application to simple system viz. free particle, particle in one dimensional, two dimensional and three dimensional box (quantization, separation of variables, degenerate wave functions). 4.3 Hydrogen like atoms, Schrodinger equation and its solutions, atomic orbital wave functions and interpretation. 4.4 Hückel MO theory, Secular equations, Secular determinant, delocalization energy, charge density, π-bond order, free valence, applications to C_2H_4, C_3H_5(radical), C_4H_6, C_4H_4, C_6H_6, C_6H_8	07 hrs 13 hrs
Pedagogy:	Mainly lectures & tutorials. Seminars / term papers /assignments / presentations / self-study or a combination of some of these may be used. Sessions shall be interactive in nature to enable peer group learning.	
References/ Readings	1. P. W. Atkins and J. D. Paula, *Physical Chemistry*, Eighth Edition, Oxford University Press, (2007) New Delhi. 2. G. M. Barrow, *Physical Chemistry*, Fifth Edition, Tata McGraw Hill, (2016) New Delhi. 3. J. E House, *Principles of Chemical Kinetics* (Second edition) Academic Press,2007 Elsevier Burlington, USA 4. I. N. Levine, *Quantum Chemistry*, Seventh Edition, Prentice-Hall, (1999) New Delhi.	

Programme: M. Sc. Part-I (Chemistry)
Course Code: PCC-402 Title of the Course: Laboratory Course in Physical Chemistry
Number of Credits: 02 Effective from AY: 2018-19

Prerequisites for the course:	Should have studied the courses in Chemistry at F Y B Sc, S Y B Sc & T Y B Sc levels so as to have basic knowledge of Physical Chemistry and basic principles.	
Course Objectives:	1. Introduction of various concepts on thermodynamics. 2. Introduction of electro chemistry and kinetics.	
Course Outcomes:	1. Students should be in a position to understand various concepts in physical chemistry by conducting experiments. 2. Students should be in a position to apply these concepts during the lab course in physical chemistry.	
Content:	1. To study the kinetics of hydrolysis of ethyl acetate and to determine a) Energy of activation b) Entropy of activation and c) Free energy change. 2. To study the kinetics of the reaction between Potassium per sulphate (K), and Potassium iodide (KI), and to determine a) Energy of activation b) Entropy of activation and c) Free energy change. 3. To determine the order of reaction between potassium persulphate and potassium iodide by graphical, fractional change and differential methods. 4. To determine the degree of hydrolysis of salt of weak base and strong acid using conductometer. 5. To determine the composition of a mixture of acetic acid, dichloroacetic acid and hydrochloric acid by condoctometric titration. 6. To determine the dissociation constants of a dibasic acid and obtain derivative plot to get equivalence point. 7. To determine the dissociation constants of a tribasic acid (Phosphoric acid obtain derivative plot to get equivalence point. 8. To determine formal redox potential of Fe^{2+}/Fe^{3+} and Ce^{3+}/Ce^{4+} system obtain derivative plot to get equivalence point. 9. To study the three component system such as toluene, ethanol and water. 10. To study the three component system such as acetic acid,chloroform; and water and obtain tie line. 11. To determine the molecular weight of polyvinyl alcohol by viscosity measurement. 12. To determine the molecular weight of polystyrene by viscosity measurement.	48 hrs
Pedagogy:	Lectures / tutorials / seminars / term papers /assignments / presentations / self-study or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.	
References/ Readings	1. A. Finlay & J.A. Kitchener,"*Practical Physical Chemistry*", Longman 2. F. Daniels & J.H. Mathews,"*Experimental Physical Chemistry*", Longman. 3. A.M.James,"*Practical Physical Chemistry*", 4. D.P. Shoemaker & C.W. Garland, "*Experimental Physical Chemistry*", McGraw-Hill.	

Programme: M. Sc. Part-I (Chemistry)
Course Code: PCO-401 **Title of the Course: Topics in Physical Chemistry**
Number of Credits: 03 **Effective from AY: 2018-19**

Prerequisites for the course:	Should have studied the courses in Physical Chemistry at F Y B Sc, S Y B Sc and T Y B Sc levels so as to have basic knowledge of Physical Chemistry and basic principles.	
Course Objectives:	1. Introduction of various mathematical concepts forChemistry. 2. Introduction of topics viz. magnetic materials and properties, photochemistry, Nano materials.	
Course Outcomes:	1. Students should be in a position to understand various concepts in physical chemistry. 2. Students should be in a position to apply these concepts during the lab course in physical chemistry. 3. Students shall be in a position to answer the NET / SET examination questions based on these topics.	
Content:	1.**Mathematical Preparations:** 1.1 Introduction to various functions and function plotting (exponential, logarithmic, trigonometric etc.), functions of many variables. Complex numbers and complex functions. 1.2 .Linear equations, vectors, matrices and determinants. 1.3 Basic rules of differentiation and integration, Partial differentiation, location and characterization of critical points of a function, Regression methods, curve fitting. 1.4 Introduction to series, convergence and divergence, power series, Fourier series, Fourier transformations and Numerical methods 2.**Magnetic Properties** 2.1 Types of magnetism (dia, para, ferro, antiferro and ferrimagnetism) Magnetic susceptibility and its determination. 2.2 Magnetization curves and hysteresis, magnetic anisotropy, magnetic exchange interactions, Neel temperature and magnetic transition. 2.3 Ceramic magnetic materials, Applications of magnetic Materials 3.**Photochemistry**: 3.1 Absorption and emission of radiation of photochemical interest. Einstein's equation. 3.2 Jablonskii's diagram illustrating fluorescence and phosphorescence. 3.3 Prompt and Delayed Fluorescence. Factors affecting Fluorescence life time and quantum yield. 3.4 Flash photolysis and lasers. Photosensitised reactions and photosynthesis. 4. **Nanomaterials:** 4.1 Introduction, Chemical synthesis and methods of structural characterization.	18 hrs 08 hrs 06 hrs 04 hrs

	4.2 Areas of application, Societal health and environmental impact.	
Pedagogy:	Mainly lectures & tutorials. Seminars / term papers / assignments / self-study / or a combination of some of these can be used to some extent. Sessions shall be interactive in nature to enable peer group learning.	
References/ Readings	1. P.L. Alger, *Mathematics for Science and Engineering*, McGraw-Hill, New York (1963). 2. E. Kreyszic, *Advance Engineering Mathematics*, Wiley-Eastern, New Delhi (1987). 3. L.N. Muley, *Magnetic susceptibility*, Interscience Publishers, New York (1963). 4. K.K. Rohatgi-Mukherjee, *Fundamentals of Photochemistry*, Wiley Eastern Ltd. New Delhi (1988). 5. G.A. Ozinand A.C. Arsenault, *Nanochemistry: A chemical approach to Nanomaterials*, RSC Publishing, Cambridge, (2005).	

Annexure-I

M Sc Part-II Revised Syllabus April 2019

Code	Title	Credits
	CORE PAPERS	
ANALYTICAL CHEMISTRY		
ACC -501	Fundamentals of Chemical Analysis	3
ACC- 502	Techniques in Chemical Analysis	3
ACC -503	Separation Techniques	3
ACC -504	Spectral methods of analysis	3
ACC- 505	Experiments in Analytical Chemistry	3
INORGANIC CHEMISTRY		
ICC -501	Coordination and Organometallic Chemistry	3
ICC- 502	Materials Chemistry	3
ICC- 503	Group Theory and Spectroscopy	3
ICC -504	Selected Topics in Inorganic Chemistry-I	3
ICC -505	Experiments in Inorganic Chemistry	3
ORGANIC CHEMISTRY		
OCC- 501	Organic Spectroscopy	3
OCC-502	Reaction Mechanisms, Stereochemistry and Asymmetric Synthesis	3
OCC- 503	Synthetic Methods in Organic Chemistry	3
OCC -504	Pericyclic and Organic Photochemical Reactions	3
OCC-505	Organic mixture separation and identification	3
PHYSICAL CHEMISTRY		
PCC-501	Quantum Chemistry and Statistical Thermodynamics	3
PCC-502	Thermodynamics and Reaction Kinetics	3
PCC-503	Electrochemistry and Surface Studies	3
PCC-504	Group Theory and Spectroscopy	3
PCC-505	Experiments in Physical Chemistry	3
PHARMACEUTICAL CHEMISTRY		
HCC-501	Pharmaceutical Chemistry II	3
HCC-502	Drug Product Formulation And Development	3
HCC-503	Drug Design And Development	3
HCC-504	Drug Quality And Regulatory Affairs	3
HCC-505	Laboratory Course In Pharmaceutical Chemistry	3
	OPTIONAL PAPERS	
ANALYTICAL CHEMISTRY		
ACO 501	Spectral Methods of Analysis	3
ACO 502	Calibrations and Validation	3
ACO 503	Advanced Mass Spectrometry	3
ACO 504	Environmental control and chemical analysis	3
ACO 505	Problems on Combined Spectroscopy	3
ACO 506	Chemometrics	3
INORGANIC CHEMISTRY		
ICO 501	Bioinorganic Chemistry	3
ICO 502	Catalysis: The basic Chemical concepts	3
ICO 503	Chemistry of P-Block Elements	3

ORGANIC CHEMISTRY		
OCO-501	Chemistry of Natural Products	3
OCO-502	Organometallic Chemistry	3
OCO-503	Introduction to Medicinal Chemistry	3
OCO-504	Retrosynthesis in Organic Chemistry	3
OCO-505	Heterocyclic Chemistry	3
OCO-506	Introduction to Polymer Chemistry-I: Basic Concepts	3
OCO-507	Introduction to Polymer Chemistry-II: Synthesis of Polymers and Processing	3
OCO-508	Selected experiments in Organic Chemistry-I	4
OCO-509	Chemistry of Life	3
PHYSICAL CHEMISTRY		
PCO-501	Solid State Chemistry I: Concepts and applications	3
PCO-502	Catalysis: Fundamentals and Applications	3
PCO-503	Solid State Chemistry II: Characterization of solid materials	3
PCO-504	Chemical kinetics and reaction dynamics	3
PCO-505	Colloids and Surface Science	3
PCO-506	Nanoscience: Concepts and Applications	3
PHARMACEUTICAL CHEMISTRY		
HCO-501	Pharmacological and Toxicological Screening Techniques	3
HCO-502	Calibration and Validation	3
HCO-503	Polymers in Pharmaceuticals and novel drug delivery systems	3
HCO-504	Biopharmaceutics	3
HCO-505	Pharmaceutical Technology	3
HCO-506	Pharmaceutical Stability	3
HCO-507	Laboratory Course in Natural Product Analysis	3
HCO-508	Laboratory Course in Drug Product Formulation and Development	4
HCO-509	Laboratory Course in Drug Design, Molecular Docking and Patents	2
HCO-510	Laboratory Course in Quality Control and Quality Assurance	4
GENERAL OPTIONAL		
CGO-500	Dissertation (as given in OA 18A)	8
CGO: 501	Selected Experiments in Chemistry	8

M.Sc. PART II SYLLABUS IN ANALYTICAL CHEMISTRY
M. Sc. PART II: ANALYTICAL CHEMISTRY

Compulsory courses			**Optional courses**		
Code	**Title**	**Credits**	**Code**	**Title**	**Credits**
ACC 501	Fundamentals of Chemical Analysis	3	ACO 501	Spectral Methods of Analysis	3
ACC 502	Techniques in Chemical Analysis	3	ACO 502	Calibrations and Validation	3
ACC 503	Separation Techniques	3	ACO 503	Advanced Mass Spectroscopy	3
ACC 504	Spectral methods of analysis	3	ACO 504	Environmental control and chemical analysis	3
ACC 505	Experiments in Analytical Chemistry	3	ACO 505	Problems on Combined Spectroscopy	3
			ACO 506	Chemometrics	3
			General Optional Courses		
			CGO-500	Dissertations	8
			CGO-501	Selected Experiments in Chemistry	8

Programme: M. Sc. Part-II (Analytical Chemistry)
Course Code: ACC-501
Title of the Course: Fundamentals of Chemical Analysis
Number of Credits: 3 **Effective from AY:** 2019-20

Prerequisites for the course:	Should have knowledge about difference between analytical chemistry and chemical analysis, role of analytical chemist, differences between conventional method of analysis and instrumental methods.	
Course Objectives:	1. Introduction to the various chemical method of analysis, details of underlying principle of chemical methods, advantages and limitations 2. Application of chemical methods for qualitative and quantitative estimation	
Course Outcomes:	1. Students should be in a position to understand basic principle behind different conventional method of analysis. 2. Student should understand the limitation of method of analysis, should be in a position to choose for appropriate chemical method for particular analysis 3. Students should be in a position to understand the basic chemistry on which the method of analysis based on.	
Content:	**1 Acid-Base Titrations** Theory of acid-base indicators for Acid-Base titrations; colour change; range of indicator; selection of proper indicator; indicator errors; neutralization curves for strong acid-strong base, weak acid-strong base and weak base-strong acid weak acid-weak base titrations; poly functional acids and bases; titration curves for poly functional acids and bases; titration curves for amphiprotic species; determining the equivalence point; feasibility of acid - base titrations; magnitude of the equilibrium constant; effect of concentration; typical applications of acid-base titrations. **2 Precipitation titrations** Introduction; feasibility of precipitation titrations; titration curves; effect of titrant and analyte concentration on titration curves; effect of reaction completeness on titration curves; titration curves for mixture of anions; indicators for precipitation titrations; the Volhard, the Mohr and the Fajans methods **3 Complexometric titrations** The complex formation reactions; stability of complexes; stepwise formation constants; organic complexing agents; amino carboxylic acid titration; EDTA; acidic properties of EDTA; EDTA complexes with metal ions; equilibrium calculations involving EDTA in solution; condition of formation constants; EDTA titration curves; effect of other complexing agents on EDTA; factor affecting the titration curves; completeness of reaction; indicators for EDTA titrations; theory of common indicators; titration methods using EDTA- direct titration, back titration and displacement titration; indirect determinations; titration of mixtures; selectivity, masking and damasking agents; applications of EDTA titrations- hardness of water; magnesium and Al in antacids; magnesium, manganese and zinc in a mixture.	10 hrs 3hrs 8hrs

	4. Basic concepts in Electrochemical Titrations Faradic and non-Faradic currents; reversible and irreversible cells; EMF series; standard electrode potential; Nernst equation; calculation of cell potential; effect of current; ohmic potential; polarization; decomposition potential; over voltage; concentration polarization; mechanism of mass transport; introduction to potentiometric methods **5. Redox titrations** Redox Titrations: Equilibrium constants for redox reactions- electrode potentials in equilibrium systems; calculation of equilibrium constants; redox titration curves- formal redox potentials; derivation of titration curves; factors affecting the shape of titration curves concentration; completeness of reaction; titration of mixtures- feasibility of redox titrations; detection of end point and redox indicators; structural aspect of redox indicators; specific and nonspecific indicators; choice of indicator; potentiometric end point detection; sample preparation- pre-reduction and pre-oxidation. **6. Radioimmunoassay** Radioimmunoassay; its principle and applications; instrumentation for radio bioassay; clinical application of the radioimmunoassay of insulin, estrogen and progesterone; receptor techniques of breast cancer; enzyme- linked immunosorbent assay; principles; practical aspects; applications. **7. Gravimetric analysis** Introduction; properties of precipitates and precipitating reagents; completeness of precipitates; super saturation and precipitate formation; particle size and filterability of precipitates; colloidal precipitates; crystalline precipitates; purity of the precipitate; co-precipitation, post precipitation; conditions for precipitation; fractional precipitation; precipitation from homogenous solution; organic reagent as precipitants-dimethyl gloxime, oxine, cupferon, salicyldoxime, washing of precipitates; drying and ignition of precipitates; calculation of results from gravimetric data; applications.	3 hrs 4 hrs 3 hrs 5hrs
Pedagogy:	lectures/ tutorials/ seminars/ term papers/assignments/ presentations/ self-study or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.	
References/ Readings	1. G. D. Christian, *Analytical Chemistry*, John Wiley, New York, 2004, 6th Ed. 2. D. A. Skoog, D. M. West & F. J. Holler, *Fundamentals of Analytical Chemistry*, Sounders College publishing, 2014, 9th Ed. 3. J. Mendham, R.C. Denney, J.D. Barnes & M. Thomas, *Vogel's Textbook of Quantitative Inorganic Analysis*, Pearson Education Asia 2000, 6th Ed. 4. D. Harvey, *Modern analytical chemistry*, The McGraw-Hill, 2000, 1st Ed. 5. G. H. Jeffery, J. Bassett, J. Mendham, R C. Denney, *Vogel's Text Book of Quantitative Chemical Analysis*, John Wiley, New York, 1989, 5th Ed.	

Programme: M. Sc. Part-II (Analytical Chemistry)
Course Code: ACC-502
Title of the Course: Techniques in Chemical Analysis
Number of Credits: 3 **Effective from AY:** 2019-20

Prerequisites for the course:	Students should have studied the theory/ instrumentation and application of some of the basic analytical techniques such as colorimetry, pH-metry, emission techniques at B. Sc. or M. Sc. Part I level for better understanding of the course content	
Course Objectives:	1. Introduction of various experimental techniques for analysis. 2. Evaluate the utility of various analytical techniques as a qualitative and quantitative tool.	
Course Outcomes:	1. Students should be in a position to differentiate between various analytical techniques based on their theory and sensitivity achieved. 2. Exposure to various electrochemical and optical techniques for its application to qualitative and quantitative estimation at trace level.	
Content:	**1. Principles and practise of optical analytical techniques –Part-1** 1.1. Nephelometry and Turbidimetry: Introduction to principle, instrumentation and application of nephelometry, turbidimetry. Factors affecting measurement, choice between nephelometry and turbidimetry; turbidimetry and colorimetry; nephelometry and fluorimetry; applications of nephelometry and turbidimetry. 1.2. Introduction, principle and Instrumentation of Polarimetry; application of optical rotation method in rate constant determination; acid- catalyzed muta rotation of glucose; inversion of cane sugar; relative strengths of acids. Introduction to terms such as optical rotatory dispersion (ORD), plan curves, cotton effect curves, circular dichroism, octant rule for ketones. **2. Principles and practise of optical analytical techniques –Part-2** 2.1. Principles and practices of Spectrophotometric Analysis: Introduction; law of absorption; absorbance and transmittance spectrum; technique for colour comparison; spectrophotometer instrumentation- single and double beam spectrophotometer; applications 2.2. Principles of Emission Techniques: Theory; excitation techniques; electrodes and their shapes; Quantitative and qualitative application, brief introduction to ICP-MS **3. Principles and practise of electro analytical and thermal techniques** 3.1. Introduction to Ion selective electrodes; construction, application and selectivity coefficient of Ion selective electrode; pH measurement; buffer solution; glass electrode; instrument for pH measurement. 3.2. Thermoanalytical Methods: Thermogravimetry, Differential Thermal Analysis (DTA), and Differential Scanning Calorimetry: DSC 3.3. Basic aspects of conductometric titration; types of conductometric titration; advantages and disadvantages of conductometric titration;	10hrs 10hrs 16hrs

	Introduction; theory; instrumentation; advantages, disadvantages and applications of High frequency titrations. 3.4. Karl Fischer Titration: Introduction; theory; instrumentation; advantages, disadvantages and applications; Karl Fischer reagent- Introduction; determination of water content in industrial samples.	
Pedagogy:	lectures/ tutorials/ seminars/ term papers/assignments/ presentations/ self-study or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.	
Text Books/ References / Readings	1. B. K Sharma, *Instrumental methods of chemical analysis*, Goel Publishing House, Meerut, 2004 2. A. I. Vogel, *Text Book of Quantitative Inorganic Analysi,* Longman Scientific & Technicial, 1989 3. G.W. Ewing, *Instrumentation Methods of Chemical Analysis*, McGraw Hill; 1985 4. S. M. Khopkar, *Basic Concepts of Analytical Chemistry*, New Age International, 1998 5. R. D. Barun, *Introduction to Instrumental analysis*, Pharma Med Press, Hyderabad, 2012 6. G. D. Christian, *Analytical Chemistry*, Fifth Edition, John Wiley and Sons, NY, 2014 7. G. Chatwal & S. Anand, *Instrumental Methods of Chemical Analysis,* Himalaya publishing House, Mumbai, 2018 8. D.A. Skoog, D.M. West, F.J. Hollar, S.R. Crouch; *Fundamentals of Analytical Chemistry*, Belmont: Brooks/Cole: Cengage Learning, cop. 2014. 9. H. Willard, L.L. Merritt, J.A. Dean, F.A. Settle, *Instrumental Methods of Analysis*, HCBS Publishing New Delhi, 2004 10. H. Gunzler and A. Williams; *Handbook of Analytical Techniques*, WILEY-VCH Verlag GmbH; 2001	

Programme: M. Sc. Part-II (Analytical Chemistry)

Course Code: ACC-503

Title of the Course: Separation Techniques

Number of Credits: 3 **Effective from AY:** 2019-20

Prerequisites for the course:	Should have knowledge of basic analytical techniques such as chromatography, electro-analytical techniques and data handling at MSc part-I level.	
Course Objectives:	1. Introduction of various statistical approach used in analytical data handling 2. Introduction of different separation techniques used for qualitative, quantitative estimation	
Course Outcomes:	1. Students should be in a position to understand principle behind different purification techniques. 2. Students should be in a position to select the separation techniques for purification of analytes from interferents. 3. To understand the HPLC method development and application in qualitative and quantitative analysis	
Content:	**1. Basic Separation Technique:** 1.1. General aspects of separation techniques-role of separation technique in analysis; 1.2. Separating the analyte from interferents 1.3. General theory of separation efficiency: Separation factor 1.4. Classifying separation techniques: Separations based on Size; Separations based on mass or density, Separations based on complexation reactions (Masking); Separations based on a change of state; Separations based on a partitioning between phases. (Note: Following techniques shall be discussed as representative example) 1.5. Basic principles of distillation; theory of vacuum, steam, azeotropic and fractional distillation. 1.6. Fractionation by solvent extraction: based on chemical nature and based on polarity of analyte. 1.7. Centrifugation techniques: Sedimentation velocity, Analytical and preparative centrifugation; Density gradient centrifugation; applications in separation. **2. Chromatographic Methods:** 2.1. Introduction to chromatography: definitions, theories, principles of chromatographic technique, terms and parameters used in chromatography, classification of chromatographic methods, Partition versus adsorption chromatography, development of chromatograms, qualitative and quantitative analysis by chromatography; 2.2. Planar Chromatography (Paper and thin layer): 2.2.1. Paper Chromatography- introduction, principle, theory, types (ascending, descending, circular, two dimensional paper chromatography); techniques; choice of solvent; multiple development, qualitative and quantitative measurement applications; 2.2.2 Thin Layer Chromatography (TLC)- definition; mechanism; efficiency of thin layer plates; methodology (technique); criteria	6 hrs 24hrs

	for selection of stationary and mobile phases (numerical to calculate elution strength of mixed solvents used as mobile phase); choice of adsorbents; preparation of plates; spotting (spot capacity); development of chromatogram; identification and detection using physical and chemical methods; reproducibility of Rf values and improving resolution; Two-dimentional TLC; comparison of TLC with paper chromatography, column chromatography, thin layer ionophoresis and electrophoresis; Qualitative, quantitative evaluation and applications; 2.3. High-performance TLC (HPTLC): introduction, principle, theory, classification (classical, high performance, ultra, preparative HPTLC); Difference between TLC and HPTLC with respects to the parameters; scanning densitometer; Quantitative analysis using TLC-densitogram and applications. 2.4. Gas Chromatography (GC): Instrumentation, selection of operating condition, choices of GC column, methods to prepare derivatives of samples (silylation, acylation, alkylation), working principle of GC detectors such as TCD, ECD, FID, Analysis of GC data and quantification methods such as normalizing peak area, internal std., external std, standard addition. 2.5. Column Chromatography- definition; types (conventional, flash, LPLC, Dry column vacuum chromatography); principle; packing, loading, eluting and collecting eluent in the column chromatography and experimental requirements; theory of development; migration rates of solutes; band broadening and column efficiency; variables that affect column efficiency; Van Deemeter equation and its modern version; scale-up and thump rule for conventional column, qualitative and quantitative analysis; applications. 2.6. Liquid-liquid partition chromatography (HPLC)- Introduction; selection of stationary and mobile phase; types of bonded phase chromatography-NPC and RPC and stationary phases used; reversed phase partition chromatography; steps in HPLC method development in partition chromatography- elution techniques (isocratic and gradient, ion pairing agents, buffer agents, organic modifiers); optimization of capacity factor, gradient selectivity factor and column plate numbers; numerical on method development using Snyder's polarity index. Preparative vs analytical HPLC; Chiral chromatography- Pirkle stationary phases, examples of enantiomer separation such as ibuprofen, calculation of enantiomeric excess. Choosing detectors- working principle of RI, UV-Vis, conductivity and ELSD. 2.7. Size Exclusion Chromatography: definition; theory; principle; types; stationary phases in gel chromatography; physical and chemical characteristics of gel, mechanism of gel permeation chromatography (GPC); instrumentation of GPC; applications of GPC- determination of molecular weight of polymer with numericals. 2.8. Supercritical-Fluid Chromatography: introduction; important properties of supercritical-fluids; instrumentation and variables, SFC column vs other column, applications.	

	3. Electrophoresis: 3.1. Theory of electrophoresis; Type of electrophoresis- Free solution and supporting medium electrophoresis, paper electrophoresis, capillary electrophoresis and gel electrophoresis. 3.2. Capillary electrophoresis-instrumentation, sample introduction in CE, types of CE methodology, electrophoretic mobility and electroosmatic mobility, total mobility, efficiency and resolution in CE column, numericals. 3.3. Gel electrophoresis - types of gel, Polyacrylamide gel electrophoresis PAGE, Agarose GE, factors affecting separation; 3.4. Staining and detecting electrophoresis band; 3.5. Separation of neutral molecule by MEKC; 3.6. Separation and determination of Vitamin B-complex by using CZE and MEKC.	6 hrs
Pedagogy:	Lectures/ tutorials/ seminars/ term papers/assignments/ presentations/ self-study or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.	
References/ Readings	1. G. D. Christian, *Analytical Chemistry*, John Wiley, New York, 2004, 6th Ed. 2. D. A. Skoog, D. M. West,F. J. Holler, *Fundamentals of Analytical Chemistry*, Sounders College Publishing, 2014, 9th Ed. 3. D. Harvey, *Modern Analytical Chemistry*, The McGraw-Hill, 2000, 1st Ed. 4. L. R. Snyder, J. J. Kirkland, J.W. Dolan*, Introduction to modern liquid chromatography*, John Wiley, New York, 2009, 3rd Ed. 5. H.H. Willard, L.L. Merritt, J.A. Dean, F.A. Settle, Instrumental *methods of Analysis*, CBS Publishing New Delhi, 7th Ed. 6. G. H. Jeffery, J. Bassett, J. Mendham, R C. Denney, *Vogel's Text Book of Quantitative Chemical Analysis*, John Wiley, New York, 1989, 5th Ed. 7. H. Gunzler, A.Williams, *Handbook of analytical techniques*, John Wiley, New York, 2002, 1st Ed.	

Programme: M. Sc. Part-II (Analytical Chemistry)
Course Code: ACC-504
Title of the Course: Spectral methods of analysis
Number of Credits: 3 **Effective from AY:** 2019-20

Prerequisites for the course:	Students should have studied the theory/ instrumentation and application of some of the basic analytical techniques at B. Sc. or M. Sc. Part I level for better understanding of the course content	
Course Objectives:	1. Introduction of various spectral methods for analysis. 2. Evaluate the utility of various analytical techniques as a qualitative and quantitative tool.	
Course Outcomes:	1. Students should be in a position to understand theory and instrumentation of various spectral methods of analysis. 2. Understanding application of studied methods for qualitative and quantitative estimation at trace level.	
Content:	**1. Automation of Analytical Method**: An overview of automated system; definition; distinction between automatic and automated system; advantages and disadvantages by automation; types of automated techniques. Discrete and continuous automation, Introduction to Flow injection analysis. **2. X-ray Absorption, Diffraction; Neutron Diffraction and Fluorescence Spectroscopy:** Introduction; origin of X-rays; interaction of X-ray with matter; X-ray spectrometer; theory of X-ray absorption; X-ray diffraction by crystal; comparison of X-ray absorption with X-ray diffraction; Bragg's law; interpretation of X-ray diffraction powder pattern; calculation of lattice parameters; neutron diffraction introduction; theory; instrumentation and applications; X-ray fluorescence- introduction; applications. Introduction to Mossbauer spectroscopy; theory and application. **3. Molecular Fluorescence, Phosphorescence and Chemiluminescence Spectroscopy**: Introduction; meaning of luminescence and chemiluminescence; principles of fluorescence, chemical structure and fluorescence; theory of molecular fluorescence; instrumentation- single and double beam filter fluorimeters, relationship between intensity of fluorescence and concentration; spectrofluorometer; phosphorimeter; factors influencing fluorescence and phosphorescence; basic differences in measurement of fluorescence and phosphorescence; advantages; limitations and precautions; selection of excitation wavelength for analysis; reporting fluorescence spectra; applications of fluorimetric analysis. Chemiluminescence: Introduction; principle; types; chemiluminescence with Luminol, instrumentation; measurement of chemiluminescence; quantitative chemiluminescence; Introduction to gas phase chemiluminescence analysis, chemiluminescence titrations and electro-chemiluminescence. **4. Microscopy:** Chemical microscopy- microscope; parts and optical path; numerical aperture and significance; applications and qualitative and quantitative study;	5 hrs 10hrs 12hrs 9 hrs

	Electron microscopy- principle, operation, sample preparation, replicas, shadowing, application to analysis; electron probe analyzer, ion microscope; metallography- metallurgy, microscopic examination; specimen preparation and examination; interpretation of micrographs; SEM, TEM, AFM. Introduction to Magnetic resonance imaging (MRI) technique and Photo acoustic spectroscopy ; theory and applications	
Pedagogy:	lectures/ tutorials/ seminars/ term papers/assignments/ presentations/ self-study or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.	
Text Books/ References / Readings	1. D. A. Skoog, *Principles of Instrumental Analysis*, Sounders, 1997, 5th Ed. 2. B. D. Cullity, *Elements of X- ray Diffraction*4, Addison Wisley, 1967 3. J. Wormald, *Diffraction Method*, Oxford University, Press, 1973 4. Baun, G.E. Butleworth, *Neutron Scattering in Chemistry,* London, 1971 5. N.N. Greenwood, T.C. Gibbs, *Mossbauer Spectroscop,* Chapmann Hall; 1971 6. V. I. Goldanski, R. H. Harber, *Chemical Application of Mossbauer Spectroscopy,* Academic Press, 1968 7. C.N.R. Rao, G.R Ferraro, *Spectroscopy in Inorganic Compounds,* Academic Press, 1970 8. R. Cheney, *Basic Principles of Spectroscopy,* Mac Grows Hill, 1971 9. M. A. Brown, R. C. Semelka; *MRI: Basic Principles and Applications*, Wiley, Chichester, 1995 10. K. burger, London, Butterworth group Coordination Chemistry: Experimental Methods; CRC Press, 1973 11. R.S. Drago, *Physical Principles in Inorganic Chemistry*, Reinhold Publishing Corp., New York, 1965 12. R. D. Broun, *Introduction to Instrumental Analysis,* Mc Graw Hill, 1987 13. A. M. Garcia-Campana, *Chemiluminescence in Analytical Chemistry,* CRC Press; 2001	

Programme: M. Sc. Part-II (Analytical Chemistry)
Course Code: ACC-505
Title of the Course: Experiments in Analytical Chemistry
Number of Credits: 3 **Effective from AY:** 2019-20

Prerequisites for the course:	Should have studied the courses in Analytical Chemistry Practicals at MSc-I levels so as to have basic knowledge of quantitative analysis.	
Course Objectives:	1. Introduction of various experimental techniques for analysis. 2. Learning data analysis, handling and interpretation of spectra	
Course Outcomes:	1. Students should be in a position to use standardized material to determine an unknown concentration. 2. To gain experience with some statistics to analyse data in lab 3. Student should be in position to use different techniques for qualitative and quantitative estimation	
Content:	This course consists of 7 units of experiments in various areas of Analytical chemistry. Minimum 14 experiments shall be carried out and at-least 2 experiments from each unit. **UNIT 1: Analysis of Pharmaceutical Tablets/Samples** 1. Estimation of streptomycin in tablet sample by Maltol method 2. Estimation of Ibuprofen / Paracetamol 3. Estimation of sulphadiazine / sulphonamide 4. Determination of moisture content in tablet powder by Karl Fischer titration **UNIT 2: Planar and column Chromatography** 1. Separation of alpha amino acids by paper chromatography and to study effect of mobile phase on resolution. 2. Thin layer chromatography analysis of commercial available analgesic and to identify the active ingredients. 3. Purification and determination of amount of paracetamol from commercial tablet by column chromatography 4. Separation of a mixture of benzoin and benzil on silica gel column **UNIT 3: Ion exchange Chromatography and Solvent Extraction Method** 1. To determine the capacity of a cation exchange resin 2. To separate organic mixture (acidic+basic+Netral) by extraction 3. To separation and estimate the zinc and nickel ions using an anion exchange resin 4. To determine the Fe ion as Fe-oxine complex **UNIT 4: HPLC Analysis:** 1. HPLC analysis of benzaldehyde and benzyl alcohol using isocratic elution 2. To study HPLC method development by using linear and stepwise gradient elution for binary system 3.To analyze a mixture (benzene and toluene, anthracene and naphthalene) by Reverse phase-HPLC 4. HPLC analysis of Analgesics in a commercial sample/tablet, Ibuprofen to develop and validate the analytical method of any one drug using HPLC	

	UNIT 5: Gas Chromatographic Analysis: 1. Quantitative analysis of a mixture of chloroform and carbon tetrachloride 2. Gas chromatographic analysis for a mixture of gases like O_2, N_2 and CO_2 **UNIT 6: Spectrophotometry Method:** 1. To determine pk value of methyl red indicator at room temperature 2. To determine the stoichiometry and stability constant of ferric salicylic acid complex by Job's method and mole ratio method 3. To determine the amount of each caffein and benzoic acid from the soft drink by UV spectrophotometry. 4. To record UV absorption spectrum of acetone in n-hexane and in water to identify the various transition. **UNIT 7: Electrochemical Method:** 1. pH-metric determination of hydrolysis constant of aniline hydrochloride 2. pH-metric determination of the acid-base dissociation constant and isoelectric point of amino acid	
Pedagogy:	Prelab exercises/assignments/ presentations/ lab hand-out or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.	
Text Books/ References / Readings	1. J. H. Kennedy, *Analytical Chemistry Practice*, Saunders College Publishing, 1990, 2nd Ed. 2. G. D. Christian, *Analytical Chemistry*, John Willey and Sons, 1994,5th Ed. 3. *Vogel's Text book of Quantitative Inorganic Analysis*, Pearson Educatio n, Asia, 2000, 6th Ed. 4. A. J. Elias, *Collection of Interesting Chemistry Experiments*, University press, 2002. 5. A R West, *Solid State Chemistry and its Applications*,John Wiley & Sons , 1987. 6. R. A. Day, L. Underwood, *Quantitative Analysis*, prentice Hall, 2001, 6th Ed. 7. J. Kenkel, *Analytical Chemistry for technicians*, Lewis publishers, 2002, 3rd Ed.	

Programme: M. Sc. Part-II (Analytical Chemistry)

Course Code: ACO-501

Title of the Course: Bioanalytical and Forensic Chemistry

Number of Credits: 3 **Effective from AY:** 2019-20

Prerequisites for the course:	Should have studied the analytical chemistry at T Y B Sc (Chemistry) and M Sc part-I (Chemistry) levels.	
Course Objectives:	1. The purpose of this course is to provide basic understanding of medical laboratory clinical chemistry and forensic chemistry 2. Identify various types of evidence that may be collected at a crime scene including procedures for identification, collection, and analysis for the purpose of investigating and prosecuting crimes.	
Course Outcomes:	1. Apply principles of safety, quality assurance and quality control in clinical and forensic chemistry. 2. The students should be in position to select methods required for forensic and clinical sample analysis. 3. The students will be in a position to understand the principal and applications of various analytical methods used in clinical and forensic laboratory.	
Content:	**1. Clinical Chemistry:** 1.1. Composition body fluid; detection of abnormal levels of certain constituents leading to diagnosis of diseases; sample collection and preservation of physiological fluids; 1.2. analysis of physiological fluids**-** blood, urine and serum; estimation of blood glucose, cholesterol, urea, haemoglobin; urine**-**urea, uric acid, albumin, globulins, barbiturates, acid and alkaline phosphates; **2. Human-nutrition:** Estimation of enzymes, carbohydrates, essential amino acids, proteins and lipids. **3. Food Analysis, Processing and Preservation:** 3.1. Analysis of food such as milk, milk products, tea, coffee and beverages (soft drinks, alcoholic drinks),. Flour, starch, honey, jams and edible oils. Analysis of preservatives, coloring matter, micronutrients. 3.2. Food processing and food preservation: Refining milling, canning, concentration, freezing Drying, pasteurisation sterilization irradiation. **4. Forensic Science: Chemistry, Narcotics and toxicology** 4.1. Narcotics and Psychotropic Substances Act: psychotropic substance; prohibition control; regulation offence and penalties. 4.2. Forensic Chemistry: Its role in crime; Types of cases received for Analysis; Procedures for sample selection, collection, preservation, identification. 4.3. Forensic chemical analysis of samples using classical and modern instrumental techniques: Analysis of alcohol and other spurious liquor, Examination of Petroleum products, Construction material for adulteration; Examination of burnt remains in arson cases; Analysis of dyes chemicals seized in crime; Types of explosives; commonly used explosives; their handling; analysis and	7 hrs 4 hrs 8 hrs 17hrs

	identification of explosive residues. 4.4. Narcotics: Definition; Narcotic drugs and Psychotropic; substances; Problems of drug abuse; drug addiction. 4.5. Classification of Narcotic drugs; 4.6. Identification of narcotic drugs by spot tests and other classical Methods for following drugs. (a) Narcotics- heroin and cocaine. (b) Stimulants- caffeine, amphetamines; (c) Depressants- Barbiturates, Benzodiazepines. (d) Hallucinogens- LSD 4.7. Extraction of Narcotic drugs from different matrices; Isolation, purification, identification and estimation. 4.8. Examination of Narcotic drugs using modern instrumental methods 4.9. Toxicology: Definition; Its role in crime; Classification of poisons; commonly used poisons; signs and symptoms of poisoning; Sample collection, Handling and packing. 4.10. Analytical Toxicology; Extraction of poisons from various matrices including visceral samples; Isolation; Purification identification and interpretation of findings. Use of both Classical and Modern Instrumental methods of chemical analysis of poisons.	
Pedagogy:	Lectures/ tutorials/ seminars/ term papers/assignments/ presentations/ self-study or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.	
References/ Readings	1. C. S. James, *Analytical Chemistry of Foods*, Blackie Academic and Professional Publisher, UK, 1995, 1st Ed. 2. R. L. Nath, *Practical Biochemistry in Clinical Medicine*, Academic Publishers, 1990, 2nd Ed 3. V. Malik, *Drug and Cosmetics Act*, Eastern book company, 2016, 25th Ed. 4. B. S. Kuchekar, A. M. Khadatare, *Forensic Pharmacy*, Nirali Prakashan publisher, 2007, 7th Ed. 5. A. H. Beckett, J.B. Stenlake, *Practical Pharmaceutical Chemistry (Part 1)*, CBS publisher, 2006, 4th Ed. 6. S. R. Mikkelsen, E. Corton, *Bioanalytical Chemistr,* John Wiley and Sons, 2016, 2nd Ed. 7. M. B. Jacob, *Chemical Analysis of Food and Food Products*, CBS publisher, 2013, 3rd Ed. 8. S. Bell, *Forensic Chemistry,* Pearson Prentice Hall Publishers, 2006, 2nd Ed. 9. *Encyclopaedia of Analytical Chemistry*, Volume 3, Academic Press, 1995	

Programme: M. Sc. Part-II (Analytical Chemistry)

Course Code: ACO-502

Title of the Course: Calibration and Validation in Analytical Chemistry

Number of Credits: 3 **Effective from AY:** 2019-2020

Prerequisites for the course:	Students should have studied the theory/ instrumentation and application of some of the basic analytical techniques and statistical calculations related to topic. Knowledge of M.Sc.-Part I analytical courses is essential for better understanding of the course content	
Course Objectives:	1. Introduction of various aspect of calibration and validation 2. Study validation parameters and qualification of instrument	
Course Outcomes:	Students should be able to understand about calibration/validation and how it can be applied to industry and thus improve the quality of the products. The subject covers the complete information about basics of calibration & validation, types, methodology and application, the qualification of various equipment's and instruments. .	
Content:	**1. Calibration** Significance of calibration in analytical chemistry. Standardizing methods; standards used, certified reference material. Blanks and controls; types and significance Statistical evaluation of analytical results; relative error, standard deviation, knowledge of q test, test of significance, linear Least Squares estimation and coefficient of regression Errors in calibration, Modes and protocols of calibration; External standard method, Standard addition method, Spiking, Internal standard method and standard bracket method. Introduction to common apparatus used in analytical laboratory and their calibration; volumetric glassware, Analytical Balances, pH mete, Oven and lab Refrigerator Excel-charts for calibration plot. **2. Validation and qualification** Introduction to validation, Validation and calibration of various instruments used for drug analysis such as UV-Visible Spectrophotometer, IR Spectrophotometer, Spectrofluorimeter, HPLC, HPTLC and GC. Validation and qualification, Overview of qualification of some instruments. Overview of installation, operation, and performance qualification (IQ, OQ, PQ) of analytical equipment. Regulatory requirements for analytical method validation International conference on harmonization (ICH) guideline Q2A Introduction to QA / QC, Safety Practices in a Chemical Laboratory **3. Validation of analytical procedures** Linearity and range criteria and their role in instrumental method validation Detailed discussion on accuracy and precision role in the method validation Role of quantification limit and specificity -Limit of Detection (LOD) and Limit of Quantification (LOQ) Robustness & method validation	13 hrs 11 hrs 12 hrs

	Ruggedness of chromatographic method Ruggedness of sample preparation procedure Complete method validation package, analytical data, protocol, plan, revisions, and change controls.	
Pedagogy:	lectures/ tutorials/ seminars/ term papers/assignments/ presentations/ self-study or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.	
Text Books/ References / Readings	1. M. E. Swartz, I. S. Krull, *Analytical method development & validation*, CRC Press book, 1997. 2. A. I. Vogel, *Text Book of Quantitative Inorganic Analysis,* Longman Scientific & Technicial, 1989. 3. A. H. Wachter, R. A.Nash, *Pharmaceutical Process Validation,* Marcel Dekker Inc, 2003. 4. L.Huber, *Validation and Qualification in Analytical Laboratories*, Informa Healthcare USA Inc; 2007. 5. M. Valcarcel, *Principles of analytical chemistry: A text book*, Springer Publications, 2000. 6. D. Harvey, *Modern Analytical Chemistry*, MC Graw Hill, 2000. *7.* B.W. Wenclawiak, M.Koch and E. Hadjicostas (Eds.), *Quality Assurance in Analytical Chemistry*, Springer, 2004.	

Programme: M. Sc. Part-II (Analytical Chemistry)
Course Code: ACO-503
Title of the Course: Advanced Mass Spectrometry
Number of Credits: 3 **Effective from AY**: 2019-20

Prerequisites for the course:	Should have studied the spectroscopy topics at T. Y. B. Sc. (Chemistry) and M. Sc. part-I (Chemistry) levels.	
Course Objectives:	1. Study of various theoretical concepts related to mass spectroscopic techniques. 2. Introduction of tandem mass spectrometry techniques. 3. Learning interpretational aspects of spectral data obtained from hyphenated techniques	
Course Outcomes:	1. Students should be in a position to understand principle behind different ionizations sources. 2. Students should be in a position to select mass analysers and ionization sources for analysis of particular type of analyte. 3. Students should be in a position to deduce structures of simple to moderately complex molecules/biomolecules by combining the spectral data obtained from hyphenated techniques.	
Content:	**1. Introduction** Mass spectrometry principle, general instrumentation, general interpretation procedure for mass spectra; **2. Ionization methods:** 2.1. Gas Phase ionization: electron ionization (EI), chemical ionization (CI), Field ionization and field desorption (FI, FD) 2.2. Particle Bomabardment: Fast atom bombardment (FAB); Secondary ion mass spectrometry (SIMS) 2.3. Atmospheric pressure Ionization: electrospray ionization (ESI), atmospheric pressure ionization (APCI) 2.4. Laser Desorprtion: MALDI 2.5. Inorganic ionization sources: thermal ionization; Spark source; Glow discharge, Inductively couple plasma (ICP) **3. Mass analyzers:** 3.1. Characteristics of analysers: nominal mass, mass accuracy, resolving power, resolutions, numericals to calculate nominal and accurate mass 3.2. Magnetic, electromagnetic and double focusing 3.3. Single Quadrupole and triple quadrupole 3.4. Time of flight analyser 3.5. Ion cyclotron resonance analyzer, 3.6. hybrid instrumentation 3.7. Detectors: electron multiplier, photon multiplier, Faraday cup (Note: instrumentation, working principles, characteristic features, advantages, practical consideration shall be discuss). **3. Hyphenated Techniques:** 3.1. Coupled techniques; Interface and their characteristic features; Importance of hyphenation of two analytical techniques; 3.2. Introduction and instrumentation of following techniques: GC-FTIR, GC-MS, LC-MS, MS-MS (tandem) mass spectrometry (use of	2 hrs 10 hrs 8 hrs 8 hrs

	stable isotopes), ICP-MS, TG-MS. 3.3. Analysis of chromatogram obtained from hyphenated techniques: Total ion chromatogram (TIC), Extracted Ion chromatogram (XIC). 4. **Tandem Mass spectrometry applications:** 4.1. Pharmacokinetic studies: Fate of drug in living organisms, metabolite identification, biotransformation of ziprasidone 4.2. Tandem MS and fragmentation pattern of following drugs: Paracetamol, 2-mercaptonicotinic acid, Sulfasalazine, Narcotics-amphetaine, 4.3. Analysis of biomolecules-Protein and peptides: structure and sequence determination using fragmentation, solve problems based on MS/MS data.	8 hrs
Pedagogy:	Lectures/ tutorials/ seminars/ term papers/assignments/ presentations/ self-study or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.	
References/ Readings	1. H. Jürgen, *Mass Spectrometry: A Textbook Gross*, Springer publisher, 2011, 2nd Ed. 2. E. De Hoffmann, V. *Stroobant, Mass Spectrometry: Principles and Applications*, J. Wiley publisher, 2007, 2nd Ed. 3. R. B. Cole, *Electrospray and MALDI Mass Spectrometry: Fundamentals, Instrumentations, Practicalities and Biological Applications*, J. Wiley publishers, 2010, 2nd Ed. 4. J. T. Watson, O. D. Sparkman, *Introduction to Mass Spectrometry: Instrumentation, Applications, and Strategies for Data Interpretation*, J. Wiley, 2007, 4th Ed. 5. K. Wanner, G. Höfner (editors.), *Mass Spectrometry in Medicinal Chemistry Applications in Drug Discovery*, Wiley-VCH, 2007, 1st Ed. 6. M. Kinter, N. E. Sherman, *Protein Sequencing and Identification Using Tandem Mass Spectrometry*, J. Wiley publisher, 2000, 1st Ed. 7. P. James, *Proteome Research: Mass Spectrometry (Principles and Practice)*, Springer publisher, 2000, 1st Ed.	

Programme: M. Sc. Part-II (Analytical Chemistry)

Course Code: ACO-504

Title of the Course: Environmental control and chemical analysis

Number of Credits: 3 **Effective from AY:** 2018-19

Prerequisites for the course:	Students should have studied the Concepts in Analytical Spectroscopy), Analytical techniques at MSC Semester I and II so as to have basic knowledge of environmental chemistry and instrumental analysis.	
Course Objectives:	1. Introduction to environmental application of chemistry 2. Studying pollution from chemical perspective. 3. Creating awareness about environmental acts of India	
Course Outcomes:	1. Develop social concern for pollution based on various chemical process 2. Evaluate the use of various analytical techniques in environmental control and monitoring	
Content:	**1. Water pollution** 1.1 Constituents of aquatic life 1.2 Nature and types of water pollutants: heavy metals, inorganic pollutants, organic pollutants, pesticides, soaps and detergents, radioactive pollutants; Water standards in India [IS 10500 (2012)] 1.3 Soaps and detergents pollutants: Analysis of Soaps and detergents, general scheme of analysis, active ingredients, Test for soap (fatty acid salts), test for synthetic detergents 1.4 Municipal water treatment 1.5 Treatment of water for industrial use 1.6 Water conditioning: principle of coagulation and flocculation, softening, disinfection, demineralisation, fluoridation, chlorination, ozone treatment, electrodialysis 1.7 Wastewater treatment: pH, aerobic and anaerobic water treatment 1.8 Mercury pollution and estimation of organomercurials; 1.9 Analysis of: Dissolved oxygen (polarography and oxygen electrode), Chemical oxygen demand, Biochemical oxygen demand; 1.10 case study -DDT, Kepone, Minamata (any other) **2 Air pollution** 2.1 Introduction to atmospheric chemistry 2.2 Photochemical processes (ozone depletion) 2.3 Chain reactions in atmosphere 2.4 Oxidation process in atmosphere 2.5 Acid-base reaction in atmosphere 2.6 Sources and sinks of air pollutants 2.7 Effect of air pollutants on living and non-living things 2.8 Methods for sampling air pollutants 2.9 Air pollution problems- world and India 2.10 Sources -analysis control of: oxides of carbon, nitrogen and sulphur, H_2S 2.11 Organic compounds in atmosphere 2.12 Air act of India 1981 2.13 Greenhouse gases and global warming 2.14 Radioisotopes in air 2.15 Methods to monitor and control air pollution: scrubbers, filters, gravity and cyclone separators, absorption, adsorption, condensation,	10 hrs 10 hrs

	flare tower, gas sensing 2.16 Noise pollution 2.17 Case study-Bhopal gas tragedy, nuclear disasters-Chernobyl and Fukushima **3 Soil pollution** 3.1 Soil macrostructure and microstructure, 3.2 Micro and macronutrients of soil 3.3 Inorganic and organic matter in soil 3.4 Reactions in soil 3.5 Fertilisers in soil; Analysis of fertilizer (N, P, K) 3.6 Excessive use of agrochemicals 3.7 Waste and pollutants in soil 3.8 Type of pesticides, degradation of pesticides in soil (chemical, phochemical biochemical), Analysis of pesticides, 3.9 Soil pollution Sources, prevention and control 3.10 Biochemical effects of pesticides; analysis of pesticides 3.11 Plastic pollution 3.12 Municipal garbage treatment **4. Instrumental Techniques in environmental chemical analysis.** 4.1 Neutron activation analysis 4.2 Anodic stripping voltammetry, (Mixture: Cu, Pb, Zn, Cd) 4.3 atomic absorption spectroscopy,(Cu, Co, Cr) 4.4 Flameless atomic absorption, (Hg, Pb,) 4.5 Inductively-coupled plasma-emission spectroscopy (B,W) 4.6 X-ray fluorescence 4.7 Infrared and non-dispersive infrared spectroscopy (nitrates, carbonate, CO) 4.8 Chemiluminescence (NOx) 4.8 Gas and liquid chromatography(NOx, CO, CO_2,VOC) 4.9 Ion-selective electrodes,(F, Ag, S, Ca) 4.10 Ion chromatography-(mixture: Ni, Co and Cu; chloride, nitrate and sulphate) Above techniques shall be discussed with minimum one environmental application	8 hrs 8 hrs
Pedagogy:	lectures/ tutorials/ seminars/ term papers/assignments/ presentations/ self-study or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.	
Text Books References / Readings	1. S. E. Manahan, *Environmental science and technology*, 2007, CRC Press, NW, 2nd Ed. 2. A. V. Salker, *Environmental Chemistry*, 2017, Narosa Nublishing, New Delhi, 1st Ed. 3. A. K. De, *Environmental Chemistry,* New Age International Publishers, New Delhi, 2005, 3rd Ed. 4. S. Mishra, D. Mani, *Soil Pollution*, Ashish Publishing House, New Delhi, 1991, 1st Ed. 5. B. K. Sharma, *Environmental Chemistry*, GOEL Publishing House,	

Meerut, 2003, 1st Ed.
6. D. Palmer, *Introduction to Air Pollution*, New Educational Press, England, 1974, 1st Ed.
7. S. M. Khopkar, *Environmental Pollution Analysis*, New Age International Publishers, New Delhi, 2005, 1st Ed.
8. R. Harrison, S. de Mora, *Introductory Chemistry for the Environmental Sciences*, Cambridge University Press, Cambridge, 1996, 1st Ed.
9. S. E. Manahan, *Fundamentals of environmental and toxicological chemistry: sustainable science*, CRC Press, NW, 2013, 4th Ed.
10. F. J. Welcher, *Standard Methods of Chemical Analysis Part-B*, D. Van Nostrand Company INC, NW, 1963, 6th Ed.
11. B. Edmund, M. Schwartz, *The Treatment of Industrial Wastes* by Publication McGraw Hill Kogakusha Limited (1976), 2nd Ed.
12. P. Patnaik, *Handbook of Environmental Analysis: Chemical pollutants in air, water and solid wastes*, Lewis Publishers, New York, 1997, 1st Ed.

Programme: M. Sc. Part-II (Analytical Chemistry)

Course Code: ACO-505
Title of the Course: Problems on combined Spectroscopy
Number of Credits: 3 **Effective from AY**: 2019-20

Prerequisites for the course:	Should have studied the spectroscopy topics at T. Y. B. Sc. (Chemistry) and M. Sc. Part-I (Chemistry) levels.	
Course Objective:	1. Study of various theoretical concepts related to organic spectroscopic techniques. 2. Introduction of commonly used 2D NMR techniques. 3. Learning interpretational aspects of spectral data pertaining to IR, PMR, CMR and MS.	
Course Outcome	1. Students should be in a position to deduce structures of simple to moderately complex molecules by combining the spectral data obtained using two or more spectral techniques. 2. Students should be in a position to apply various concepts in organic spectroscopy (PMR, CMR, MS and 2D NMR) and generate/ predict PMR, CMR, MS and 2D NMR spectral data based on given structures of simple molecules.	
Content:	**1. Electronic and Infrared Spectroscopy:** basic concepts; Application of electronic and IR spectroscopy in structural elucidation of organic compounds **2. NMR Spectroscopy:** Theory of Nuclear magnetic resonance, quantum description of NMR, classical description of NMR, Types of NMR spectra, environmental effects of NMR Spectra, the chemical shift, Applications of proton NMR in qualitative and quantitative analysis (in general). **3. ^{13}C –NMR spectroscopy:** Introduction, proton coupled and proton decoupled ^{13}C- spectra. Off- resonance decoupling, APT & DEPT techniques; 13C chemical shifts – factors affecting the chemical shifts – Homonuclear (^{13}C -^{13}CJ) and heteronuclear (^{13}C – ^{1}H, ^{13}C – ^{2}HJ) couplings. **4. Two-dimensional NMR spectroscopy:** Introduction to 2D-NMR, Classification of 2D experiments- 2DJ resolved spectroscopy; interpretation of spectra of simple organic compounds using following 2D-NMR techniques-COSY, NOESY, HSQC, HMQC, HMBC, TOCSY and INADEQUATE **5. Identification of organic compounds** using combined spectral methods: UV, IR, PMR, CMR, 2D NMR, Mass *(Note: More emphasis shall be given for solving combined spectroscopic data for structural elucidation*)	04 hrs 05 hrs 06 hrs 07 hrs 14 hrs
Pedagogy:	lectures/ tutorials/ seminars/ term papers/assignments/	

	presentations/ self-study/ Case Studies etc. or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.	
References/Readings	1. D. L. Pavia, G. M. Lampman, G. S. Kriz, J. R. Vyvyan, *Introduction to Spectroscopy*, Brooks Cole, 2009, 4th Ed, 2. J. R. Dyer, *Applications of Absorption Spectroscopy of Organic compounds*, Prentice Hall of India, 1987 3. W. Kemp, *NMR in Chemistry: A Multinuclear Introduction*, Macmillan, 1986. 4. R.M. Silverstein, F. X. Webster, *Spectrometric Identification of Organic compounds*, John Wiley & Sons Inc., 2011, 7th Ed. 4. D.H Williams & I. Fleming, *Spectroscopic methods in organic chemistry*, Tata Mcgraw Hill Education, 2011, 6th Ed. 6. W. Kemp, *Organic spectroscopy*, Palgrave Macmillan, 1991, 3rd Ed. 7. P.S. Kalsi, *Spectroscopy of Organic compounds*, New Age International Pub. Ltd. & Wiley Eastern Ltd., 1995, 2nd Ed. 8. L. D. Field, H. L. Li, A. M. Magill, *Organic Structures from 2D NMR Spectra*, Wiley, 2015.	

Programme: M. Sc. Part-II (Analytical Chemistry)
Course Code: ACO-506
Title of the Course: Chemometrics
Number of Credits: 3 **Effective from AY**: 2019-20

Prerequisites for the course:	Should have studied the spectroscopy topics at T. Y. B. Sc. (Chemistry) and M. Sc. Part-I (Chemistry) levels.	
Course Objective:	1. Introduction of various chemistry software used in quantification and calculations 2. Study validation parameters and qualification of instrument	
Course Outcome	Students should be able to understand about various software in chemometric and how it can be applied to analysis and thus improve the quality of the products. The subject covers the complete information about software and their application in quantifications. .	
Content:	**1. Introduction to Data and Statistics:** Introduction; Univariate Statistics Review, Probability, Variance and Sampling, Linear Regression and Calibration Data, Digitization, and the Nyquist Theorem, Detection Limit, S/N ratio, and Signal Filtering; Review of Linear Algebra: Scalers, Vectors, and Matrices, Matrix Notation and Matrix Operations Orthogonality, Analysis of Variance (ANOVA) - 1 Variable, Analysis of Variance - 2 Variables; Introduction to MatlabTM: Program Basics and Layout, Matrix Operations in MatlabTM The Diary Command and Examples, ANOVA in MatlabTM; Experimental Design: Factorial Design, Simple *versus* Complex Models, Factorial Design in MatlabTM ; Half-Factorial Design. **2. Multivariate Methods I:** Introduction to various multivariate methods; the Six Habits of a Chemometrician; Principle Component Analysis (PCA); data pretreatment- Mean Centering and Normalization; PCA in MatlabTM. **3. Multivariate Methods II:** Classical Least Squares (CLS), CLS in MatlabTM; Inverse Least Squares (ILS). **4. Multivariate Methods III:** Multiple Linear Regression (MLR); Principle Component Regression (PCR); Partial Least Squares, Examples in MatlabTM; Summary of Multivariate Methods; Pattern Recognition- Supervised versus Unsupervised Pattern Recognition, K Nearest Neighbours (KNN); Soft Independent Modelling for Chemical Analysis(SIMCA), Summary of Pattern Recognition. **5. Computers in Chemistry:** The students shall learn how to operate a PC and run standard programs and packages like MS-WORD, EXCEL, ORIGIN, SIGMA PLOT, and CHEM SKETCH; to solve Chemistry numerical (numerical taken preferably from Physical Chemistry for plotting first and second derivative curves, linear plots); numerical from Analytical Chemistry, Chemical Kinetics, Electrochemistry, Spectroscopy and other related topics; writing the structures of inorganic and organic molecules, chemical equations and other	10 hrs 05 hrs 04 hrs 07 hrs 10 hrs.

	interesting applications will be taught.	
Pedagogy:	lectures/ tutorials/ seminars/ term papers/assignments/ presentations/ self-study/ Case Studies etc. or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.	
References/Readings	1. K. R. Beebe, R. J. Pell, M. B. Seasholtz, *Chemometrics*, *A Practical Guide,* John Wiley & Sons, Inc., New York, 1998. 2. The computer program MATLABTM will be required for some portions of the course. 3. P. J. Gemperline, *Practical Guide to Chemometric*, CRC Press Taylor & Francis Group, 2006, 2nd Ed. 4. R. Kramer, *Chemometric Techniques for Quantitative Analysis*, Marcel Dekker publisher, New York (1998). 5. K.V. Raman, *Computers in chemistry*, Tata Mc.Graw-Hill, 1993. 6. D. A. Skoog, D. M. West and F. J. Holler, *Fundamentals of Analytical Chemistry*, Sounders College publishing, 2014, 9th Ed.	

M Sc-II Inorganic chemistry
Semester III and IV Courses (Academic year 2019-2020 onwards)

Compulsory courses			**Optional courses**		
Code	**Title**	**Credits**	**Code**	**Title**	Credits
ICC 501	Coordination and organometallic Chemistry	**3**	**ICO 501**	Bioinorganic Chemistry	**3**
ICC 502	Materials Chemistry	**3**	**ICO 502**	Catalysis: The Basic Chemical concepts	**3**
ICC 503	Group Theory and Spectroscopy	**3**	**ICO 503**	Chemistry of P-Block Elements	**3**
ICC 504	Selected Topics in Inorganic Chemistry - I	**3**			
ICC 505	Experiments in Inorganic Chemistry	**3**	**General Optional Courses**		
			CGO-500	Dissertation	8
			CGO-501	Selected Experiments in Chemistry	8

Programme: M. Sc. Part-II (Inorganic Chemistry)
Course Code: ICC-501
Title of the Course: Coordination and organometallic Chemistry
Number of Credits: 03 **Effective from AY:** 2019-20

Prerequisites for the course:	The students with MSc-I Chemistry are eligible for this course.	No. of lectures
Course Objectives:	1. To make understand the electronic structure of compounds of d-block elements. 2. To provide sufficient knowledge of CFT and MOT in coordination and organometallic compounds. 3. To understand interpretation of magnetic and electronic properties of coordination compounds. 4. To understand fundamental concepts of inorganic chemistry reaction mechanisms 5. To provide knowledge on applications of organometallic compounds in homogenous catalysis.	
Course Outcomes:	1. The students will be able to understand the electronic structure of coordination and organometallic compounds. 2. They will be well equipped with knowledge of CFT and MOT 3. They will be in position to understand the magnetic and electronic properties. 4. The concepts of inorganic reactions will be clear to them. 5. They will know the applications of organometallic compounds in industries	
Content:	**1. Electronic structure of coordination compounds**: 1.1 Crystal field theory and its applications: a) Octahedral compounds; b) tetrahedral compounds; c) square-planar compounds and other geometries; d) tetragonally distorted compounds (Jahn-Teller Effect); e) octahedral vs tetrahedral 1.2 Ligand filed theory: a) σ bonding; b) π-bonding **2. Magnetic Properties coordination compounds** a) diamagnetism, b) paramagnetism; c) ferromagnetism, d) antiferromagnetism, d) temperature dependence magnetism; Curie law, Curie-Weiss Law.; e) spin cross over phenomenon **3. Spectra of coordination compounds** 3.1 Electronic structure of atoms: a) spectroscopic terms; b) classification of microstates and energies of the terms; d) Racah parameters 3.2 Electronic spectra: a) ligand field transitions; b) selection rules; c) spectroscopic terms of complexed ion; d) correlation and Orgel diagrams; d) Tanabe-Sugano diagrams; e) Charge-Transfer bands: LMCT transitions and MLCT transitions; f) Luminescence **4. Inorganic reaction mechanisms**: 4.1 Substitution reactions in coordination compounds; b)	8 hr 2 hr 8 hr 8 hr

	thermodynamic considerations; c) kinetic considerations; d) substitution reactions in octahedral compounds; e) substitution reactions in square planar compounds. 4.2 Electron transfer reactions: inner sphere and outer sphere mechanism, Frank Condon principle, Marcus equation **5. Organometallic compounds and reactions** Significance of 18 electron rule, metal carbonyls & nitrosyls, reactions of organometallic compounds, metal centered catalysis in complex compounds, homogenous catalysis such as hydrogenation, hydro formulations, coupling reactions and isomerization of alkanes. Asymmetric catalysis, stereochemically rigid molecules.	10 hr
Pedagogy	Mainly lectures / tutorials / assignments /self-study or a combination of some of these could also be used to some extent.	
Text books / Reference books	1. P.W. Atkins, T.L. Overton, J.P. Rourke, M.T. Weller & F.A. Armstrong 2010, *Shriver & Atkins' Inorganic Chemistry*, Oxford University Press, 2010, 5th Ed. 2. J.E. Huheey, E.A. Keiter & R.L. Keiter, *Inorganic Chemistry: Principles of structure and reactivity*, Pearson, 2014, 4th Ed. 3. J.D. Lee, *Concise Inorganic Chemistry*, Chapman and Hall, 1996, 5th Ed. 4. F.A. Cotton, G. Wilkinson & P.L. Gaus, *Basic Inorganic Chemistry*, John Wiley, 1995, 3rd Ed. 5. F.A. Cotton & G. Wilkinson, *Advanced Inorganic Chemistry*, Wiley Eastern, New Delhi, 1984, 3rd Ed. (4th & 5th Eds. preferred) 6. D. Banerjee, *Coordination Chemistry,* Tata McGraw–Hill, New Delhi, 1994 7. N.N. Greenwood & A. Earnshaw, *Chemistry of the Elements*, Pergamon Press, Exeter, Great Britain, 1984. 8. G. Rodgers, *Introduction to coordination, solid state and descriptive Inorganic chemistry*, McGraw–Hill, 1994.	

Programme: M. Sc. (Inorganic Chemistry)
Course Code: ICC-502
Title of the Course: Materials Chemistry
Number of Credits: 03 **Effective from AY:** 2019-20

Prerequisites for the course:	Students should have studied the courses in Inorganic Chemistry at F Y B Sc, S Y B Sc, T Y B Sc and ICC-401 course at M.Sc. Part-I Chemistry so as to have basic knowledge of Materials Chemistry	No. of Hours
Course Objective:	To provide basic and advanced knowledge about solid state chemistry	
Course Outcome	This course will give sufficient information about the preparation of different types of materials, their structures, reactivity and properties.	
Content:	**1. Introduction to Materials chemistry**	1 hr
	2. Structure and bonding in solid materials: Crystal lattice; unit cell; Miller indices and planes; X-ray diffraction method; metallic, covalent and ionic solids; structural classification of binary and tertiary compounds.	4 hr
	3. Non-stoichiometry in material solids: Oxygen deficient oxides, metal deficient oxides and classification of non-stoichiometry.	2 hr
	4. Crystal defects: Types of defects**:** Point defects; Dislocations: Line defects and Plane defects	3 hr
	5. Materials preparation techniques: I) Ceramic method II) Different wet chemical methods: A) For Powder materials: Co-precipitation, Precursor, Combustion, Sol-gel, Spray roasting, Freeze drying. B) For Single crystals: i) Growth from melt ii) Flux method iii) Epitaxial growth of single crystal thin films: Chemical and Physical methods iv) Chemical vapour transport v) Hydrothermal method vi) Dry high pressure method. C) For Amorphous Materials D) For Nanomaterials	7 hr
	6. Reactivity of Solid Materials: Tarnish reactions, decomposition reaction, solid-solid reactions, addition reactions, double decompositions reaction, electron transfer reaction, solid-gas reactions, sintering, factors influencing reactivity of solids.	3 hr
	7. Phase Transformations in Solid Materials: Thermodynamic consideration, structural change in phase transformation, Martensite transformation, temperature and pressure induced transformations, order- disorder transitions,	3 hr

	electronic transition, transformation with a change in composition. **8. Electrical Properties:** Electrical conductivity, free electron theory, fermi energy, insulators, semiconductor and conductors, band theory of semiconductor, Brilliouin zones, Hall effect, the Seebeck effect, Superconductivity, BCS theory, Meissner effect, high temperature superconductor. **9. Semiconductor Devices:** Diodes, transistors and Junction field effect transistor, light meter, photodiode, phototransistor, solar cells, light emitting diodes, laser materials. **10. Optical and dielectric properties:** Luminescence and phosphorescence, piezoelectric, ferroelectric materials and applications. **11. Magnetic properties:** Introduction to magnetism, behaviour of substance in a magnetic field, magnetic moments, diamagnetism, paramagnetism, experimental determinations of susceptibility, ferromagnetism, anti-ferromagnetism and ferrimagnetism.	4 hr 4 hr 2 hr 3 hr
Pedagogy:	Lectures/ tutorials/ self-study or a combination of some of these.	
Text/Reference books/ Readings	1. A. R. West, *Solid State Chemistry and its applications*, Wiley India Pvt. Ltd., New-Delhi, 2003 Ed. 2. L. V. Azaroff, *Introduction to solids*, Tata McGraw Hill, New-Delhi, 2009, 1977 Ed. (33rd Reprint). 3. N. B. Hannay, *Treatise on Solid State Chemistry Vol.4 Reactivity of Solids*, Plenum Press, New York, 1976, 1st Ed. 4. D. K. Chakraborty, *Solid State Chemistry*, New Age International Publisher, New-Delhi, 2010, 2nd Ed. 5. H. V. Keer, *Principles of the Solid State*, New Age International (P) Ltd., New-Delhi, (Wiley Eastern Ltd, New-Delhi), 1993, 1st Ed. (Reprint 2005). 6. C. N. R. Rao & K. J. Rao, *Phase Transitions in Solid*, McGraw Hill, New York, 1977, 1st Ed. 7. W. D. Callister, *Material Science and Engineering: An Introduction*, John Wiley, New York, 2007, 7th Ed. 8. B. D. Fahlman, *Materials Chemistry*, Springer, Netherlands, 2011, 2nd Ed. 9. Harry R. Allcock, *Introduction to materials Chemistry*, John Wiley & Sons, 2011, 1st Ed. 10. C. N. R. Rao & J. Gopalakrishnan, *New directions in solid state chemistry*, Cambridge University Press, Cambridge, 1997, 2nd Ed.	

Programme: M. Sc. Part-II (Inorganic Chemistry)
Course Code: ICC-503
Title of the Course: Group Theory & Spectroscopy
Number of Credits: 03 **Effective from AY:** 2019-20

Prerequisites for the course:	The students who have done ICC-401, ICC-402 and ICO-401 at MSc-I level are eligible for attend this course.	No. of lectures
Course Objectives:	1. To train students to understand the concepts of molecular symmetry and group theory and their applications. 2. To train the students to understand different spectroscopic techniques viz. magnetic resonance, vibrational & Mössbauer spectroscopy with emphasis on spectral interpretation.	
Course Outcomes:	1. Students will be able to understand symmetry aspects of simple molecules. 2. Students will get to know about applications of group theory and concepts of molecular orbital theory. 3. Students will be able interpret IR, Raman, ESR, NMR, Mossbauer spectra of simple molecules and determine molecular geometry	
Content:	**1. Group Theory:** Basic definitions and theorems of group theory, Molecular symmetry and the symmetry groups, symmetry elements and operations, symmetry planes and reflections, inversion center, proper axes and proper rotations, improper axis and improper rotations. Products of symmetry operations, equivalent symmetry elements and equivalent atoms, symmetry point groups, systematic symmetry classification of molecules, classes of symmetry operations, representations of groups, the great orthogonality theorem, some properties of matrices and vectors, reducible and irreducible representations, properties of the characters of representations, character tables, group theory and quantum mechanics, wave functions as basis for irreducible representations, direct product, Symmetry aspects of molecular orbital theory, general principles, the secular equation, the Huckel approximation, simple LCAO-MO theory of homocyclic π systems. More general cases of LCAO-MO pi-bonding, Molecular orbitals for the metal sandwich compounds. **2. Spectroscopic Methods:** Magnetic Resonance Spectroscopy, interaction between electron / nuclear spin and magnetic field, Resonance condition, instrumental requirements, presentation of NMR, ESR spectra, line widths of NMR and ESR spectra, hyperfine coupling in isotropic systems (e.g. H atom, methyl radical etc.), anisotropic system, zero field splitting and Kramer's degeneracy, Spin energy levels of octahedral Mn(II) complexes, ESR spectra of some transition metal compounds, Electron	18 hr 18 hr

	delocalization, NMR spectral interpretation of a few nuclei like ^{19}F, ^{29}Si ^{31}P, Mössbauer spectroscopy; Recoilless emission and absorption spectral line widths, Doppler shift, experimental arrangement of Mossbauer spectroscopy, chemical shift (isomer shift), quadrupole splitting, Magnetic hyperfine interaction. Discussion of selected Mossbauer nuclei (^{57}Fe, ^{129}I) Vibrational spectroscopy (IR & Raman) – recapitulation of basics, reduced mass, isotope effect, a few applications for determination of molecular geometry (See Ref. 7 and 8)	
Pedagogy	Mainly lectures / tutorials / assignments / self-study or a combination of some of these could also be used to some extent.	
Text books / Reference books	1. F. A. Cotton, *Chemical Applications of Group theory*, John Wiley, 1990, 3rd Ed. 3. R. L. Dutta & A. Syamal, *Elements of Magnetochemistry*, Affiliated East-West Press, New Delhi, 1993, 2nd Ed. 4. C. N. Banwell & E. M. McCash, *Fundamentals of Molecular Spectroscopy*, Tata McGraw Hill, New Delhi, 1994, 4th Ed. (Chapter 7) 5. G. Aruldhas, *Molecular structure and spectroscopy*, Prentice Hall of India, 2001. 6. P Atkins, J De Paula & J Keeler, *Atkins' Physical Chemistry*, International Edition, Oxford University Press, 2018 (Focus 16) 7. M Weller, T Overton, J Rourke & F Armstrong *Inorganic Chemistry* International Edition, Oxford University Press, 2018 (Chapter 8) 8. P Atkins, T Overton, J Rourke, M Weller & F Armstrong, *Shriver & Atkins' Inorganic Chemistry* Oxford University Press, 2010, 5th Ed. (Chapter 8) 9. E.A.V. Ebsworth, D.W.H. Rankin & S. Cradock, *Structural Methods in Inorganic Chemistry,* ELBS, 1988.	

Programme: M. Sc. Part-II (Inorganic Chemistry)
Course Code: ICC-504
Title of the Course: Selected topics in inorganic chemistry - I
Number of Credits: 03 **Effective from AY:** 2019-20

Prerequisites for the course:	The students with MSc-I Chemistry are eligible for this course.	No. of lectures
Course Objectives:	1. To gain knowledge in selected topics in inorganic chemistry. 2. To learn s-block elements, selected compounds of d-block and f-block elements. 3. To understand the basic electrochemical processes in inorganic compounds. 4. To study the applications of inorganic compounds in selected areas.	
Course Outcomes:	1. Students will be able to gain knowledge regarding chemistry (abundance, preparation, properties) of s, d and f block elements. 2. Students will be able to gain knowledge of fundamentals of inorganic electrochemistry and medicinal chemistry.	
Content:	**1. S-block elements and their compounds** 1.1 Hydrogen and hydrides: Electronic structure, position in periodic table, abundance, preparation, properties, isotopes, ortho and para hydrogen. Classification of hydrides, preparation & properties of hydrides; hydrogen ion, hydrogen bonding and its influence on properties. 1.3 Group 1 Elements: Introduction, abundance, extraction, physical and chemical properties, solubility and hydration, solutions of metal in liquid ammonia, complexes, crowns and cryptands, electrides, alkalides, difference between lithium and the other group 1 elements, diagonal relationship between Li and Mg. 1.4 Group 2 Elements Introduction, abundance, extraction, physical and chemical properties, solutions of metal in liquid ammonia, complexes, anomalous behaviour of beryllium, difference between beryllium and the other group 2 elements, diagonal relationship between Be and Al, preparation and properties Grignard reagent. **2. Chemistry of d-block and f-block compounds** 2.1 Polyoxometallates; 1.2 metal sulphides and sulfido compounds; 1.3 Nitrido & alkylidyne compounds; 1.4 Metal-metal bonded compounds and clusters; 1.5 coordination & organometallic compounds of lanthanides; 1.6 Electronic spectra of lanthanides & actinide compounds; 1.6 Brief chemistry of thorium, uranium, neptunium, plutonium &	10 hr 6 hr

	americium. **3. Fundamentals of Inorganic Electrochemistry** Basic aspects of electrochemistry, electron transfer reactions at electrode surface, potential and electrochemical cells, voltammetric techniques, linear voltammetry, cyclic voltammetry; reversible, irreversible and quasi-reversible processes; applications of cyclic voltammetry with reference to ferrocenes, transition metal complexes. **4. Inorganic medicinal chemistry** Anticancer agents: Platinum and Ruthenium complexes as anticancer drugs, Cancer chemotherapy, phototherapy, radiotherapy using borane compounds, Chelation therapy, Gadolinium and technetium complexes as MRI contrast agents, X-ray contrast agents, Anti-arthritis drugs, Anti-bacterial agents (Ag, Hg, Zn and boron compounds), Antiseptic and anti-biotic, Deodorants and anti-perspirants, Anti-viral agents (influenza, herpes, hepatitis and HIV viruses), Li drugs. **5. Nuclear Chemistry** Radioactivity, Decay processes and decay energy, half-life of radioactive elements, Nuclear fission and fusion processes, Nuclear reactor components and functions, Q values for nuclear reactions, Nuclear waste management, Radiation detection principles, Chemical separation techniques of radioactive elements, Radio-analytical techniques, Activation analysis.	4 hr 8 hr 8 hr
Pedagogy	Mainly lectures / tutorials / assignments / self-study or a combination of some of these could also be used to some extent.	
Text / Reference Books	1. P.W. Atkins, T.L. Overton, J.P. Rourke, M.T. Weller & F.A. Armstrong 2010, *Shriver & Atkins' Inorganic Chemistry,* Oxford University Press, 2010, 5th Ed. 2. J.E. Huheey, E.A. Keiter & R.L. Keiter, *Inorganic Chemistry: Principles of structure and reactivity*, Pearson, 2014, 4th Ed. 3. J. D. Lee, *Concise Inorganic Chemistry*, Blackwell Science Wiley, 2015, 5th Ed. (Reprint) 4. F.A. Cotton, G. Wilkinson & P.L. Gaus, *Basic Inorganic Chemistry*, John Wiley 1995, 3rd Ed. 5. F.A. Cotton & G. Wilkinson, *Advanced Inorganic Chemistry*, Wiley Eastern, New Delhi, 1984, 3rd Ed. (4th & 5th Ed. preferred) 6. N. N. Greenwood & A. Earnshaw, *Chemistry of the Elements,* Pergamon Press, Exeter, Great Britain, 1984. 7. D. T. Sawyer, A. Sobkowak, J. L. Roberts Jr., *Electrochemistry for chemists*, John Wiley, Inc., New York, 1995, 2nd Ed.	

	8. A. G. Sykes, *Advances in Inorganic Chemistry,* Academic Press Ltd., UK Ed. 1991. 9. H. J. Arnikar, *Essentials of Nuclear Chemistry*, New Age Intl. Publishers, 2011, 4th Revised Ed. 10. G. Friedlander, J. W. Kennedy, E. S. Macias, J. M. Miller, *Nuclear & Radiochemistry*, John Willey & Sons, New York, 1981, 3rd Ed.	

Programme: M. Sc. Part-II Inorganic Chemistry
Course Code: ICC-505
Title of the Course: Experiments in Inorganic Chemistry
Number of Credits: 03 **Effective from AY:** 2019-20

Prerequisites for the course:	Students should have studied the courses ICC-401, ICC-402 and ICO-401 ta M. Sc.-I level	No. of lectures
Course Objectives:	1. To introduce to practical knowledge in Inorganic Chemistry. 2. To learn techniques of crystallization of ligands and synthesis of coordination compounds 3. To learn characterization of compounds using different instruments 4. To provide experience of synthesis and characterization of materials 5. To introduce analysis of ores for metal content	
Course Outcomes:	1. Students will be in a position to understand general aspects involved in purification of ligands and synthesis of coordination of compounds 2. Students will be able to understand the methods for characterization of coordination compounds. 3. Students will be in a position to understand the solid state material synthesis and characterization. 4. Students will be able to separate metal ions by ion exchange chromatography. They will also gain knowledge about the analysis of ores and alloys	
Content:	**EXPERIMENTS IN INORGANIC CHEMISTRY** *Total sixteen experiments to be performed from the following.* **Group – 1**: Experiments in coordination chemistry: Ligand and complex synthesis, metal analysis **(Minimum 3)** 1) Purification (distillation / recrystallization) of ligands like acacH, en, carboxylic acids etc) 2) Preparation of manganic tris(acetylacetonate) and estimation of managanese 3) Preparation of tris(thiourea) copper(I) sulfate and estimation of copper 4) Preparation of isomers; *cis* & trans dichloro-(ethylenediamine)-cobalt(III) chloride and estimation of cobalt 5) Preparation and resolution of tris(ethylenediamine)cobalt(III) ion and estimation of chloride 6) Preparation of *cis* and *trans*- potassium dioxalatodiaquo-chromate(III) and estimation of chromium 7) Preparation of nitro and nitrito-penta aminecobalt(III)chlorides and estimation of cobalt 8) IR spectral characterization of free ligands and coordinated ligands	18

	9) Single crystal structure analysis *NOTE: In complex synthesis, the student is expected to recrystallize the product, record IR spectra and carry out metal analysis. Spectral analysis can be carried over.* **Group –2** Experiments in Solid State Chemistry **(Minimum 3)** 1) Preparation of spinel oxides by precursor method and estimation of metals in precursors and oxides, 2) Characterization of precursors by thermal analysis and infrared analysis 3) X-ray diffraction studies of oxides 4) Electrical characterization: i) Direct current electrical resistivity of semiconductor (Ge/Si) by Four Probe 4) Curie temperature determination of dielectric material (PZT) by measurement of dielectric constant v/s temperature 5) Measurement of magnetization parameter: Ms, Mr and Hc, 6) Determination of Curie temperature of magnetic oxides by A.C. susceptibility studies. **Group – 3**: Instrumental methods / spectral analysis / ion exchange **(Minimum 3)** A) Determination of stability constant of complex ions in solution 1) Fe(III) – thiocyanate compound B) Determination of instability constant of complex ions in solution 2) Determination of instability constant for the reaction between Ag^+ and NH_3 3) Determination of instability constant for the reaction between Ag^+ and en 4) Determination of instability constant for the reaction between Cu^{2+} and NH_3 5) Determination of instability constant for the reaction between Cu^{2+} and en C) Ion exchange chromatography 6) Separation of Mg^{2+} and Co^{2+}/Zn^{2+} by anion exchange column 7) Separation of transition metal cations by anion exchange column **Group – 4**: Ore / Alloy/ commercial sample analysis **(Minimum 3)** 1) Analysis of Goan Iron ore: Hematite / magnetite 2) Analysis of Devardas alloy 3) Analysis of Solder (Pb and Sn) 4) Analysis of Calcite/ Dolomite 5) Analysis of Pyrolusite 6) Analysis of Nickel-Aluminium alloy 7) Analysis of Brass / Bronze	18 18 18
Pedagogy	Pre-labs, practical / self-study or a combination of some of these could also be used to some extent.	

Reference Books	1. G. Brauer, Handbook of Preparative Inorganic chemistry, Vol. 1 & 2, Academic Press New York, 1967, 2nd Ed. 2. J. Bassett, R.C. Denny, G. H. Jeffery & J. Mandham, *Vogel's Text Book of Quantitative Inorganic Analysis* ELBS, 1985, 4th Ed. 3. G. Marr & B. W. Rockett, *Practical Inorganic Chemistry*, Van Nostrnad Reinhold London, 1972. 4. G. Pass & H. Sutcliffe, *Practical Inorganic Chemistry,* Chapman and Hall, 1985, 2nd Ed. 5. J. D. Woolins, *Inorganic Experiments,* Wiley–VCH Verlag GmbH and Co, 2003.	

Programme: **M. Sc. Part-II (Inorganic Chemistry)**
Course Code: **ICO-501**
Title of the Course: Bioinorganic Chemistry
Number of Credits: **03** Effective from AY: **2019-20**

Prerequisites for the course:	The students who have done MSc-I Chemistry core courses are eligible to attend	No. of lectures
Course Objectives:	1. To introduce, describe and highlight the role of inorganic elements especially metal ions in biology. 2. To describe the role of small molecular weight model compounds.	
Course Outcomes:	In addition to knowing the essential elements in biology the students will be able to understand the role played by metal ions in vital processes like i) oxygen storage and transport and ii) electron transfer.	
Course Content:	1. Essential elements in biology, distribution of elements in biosphere, bio-availability, bio-stability, building blocks of the biosphere; carbohydrates, nucleic acids and proteins, Biological importance of water, and brief review of the chemistry of biopolymers. Metallobiomolecules: classification of metallobiomolecules, metalloproteins (enzymes), metal activated proteins (enzymes), metal functions in metalloproteins, Principles of coordination chemistry related to bioinorganic research, physical methods in bioinorganic chemistry 2. Introduction, biological importance of the alkali and the alkaline earth cations, Cation transport through membranes (ion pumps). Photosynthesis, Hill reaction, Chlorin macrocycle and chlorophyll, Absorption of light by chlorophyll, role of metals in photosynthesis, in vitro photosynthesis. 3. Non redox metalloenzymes, zinc metalloenzymes like carboxypeptidase, carbonic anhydrase and alcohol dehydrogenase, Bio-functions of zinc enzymes, active site structure and model complexes. 4. Biochemistry of a few transition metals viz. Fe, Mo, Cu and Ni, Oxygen carriers and oxygen transport proteins, iron porphyrins (Haemoglobin and myoglobin). Haemocyanins and Haemerythrins, Synthetic models for oxygen binding haemprotiens. cytochrome 'c', catalase peroxidase, and superoxide dismutase, blue copper proteins, vitamin B_{12} coenzymes, nitrogen fixation and iron-sulfur proteins, biological nitrogen fixation, nitrogenase and dinitrogen complexes, iron-sulfur proteins, synthetic analogues for Fe-S proteins, core extrusion reactions.	6 hr 6 hr 6 hr 6 hr 6 hr

	5. Metal transport and storage: A brief review of iron transport. 6. Synthesis of simple ligands or isolation of S-containing amino acid or extraction of chlorophyll from green leaves (this will involve both collection of synthetic procedures from library, term paper presentation / discussion)	
Pedagogy	Mainly lectures / tutorials / assignments /group discussion / self-study or a combination of some of these could also be used to some extent.	
Text books / Reference books	**Reference books**: 1. S. J. Lippard & J. M. Berg, *Principles of Bioinorganic chemistry*, Panima Publishing Corporation 2. B. I. Britini, H. B. Gray, S. J. Lippard & J. S. Valentine, *Bioiorganic chemistry*, University Science books, Mill Valey, CA, 1994. 3. D. E. Fenton, *Biocoordination Chemistry*, Oxford Chemistry Printers, 25 Oxford University Press, 1995 4. E. E. Conn, P.K. Stumpf, G. Bruening & R. H. Doi, *Outlines of Bioinorganic Chemistry*, Wiley Eastern, New Delhi, 1983, 5th Ed. 5. F.A. Cotton, G. Wilkinson, P.L. Gaus, *Basic Inorganic Chemistry*, Wiley India, 2007, 3rd Ed. (Chapter 31) 6. M Weller, T Overton, J Rourke & F Armstrong *Inorganic Chemistry*, Oxford University Press, 2018, Int. Ed. (Chapter 25) 7. P Atkins, T Overton, J Rourke, M Weller & F Armstrong, *Shriver & Atkins' Inorganic Chemistry,* Oxford University Press, 2010, 5th Ed. (Chapter 27) 8. J. E. Huheey, E.A. Keiter, R.L. Keiter, *Inorganic Chemistry: Principles of Structure and Reactivity,* Addison Wesley Publishing, 5th Ed. (Chapter 19) 9. R. W. Hay, *Bioinorganic chemistry*, Ellis Horwood Chichester, 1984 10. M.N. Hughes, *The Inorganic Chemistry of Biological processes*, Wiley (Interscience) New York, 1984, 2nd Ed.	

Programme: M. Sc. Part-II (Inorganic Chemistry)
Course Code: ICO-502
Title of the Course: Catalysis: The Basic chemical concepts
Number of Credits: 03 **Effective from AY:** 2019-20

Prerequisites for the course:	The students with Chemistry back ground are eligible for this course.	No. of lectures
Course Objectives:	1. To understand fundamentals concepts of chemical reactions over the catalysts. 2. To understand energy saving and making green processes in chemical reactions. 3. To understand fundamentals concepts of chemical reactions for developing higher productivity, mechanisms and viability. 4. To provide knowledge on applications of heterogeneous, homogenous and other catalytic processes.	
Course Outcomes:	1. The students will be able to understand the green chemical processes. 2. They will be well equipped with the knowledge of catalytic reactions. 3. They will be in position to understand the reaction mechanism process. 4. The concepts of catalytic reactions will be cleared to them. 5. They will know the applications of catalyst compounds in chemical reactions and industries.	
Content:	**1. Origin and development of catalysis;** Difference between heterogeneous, homogeneous, auto and photocatalysis, Importance of heterogeneous and homogeneous catalysts in chemical reactions. **2. Heterogeneous Catalysis:** i. Adsorptions: Physical and chemical adsorption, dissociative adsorptions, simple adsorptions isotherm, Langmuir adsorption and the BET adsorption isotherm. ii. Types of Catalysts; Preparations of the Catalysts, nano-materials, significance of zeolites and supported catalysts. iii. Characterization of solid catalysts: Surface area, structure and surface morphology, X-ray diffraction, SEM, TEM, X-ray absorption spectroscopy, XPS and Auger spectroscopy to surface studies. iv. Activity and life of the catalysts, active centers, promoters and poisons, catalyst deactivations. v. Heterogeneous reactions: Thermodynamic consideration in surface reactions, ammonia synthesis, oxidation reduction reactions (selected examples), mechanism of catalytic reactions, method of finding rate of the reactions and the rate determining steps. vi. Theories of Catalysis: Boundary layer theory, Catalysis by semiconductors, Wolkenstein theory, Balanding's approach,	2 hr 17 hr

	electronic factors is catalysis by metals. **3. Homogeneous Catalysis:** Intermediate stages in homogenous Catalysis, energy profile diagram, general scheme for calculating kinetics of reactions, decomposition of hydrogen peroxide, acid-base catalysis, hydrogenation, Mosanto acetic acid, Carboxylation reaction and Wacker reaction. **4. Introduction to followings:** Photocatalysis, catalytic polymerizations, phase transfer catalysis and biocatalysis with suitable examples. **5. Catalysts for energy and environmental:** Catalytic gasification, steam reforming, fuel cells and auto-industrial emission control.	7 hr 6 hr 4 hr
Pedagogy	Mainly lectures / tutorials / assignments /self-study or a combination of some of these could also be used to some extent.	
Text books / Reference books	1. P. H. Emmett, *Catalysis*,Vol I, Reinhold, New York, 1955. 2. A.V. Salker, *Catalysis: Principles and Basic Concepts*, Scientific International, 2019. 3. D. K. Chakraborty, *Adsorption and Catalysis by Solids,* New Age Intl. (P) Ltd., 2008. 4. J. M. Thomas & W.J. Thomas, *Heterogeneous Catalysis*, VCH publication, 1997. 5. A. Clark, *The Theory of Adsorption and Catalysis*, Academic Press, 1970. 6. E. R. Rideal, *Concept in Catalysis*, Academic Press, 1968. 7. G. M. Panchenov & V. P. Lebedev, *Chemical Kinetics and Catalysis*, Mir publication, 1976. 8. S. J. Thomson & G. Webb, *Heterogeneous Catalysis*, Oliver and Boyd Publications, 1968. 9. R. A. Van Santen & J. W. Niemantsvedict, *Chemical Kinetics and Catalysis*, Plenum Press, New York, 1995.	

Programme: M. Sc. (Inorganic Chemistry)
Course Code: ICO-503
Title of the Course: Chemistry of P-Block Elements
Number of Credits: 03 **Effective from AY: 2019-20**

Prerequisites for the course:	Students should have studied the courses in Inorganic Chemistry at F Y B Sc, S Y B Sc, T Y B Sc and ICO-401 course at M.Sc. Part-I Chemistry so as to have basic knowledge of P-Block Elements	No. of Lectures
Course Objective:	To provide basic and advanced knowledge about P-Block elements, their compounds and complexes.	
Course Outcome	This course will give sufficient information about the periodic table in general and P-Block elements and their compounds in particular.	
Content:	**1. General trends of different properties in groups and periods in periodic table**	2 hr
	2. Chemistry of Group 13 Elements and their Compound 2.1 Introduction, physical properties, chemical reactions with oxygen, nitrogen, sulphur, halogens, HCl, NaOH, NH_3, mono-di-tri-chlorides, alums, organo-compounds of B and Al, difference between boron and other Gr. 13 elements, diagonal relationship. 2.2 Preparation, bonding and structure of diborane, higher boranes, borane anions, carboranes and metallocarboranes.	9 hr
	3. Chemistry of Group 14 Elements and their Compound 3.1 Introduction, physical properties, compound of Gr.14: Oxides, di & tetra halides, hydrides, sulphides, complexes of Gr.14, organosilicon compounds (except silicones), cluster compounds of Ge, Sn and Pb. 3.2 Carbon dating, graphene, metallocarbohedrenes, freons.	5 hr
	4. Chemistry of Group 15 Elements and their Compound 4.1 Introduction, allotropes, physical properties, Preparation, properties and structure of: Hydrides, halides, oxohalides; 4.2 Preparation, properties and structure of Phosphorous: Oxides, oxyacids, sulphides, oxosulphides; organophosphorous compounds. 4.3 Classification, preparation, properties and structures of phosphazenes.	5 hr
	5. Chemistry of Group 16 Elements and their Compound 5.1 Introduction, allotropes, physical properties, Preparation, properties and structure of: Hydrides, halides, oxohalides, oxides (except sulphur), oxyacids (except sulphur), classification of oxides. 5.2 Polyatomic sulphur cations, anionic polysulphides, compounds with sulphur as a ligand.	6 hr

	6. Chemistry of Group 17 Elements and their Compound 6.1 Introduction, physical properties; preparation, properties and structure of: Oxides, oxyacids, halides, oxohalides, hydrogenoxide fluorides and related compounds. 6.2 Preparation, properties and structure of: Polyhalide anions, polyhalonium cations, halogen cations. **7. Chemistry of Group 18 Elements and their Compound** 7.1 Introduction, physical properties; preparation, properties and structure of xenon compounds (fluorides and oxides); organoxenon compounds, coordination compounds. 7.2 Preparation, properties and structure of compounds of other noble gases.	6 hr 3 hr
Pedagogy:	Mainly lectures/ tutorials/ assignments /seminars/ presentations/ self-study or a combination of some of these could be used to some extent. Sessions shall be fractionally interactive in nature.	
Text books: **References/Readings:**	1. J. D. Lee, *Concise Inorganic Chemistry*, Blackwell Science Wiley, 2015, 5th Ed. (Reprint) 2. P. W. Atkins, T. Overton, J. Rourke, M. Weller and F. Armstrong, *Shriver & Atkins Inorganic Chemistry*, Oxford publications, 2009, 5th Ed. 3. N. N. Greenwood & A. Earnshaw, *Chemistry of the Elements,* Elsevier, 2014 (Reprint), 2nd Ed. 4. J. E. Huheey, E. A. Keiter, R. L. Keiter and O. K. Medhi, *Inorganic Chemistry: Principles of structure and reactivity,* Dorling Kindersley (India) Pvt. Ltd., 2009 (Reprint), 4th Ed.	

M Sc-II Organic chemistry

Semester III and IV Courses (Academic year 2019-2020 onwards)

Compulsory courses			**Optional courses**		
Code	**Title**	**Credits**	**Code**	**Title**	**Credits**
OCC-501	Organic Spectroscopy	3	OCO-501	Chemistry of Natural Products	3
OCC-502	Reaction Mechanisms, Stereochemistry and Asymmetric Synthesis	3	OCO-502	Organometallic Chemistry	3
OCC-503	Synthetic Methods in Organic Chemistry	3	OCO-503	Introduction to Medicinal Chemistry	3
OCC-504	Pericyclic and Organic Photochemical Reactions	3	OCO-504	Retrosynthesis in Organic Chemistry	3
OCC-505	Organic mixture separation and identification	3	OCO-505	Heterocyclic Chemistry	3
			OCO-506	Introduction to Polymer Chemistry-I: Basic Concepts	3
			OCO-507	Introduction to Polymer Chemistry-II: Synthesis of Polymers and Processing	3
			OCO-508	Selected experiments in Organic Chemistry-I	4
			OCO-509	Chemistry of life	3
			General Optional Courses		
			CGO-500	Dissertations	8
			CGO-501	Selected Experiments in Chemistry	8

Programme: M. Sc. (Chemistry, Part-II)
Course Code: OCC-501
Title of the Course: Organic Spectroscopy
Number of Credits: 3 **Effective from AY:** 2019-20

Prerequisites for the course:	Should have studied the spectroscopy topics at T Y B Sc (Chemistry) and M Sc part-I (Chemistry) levels.	
Course Objective:	1. Study of various theoretical concepts related to organic spectroscopic techniques. 2. Introduction of commonly used 2D NMR techniques. 3. Learning interpretational aspects of spectral data pertaining to IR, PMR, CMR and MS.	
Course Outcome	1. Students should be in a position to deduce structures of simple to moderately complex molecules by combining the spectral data obtained using two or more spectral techniques. 2. Students should be in a position to apply various concepts in organic spectroscopy (PMR, CMR, MS and 2D NMR) and generate/ predict PMR, CMR, MS and 2D NMR spectral data based on given structures of simple molecules.	
Content:	**1. Electronic and Infrared Spectroscopy:** Theory of electronic and IR spectroscopy (revision of the basic concepts/solving problems). Application of electronic and IR spectroscopy in structural elucidation of organic compounds (various functional classes to be considered). **2. NMR Spectroscopy** Principles of NMR, instrumentation, chemical shift- (revision of the basic concepts); Interpretation of PMR spectra. a) Coupling constants and AB, A_2B_2/A_2X_2, AMX and ABX spin systems. b) Double resonance and decoupling c) Nuclear Overhauser Effect and its applications. d) NMR Shift reagents **3. ^{13}C –NMR spectroscopy:** Introduction, 13C- chemical shifts effects (α-, ß-, γ-, δ-substituent effects, π-conjugation, heavy atom effect and ring size effects), proton coupled and proton decoupled 13C-spectra. Off- resonance decoupling, APT & DEPT techniques. **4. ^{19}F- NMR and ^{31}P- NMR spectroscopy:** Principles and applications; heteronuclear coupling of carbon to ^{19}F and ^{31}P.	04 hours 07 hours 07 hours 04 hours

	5. Two-dimensional NMR spectroscopy: Introduction to 2D NMR techniques and interpretation of spectra of simple organic compounds using following 2d-NMR techniques- COSY, NOESY, HSQC, HMQC, HMBC, TOCSY and INADEQUATE **6. Mass spectrometry** Even and odd electron ions and fragmentation modes a) McLafferty rearrangement and retro-Diels-Alder fragmentation. b) Mass spectra of compounds like alcohols, amines, ethers carbonyl compounds, hydrocarbons, halogen compounds, nitro compounds and cyanides. Note: Problems involving combined use of different type of spectra, in line with course objective/ learning outcome are to be emphasized.	08 hours 06 hours
Pedagogy:	lectures/ tutorials/ seminars/ term papers/assignments/ presentations/ self-study/ Case Studies etc. or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.	
References/Readings	1. P.S. Kalsi, *Spectroscopy of Organic compounds*, New Age International Pub. Ltd. & Wiley Eastern Ltd., 1995, 2nd Ed. 2. J. R. Dyer, *Applications of Absorption Spectroscopy of Organic compounds*, Prentice Hall of India, 1987. 3. R.M. Silverstein, F. X. Webster, *Spectrometric Identification of Organic compounds*, John Wiley & Sons Inc., 2011, 7th Ed. (reprint). 4. V.M. Parikh, *Absorption Spectroscopy of Organic Molecules*, Addison Wesley Longman Publishing Co., 1974. 5. D.H Williams & I. Fleming, *Spectroscopic Methods in Organic Chemistry*, Tata Mcgraw Hill Education, 2011, 6th Ed. 6. William Kemp, *Organic Spectroscopy*, Palgrave Macmillan, 1991, 3rd Ed. 7. William Kemp, *NMR in Chemistry: A Multinuclear Introduction*, Macmillan, 1986. 8. Donald L. Pavia, Gary M. Lampman, George S. Kriz, James R. Vyvyan, *Introduction to Spectroscopy*, Brooks Cole, 2009, 4th Ed. 9. L. D. Field, H. L. Li & A. M. Magill, *Organic Structures from 2D NMR Spectra*, Wiley, 2015.	

Programme: M. Sc. (Chemistry, Part-II)
Course Code: OCC-502
Title of the Course: Reaction Mechanisms, Stereochemistry and Asymmetric Synthesis
Number of Credits: 3 **Effective from AY:** 2019-20

Prerequisites for the course:	Should have studied the topics on Reaction Mechanisms, stereochemistry at T Y B Sc (Chemistry) and M. Sc. part-I (Chemistry) levels.	
Course Objective:	1. Introduction to important principles of stereochemistry such as Baldwin's rules. 2. Understand the importance of chirality in organic syntheses. 3. Learn about non-catalytic asymmetric synthesis methods in the classical chemistry involving alkenes and carbonyl compounds. 4. Analyse and understand mechanistic aspects for fundamental reactions studied at TYBSc/ MSc Part I levels.	
Course Outcome	1. Students should be in position to understand the importance of asymmetric synthesis in organic reactions. 2. Students should be in position to understand to apply various principles of stereochemistry and understand the mechanistic aspects of fundamental reactions.	
Content:	**I. Reaction Mechanisms**- 1**. Intramolecular Reactions** (Baldwin's Rules) **2. Molecular rearrangements and their synthetic applications** 2.1 Unifying principles and mechanisms of rearrangements taking place at an electron deficient and electron rich substrates. 2.2 Rearrangements taking place at carbon: Arndt Eistert, Wagner Meerwein, benzil-benzilic acid, Pinacol, semipinacol, Tiffeneau Demjanov, dienone phenol, Wittig, Favorskii, Stevens, Wolff, Baker-Venkatraman rearrangement, Barton decarboxylation, Pummerer rearrangement. 2.3 Rearrangements at nitrogen: Hofmann, Curtius, Lossen, Schmidt, Beckmann, Neber, Stieglitz rearrangement. 2.4 Rearrangements at oxygen: Payne (including aza and thia Payne) rearrangement, hydroperoxide rearrangement, Criegee rearrangement. 2.5 Aromatic rearrangements: Benzidine, Fries, Von Richter, Sommelet-Hauser, Smile's, Jacobsen. Rearrangement on aniline derivatives- Bamberger rearrangement, Fischer-Hepp, Orton, Hofmann-Martius,	02 hours 07 hours

	Reilly-Hickinbottom, rearrangements of N-arylazoanilines, Phenylnitramines, Phenylsulfamines. 2.6 Rearrangements involving fragmentations: Eschenmoser fragmentation. **II Stereochemistry** **1.1 Stereoselctivity in cyclic compounds** (1) Introduction (2) Stereochemical control in six membered rings (3) Reactions on small rings (4) Regiochemical control in cyclohexene epoxides (5) Stereoselectivity in bicyclic compounds **1.2 Conformations, stability and reactivity of fused ring compounds** 1.2.1 Fused bicyclic systems with small and medium rings: (1) Bicyclo [4.4.0] decanes (cis- and trans-decalins) (2) cis- and trans- decalones and decalols (3) Octahydronaphthalins (octalins) (4) Bicyclo [4.3.0] nonane (cis- and trans-hydrindanes) **1.3 Fused polycyclic systems** (1) Perhydrophenanthrenes (2) Perhydroanthracenes (3)Perhydrocyclopentenophenanthrene system (steroids, triterpenoids and hormones). Conformations and reactivity towards esterification, hydrolysis, chromium trioxide oxidation, ionic additions (of X_2) to double bonds, formation and opening of epoxide ring, epoxidation by peroxy acids. 1.4 Spirocyclic compounds 1.5 Reactions with cyclic intermediates or cyclic transition states **2. Conformation of bridged ring compounds** 2.1 Bicyclo [2.2.1] heptane (norbornane) (1) Geometry and topic relationship of hydrogens. (2) Solvolysis of bicyclo[2.2.1]heptyl systems, formation, stability and reactivity of norbornylcation. (3) Relative stability and the rate of formation of *endo* and *exo* isomers in both bornane and norbornane systems. 2.2 Bicyclo [2.2.2] octane system (1) Geometry and topic relationship of hydrogens (2) Solvolysis of bicyclo[2.2.2]octyl system. 2.3 Other bridged ring systems: starting from bicyclo[1.1.1]pentane to bicyclo[3.3.3] undecane 2.4 Bicyclo system with heteroatom: the relative stabilities of	8 hours 4 hours

	tropine, pseudotropine and benzoyl derivatives of norpseudotropine. **3. Dynamic Stereochemistry: Stereoselective Reactions** 3.1 Stereoselectivity: classification, terminology and principle. Selectivity in chemistry– substrate and product selectivity. 3.2 Stereoselective reaction of cyclic compounds: Introduction, reactions of four, five and six-membered rings. Conformational control in the formation of six-membered ring. 3.3 Diastereoselectivity: Introduction, making single diastereoisomers using stereospecific reactions of alkenes. 3.4 1,2-Addition to carbonyl compounds: Predicting various addition outcomes using different predictive models such as, Cram Chelate, Cornforth, Felkin-Anh. Specific reactions: allylation/crotylation by Brown, Roush, BINOL catalyzed. 3.5 Stereoselective reaction of acyclic alkenes: The Houk model **4. Asymmetric synthesis** 4.1 Chiral pool (chiron approach) 4.2 Chiral auxiliary approach Oxazolidinone & norephedrine-derived chiral auxiliary controlled Diels-Alder reaction and alkylation of chiral enolates and aldol reaction, Alkyation using SAMP and RAMP 4.3 Chiral Reagents (Use of (-)-sparteine 4.4 Asymmetric catalysis CBS catalyst, Ruthenium catalyzed chiral reductions of ketones, Catalytic asymmetric hydrogenation of alkenes, Asymmetric epoxidation (Sharpless and Jacobson), Sharpless asymmetric dihydroxylation reaction Organocatalysed aldol reaction (Use of proline) **5. Stereoisomerism due to axial chirality, planar chirality and helicity.** 5.1 Stereochemistry and configurational (R/S) nomenclature in appropriately substituted allenes, alkylidenecycloalkenes, spiranes, adamantoids, biaryls, trans-cycloalkenes, cyclophanes and ansa compounds. 5.2 Atropisomerism in biphenyls and bridged biphenyls.	6 hours 6 hours 3 hours
Pedagogy:	Lectures/ tutorials/ seminars/ term papers/assignments/ presentations/ self-study/ Case Studies etc. or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.	
References/Readings	1. M. B. Smith & Jerry March, *Advanced Organic Chemistry-*	

	Reaction, Mechanism and Structure, Wiley, 2006, 6th Ed. 2. D. Nasipuri, *Stereochemistry of Organic compounds, Principles and applications*, New Age International Pvt. Ltd., 1994, 2nd Ed. 3. E.L. Eliel, *Stereochemistry of Carbon Compound*, Tata Mc-Graw Hill, 1975. 4. W. Caruthers & I. Colddham, *Modern Methods of Organic Synthesis*, Cambridge University Press, 2016, 4th Ed. 5. J. Clayden, N. Greeves and S. Warren, Oxford, 2016. 6. I. L. Finar, *Stereochemistry and the Chemistry of Natural Products*, ELBS, Vol. 2, Longman Edn, 1975. 5th Ed. 7. E.S. Gould, *Mechanism and Structure in Organic Chemistry*, Holt, Reinhart and Winston, 1965. 8. F. A. Carey & R. J. Sundberg, *Advanced Organic Chemistry*: *Part A and B*, Springer India Private Limited, 2007, 5th Ed. 9. R. O. C. Norman & J. M. Coxon, *Principles of Organic Syntheses,* CRC Press Inc, 1993, 3rd Ed. 10. V.M. Potapov & A. Beknazarov, *Stereochemistry*, Central Books Ltd., 1980. 11. D. G Morris, *Stereochemistry*, Wiley-RSC, 2002, 1st Ed. 12. Clayden, Greeves, Warren & Wothers, *Organic Chemistry*, Oxford University Press, 2002, 2nd Ed. 13. M. Nogradi, *Stereoselective Synthesis*, VCH Publishers, Inc., 1994, Revised and Enlarged Ed.	

Programme: M. Sc. (Chemistry, Part-II)
Course Code: OCC-503
Title of the Course: Synthetic Methods in Organic Chemistry
Number of Credits: 3 **Effective from AY:** 2019-20

Prerequisites for the course:	Should have studied the synthetic organic chemistry at M. Sc. Part-I (Chemistry) levels.	
Course Objective:	1. Study of various concepts related to making carbon-carbon bonds. 2. To understand designing of organic synthesis to make molecules of interest. 3. To plan total synthesis based on protection-deprotection strategy.	
Course Outcome	1. Students should be in a position to understand how a carbon-carbon bond can be constructed. 2. Students should be in a position to apply various reactions in constructions of simple to complex molecules.	
Content:	**1. Formation & reactions of enols and enolates.** 1.1. Keto-enol tautomerism: introduction, acidity, basicity concepts & pKa scale, neutral nitrogen and oxygen bases. Formation of enols by proton transfer, requirements for and mechanism of enolisation 51pprox.51d by acids & bases, types of enols & enolates, kinetically & thermodynamically stable enols, consequences of enolisation, stable enolate equivalents, preparation and reactions of enol ethers. 1.2. Formation of Enolates: Introduction, preparation & properties, non-nucleophilic bases, E / Z geometry in enolate formation, kinetic vs. thermodynamic control, other methods for the generation of enolates, issue of enolate ambidoselectivity. 1.3. Alkylation of enolates: diverse reactivity of carbonyl groups, alkylation involving nitriles and nitroalkanes, choice of electrophile for alkylation, lithium enolates of carbonyl compounds and alkylation, specific enol equivalents to alkylate aldehydes and ketones, alkylation of *β*-dicarbonyl compounds, problem of regioselectivity during ketone alkylation and the remedy provided by enones. 1.4. Reaction of enolates with aldehydes and ketones: introduction, aldol reaction including cross & intramolecular version, enolizable substrates which are not electrophilic in nature, controlling aldol reactions with specific enol equivalents, specific enol equivalents for carboxylic acids, aldehydes and ketones. 1.5. Acylation at carbon: Introduction, the Claisen ester condensation (intramolecular and inter / crossed),	18 hours

	acylation of enolates by esters, preparation of keto-esters by the Claisen reaction, directed C-acylation of enols and enolates & acylation of enamines. 1.6. Conjugate addition of enolates: Introduction, thermodynamic control vs. conjugate addition, utility of various electrophilic alkenes in conjugate addition, formation of six-membered rings *via* conjugate addition and nitroalkanes as versatile synthons. 1.7. Examples pertaining to the application of following condensation reactions in organic synthesis: Mukaiyama reaction, Perkin reaction, Dieckmann condensation, Knoevenagel condensation & Doebner modification, Stobbe condensation, Darzen's glycidic ester condensation, Michael addition, Robinson annulation, and the Sakurai reaction.	
	2. Synthetic utility of the following name reactions / methodology with specific examples: 2.1 Mannich Reaction, Nef Reaction, Mitsunobu and Appel Reaction, Baylis Hillman reaction, Mc. Murry coupling, vicarious nucleophilic substitution, Steglich and Yamaguchi esterification, Ring closing and cross metathesis: Grubb's various generation, Grubbs-Hoveya, Schrock catalysts-Scope and challenges in terms of ring sizes as well as FG tolerance.	6 hours
	3. The Ylids in Organic Synthesis. 3.1. Phosphorus Ylids: Nomenclature and Preparation. Wittig olefination:mechanism, stereoselectivity, cis- and trans-selective reactions, Wittig reagents derived from α-halo carbonyl compounds, 3.2 Modified Wittig, Horner – Wadsworth – Emmons, Stille-Gennari modification with achiral and chiral substrates, Peterson reaction, Julia Olefination. 3.3. Sulfur Ylids: sulfonium & sulfoxonium ylids in synthesis, diphenylcyclopropyl sulfonium ylids & their reactions with carbonyl compounds / Michael acceptors.	6 hours
	4. Protecting Groups in Organic Synthesis. 4.1. Introduction, when are Protecting Groups needed? Effective use of protective groups. Umpolung of reactivity & protecting groups. 4.2. Common protective groups namely acetals & ketals, ditho acetal/ketals, trialkylsilyl, TBDMS, THP, -OMPM, MOM, MTM, MEM, SEM & benzyl ether, methyl ether, benzyl amine, Cbz, t-Boc, Fmoc, t-butyl ester and methods for deprotection. Examples of multistep synthesis using	6 hours

	protection-deprotection procedures.	
Pedagogy:	Lectures & tutorials. Seminars / assignments / presentations / self-study or a combination of some of these could also be used to some extent	
References/Readings	1. R. Bruckner, *Advanced Organic Chemistry – Reaction Mechanisms*, San Diego,CA: Harcourt /Academic Press, San Diego, 2002. 2. M. B. Smith, *Organic Synthesis*, McGraw–HILL, New York,1994, International Edition. 3. W. Caruthers & I. Coldham, *Modern Methods of Organic Synthesis*, Cambridge University Press, 2016. 4th Ed. 4. J. Fuhrhop & G. Penxlin, *Organic Synthesis – Concepts, Methods, Starting Materials,* VCH Publishers Inc., New York, 1994. 5. M. Nogradi, *Stereoselective Synthesis,* VCH Publishers, Inc., 1994, Revised and Enlarged Edition. 6. H. O. House, *Modern Synthetic Reactions*, W. A. Benjamin, 1965, 2nd Ed. (revised with corrections). 7. T. Laue & A. Plagens, *Named Organic Reactions*, John Wiley and Sons, Inc., 2005. 8. J. Clayden, N. Greeves & S. Warren, Oxford, 2016. 9. F. A. Carey & R. J. Sundberg, *Advanced Organic Chemistry*, Springer India Private Limited, 2007, 5th Ed.	

Programme: M. Sc. (Chemistry, Part-II)
Course Code: OCC-504
Title of the Course: Pericyclic and Organic Photochemical Reactions.
Number of Credits: 3 **Effective from AY:** 2019-20

Prerequisites for the course:	Should have studied the courses/topics in Synthetic Organic Chemistry & organic spectroscopy at M Sc Part-I level.	
Course Objective:	1. Introduction of various concepts in pericyclic chemistry based on molecular orbital theory. 2. Introduction of analysis of pericyclic reactions using theoretical concepts. 3. Learning mechanistic aspects of pericyclic & phtochemical reactions in organic synthesis.	
Course Outcome	1. Students should be in a position to predict course of given pericyclic reaction using the theoretical concepts. 2. Students should be in a position to apply various to understand stereochemical output in a reaction. 3. Students shall be in a position to understand/propose plausible mechanism of pericyclic/photochemical reactions.	
Content:	1. **Pericyclic Reactions** Theory of pericyclic reactions- a) Frontier Molecular Orbital (FMO) theory b) Transition state aromaticity (Mobius-Huckel theory) concept c) Orbital correlation diagram method Analysis of pericyclic reactions (including stereochemistry) using the above concepts a) Cycloaddition reactions b) Electrocyclic reactions c) Sigmatropic rearrangements (Note: Various important features to be discussed taking examples of well-known reactions of each type) Some synthetically useful reactions (theory and examples) a) 1, 3-dipolar additions (Application of FMO theory and examples) b) [3, 3] Shifts; Claisen and Cope rearrangements and fluxional molecules, c) ene reaction, retro-Diels-Alder reactions. **2. Organic Photochemistry** a) Principles of energy transfer, theoretical concepts in organic photochemistry w. r. t.	24 hours 12 hours

	cycloadditions, electrocyclic reactions etc., b) Some photochemical reactions of alkenes, dienes, carbonyl compounds and arenes including the following- Cis-trans isomerization and photostationary equilibrium; Paterno-Buchi reaction ; Norrish Type cleavages; Di-pi methane rearrangement; bicycle rearrangement c) Reactions involving singlet and triplet oxygen	
Pedagogy:	lectures/ tutorials seminars/ term papers/assignments/ presentations/ self-study/ Case Studies etc. or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.	
References/Readings	1. R E Lehr & A P Marchand, Orbital Symmetry: A Problem Solving Approach, Academic Press, 1972. 2. R B Woodward & R Hoffmann, Conservation of Orbital Symmetry, Verlag chemie, Academic Press, NY, 1972. 3. I Fleming, Frontier Orbitals and Organic Chemical Reactions, John Wiley & Sons. 4. T L Gilchrist & R C Storr, Pericyclic Reactions, Cambridge Univ. Press, 1972. 5. F A Carrey & R J Sundberg , Advanced Organic Chemistry-Part A and B, Pelnum Pub. 1990, ., 3rd Ed. 6. T Lowery & K Richardson, Mechanisms and Theory in Organic Chemistry, Harper and Row Pub., NY, 1987, 3rd Ed. 7. Biswanath Dinda, Essentials of Pericyclic and Photochemical Reactions, Springer, 2017. 8. Sunil Kumar, Vinod Kumar, S.P. Singh, Pericyclic Reactions: A Mechanistic and Problem-Solving Approach, Elsevier, 2016. 8. N. Turro, Modern Molecular Photochemistry, Benjamin 9. C. H. DePay, Molecular Reactions and Photochemistry, Prentice Hall (I) Ltd, NewDelhi. 10. J. Kopecky, Organic Photochemistry- A Visual Approach, VCH Pub., 1992.	

Programme: M. Sc. (Chemistry, Part-II)
Course Code: OCC-505
Title of the Course: Organic mixture separation and identification
Number of Credits: 3 **Effective from** AY: 2019-20

Prerequisites for the course:	Should have studied the relevant theory and practical courses in Organic Chemistry at M. Sc. Part-I levels.	
Course Objective:	To translate certain theoretical concepts learnt earlier into experimental knowledge by providing hands on experience of basic laboratory techniques required for organic separations.	
Course Outcome	Students shall gain the understanding of: 1. Separation of organic components based on solubility. 2. Separation of organic components based on functionality. 3. Separation of organic components based on boiling points. 4. Distillation, recrystallization and derivatisation. 5. Safe and Good laboratory practices, handling laboratory glassware, equipment and chemical reagents.	
Content:	Three component mixture separation based upon differences in the physical and the chemical properties of the components. Elemental and functional group analysis and determination of physical constants of the individual compounds. Derivative preparation, its recrystallization and m. p. of each component and characterization of each component and its derivative by m. p. comparison. (Minimum 12 experiments of 6h each.) Assessment to be done through a 6hr examination comprising of an experiment emphasizing separation of mixture, elemental analysis of all three components and preparation of derivative of any one component suggested by examiner and recording of the physical constants and an oral assessment.	72 hours
Pedagogy:	Lectures/ pre-lab and post-lab exercises/ laboratory work /assignments/ presentations/ self-study/ Case Studies etc. or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.	
References/Readings	1. N.K. Vishnoi, *Advanced Practical Organic Chemistry*, Vikas Publishing, 2009, 3rd Ed. 2. A. I. Vogel, *Elementary Practical Organic Chemistry: Part 1- Small Scale Preparations*, Pearson, 2010, 2nd Ed. 3. A. I. Vogel, *Elementary Practical Organic Chemistry: Part 2 –*	

	Qualitative Organic Analysis, Pearson, 2010, 2nd Ed. 4. A. I. Vogel, *Elementary practical organic chemistry: Part 3- Quantitative organic analysis*, Pearson, 2010, 2nd Ed. 5. F G Mann & B C Saunders, *Practical Organic Chemistry*, Pearson, 2009, 4th Ed. 6. A.R. Tatchell, B.S. Furnis, A.J. Hannaford & P.W.G. Smith, *Vogel's Textbook of Practical Organic Chemistry*, Longman, 1989, 5th Ed.	

Programme: M. Sc. (Chemistry, Part-II)
Course Code: OCO-501
Title of the Course: Chemistry of Natural Products
Number of Credits: 3 **Effective from AY:** 2019-20

Prerequisites for the course:	Should have studied the topics on stereochemistry, spectroscopy and synthetic organic chemistry at M. Sc. part-I (Chemistry) levels.	
Course Objective:	1. To study the main classes of natural products. 2. To understand the different methods that are used in natural product chemistry, including extraction, isolation and structural elucidation. 3. To understand the key biosynthetic pathways for the biosynthesis of terpenes, alkaloids and steroids.	
Course Outcome	3. Students should able to identify different types of natural products, their occurrence, structure biosynthesis and properties. 4. Students should able to carry out independent investigations of plant materials and natural products.	
Content:	**1. General methods of purification and structure elucidation of Natural Products** 1.1 General methods of isolation-The modern distillation process, maceration, enfleurage, extraction by cold pressing and extraction with solvents. 1.2 Fractionation of the crude extracts and purification of the individual compounds from the respective fractions using chemical and chromatographic techniques such as Column Chromatography, TLC, Preparative TLC, HPLC, etc. 1.3 Chemical methods based on the functional groups present. Bicarbonate extraction, sodium bisulphite adduct formation, derivatization, etc. 1.4 General approach to structure elucidation of the isolated pure compounds using UV, IR, NMR spectroscopy, MS spectrometry, optical polarimetry. **2. Structure elucidation by classical chemical methods** 2.1 Terpenoids: α-cedrene 2.2 Alkaloids: Morphine, thebaine and codeine 2.3 Steroids: Cholesterol, bile acids **3. Structure elucidation by combination of chemical and spectral methods** 3.1 Terpenoids: α- and β-vetivones, Ishwarone 3.2 Hormones: Cecropia Juvenile hormone, brevicomin and frontalin 3.3 Oxygen heterocycles: Aflatoxin-B1, rotenone	5 hours 6 hours 8 hours

	4. Structure elucidation involving stereochemistry, spectral and Chemical methods 4.1 Terpenoids: Menthol and hardwickiic acid 4.2 Alkaloids: Reserpene **5. Synthesis of selected Natural Products, planning and execution** 5.1 Terpenoids: Longifolene (E J Corey), Caryophyllene (E J Corey) Nootkatone (A Yoshikoshi), Menthol (Tagasago) 5.2 Alkaloids: Reserpine (R B Woodward), Morphine (Marshall Gates) 5.3 Hormones: Cecropia JH (Edward), Progesterone 5.4 Prostaglandins: Prostaglandin E_2 (E J Corey) 5.5 Antibiotics: Cephalosporin (R B Woodward) **6. Biogenesis and biosynthesis of Natural Products** 6.1 Terpenoids and Steroids: General approach towards biosynthesis of mono-, sesqui-, di-, tri-, tetraterpenoids and steroids through mevalonate pathway with special reference to the biosynthesis of terpenoids and steroids included in topics 3 to 6 6.2 Alkaloids: The shikimate pathway formation of hydroxybenzoic acid derivatives, aromatic amino acids, L-phenylalanine, L-tyrosine, phenolic oxidative coupling, biosynthesis of thebaine, codeine and morphine.	4 hours 8 hours 5 hours
Pedagogy:	Lectures/ tutorials/ seminars/ term papers/assignments/ presentations/ self-study/ Case Studies etc. or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.	
References/Readings	1. I. L. Finar, *Organic Chemistry: Stereochemistry and the Chemistry of Natural Products*, Pearson Education India, 1956. 2. K. Nakanishi, *Natural Product Chemistry*, Academic Press, 1975. 3. D. R. Dalton, *The Alkaloids*. New York:M. Dekker. 4. Barton and Olis, *Comprehensive Organic Chemistry*, Pergamon, 1979. 5. Derick Paul, *Medicinal Natural Products, a Biosynthetic Approach*, John Wiley and Sons, 2002. 6. Mannitto Paolo, *Biosynthesis of Natural Products*, Wiley. 7. Ian Fleming, *Selected Organic Synthesis,* John Wiley and Sons 8. J. ApSimon, *Total sSynthesis of Natural Products*, John Wiley and Sons. 9. E. J. Corey & X-M. Cheng, *The Logic of Chemical Synthesis*, Wiley Interscience, a division of John Wiley and Sons Inc.	

	10. K. C. Nicolaou & E. J. Sorensen, *Classics in Total Synthesis*, Weinhem: VCH, 1996	

Programme: M. Sc. (Chemistry, Part-II)
Course Code: OCO-502
Title of the Course: Organometallic Chemistry
Number of Credits: 3 **Effective from AY:** 2019-20

Prerequisites for the course:	Should have studied the synthetic organic chemistry at M. Sc. Part-I (Chemistry) levels.	
Course Objective:	1. Study of various concepts related to making carbon-carbon bonds using organometallic reagents. 2. To understand the chemistry of main group chemistry towards organic synthesis. 3. To understand the chemistry of transition metals towards application in organic synthesis.	
Course Outcome	1. Students should be in a position to understand how organometallic chemistry can be used in making carbon-carbon bonds. 2. Students should be in a position to apply various reactions in constructions of simple to complex molecules.	
Content:	**1. Introduction to organometallic chemistry:** 1.1 Metal-carbon bonds with main-group metals and transition metals: 1.2 Sigma and pI bonds 1.3 Nomenclature and heptacity 1.4 Electron counting and 18e rule 1.5 Orbital interactions and bonding 1.6 Kinetic stability **2. Organomatallic compounds Main group elements** 2.1 Preparation, properties and applications of Lithium Magnesium, Cadmium, Zinc, Cerium, Murcury and Chromium Compounds. 2.2 Heteroatom directed lithiation reactions **3. Transition metals in organic synthesis** 3.1 Preparation, properties and applications of Copper, Palladium, Nickel, Rhodium, Ruthenium and Gold reagents/complexes. (Mechanism and applications of Mizoroki-Heck, Suzuki, Stille, Hiyama, Negishi, Sonogashira, Wacker, Kumada, Buckwald-Hartwig, carbonylation, homogenous hydrogenation, cabonylation, allylic substitution)	6 hours 12 hours 18 hours
Pedagogy:	Lectures & tutorials. Seminars / assignments / presentations /	

	self-study or a combination of some of these could also be used to some extent	
References/Readings	1. *Comprehensive Organometallic Chemistry*, 14 vols. Pergman, 1995, 2nd Ed. 2. F.R. Hartley, *Chemistry of Metal-Carbon Bond*, 6 vols. Wiley 1982-83. 3. F. A. Carey and R. Sundberg, *Advanced Organic Chemistry*, Vol. B, Plenum Press, old and new editions. 4. M. Schlosser, *Organometallics in Synthesis - A Manual*, John & Wiley, 1994. 5. R.H. CraJohn, *The Organometallic Chemistry of the Transition Metals*, Wiley, 1994. 6. G.R. Stephenson, *Transition Metal Organometallics for Organic Synthesis*, Cambridge University Press, 1991. 7. L.S. Liebeskind, *Advances in Metal Organic Chemistry*, Vols. 1 and 2 (Ed.), JAI Press,1989. 8. J. P. Colliman, L. S. Hegedus, J. R. Norton & R. G. Finke, *Principles and Applications of Organotransition Metal Chemistry*, University Science Books, 1987. 9. A. Yamamoto, *Organotransition Metal Chemistry - Fundamental Concepts and Applications,* Wiley, 1986. 10. A. J. Pearson, *Metallo-Organic Chemistry*, John Wiley, 1985.	

Programme: M. Sc. (Chemistry, Part-II)
Course Code: OCO-503
Title of the Course: Introduction to Medicinal Chemistry
Number of Credits: 3 **Effective from AY**: 2019-20

Prerequisites for the course:	Should have studied the topics on Reaction Mechanisms, stereochemistry and spectroscopy at M. Sc. part-I (Chemistry) levels.	
Course Objective:	4. Study of drugs and drug development. 5. Introduction to the concepts and processes of drug discovery, delivery, absorption and metabolism. 6. It also provides brief introduction to pharmacology, pharmacokinetics and pharmacodynamics.	
Course Outcome	1. Understand the historical and advanced concepts of medicinal chemistry and its advantages 2. Identify the medicinal properties of different organic molecules.	
Content:	**1. Introduction to Drugs** 1.1. Requirement of an ideal drug 1.2. Sources of drugs 1.3. Important terms used in chemistry of drugs 1.4. Classification and nomenclature of drugs **2. Drug Design** 2.1. Analogues and pro-drugs 2.2. Concept of lead compounds 2.3. Features governing drug design – The method of variation, drug design through disjunction, conjunction, tailoring of drugs 2.4. Cimetidine – a rational approach to drug design. **3. Drug Development and drug action** 3.1. Screening of natural products, isolation and purification, structure determination 3.2. Structure-activity relationship, QSAR, Synthetic analogues 3.3. Natural Products as leads for new pharmaceuticals 3.4. Receptor theories 3.5. Oxaminiquine – a case study. 3.6 Mechanism of drug action. 3.6. Introduction 3.7. Enzyme stimulation 3.8. Enzyme inhibition 3.9. Sulfonamides **4. Study of the following class of major drugs:** **4.1. Pharmacodynamic Agents.** a) Local anaesthetics b) Analgesics: Narcotic and non-steroidal anti-inflammatory,	5 hours 5 hours 8 hours 8 hours

	narcotic antagonists (Mechan ism of Action and Synthesis of Ibuprofen) c) Antiepileptic drugs d) Antiparkinsonism drugs e) Antihistaminics (SAR and synthesis of chlorpheniramine) f) Sedatives and hypnotics (Mechanism of Action of and synthesis of Phenobarbital) g) Antipsychotics h) Cardiovascular agents: Cardiovascular diseases, Antianginal agents and vasodilators, Antihypertensive agents, Antiarrhythmic drugs, Adrenergic blocking agents (Mechanism of Action of Methyl Dopa and synthesis of Propranolol) i) Antihyperlipidemic and antiatherosclerotic agents j) Anticoagulants, blood coagulation and anticoagulant mechanism k) Diuretics l) Drugs and diabetes: Synthetic hypoglycemic agents. **5.1 Chemotherapeutic Agents.** a) Sulfonamides (Mechanism of Action of sulphonamides) b) Antitubercular and Antilepral agents (Mechanism of Action of p-Aminosalicylic acid and Dapsone) SAR of Dapsone c) Antiamoebics (Mechanism of Action of Metronidazole) d) Anthelmintics e) Antimalarials f) Antiviral agents g) Antineoplastic Agents Synthesis of Dapsone sulphacetamide Isoniazid Metronidazole **5.2. Antibiotics : General information, mode of action and application of:** a) β-Lactam antibiotics: Penicillins and Cephalosporins b) Aminoglycocides: Streptomycin, Neomycin c) Tetracyclines d) Macrolides: Erythromycin, Rifamycin e) Lincomycin f) Polypeptides: Bacitracin g) Unclassified antibiotic: Chloramphenicol (SAR and Synthesis)	4 hours 6 hours
Pedagogy:	Lectures/ tutorials/ seminars/ term papers/assignments/ presentations/ self-study/ Case Studies etc. or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.	
References/Readings	1. R. F. Doerge, *Wilson and Gisvold's Text book of Organic Medicinal and Pharmaceutical Chemistry*, Edited by, J. B.	

	Lippincott Company, Philadelphia, USA, 8th Ed. 2. M. E. Wolff, *Burger's Medicinal Chemistry, Part I and II*, John Wiley, 4th Ed. 3. W. O. Foye, *Principles of Medicinal Chemistry,* K. M. Varghese and Co., Bombay, 3rd Ed. 4. Lednicer & Mitscher, *Organic Chemistry of Drug Synthesis Vols I and II*, John Wiley. 5. Graham Patrick, *An Introduction to Medicinal Chemistry*, Oxford University Press, Oxford, 1998. 6. D. J. Abraham, *Burgers Medicinal Chemistry and Drug Discovery, Vol. I*, John Wiley and Sons, New Jersey, 2003, 6th Ed.	

Programme: M. Sc. (Chemistry, Part-II)
Course Code: OCO-504
Title of the Course: Retrosynthesis in Organic Chemistry
Number of Credits: 3 **Effective from AY:** 2019-20

Prerequisites for the course:	Should have studied the synthetic organic chemistry at M. Sc. part-I (Chemistry) levels and part II organic level CHOC-501, 502, 503 and 504 courses.	
Course Objective:	1. Study of various logical steps related to planning of organic synthesis. 2. To apprehend the complexity of synthesis of complex organic molecules. 3. To apply the knowledge gained in organic synthesis for making new molecules.	
Course Outcome	1. Students should be in a position to understand how retrosynthesis can be used in finding out easily available chemical precursors for making organic molecules. 2. Students should be in a position to apply various reactions in constructions of simple to complex molecules.	
Content:	**1. Introduction to disconnection** **2. One-Group disconnection** 2.1 Disconnection of simple alcohols 2.2 Compounds derived from alcohols. 2.3 Review problems. 2.4 Disconnections of simple olefins 2.5 Disconnection of aryl ketones 2.6 Control 2.7 Disconnection of simple ketones and acids 2.8 Summary and revision **3. Two-group disconnection** 3.1 1,3-Dioxygenated Skeletons 3.2 B-Hydroxy carbonyl compounds 3.3 a,b-Unsaturated carbonyl compounds. 3.4 Review problems 3.5 1,5-Diacrbonyl compounds 3.6 Mannich reaction 3.7 Summary and revision **4. 'Illogical' Two group disconnection** 4.1 The 1,2-Dioxygenated Pattern (a) a-Hydroxy carbonyl compounds.	2 hours 3 hours 4 hours 8 hours

	(b) 1,2-Diols (c) 'Illogical' Electrophiles (d) Review problems 4.2 The 1,4-Dioxygenated Pattern (a) 1,4-Dicarbonyl Compounds (b) Y-Hydroxy Carbonyl Comppunds. (c) Other 'Illogical' Synthons (d) Review Problems 4.3 1,6-Dicarbonyl compounds 4.4 Synthesis of lactones, Review Problems	
	5. General review problems.	2 hours
	6. Pericyclic reactions: problems	2 hours
	7. Heteroatom and heterocyclic compounds 7.1 Ethers and amines 7.2 Heterocyclic compounds 7.3 Amino acids 7.4 Review problems	3 hours
	8. Special methods for small rings. 8.1 Three-Membered Rings. 8.2 Four-membered rings. 8.3 Review Problems	2 hours
	9. General review problems.	2 hours
	10. Strategy 10.1 Convergent synthesis 10.2 Strategic Devices (a) C-Heteroatom Bonds. (b) Polycyclic compounds: The Common Atom Approach 10.3 Considering All Possible Disconnections, 10.4 Alternative FGI's Before Disconnection- The Cost of Synthesis 10.5 Features Which Dominate Strategy, 10.6 Functional Group Addition 10.7 Molecules with Unrelated Functional Groups. 10.8 Revision Problems.	8 hours
Pedagogy:	Lectures & tutorials. Seminars / assignments / presentations / self-study or a combination of some of these could also be used	

	to some extent	
References/Readings	1. S. Warren, *Designing Organic Synthesis,* John Wiley & Sons. 2. G. S. Zweifel & M. H. Nantz, *Modern Organic Synthesis: An Introduction,* W.H. Freeman and Company, New York. 3. J. Clayden, N. Greeves & S. Warren, *Organic Chemistry*, Oxford, 2016.	

Programme: M. Sc. (Chemistry, Part-II)
Course Code: OCO-505
Title of the Course: Heterocyclic Chemistry
Number of Credits: 3 **Effective from AY:** 2019-20

Prerequisites for the course:	Should have studied the synthetic organic chemistry at M. Sc. part-I (Chemistry) levels, part II organic level CHOC-501, 502, 503 and 504 courses and must be simultaneously studying CHOO-503 and 504, courses.	
Course Objective:	1. Understand the fundamentals of heterocyclic chemistry 2. Knowledge of synthesis of heterocycles.	
Course Outcome	1. Understand the reactivity of heterocyles towards electrophilic, nucleophilic, reducing and oxidizing reagents. 2. Knowledge of synthesis of heterocycles.	
Content:	1. **Introduction, classification and Nomenclature of mono- and bicyclic heteroaromatic molecules** **2. Physical properties, dipole moment, acidity-basicity, Aromaticity electron density distribution and reactivity of-** 2.1 Furan, Thiophene,Pyrrole, Indole 2.2 Pyridine, Pyridine-N-oxide 2.3 Quinoline and isoquinoline 2.4. Diazines and triazines 2.5. 1,3- and 1,2- azoles 3. **Synthetic strategies based on reterosynthetic approach: General methods of synthesis of the following-** 3.1 Furan, Thiophene, Pyrrole, Indole 3.2 Pyridine, Quinoline and isoquinoline 3.3 Chromones	04 hours 20 hours 12 hours
Pedagogy:		
References/Readings	1. J. A. Joule & G. F. Smith, *Heterocyclic Chemistry*, ELBS, 2. J. A. Joule & K. Mills, Heterocyclic *Chemistry*, Wiley-Blackwell, 2010. 5th Ed. 3. T. L. Gilchrist, *Heterocyclic Chemistry*, Pitman Publishing, 1985. 4. R. M. Acheson, *An Introduction to Chemistry of Hetreocyclic Compounds*, John Wiley and Sons, 1977, 3rd Ed. 5. D. W. Young, *Heterocyclic Chemistry*, Longman Group Ltd., London, 1975. 6. A. R. Katritzky & J. M. Lagowskii, *Principles of Heterocyclic Chemistry*, Mathesons and Co., 1967.	

	7. A. Weissberger & E. Taylor, *Chemistry of Heterocyclic Compounds*, Vol. 1 to 47, 1987. 8. A. R. Katritzky etal., *Advances in Heterocyclic Chemistry*, Vol. 1 to 50, Academic Press	

Programme: M. Sc. (Chemistry, Part-II)
Course Code: OCO-506
Title of the Course: Introduction to Polymer Chemistry-I: Basic Concepts
Number of Credits: 03 **Effective from AY:** 2019-20

Prerequisites for the course:	Should have studied the courses in Organic Chemistry at T. Y. B Sc. and M. Sc. Part-I levels.	
Course Objective:	Introduction to various concepts in organic polymer chemistry.	
Course Outcome	1. The students will be in a position to understand the differences in structures and properties of small molecules and macromolecules. 2. The students will be in a position to understand concepts involved in polymer synthesis and characterization.	
Content:	**1. Brief history of natural and synthetic polymers**: Classification & nomenclature of polymers, Functionality concept- linear, branched and cross-linked polymers. Introduction to biodegradable polymers. **2. Methods and Chemistry of polymerization:** Bulk, solution, suspension, emulsion, addition, condensation polymerizations. Free-radical, Ionic and co-ordination polymerization reactions and copolymerization. Introduction to controlled free radical polymerization. Carothers equation in condensation polymerizations. **3. Some properties of polymers:** Number and weight average molecular weights, Molecular weight distribution, polydispersity, Glassy state and glass transition temperature, crystallinity in polymers. Introduction to characterization of polymers. **4. Additives in polymers:** Lubricants, plasticizers, stabilizers, antioxidant, fire retardants, blowing agents, fillers, colorants, crosslinking agents, UV-Vis degradants etc., (properties and examples)	07 hours 12 hours 10 hours 07 hours
Pedagogy:	lectures/ tutorials/ project work/ vocational training/viva/ seminars/ term papers/assignments/ presentations/ self-study/ Case Studies etc. or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.	
References/Readings	1 V. R. Gowarikar, N.V. Vishwanathan, Jayadev Sreedhar, *Polymer Science*, New Age International, 2015. 2. P Bahadur & N V Sastry, *Principles of Polymer Science*-	

Narosa Publishing House, 2003.
3. J R Fried, *Polymer Science and Technology*, PHI Pvt. Ltd., 2000.
4. R Sinha*, Outlines of Polymer Technology: Manufacture of Polymers*, PHI Pvt Ltd., 2000.
5. J A Brydson, *Plastic Materials*, Newnes-Butterworths, 1979, 3rd Ed.
6. J Urbansky, *Handbook of Analysis of Synthetic Polymers and Plastics*, John Wiley, 1977.
7. K Y Saunders, *Organic Polymer Chemistry*, Chapman and Hall, UK, 1976.
8. R W Lenz, *Organic Chemistry of Synthetic High Polymers*, Interscience, 1967.
9. Kircheldorf H R (Ed), *Handbook of Polymer Synthesis, PART A and B,* Marcel Dekkar Inc., 1992,
10. Brown R P, *Handbook of Plastic Test Methods*George Godwin Ltd., 1981, - 2nd Ed.
11. M P Stevens, *Polymer Chemistry- An Introduction*, Oxford Univ. Press, 1990, 2nd Ed.
12. W Y Mijs (Ed), *New Methods in Polymer Synthesis*, Pelnum Press Ltd., NY, 1992.
13. P C Hiemenz, *Polymer Chemistry- The Basic Concepts,* Marcell Dekkar Inc., 1984.
14. W R Moore, *Introduction to Polymer Chemistry*, Univ. of London Press, 1967.

Programme: M. Sc. (Chemistry, Part-II)
Course Code: OCO-507
Title of the Course: Introduction to Polymer Chemistry-II: Synthesis of Polymers and Processing
Number of Credits: 3 **Effective from AY:** 2019-20

Prerequisites for the course:	Should have studied the course entitled- Introduction to polymer Chemistry-I: Basic Concepts	
Course Objective:	Introduction to various concepts involved in the synthesis and processing of organic monomers and polymers.	
Course Outcome	1. The students will be in a position to understand the synthetic methodology and applications of various monomers and polymers. 2. The students will be in a position to understand concepts involved in polymer processing.	
Content:	1. **Resources for monomers, manufacture of some important monomers and reagents**: Ethylene, propylene, butadiene, isoprene, styrene, divinyl benzene, acrylates, acrylonitrile, vinyl chloride, formaldehyde, adipic acid, urea, bisphenol-A, melamine, terephthalic acid, phthalic anhydride, dimethyl terephthalate, glycol, glycerol, ethylene oxide, epichlorohydrin, ϵ-caprolactum, di-isocyanates, pentaerythritol, allylic carbonate monomers. 2. **Synthesis, properties and applications of certain polymers:** Vinyl polymers- LDPE, HDPE, PVC, PVA, polyvinyl acetate, polyacrylates, methacrylates, polystyrene, teflon, ABS, SBR, SAN. Condensation polymers- Nylons, polyesters, polyurethanes, polycarbonates. Thermoset polycarbonates like CR-39 Cellulose esters- cellulose acetate, nitrates and acetate-butyrates. Natural rubber, Thermoset resins- phenol-formaldehyde, resols and novolacs, melamineformaldehyde, urea-formaldehyde, epoxy resins - their curing. 3. **Polymer processing** – Introduction to compounding, and processing techniques like calendaring, casting, moulding and spinning in polymer processing.	14 hours 14 hours 08 hours
Pedagogy:	lectures/ tutorials/ project work/ vocational training/viva/ seminars/ term papers/assignments/ presentations/ self-study/ Case Studies etc. or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.	

References/Readings	1. Von W. L. Faith, D. B. Keyes & R. L. Clark, *Industrial Chemicals*- John Wiley and Sons, 1965. 2. H. A. Wittcoff, B. G. Reuben, J. S. Plotkin, *Industrial Organic Chemicals,* Wiley-Interscience, 2004, 2nd Ed. 3. N. P. Cheremisinoff (Ed), Handbook of Polymer Science and Technology- Vol 1-4, 1989. 4. Finch, C. A., *Comprehensive Polymer Science—The Synthesis, Reactions and Applications of Polymers*, Sir Geoffrey Allen (Ed), Vol. 1-7, Pergamon Press, Oxford, 1989. 5. R. Sinha, *Outlines of Polymer Technology: Processing Polymers*, PHI Pvt. Ltd., 2003. 6. J. A. Brydson, *Plastic Materials*, Newnes-Butterworths, 1979, 3rd Ed. 7. J. Brandrup, E. H. Immergut, & E. A. Grulke, *Polymer Handbook*, Wiley, 1999.	

Programme: M. Sc. (Chemistry)
Course Code: OCO-508 **Title of the Course:** Selected Experiments in Organic Chemistry-I
Number of Credits: 4
Effective from AY: 2019-20

Prerequisites for the course:	Should have studied the relevant theory and practical courses in Organic Chemistry at M Sc Part-I levels.	
Course Objective:	To translate certain theoretical concepts learnt earlier into experimental knowledge by providing hands on experience of basic laboratory techniques required for organic syntheses.	
Course Outcome	Students shall gain the understanding of: 1. Stoichiometric requirements during organic syntheses. 2. Safe and Good laboratory practices, handling laboratory glassware, equipment and chemical reagents. 3. Common laboratory techniques including reflux, distillation, steam distillation, vacuum distillation, aqueous extraction, thin layer chromatography (TLC), reactions under dry conditions, use of microwave, photochemistry, low temperature synthesis etc. 4. Use of organic spectroscopic techniques in monitoring the organic syntheses.	
Content:	**(Group A: minimum 8 experiments)** 1. Dimedone from mesityl oxide (Dieckmann condensation). 2. 1,2,3.4-tetrahydrocarbazole from cyclohexanone (Fisher indolisation reaction). 3. o-Chlorobenzylidene rhodanine (Perkin reaction). 4. Diels- Alder reaction of anthracene and maleic anhydride using microwave irradiation. 5. Oxidation of a primary / secondary alcohol to carbonyl compound by polymer supported chromic acid (Amberlyst A - 26, chromate form). 6. Phenytoin from benzil and urea. 7. Use of protecting groups: Synthesis of 1 ,1-diphenylbut-1-en-3-one 1) Ethyl acetoacetate ethylene acetal. 2) 1,1-Diphenyl -1-hydroxy-3- butanone ethylene acetal. 3) 1,1-Diphenyl -1-hydroxy- 3-butanone. 4) 1,1-Diphenylbut-1-en- 3 -one. 8. Isoborneol from camphor ($NaBH_4$ reduction) 9. 3 -Methyl -2-phenyl-2-butanol from 2-bromopropane and acetophenone 10. Friedel- Crafts acylation of anisole.	48 hours

	11. Diethyl 4- butyl malonate by malonic ester condensation **(GROUP B: minimum 8 experiments)** 1. Epoxidation of cholesterol or related compounds 2. 2,2 - dichloro bicyclo (4.1.0) heptane from cyclohexene and dichloro cabene using PTC. 3. Reduction of Nitrobenzene to aniline by Sn / HCl. 4. 2 - methyl benzimidazole from o-phenylene diamine. 5. Benzophenone oxime to benzanilide (Beckmann rearrangement). 6. Ferric chloride oxidative coupling of 2-naphthol: 2,2'-dihydroxy dinaphthyl 7. Dicoumarol from coumarin derivative. 8. LAH reduction of Anthranilic acid. 9. Norborneol to norcarnphor using chromiurn trioxide/sulfuric acid 10. Halogenation using NBS: preparation of 9-bromoanthracene (or benzylic bromides) 11. Benzhydrol from benzaldehyde (Grignard reaction) 12. Ethyl n-butyl acetoacetate by acetoacetic ester condensation Note: Students are expected to use techniques like TLC, IR, GC for monitoring/ establishing purity, identity of the synthesized compounds.	48 hours
Pedagogy:	Lectures/ pre-lab and post-lab exercises/ laboratory work /assignments/ presentations/ self-study/ Case Studies etc. or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning. The students are required to undertake pre-lab. and post – lab. assignment as instructed by the concerned teacher and the same may be evaluated by according suitable weightage as an ISA component while prescribing the mode of assessment.	
References/Readings	1. N.K. Vishnoi, Advanced Practical Organic Chemistry – 3rd Ed, Vikas Publishing, 2009. 2. A. I. Vogel, Elementary practical organic chemistry: Part 1-Small scale preparations, 2nd Edition, Pearson, 2010. 3. A. I. Vogel, Elementary Practical Organic Chemistry: Part 2 - Qualitative Organic Analysis, 2nd Edition, Pearson, 2010. 4. A. I. Vogel, Elementary practical organic chemistry: Part 3-Quantitative organic analysis, 2nd Edition, Pearson, 2010.	

	5. F G Mann and B C Saunders, Practical organic chemistry, 4th Ed., Pearson, 2009. 6. A.R. Tatchell, B.S. Furnis, A.J. Hannaford, P.W.G. Smith, Vogel's Textbook of Practical Organic Chemistry, 5th Ed., Longman, 1989. 7. John C. Gilbert, Stephen F. Martin, Experimental Organic Chemistry: A Miniscale and Microscale Approach,5th Ed., Brooks Cole, 2011. 8. Kenneth L. Williamson, Katherine M. Masters, Macroscale and Microscale Organic Experiments, 6th Ed., Brooks Cole, 2011. 9. Donald L. Pavia, Gary M. Lampman, George S. Kriz, Randall G. Engel, Microscale and Macroscale Techniques in the Organic Laboratory, Thomson, 2002. 10. B. N. Campbell, Jr., M. M. Ali, Organic Chemistry Experiments, Brooks Cole, 1994. 11. D. L. Pavia, G. M. Lampman and G. S. Kriz, Introduction to Organic Laboratory Techniques: A Contemporary Approach, W. B. Saunders, 1976. 12. J W. Lehman, Operational Organic Chemistry - A laboratory course, 4th Ed, Allyn and Bacon,2008. 13. Koichi Tanaka, Solvent Free Organic Synthesis, WILEY - VCH, 2003. 14. D. W. Mayo, R. M. Pike and S. S. Butcher, Microscale organic laboratory, John Wiley and Sons, N. York, 1989 15. H. Dupont Durst, George W. Gokel, Experimental organic chemistry, McGraw-Hill, 1987.	

Programme: M. Sc. (Chemistry, Part-II)
Course Code: OCO-509
Title of the Course: Chemistry of Life
Number of Credits: 3 **Effective from AY:** 2019-20

Prerequisites for the course:	Should have studied the basic of amino acid, fatty acid and types of carbohydrates at BSc (Chemistry)	
Course Objective:	1. Introduction of types of amino acid and proteins 2. Introduction of carbohydrates and lipids 3. Understanding characteristics of proteins, carbohydrates & lipids and their applicability in daily life 4. Understanding chemicals used in food production through food processing, storage and cooking. 5. Understanding food analysis and the chemistry of the digestion of food and the energy provided by food.	
Course Outcome	1. Students should be in a position to predict type of proteins, lipids and carbohydrates available in food. 2. Students should be in a position to apply knowledge role of cooking in daily food. 3. Students shall be in a position explore the chemical structure and functionality for the macronutrient categories like carbohydrates, lipids, and protein in food 4. Student will be able to design experiments through an inquiry-oriented, food chemistry focused laboratory program. 5. The students should be able to identify the essential chemical components of food and have knowledge of their analyses, gained a working knowledge of the chemistry of lipids, carbohydrates and proteins	
Content:	**1.** ***Chemistry and Functionality of Proteins Major food proteins Structure, physical function in food Analysis:*** **Proteins** a) Introduction of amino acid and role of polar, non-polar, acidic and basic side chains and also their properties, and Isoelectric point b) Introduction of peptide, dipeptides and proteins. c) Types of proteins (primary (1˚), secondary (2˚), tertiary, (3˚) and Quaternary (4˚) • Hydrogen bonding between side chains • Salt Bridges between side chains • Hydrophobic - non-polar interactions • Disulfide linkage d) Protein folding, denaturation, functional properties of proteins. e) Food Proteins – Source of Nutrients and Analysis of proteins and amino acids f) Other Methods used in the Study of Food Proteins **2. Chemistry and *Functionality of Major Components of Food:* Carbohydrates** Introduction of Mono, di and oligosaccharides, starch, Dietary fibre and gums, their reactions and physical function in food and their analysis.	12 hours 12 hours

	a) Content in common foods b) Discuss Fischer projections, Haworth Projections, stereoisomerism c) Major reactions d) Sugars: Hydrolysis, thermal degradation, Maillard reaction (non-enzymic browning reaction between reducing carbohydrates and proteins) e) Starch retrogradation (staling of bread) f) Mutarotation g) Decomposition of sugars: Maillard Reaction (Maillard Browning), Amadori Rearrangement and Analysis of Sugars h) Discuss Fischer projections, Haworth Projections, stereoisomerism **3. *Chemistry of Major Components of Food: Lipids*** a) *Fats:* ***Fats in nutrition to be discussed*** b) *Classes of lipids, fatty acids,* c) *monoglycerides,* d) *diglycerides,* e) *triglycerides, polar* f) *lipids* g) *Reaction of fats- Oxidative and hydrolytic rancidity* h) *Analysis* i) *Fats in food- for e.g. Chocolate* j) Other Methods Used in the study of food lipds to be discussed	12 hours
Pedagogy:	lectures/ tutorials seminars/ term papers/assignments/ presentations/ self-study/ Case Studies etc. or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.	
References/Readings	1. T.P. Coultate, *Food - The Chemistry of its Components*, Royal Society of Chemistry, 2009, 5th Ed. 2. H.D. Belitz. & W. Grosch, *Food Chemistry*, Springer, 2009, 4th Ed. 3. B. Selinger, *Chemistry in the Marketplace*, Harcourt Brace, 1986, 3rd Ed. 4. O.R. Fennema, *Food Chemistry*, Marcel Dekker, 2008, 4th Ed. *There is an enormous amount of information on the web. Useful web sites will be provided through the lecture overheads.*	

M Sc-II Physical chemistry
Semester III and IV Courses (Academic year 2019-2020 onwards)

Compulsory courses			**Optional courses**		
Code	**Title**	**Credits**	**Code**	**Title**	Credits
PCC-501	Quantum Chemistry and Statistical Thermodynamics	**3**	**PCO-501**	Solid State Chemistry I: Concepts and applications	**3**
PCC-502	Thermodynamics and Reaction Kinetics	**3**	**PCO-502**	Catalysis: Fundamentals and Applications	**3**
PCC-503	Electrochemistry and Surface Studies	**3**	**PCO-503**	Solid State Chemistry II: Characterization of solid materials	**3**
PCC-504	Group Theory and Spectroscopy	**3**	**PCO-504**	Chemical kinetics and reaction dynamics	**3**
PCC-505	Experiments in Physical Chemistry		**PCO-505**	Colloids and Surface Science	**3**
			PCO-506	Nanoscience: Concepts and Applications	**3**
	Core		**General Optional Courses**		
			CGO-500	Dissertations	8
			CGO-501	Selected Experiments in Chemistry	8

Programme: M. Sc. Part-II (Chemistry)
Title of the Course: Quantum Chemistry and Statistical Thermodynamics
Course Code: PCC-501
Number of Credits:03 **Effective from AY:** 2019-20

Prerequisites for the course:	Should have studied the courses PCC-401, PCC-402 and PCO-401. Should have basic knowledge of Physical Chemistry.	No. of lectures
Course Objectives:	To introduce quantum chemistry so of the advance topics. To introduce various concepts statistical thermodynamics.	
Course Outcomes:	Students should be in a position to understand various concepts of quantum chemistry viz. the wave function and applications. Students should be in a position to understand various concepts in statistical thermodynamics viz. the partition function and applications.	
Content:	1. **Quantum Chemistry** 1.1 The origin of quantum mechanics: Planck's quantum theory, wave particle duality, uncertainty principle concept of wave function, the Born interpretation of wave function. Normalization and orthogonalizations, quantisation, Eigen values and Eigen functions. 1.2 Postulates of quantum mechanics; Schrödinger equation for free particle, particle in a box, degeneracy. Quantum mechanical operators and their properties, commutation relations, Hamiltonian and Laplacian operators, Harmonic oscillators, Angular momentum, Ladder Operators. 1.3 Approximate methods, Schrödinger equation, its importance and limitations, Born-Oppenheimer approximation, Anti-symmetric wave functions and Slater determinants (many electron system e.g. He atom), Exclusion and Aufbau principle, Variation method, Linear Variation Principle, Perturbation theory (first order non-degenerate) and their applications to simple systems. 1.4 VB and MO theory, Huckel MO theory, Bond-order, Charge density matrix, Unification of HMO and VB theory, their applications in spectroscopy and chemical reactivity, electron density forces and their role in chemical bonding. Hybridization and valence MOs of H_2O, NH_3 and CH_4. Application of Huckel Theory to ethylene, butadiene and benzene molecules. **2. Statistical Thermodynamics** 2.1 The language of statistical thermodynamics: Probability, ensemble, macrostate, microstate, degeneracy, permutations and combinations. Configuration and weights, the dominant configuration. The Boltzmann distribution. The molecular partition function: its interpretation and its relation to uniform energy levels. 2.2 Translational, Rotational, Vibrational and Electronic Partition functions for diatomic molecules. Relation between thermodynamic functions and partition functions and their statistical interpretations. Equilibrium constants from partition	18 hours 18 hours

	function. 2.3 Law of Equipartition energy. Theories of specific heat of solids. Comparison between Einstein and Debye theories. 2.4 Concept of symmetric and antisymmetric wave functions. Ortho and para hydrogens. Quantum Statistics: Fermi-Dirac (FD)and Bose-Einstein (BE) statistics. Comparison between MB, FD and BE Statistics.	
Pedagogy:	Mainly lectures/ tutorials /assignments/ presentations/ self-study or a combination of these could also be used. Sessions shall be interactive in nature to enable peer group learning.	
Text Books/ Reference Books	1. P.W. Atkins & J. De. Paulo, *Atkins' Physical Chemistry,* Oxford Univ. Press, 2007, 8th Ed. 2. I. N. Levine, *Quantum Chemistry*, Prentice-Hall, New Delhi, 1995, 4th Ed 3. A.K. Chandra, *Introductory Quantum Chemistry*, Tata McGraw Hill, New Delhi, 1992. 4. R. McWeeny, *Coulson's Valence*, ELBS, Britain, 1979. 5. M.C. Gupta, *Statistical Thermodynamics*, Wiley Eastern, New Delhi, 1990. 6. K. Huang, *Statistical Mechanics*, Wiley India, 2nd Ed. 7. H. Metiu, *Physical Chemistry, Statistical Mechanics,* Taylor & Francis, New York, 2006.	

Programme: M. Sc. Part-II (Chemistry)
Title of the Course: Thermodynamics and Reaction Kinetics
Course Code: PCC-502
Number of Credits:03 **Effective from AY:** 2019-20

Prerequisites for the course:	Should have studied the courses PCC-401, PCC-402 and PCO-401. Should have basic knowledge of Physical Chemistry.	No. of lectures
Course Objectives:	To introduce to classical & non-equilibrium thermodynamics. To introduce advances in reaction kinetics.	
Course Outcomes:	Students should be in a position to understand various concepts of thermodynamics and kinetics. Students should be in a position to apply the knowledge of thermodynamics and kinetics for their lab course in physical chemistry, dissertation and research work.	
Content:	2. **Equilibrium Thermodynamics** 1.1 Thermodynamic state functions. Exact and inexact differentials; partial derivatives. Maxwell relations. 1.2 Thermodynamic equations of state. Temperature and pressure dependence of Gibbs function. Gibbs-Helmholtz equation. Partial molar quantities. Free energy change accompanying a chemical reaction, chemical potential, Gibbs-Duhem equation. Duhem-Margules equation. 1.3 Entropy of mixing for gases and liquids. Gibbs paradox. 1.4 Thermodynamic derivation of phase rule. **2. Non-equilibrium Thermodynamics** 2.1 Concept of internal entropy and spontaneity of a process in relation to free energy. Chemical affinity and extent of a reaction. Mass and energy balance equations. Entropy production in heat flow, chemical reactions and open system. 2.2 Postulates and methodologies, linear laws, Gibbs equations, Onsager's reciprocal theory. Validity of Onsager's equation and its verification. Application to thermo-electric and electro-kinetic phenomena. **3. Reaction Kinetics** 3.1 Collision theory of reaction rates and treatment of unimolecular reactions. Theory of absolute reaction rates and its applications to reactions in solution. Thermodynamic study from reaction kinetics, comparison of results with Eyring and Arrhenius Equations. Solvent and salt effects; influence of ionic strength and solvent on the rates of reaction, primary and secondary salt effects. 3.2 Mechanism of photochemical, chain, coupled and Reversible reactions. Oscillatory reactions. Chemical Hysteresis in Belousov-Zhabotinskii reaction. 3.3 Fast reactions and study by stopped flow technique, relaxation method, pulse radiolysis, flash photolysis and magnetic resonance methods. 3.4 Homogeneous catalysis and Michaelis-Menten kinetics. Kinetic	9 hours 9 hours 18 hours

	rate law for autocatalytic reactions. Kinetics of heterogeneous reactions, heterogeneous catalysis, inhibition, product induced and non–reactive inhibition. 3.5 Potential energy surfaces and introduction to molecular reaction dynamics, theoretical calculation of energy of activation, chemical lasers.	
Pedagogy:	Mainly lectures/ tutorials /assignments/ presentations/ self-study or a combination of these could also be used. Sessions shall be interactive in nature to enable peer group learning.	
Text Books/ Reference Books	1. P.W. Atkins & J. De. Paulo, *Atkins' Physical Chemistry*, Oxford Univ. Press, 2007, 8th Ed. 2. J. Rajaram, J.C. Kuriacose, S.N. & Co., *Thermodynamics for students of Chemistry, Classical, Statistical and Irreversible*, Jalandhar, 1996. 3. E. N. Yeremin, *Fundamentals of Chemical Thermodynamics*. 4. K.J. Laidler, *Chemical Kinetics*, Tata McGraw, New Delhi, 1985. 5. D. A. McQuarrie & John D. Simon, *Physical Chemistry*, Viva Books Pvt. Ltd., New Delhi.	

Programme: M. Sc. Part-II (Chemistry)
Title of the Course: Electrochemistry and Surface Studies
Course Code: PCC-503
Number of Credits:03 **Effective from AY:** 2019-20

Prerequisites for the course:	Should have studied the courses PCC-401, PCC-402 and PCO-401. Should have basic knowledge of Physical Chemistry.	No. of lectures
Course Objectives:	To introduce electrochemical processes such as ion-ion and ion solvent interactions. To introduce thermodynamics of electrochemical processes, kinetics of electrochemical reactions, electrochemistry of fuel cells, batteries and super capacitors.	
Course Outcomes:	Students should be in a position to understand various concepts of electrochemistry. Students should be in a position to apply the knowledge of electrochemistry for their dissertation and research work. Students should be in a position to apply these concepts during the lab course in physical chemistry.	
Content:	3. **Electrolyte Solutions** 1.1 Ion-solvent interactions. Born Theory, validity and limitations. 1.2 Difference between solvation number and coordination number. 1.3 Ion-ion interactions and Debye-Huckel theory of ion cloud. 1.4 Concept of ionic strength and activity coefficient. 1.5 Debye-Huckel limiting law and its modifications. 1.6 Transport of ions in solution. Relaxation and Electrophoretic effects. 1.7 Debye-Huckel-Onsager equation, validity and limitations. **2. Electrified Interfaces** 2.1 Formation of an electrified interface and its structure. 2.2 Polarizable and non-polarizable interfaces. 2.3 Concepts of outer potential, surface potential, inner potential and relationship between them, chemical and electrochemical potentials. 2.4 Concept of surface excess, Electro-capillary curves, Condition for thermodynamic equilibrium at electrified interface. 2.5 Generalized Gibbs equation, Lippmann equation and capacity of the double layer. 2.6 Models of the electrified interface. 2.7 Surface phase and Gibbs adsorption equation. Surface tension and adsorption on solid. Determination of surface excess. **3. Electrode Kinetics and Corrosion** 3.1 Disturbance of electrode equilibrium, cause of electron transfer, fast and slow systems and their current-potential relationship. 3.2 Butler-Volmer equation and its low and high field approximations. 3.3 Nernst equation as a special case of B-V equation. 3.4 Tafel plots for anodic and cathodic processes. 3.5 Study of pH-potential diagrams.	8 hours 8 hours 8 hours

	3.6 Pourbaix diagram for corrosion of iron. **4. Colloids and Mircoemulsions.** 4.1 Charge and Stability of Sols. DLVO theory 4.2 Electrokinetic phenomena: Electroosmosis, streaming potential and current, electrophoresis. Zeta potential. 4.3 Donnan membrane equilibria. 4.4 Micelles and reverse micelles: solubilisation, and bilayers. 4.5 Microemulsions **5. Electrochemical Energies** 5.1 Thermodynamics of electrochemical energy conversion. 5.2 Batteries: basic principles; rating and shelf life. Zinc-manganese dioxide: Leclanche and alkaline batteries. Lithium ion batteries and recharge ability. 5.3 Fuel cells: Principle of a hydrogen-oxygen fuel cell. Classification of fuel cell systems based on types of electrolytes/temperature. Direct methanol-polymer electrolyte fuel cell and electro-catalysts - a case study. Reactions occurring in various fuel cells and calculation of their electrode and cell potentials 5.4 Super capacitors: Introduction: Origin of supercapacitance. Aqueous systems – ruthenium oxide/carbon with sulphuric acid and or solid polymer electrolytes.	6 hours 6 hours
Pedagogy:	Mainly lectures/ tutorials /assignments/ presentations/ self-study or a combination of these could also be used. Sessions shall be interactive in nature to enable peer group learning.	
Text Books/ Reference Books	6. J.O.M. Bockris & A.K.N. Reddy, *Modern Electrochemistry*, Springer India Pvt. Ltd, 2000, Vol. 1, 2 and 3. 7. D.Crow, *Principles and Applications of Electrochemistry*, Blackie Academy and Professional, 1994. 2. C.M.A. Brett & A.M.O. Brett, *Electrochemistry: Principles, methods and applications*, Oxford, New York Oxford University Press, 1993 3. R.D. Vold & M.J. Vold, *Colloid and Interface Chemistry*, Addison-Wesley, 1983. 4. A. Vincent & B. Sacrosati, *Modern Batteries*, John Wiley, New York, 1997. 5. J.O. M. Bockris & S. Srinivasan, *Fuel cells: their Electrochemistry*, McGraw-Hill Book Co., 1969.	

Programme: M. Sc. Part-II (Chemistry)
Title of the Course: Group Theory and Spectroscopy
Course Code: PCC-504
Number of Credits:03 **Effective from AY:** 2019-20

Prerequisites for the course:	Should have studied the courses PCC-401, PCC-402 and PCO-401. Should have basic knowledge of Physical Chemistry.	No. of lectures
Course Objectives:	To introduce concepts in Group Theory and it applications to chemistry. To introduce some advance topics in spectroscopy.	
Course Outcomes:	Students should be in a position to understand various concepts of in Group Theory. Should be able to apply character table to solve various problems. Students should be in a position to apply the knowledge of spectroscopy for their dissertation and research work.	
Content:	4. **Elements of Group Theory** 1.1 Symmetry elements and symmetry operations, Concept of group and group multiplication tables, order of the group, classes and subgroups in a group, Different types of groups (cyclic, abelian and non-abelian groups). 1.2 Point groups, Matrix representations of a group, Reducible and Irreducible representations groups, Great Orthogonality Theorem, Properties of Irreducible representations, Mulliken symbols for Irreducible representations, Character tables. 1.3 Standard reduction formula, Direct products of representations and it applications Quantum Chemistry and spectroscopy: Vanishing of integrals, Selection rules. Applications of group theory for hybridization of atomic orbitals. Projection operator and Symmetry adapted linear combinations (SALCs), MO treatment (within Huckel Molecular Orbital Theory) of large molecules with symmetry. Applications of group theory to Infra-red and Raman spectroscopy. **2. Microwave, IR and Raman Spectroscopy** 2.1 Theoretical treatment of Rotational and Vibrational spectroscopy. 2.2 Principle of Fourier Transform (FT) spectroscopy, FTIR spectroscopy Theory, instrumentation and applications. 2.3 Quantum theory of Raman effect, Raman shift, Instrumentation, Resonance Raman spectroscopy, Complimentary nature of IR and Raman spectroscopy in structure determination, Applications. **3. NMR Spectroscopy** 3.1 Basic principles of NMR. 3.2 Theory of pulse NMR and Fourier analysis, FT-NMR. 3.3 Solid state NMR, magic angle spinning (MAS), dipolar decoupling and cross polarization, applications of solid state NMR. 3.4 Double resonance, NOE, Spin tickling, Solvent and shift reagents, Structure determination by NMR. **4. ESR Spectroscopy**	18 hours 6 hours 8 hours 4 hours

	4.1 Theory and experimental techniques, Identification of odd-electron species (methyl and ethyl free radicals) and radicals containing hetero atoms. 4.2 Spin trapping and isotopic substitution, Spin densities and McConell relationship, Double resonance techniques.	
Pedagogy:	Mainly lectures/ tutorials /assignments/ presentations/ self-study or a combination of these could also be used. Sessions shall be interactive in nature to enable peer group learning.	
Text Books/ Reference Books	8. P.W. Atkins & J. De. Paulo, *Atkins' Physical Chemistry,* Oxford Univ. Press, 2007, 8th Ed. 9. F.A. Cotton, *Chemical Applications of Group Theory,* John Wiley & Sons-Asia, New Delhi, 1999, 3rd Ed. 10. K. V. Raman, *Group Theory and its applications to chemistry*, Tata McGraw-Hill, New Delhi. 11. C. N. Banwell & E.M. McCash, *Fundamentals of Molecular Spectroscopy,* Tata McGraw-Hill, New Delhi, 1994. 12. W. Kemp, *NMR in Chemistry a multinuclear introduction*, Macmillan, 1986. 13. R.S. Drago, *Physical Methods in Chemistry,* W.B. Saunders Company, 1977.	

Programme: M. Sc. Part-II (Chemistry)
Title of the Course: Experiments in Physical Chemistry
Course Code: PCC-505
Number of Credits: 03 **Effective from AY:** 2019-20

Prerequisites for the course:	Students should have studied the laboratory course in Physical chemistry (PCC402), so as to have basic knowledge of instruments and practical experimental chemistry.	No. of lectures/hours 72
Course Objectives:	1. To introduce concepts of Kinetics and Thermodynamics 2. To introduce concepts of Surface science and Catalysis 3. To introduce various concepts of Electrochemistry 4. Introduction to use of computers and computational tools in chemistry	
Course Outcomes:	1. Student should be in a position to better understand the concepts of physical chemistry through practical experimental knowledge. 2. Students should be in a position to apply this knowledge to other practical chemistry applications.	
Content:	**Group - A. Instrumental** 1. To determine the energy of activation of reaction of $Zn + PbSO_4 \text{ ----> } ZnSO_4 + Pb$ potentiometrically. 2. To determine the instability constant of the reaction $[Ag(NH_3)_2] \text{----> } Ag + 2NH_3$ potentiometrically 3. To study the electro-kinetics of rapid reaction between SO_4^{2-} and I^- in an aqueous solution. 4. To verify Nernst equation and determine the standard oxidation potential of copper and zinc ion electrodes. 5. To study effect of ionic strength on activity coefficient of Ag^+ ions. 6. To study spectrophotometric titration of ferrous ammonium sulphate with potassium permanganate (or dichromate vs permanganate) 7. To investigate the reaction kinetics between potassium persulphate and potassium Iodide colorimetrically. 8. To determine the equivalent conductance of a strong electrolyte at several concentrations and verify Onsager's equation. 9. To estimate the concentration of sulphuric acid, acetic acid and copper sulphate in a given solution conductometrically. 10. To determine the concentration of Fe(II) ions by titrating with potassium dichromate conductometrically. 11. To study the kinetics of hydrolysis of tertiary butyl chloride by conductometry 14. To determine the half wave potential of $Cu^{2+}/Cd^{2+}/Zn^{2+}$ by using polarography **Group - B. Non-Instrumental**	**24 hr** **24 hr**

	1. To determine the partial molal volume of ethanol-water mixture at a given temperature 2. To study the phase rule for two component system 3. To determine the partial molal volume of sodium chloride-water, ethanol-water and methanol-water system (apparent molal volume method) 4. To determine the effect of salt on surface tension of water using by capillary rise method 5. To study effect of surfactants on surface tension of water using stalagmometer 6. To study the variation of viscosity with composition of mixtures and to verify the formation of compounds by Oswald's viscometer 7. To study the effect of pH on the kinetics of iodination of aniline 8. To study the kinetics of reaction between H_2O_2 and KI (clock reaction) 9. To study the kinetics of rapid reaction between bromine and iodine in aqueous media 10. To investigate the autocatalytic reaction between potassium permanganate and oxalic acid. 11. To study the electroless deposition of Ni on non-conductor substrate and to determine the rate of deposition 12. To study the acid and alkaline corrosion susceptibility of metal and to determine the rate of corrosion 13. To study the catalytic activity of three different metal oxides in heterogeneous systems with H_2O_2 decomposition reaction 14. To determine the molecular weight of a polymer by intrinsic viscosity method. **Group - C. Computers in Chemistry** 1. To generate a mark sheet to learn various features of spreadsheets (revision) 2. To generate a plot for a given function (like solutions of 1D box, harmonic oscillator, H-like atom wave functions, Gaussians distributions etc) (revisions) 3. To write a computer program to obtain equivalence point in pH-metry and potentiometric experiments (derivative method) 4. To write a computer program to find percent composition for various atoms of a given molecular formula 5. To write a computer program to obtain slope and intercept for linear data using least square fit method 6. To write a computer program to obtain center of mass of a given molecule and moment of inertia, hence obtain	**24 hr**

	classification of the given molecule 7. To write a computer program to find out various parameters for data analysis viz. minimum, maximum, average, standard deviation, variance, covariance, correlation coefficient, frequency distribution etc. 8. To write a computer program to obtain thermodynamic probability. 9. To write a computer program to obtain degeneracy of a given energy level for a particle in a cube. ***Note:*** *A minimum of 4 experiments from each group A-C are to be carried out.*	
Pedagogy:	Practical / Hands on sessions will be conducted.	
Text Books / Reference Books	1. A. Finlay & J.A. Kitchener, *Practical Physical Chemistry, Longman Publisher,* 1963. 2. A. M. James, *Practical Physical Chemistry*, Longman Publisher, 1974. 3. D.P. Shoemaker & C.W. Garland, *Experimental Physical Chemistry,* McGraw-Hil,1981. 4. J. B. Yadav, *Advance Practical Physical Chemistry*, Krishna Educational Publishers, 2014.	

Programme: M. Sc. Part-II (Chemistry)
Course Code: PCO-501
Title of the Course: Solid State Chemistry I: Concepts and applications
Number of Credits: 03 **Effective from AY:** 2019-20

Prerequisites for the course:	Students should have studied the course PCC 401, PCO 401 in M.Sc. I. so as to have basic knowledge of material chemistry and reaction kinetics.	
Course Objectives:	1. To introduce concepts of solid state science 2. To provide fundamental knowledge of solids, description of crystal chemistry and classification of crystal structure and significance of crystal defects. 3. To provide basic understanding of temperature dependence of crystal structure, phase modifications and its influence on magnetic and electric properties of solids	
Course Outcomes:	1. Students should be in a position to understand the concept of solid state synthesis. 2. Students should be able to identify different solids based on crystal structure 3. Students should be in a position to understand the significance of crystal structure and its modifications, so as to enhance the magnetic and electrical properties to suit energy applications.	
Content:	**1. Solid State: Introduction** 1.1 General Principles and experimental procedure. 1.2 Hydrothermal and thin film method in solid state synthesis 1.3 Kinetics of solid state reactions, ion exchange and intercalation reactions. **2. Crystal Chemistry:** 2.1 Unit Cells, close packed structures-ccp and hcp. 2.2 Ionic structures and covalent networks. 2.3 Some important structure types – rock salt, zinc blende, wurtzite, nickel arsenide and rutile. 2.4 Factors that Influence Crystal Structures: valencies and coordination numbers. 2.5 Significance of radius ratio rule and non-bonding electron effects. **3. Crystal Defects and non stoichiometry:** 3.1 Types of defects. Point defects and thermodynamics. 3.2 Colour Centres, vacancies and interstitials in non stoichiometric crystals. 3.3 Dislocations, mechanical properties and reactivity of solids. **4. Symmetry, Point Groups and Space Groups:** 4.1 Symmetry, miller Indices, lattice planes, d-spacings and multiplicities 4.2 Representation of point groups and space groups **5. Phase Diagrams and Phase Transitions** 5.1 Basic Concepts and definitions. 5.2 Three component condensed systems. Martensitic	5 hours 10 hours 5 hours 4 hours 4 hours

	transformations. Order-disorder transitions. **6. Ionic Conductivity and Solid Electrolytes:** 6.1 General Introduction 6.2 Conduction in NaCl and AgCl 6.3 DC and AC resistivity measurements **7. Electronic Properties and Band Theory** 7.1 Electronic structure and band theory of solids. 7.2 Band structure of metals and semiconductors. 7.3 Magnetic properties of transition metal oxides and applications	 4 hours 4 hours
Pedagogy:	Mainly lectures / tutorials. Seminars / assignments / presentations / self-study or a combination of some of these could also be used to some extent.	
Text Books / Reference Books	1. A. R. West, *Solid State Chemistry and Its Applications,* John Wiley & Sons 2003. 2. H. V. Keer, *Principles of the Solid State,* New Age International Publishers, 1993.	

Programme: M. Sc. Part-II (Chemistry)
Course Code: PCO-502
Title of the Course: Catalysis: Fundamentals and Applications
Number of Credits: 03 **Effective from AY:** 2019-20

Prerequisites for the course:	Students should have studied the course PCC 401, PCO 401 in Semester I/II, so as to have basic knowledge of material chemistry and reaction kinetics.	No. of lectures/hours
Course Objectives:	1. To introduce concepts of surface science and catalysis 2. To provide fundamental knowledge of theories that govern heterogeneous catalytic reactions 3. To introduce newer methods of synthesizing nanocatalyst, porous catalyst and its characterization. 4. To introduce latest developments about application of catalyst in environment and energy sector.	
Course Outcomes:	1. Students should be in a position to understand the concept of heterogeneous surface science. 2. Students should be able to understand methods of synthesizing nano catalyst, tailoring morphological and chemical properties of the catalyst and its characterization. 3. Students should be in a position to understand and apply their knowledge in surface catalysed reaction of industrial and environmental significance.	
Content:	**1. Basic Concepts:** 1.1 General Introduction: Catalysis and activation energy. Homogeneous and heterogeneous reactions with suitable illustrations. Catalytic activity, selectivity and stability. Steps in a heterogeneous catalytic reaction. Factors affecting rate of reaction such as temperature, flow rates, molar composition etc. 1.2 Adsorption and Surface Area: Cause of adsorption. No of molecules striking the surface and sticking probability. Adsorption isotherms for gases and solutes. Basic types of BET isotherms. Chemisorption of H_2, O_2 and CO. Surface area and Porosity: Determination of surface area. Porosity and pore size distribution. 1.3 Classification of catalysts based on electrical conduction. Adsorption on specific crystal planes; geometric factor in catalysis: Balandin's multiplet theory and Valence angle conservation. Electronic effect in catalysis by metals. Role of diffusion in catalysis. **2. Kinetics and mechanisms of catalysed reactions** 2.1 Kinetics of catalysed reactions and rate expressions. Mechanism of catalysed reactions obeying Langmuir-Hinshelwood, Eley- Rideal and Mars van Krevelen models with suitable examples. **3. Preparation of Catalysts** 3.1 Various methods for preparation of bulk catalysts:	13 hours 6 hours 3 hours

	Precipitation method, Impregnation method catalyst impregnation with or without interaction between support and catalyst. Synthesis of microporous solids. Synthesis of mesoporous solids. 4. **Thermal and Spectroscopic Methods in Heterogeneous Catalysis** 4.1 Characterization of the catalysts by temperature programmed desorption using probes such as ammonia and pyridine molecules. Characterization of adsorbed molecules /intermediates by IR spectroscopy and XPS. **5. Selected Catalytic Applications** 5.1 Introduction to zeolites, structure building in zeolites with suitable example. Zeolite catalysis in MTG process. Introduction to semi-conductor surface and electrocatalysis with application in photocatalytic and electrocatalytic water splitting and treatment of waste water contaminated with dyes	4 hours 10 hours
Pedagogy:	Mainly lectures, tutorials, assignments, self-study or a combination of some of these could also be used to some extent.	
Text Books / Reference Books	1. D. K. Chakrabarty & B. Viswanathan, *Heterogeneous Catalysis,* New Age International Publishers, 2008. 2. G. A. Somorjai, *Introduction to Surface Chemistry and Catalysis,* John Wiley, 2002 3. M. Thomas & W. J. Thomas, *Principles and Practice of Heterogeneous Catalysis*, VCH Publishers, 1996.	

Programme: M. Sc. Part-II (Chemistry)
Course Code: PCO-503
Title of the Course: Solid State Chemistry II: Characterization of solid materials
Number of Credits: 03 **Effective from AY:** 2019-20

Prerequisites for the course:	Students should have studied the course Solid State Chemistry I : Concepts and Application, so as to have basic knowledge of solids state chemistry.	No. of lectures/hours
Course Objectives:	1. To introduce solid state characterization methods and techniques. 2. To provide fundamental knowledge of principles and instrumentation involved in selected techniques. 3. To provide comparative evaluation of data obtained from various techniques and its use in elucidating the chemical and morphological structure of solid materials	
Course Outcomes:	1. Students should be in a position to understand the design of the instrumental techniques, data acquisition and storage. 2. Students should be able to understand the fundamental principles governing the technique, data interpretation and analysis to elucidate structural information of solid materials 3. Students should be in a position to understand and apply the concept learned to make the best choice of a characterization technique(s) for elucidation of unknown solids under investigation.	
Content:	1. **Thermal Analysis** 1.1Thermogravometric analysis, Differential Thermal Analysis 1.2 Differential scanning calorimetry 1.3 Application to characterization of materials **2. X – Ray Diffraction:** 2.1 The powder X-ray diffraction experiment, instrumentation 2.2 Intensities: scattering of X-Rays and factors that affect intensities, powder x-ray pattern 2.3 Introduction to single crystal x-ray diffraction. 2.3 Applications of high temperature powder diffraction. 2.4 Identification of crystal phases and evaluation of lattice characteristics 3. **Microscopic Techniques** 3.1 Introduction to Electron Microscopy: Generation of electron beam, elastic and inelastic scattering of electrons by atoms 3.2 Scanning Electron Microscopy (SEM): Instrumentation, optics, resolution and compositional imagining, acquisition and data storage. Preparation of specimen, crystallographic information from SEM and environmental scanning electron microscopy	5 hours 10 hours 6 hours

	3.3 High Resolution Transmission Electron Microscopy (HR-TEM): Instrumentation, contrast mechanism, high voltage and scanning transmission microscopy, preparation of specimen and data interpretation. 4. **Selected Spectroscopic Techniques** 4.1 Vibrational spectroscopy: IR and Raman spectroscopy, fundamental principle, instrumentation and design, applications to ferroelectric materials such as $LiNbO_3$ and Li TaO_3. 4.2 Visible and UV spectroscopy of solids: Fundamental principle, diffuse reflectance measurement, instrumentation and design, structural studies of transition metal oxides, glass and laser materials. 4.3 X ray Spectroscopy: XRF, XANES and EXAFS: Absorption coefficient, absorption edges, resonance emission, extended absorption and photoelectron scattering. Instrumentation and design, characterization of transition metal oxides. 4.4 Mössbauer Spectroscopy: Mössbauer effect, recoil free absorption and emission in solids, isomer shift, quadrupole splitting, magnetic splitting, instrumentation and design, characterization of Iron compounds.	15 hours
Pedagogy:	Mainly lectures, tutorials, assignments and presentations or a combination of some of these could also be used to some extent.	
Text Books / Reference Books	1. A. R. West, *Solid state chemistry and its applications*, John Wiley & Sons, 2005. *2.* D. Brandon & W. Kaplan, *Microstructural Characterization of Materials,* John Wiley & Sons, 1999. 3. P. J. Goodhew, J. Humphreys & R. Beanland *Electron Microscopy and Analysis*, Taylor and Francis, 2001. *4.* C. N. Banwell & E. M. McCash, *Fundamentals of molecular spectroscopy,* Mcgraw Higher Ed, 2016, 4th Ed.	

Programme: M. Sc. Part-II (Chemistry)
Course Code: PCO-504 Title of the Course: Chemical kinetics and reaction dynamics
Number of Credits: 03
Effective from AY: 2019-20

Prerequisites for the course:	Students should have studied the course PCC- 401, PCO- 401 in Semester I/II, so as to have basic knowledge of reaction kinetics.	No. of lectures/hours
Course Objectives:	1. To introduce concepts of reaction kinetics and dynamics 2. To provide fundamental knowledge of theories that govern chemical reactions 3. To introduce newer classes of reaction types and their kinetics 4. To introduce latest developments in the advance instrumental techniques and methods for monitoring reaction kinetics and dynamics.	
Course Outcomes:	1. Students should be in a position to understand the concept of reaction kinetics and its significance. 2. Student will be able to differentiate between different reaction types, their kinetic analysis and its significance 3. Students should be able to apply these kinetic concepts to perform laboratory experiments in reaction kinetics. 3. Students should be in a position to apply these concepts of real life applications such as combustion engines, photochemical systems and atmospheric chemistry research.	
Content:	1.0 Theories of reaction rates 1.1 Generalized kinetic theory and extended collision theory. Concept of collisional number, collisional frequency factor, collisional and reactive cross section, steric factor, microscopic rate constant. Assumptions and limitations of collision theory 1.2 Conventional transition state theory, equilibrium hypothesis and derivation of reaction rates. Thermodynamic formulation of transition state theory. Arrhenius temperature dependent and independent activation energy and its significance. Assumptions and limitations of transition state theory. Introduction to extended transition state theory and microscopic reversibility. 1.3 Lindemann-Hinshelwood theory of thermal unimolecular reactions. Statistical energy dependent rate constant. Introduction to RRK and RRKM Theory and its applications. 2.0 Elementary reactions in solutions 2.1 Collisional kinetics in solution, effect of solvent polarity solvent cohesion energy, influence of ionic strength and ion-dipole and dipole-dipole reactions on reaction rates. Comparison of gas phase and solution reactions. 3.0 Homogeneous and surface reactions	8 hr 3 hr 8 hr

	3.1 Homogeneous kinetics, enzymatic reactions and Michaelis-Menten, Lineweaver-Burk and Eadie Analysis 3.2 Autocatalytic and inhibition reactions. Product induced competitive and non-competitive inhibition reactions. 3.3 Adsorptions: competitive, non-ideal and dissociative adsorptions 3.4 Mechanism of surface reactions, kinetic effects of surface heterogeneity and interactions. 3.5 Eley-Rideal, Langmuir Hinshelwood and Mars van Krevelen kinetic models of surface reactions	
	4.0 Composite reactions 4.1 Types of composite mechanisms, rate equation for composite mechanisms, simultaneous and consecutive reactions 4.2 Decomposition reactions of ozone and acetaldehyde 4.3 Gas phase combustion reactions, hydrogen – oxygen combustion, introduction to shock tube method and its use in combustion analysis. 4.4 Polymerization kinetics, stepwise and chain polymerization.	4 hr
	5.0 Fast Reactions 5.1 Photochemical fast reactions: primary photochemical processes, reactions of electronically excited species and photochemical equivalence. 5.2 Pulsed laser photolysis, multiphoton excitation processes and its use in monitoring fast reactions. 5.3 Radiation-chemical reactions: radiation chemical primary processes, kinetic measurements in radiolysis method. 5.4 Comparison of relaxation method and stopped flow technique.	5 hr
	6.0 Reversible, Irreversible and Oscillatory reactions. 6.1 Kinetics of reversible, irreversible reactions and graphical analysis 6.2 Voltera-Lotka hypothesis of oscillatory reactions. The significance of bi-stability in the Briggs-Rauscher Reaction and Belousov-Zhabotinskii reaction.	4 hr
	7 Reaction Dynamics 7.1 Reactive collisions, chemiluminescence and laser induced fluorescence. 7.2 Introduction to potential energy surfaces, internal coordinates and modes of vibration with suitable examples. 7.3 Introduction to molecular reaction dynamics, investigation of reaction dynamics with ultrafast lasers.	4 hr

Pedagogy:	Mainly lectures / tutorials. Seminars / assignments / presentations / self-study or a combination of some of these could also be used to some extent.	
Text Books / References	1. K. J. Laidler, *Chemical Kinetics, Pearson Education, 1987; (printed in India by Anand Sons,2004), 3rd edition*. 2. P.W. Atkins and J. De. Paulo, *Atkins' Physical Chemistry, Oxford University Press, 2007, 8th edition.* 3. J. I. Steinfeld, J. S. Francisco and W. L. Hase, *Chemical Kinetics and Dynamics, Prentice Hall, 1999, 2nd edition.* 4. D. K. Chakrabarty and B. Viswanathan, *Heterogeneous Catalysis, New Age International Publishers, 2008* 5. S. K. Scott, *Oscillations, waves and Chaos in chemical kinetics, Oxford Science Publications, 1994.* 6. Thomas S. Briggs, and Warren C. Rauscher, *An oscillating iodine clock, J. Chem. Educ., 1973, 50 (7), 496*	

Programme: M. Sc. Part-II (Chemistry)
Title of the Course: Colloids and Surface Science
Course Code: PCO-505
Number of Credits:03 **Effective from AY: 2019-20**

Prerequisites for the course:	Should have studied the courses PCC-401, PCC-402 and PCO-401. Should have basic knowledge of Physical Chemistry.	No. of lectures/ hours
Course Objectives:	To Introduce surface properties of materials and forces at different interfaces. To introduce the concept of micelles, microemulsions. To introduce different adsorption models.	
Course Outcomes:	Students should be in a position to understand surface phenomenon and properties of interfaces. Students should be in a position to understand electrochemical phenomenon at interfaces. Students should be in a position to apply these concepts during the lab course in physical chemistry	
Content:	**1. Liquid Surfaces and Interfaces** 1.1 General Introduction. Microscopic picture of liquid surface. 1.2 Surface tension and its measurement. Curved liquid surfaces. 1.3 The Kelvin equation and capillary condensation. 1.4 Nucleation Theory. 1.5 The surface excess. Gibbs energy and surface tension. The surface tension of pure liquids. Gibbs adsorption isotherm. **2. Electrokinetic Phenomena and Surface Forces** 2.1 Electrocapillarity – theory and measurement. 2.2 Charged surfaces such as mercury, silver iodide and oxides. Measurement of surface charge densities. 2.3 Electrokinetic phenomena: concept of zeta potential. 2.4 Surface forces – Van der Waals forces between molecules. Surface energy and Hamaker constant. 2.5Measurement of surface forces. The DLVO theory and beyond. 2.6 Contact angle and its measurements. The line tension. Wetting and wetting transitions. **3. Solid Surfaces** 3.1 Surface stress and surface tension. Determination of surface energy. Surface steps and defects 3.2 Solid – solid interfaces 3.3 Microscopy of Solid surfaces: Optical microscopy, Electron Microscopies, Scanning Probe Microscopy (STM, AFM). 3.4 Diffraction Methods. **4. Adsorption** 4.1 Types of adsorption and adsorption times. Classification of adsorption isotherms. 4.2 Thermodynamics of adsorption.	7 hr 9 hr 6 hr 6 hr

	4.3 Adsorption Models. The potential theory of Polanyi. 4.4 Experimental aspects of adsorption from gas phase. 4.5 Adsorption on porous solids. 4.6 Adsorption from solution. **5. Surfactants, Micelles, Emulsions and Thin films** 5.1 Classification of surfactants. 2.2 Spherical micelles: cmc and influence of temperature. Thermodynamics of micellization. Structure of surfactant aggregates 5.3 Macroemulsions: properties, formation and stabilization. Evolution and aging. Coalescence and demulsification. 5.4 Microemulsions: size of droplets. Elastic properties of surfactant films. Factors influencing the structure of microemulsions.	8 hr
Pedagogy:	Mainly lectures / tutorials. Seminars/assignments/ presentations/ self-study or a combination of some of these could also be used to some extent. Sessions shall be interactive in nature to enable peer group learning.	
Text Books/ Reference Books	**Text Book** 1. H J Butt, K. Graf and M. Kappl, Physics and Chemistry of Interfaces, Wiley-VCH, 2006. 2. A.W. Adamson and A.P.Gast, Physical Chemistry of Surfaces, New York John Wiley & Sons, 1976. 3. D. Myers, Surfaces, interfaces, and colloids—principles and applications. VCH Publishers, New York, 1991, 4. R. D. Vold and M.J. Vold, Colloid and Interface Chemistry, Addison-Wesley Publishing Company, 1983.	

Programme: M. Sc. Part-II (Chemistry)
Title of the Course: Nanoscience: Concepts and Applications
Course Code: PCO-506
Number of Credits:03 **Effective from AY: 2019-20**

Prerequisites for the course:	Should have studied the courses PCC-401, PCC-402 and PCO-401. Should have basic knowledge of Physical Chemistry.	No. of lectures/hours
Course Objectives:	1. Introduction of various concepts for nanoscience. 2. Introduction of various synthesis methods of nanomaterials. 3. Introduction of various characterisation techniques and application study of nanomaterials	
Course Outcomes:	Students will learn different techniques of synthesis and characterisation of nanomaterials. Students should be in a position to understand magnetic, electrical, optical and catalytic properties of materials at nanoscale level. Students should be in a position to apply the knowledge of subject for their dissertation and research work.	
Content:	**1. Essential concepts and definitions** Nanoscale, interdisciplinary nature of nanoscience, quantum effects, colours from colloidal gold, Surface to volume ratio of nanoparticles, surface effects and surface energy on nanoparticle surface. **2. Electronic and Electrical properties** Chemistry of solid surfaces, Zero dimensional systems: nanoparticles One dimensional systems:nanowires and nanorods Metallic nanowires and quantum conductance. **3. Fabrication of nanoscale materials: top-down vs bottom-up approach** **i.** Physical nanofabrication methods for the two dimensional nanostructures such as Thin film deposition of metallic copper, aluminium, tungsten and semiconducting silicon and Gallium arsenide films; Epitaxial growth; chemical vapour deposition and molecular beam epitaxial methods for the synthesis of semiconducting thin films, **ii.** Plasma Lithographic, photolithography, e-beam lithographic techniques for the transfer of circuit and nanopatterns on thin films. Positive and negative photoresists, different etching methods for the final pattern transfer on thin films. **iii.** Synthesis of colloidal metallic nanoparticles using different stabilizing and complexing agents such as citric acid and use of surfactants. iv. Discussion of Self assembly growth modes for thin films and colloidal nanoparticles : Stransky-Krastinova and Ostwald ripening	5 hr 5 hr 8 hr

	4. Investigation of important nanomaterials: Silica: discussion of sol-gel and liquid crystal synthesis method, self assembly of colloidal silica particles, photoluminescence property of opals, different surface functionalization methods and application study Gold: Different colloidal synthesis methods, self assembly methods, surface Plasmon resonance (SPR) of colloidal gold nanoparticles surface functionalization strategies and application study CdSe: Different synthesis methods, synthesis of coreshell particles, Sudy of CdSe excitons and CdSe quantum dots, functionalization and application study. Iron oxide, Different synthesis methods Superparamagnetism property of nanoparticles, Hysteresis and magnetisation of Fe_3O_4 nanomaterial, catalytic and Biomedical applications. Carbon: synthesis methods for carbon nanotubes, Graphene and Buckminster fullerene, structural study of these materials, electrical property study of these materials, surface functionalization statergies and application study **5. Characterisation of nanomaterials** **i.** Beam probe methods: Instrumentation, physical principle and different modes of operations in electron microscopic techniques such as Transmission electron microscope Scanning electron microscope and *Energy-dispersive* X-ray *spectroscopy*. **ii**. Electron and Scanning probe methods: Instrumentation, physical principle and different modes of operations in scanning tunnelling microscopy (STM) and Atomic force microscop.y **iii.** Optical Microscopes: Instrumentation, physical principle and different modes of operations in *Stimulated emission depletion* (STED) *microscopy* STED, Single molecule microscopy and *Dynamic light scattering* (*DLS*) is a *technique*. **6. Applications of nanomaterials** Polymer vesicles for drug delivery, interaction of nanoparticles with DNA, Biosensors, Heterogeneous catalysts for the synthesis of fine chemicals, use of nano TiO_2 and ZnO for water and air pollution control.	10 hr 4 hr 4 hr
Pedagogy:	Mainly lectures / tutorials. Seminars/assignments/ presentations/ self-studyor a combination of some of these could also be used to some extent. Sessions shall be interactive in nature to enable peer group learning.	

Text Books/ Reference Books	1. L. Cademartiri and G.A.Ozin, Concepts of Nanochemistry, Wiley-VCH, 2009. 2. C.N.R. Rao and A. Govindaraj, *Nanotubes and nanowires,*Royal society of Chemistry, *2005*. 3. G. Cao, *Nanostructures and Nanomaterials,*Imperial College Press, *2004.* *4.* J. M. Tour, *Molecular Electronics*, Imperial College Press, 2004 5. H. S. Nalwa (Ed),*Encyclopedia of Nanoscience and Nanotechnology,*American Scientific Publishers, Los Angeles, 2004. 6. E.Roduner, Nanoscopic Materials Size-Dependent Phenomena, RSC, Publishing, Cambridge, 2006. 7. G.A. Ozin and A.C. Arsenault, Nanochemistry: A Chemical Approach to Nanomaterials, RSC Publishing, Cambridge, 2005. 8. C.P. Poole and F.J. Owens, Introduction to Nanotechnology, John Wiley and Sons, Singapore, 2003.	

M Sc-II Pharmaceutical Chemistry
Semester III and IV Courses (Academic year 2019-2020 onwards)

Compulsory courses			**Optional courses**		
Code	**Title**	**Credits**	**Code**	**Title**	**Credits**
HCC-501	Pharmaceutical Chemistry II	3	HCO-501	Pharmacological and Toxicological Screening Techniques	3
HCC-502	Drug Product Formulation And Development	3	HCO-502	Calibration and Validation	3
HCC-503	Drug Design And Development	3	HCO-503	Polymers in Pharmaceuticals and novel drug delivery systems	3
HCC-504	Drug Quality And Regulatory Affairs	3	HCO-504	Biopharmaceutics	3
HCC-505	Laboratory Course In Pharmaceutical Chemistry	3	HCO-505	Pharmaceutical Technology	3
			HCO-506	Pharmaceutical Stability	3
			HCO-507	Laboratory Course in Natural Product Analysis	3
			HCO-508	Laboratory Course in Drug Product Formulation and Development	4
			HCO-509	Laboratory Course in Drug Design, Molecular Docking and Patents	2
			HCO-510	Laboratory Course in Quality Control and Quality Assurance	4

Programme: M. Sc. (Pharmaceutical Chemistry)
Course Code: HCC-501
Title of the Course: Pharmaceutical Chemistry II
Number of Credits: 3 **Effective from AY:** 2018-19

Prerequisites for the course:	Should have studied the course in Pharmaceutical Chemistry at T Y B Sc level.	
Course Objective:	To learn major classes of drugs and understand its SAR and Mechanism of action.	
Course Outcome	• Students should be able to identify the examples in different classes of drugs • Students should be able to write IUPAC names and Structure of drugs. • Students shall be in a position to understand the mechanism of action of selected classes of drugs. • The students will have a clear understanding of concepts on SAR analysis. • The students will be able to apply synthetic organic chemistry knowledge in devising a synthesis for a drug.	
Content:	**1. Cholinergic and Adrenergic Agents, General Anaesthetics and Hypotensive agents** Drugs acting on cholinergic nervous system: Bethanechol, Methacholine$, Neostigmine, Pyridostigmine, Parathion, Malathion, Atropine, Dicyclomine$, Tropicamide$, Papaverine, Drugs acting on adrenergic nervous system: Methyldopa (MA,$), Guanethidine, Ephedrine, amphetamine, Tranylcypromine, Pragyline, Norepinephrine, Epinephrine, Pronetalol, Propanalol$, Atenolol$, Metoprolol. General Anaesthetics: Ether, Nitrous oxide, Halothane$, Ultra short acting Barbiturates-Thiopental sodium $. Hypotensive agents acting on vascular smooth muscles: Nitrites, Amyl nitrites, Glyceryl nitrite$, Pentaerythritol tetranitrate, Isosorbide dinitrate. **2. Drugs acting on the central nervous system**: Hypnotics and sedatives: Chloral hydrate, Phenobarbital$, Secobarbital, Thiopental$, Nitrazepam, Drugs acting as anticonvulsants: Phenytoin$, phenacemide, Clonazepam, Phensuximide, Phenobarbital, (Classification of Barbiturates), Primidone, Carbamazepine$. Psychotherapeutic agents: Phenothiazines such as Chloropromazine, Chlorodiazepoxide$, Oxazepam, Diazepam, Imipramine, Nialamide, Tranylcypromine, Pargyline. CNS stimulants: Phenmetrazine, Nikethamide$, Iproniazid, Picrotoxines, Tetrazole, Amphetamine. **3. Antihistaminics, antiemetic, antiulcer drugs, Drugs used parkinsonism and Alzhemeier's** Diphendydramine, Triprolidine, Cyclizine, Promethazine$, Cimetidine, Omeprazole (MA),Ranitidine, Sumatriptan, Ondisitron.	10 hours 10 hours 05 hours

	Drugs used in Parkinsonism: Benzotronine mesylate, Levodopa, Carbidopa, Amantadine hydrochloride. Drugs for Alzeimer's diseases: Serin, Velnacrine, Aniracetam. **4. Cardiovascular drugs, antihypertensive agents, and antibiotics:** Digitoxin, Quinidine, Procainamide, Verapamil. Antihypertensive agents which elicit their action through autonomous nervous system previously described under 1 and 2, clonidine, hydralazine, ACE inhibitors- Enalapril and related drugs vasodilators such as Nitroglycerine, Isoxsuprine, Nylidrin, Antibiotics: Penicillin and semisynthetic pencillins and Cepholosporins, Amoxicillin, Cloxacillin, Streptomycin, Chloromphenicol, Tetracycline and derivatives, Erythromycin. **5. Analgesics, Antipyretics and Inflammatory agents:** Analgesics, antipyretics and anti-inflammatory agents: Aspirin$, Sodium salicylate, Acetaminophen$, Phenacetin, Phenylbutazone, Oxyphenabutazone, Ibuprofen$, Naproxen$, Probenacid, Allopurinol, Profen, Diclofenac $. Narcotic analgesic agents: Morphine, Codeine, Levarphanol, Meperidine, Methadone, Dextropropoxyphene. Non-narcotic analgesic agents: Dextropropoxyphene morphine antagonist n-allyl-nor morphine, Levellorphan. Note: $- Synthesis to be studied.	05 hours 06 hours
Pedagogy:	Mainly Lectures & tutorials. Seminars/ assignments/ presentations/ self-study/group discussion or a combination of some of these could also be used to some extent.	
References/Readings	1. D. A. Williams & T. L. Lemke, *Foye's Principles of Medicinal Chemistry*, Lippincott Williams and Wilkins.2006, 5th Ed. 2. Chatwal, *Medicinal Chemistry*, Himalaya Publishing House, 2002. 3. Wilson & Gisvold, *Text book of Medicinal Chemistry*, Philadelphia, Williams & Lippincott Wilkins, 2004. 4. Burger, *Medicinal Chemistry*, John Wiley & Sons N.Y, 1997. 5. D. Shriram, P. Yogeshwari, *Medicinal Chemistry*, Pearson Education, 2007. 6. D. Lednicer & L.A. Mitcher *Organic Chemistry of Drug Synthesis* Vo l to III. John Wiley & Sons, 2005. 7. Drug of today, Drugs of future (Journal). 8. Foye, *Principles of Medicinal Chemistry,* Lippincott Williams & Wilkins, 2006. 9. Burger, *Medicinal Chemistry,* John Wiley & Sons N.Y,1997.	

Programme: M. Sc. (Pharmaceutical Chemistry)
Course Code: HCC-502
Title of the Course: Drug Product Formulation and Development
Number of Credits: 3 **Effective from AY:** 2018-19

Prerequisites for the course:	Should have some knowledge on drug formulations	
Course Objective:	To understand the concept of drug dosage forms types of formulations and pilot plant process. To study the drug formulation development with specific examples.	
Course Outcome	• Students should be able to formulate drugs • Students should be able to apply this knowledge for formulation experiments in laboratory.	
Content:	1. **Introduction and Classification**: Introduction to drugs, Dosage Forms & Drug Delivery system – Definitions of Common terms. Drug Regulation and control, pharmacopoeias-formularies, sources of drug, drug nomenclature, routes of administration of drugs products, need for a dosage form, classification of dosage forms & brief description, study of excipients. **2. Drug Product Development** Preformulation studies, objectives, factors to be considered, study protocol. Brief discussion on various parameters to be investigated. formulation and development of the dosage form/drug delivery system-general consideration. **3. Pilot plant** Scale up tec hniques, Benefits of pilot plant- Broad guidelines of process development. General Consideration. Industrial manufacturing method and flow charts of sulphamethoxazole, Rifampicin, Chloramphenicol maleate. 4. **Pharmaceutical manufacturing operations** Brief discussion on unit operations and types of equipments/ machines used. Unit operations like size reduction, mixing/blending, drying, compression etc. **5. Dosage forms-formulation components, manufacturing and QC** Liquids-monophase & biophase including ENT preparation. Semisolid e.g. Ointment, creams, gels etc. Solid dosage forms, e.g. Tablets, capsules, granules & powders. Sterile dosage forms, e.g. Injectables and ophthalmic preparations.	08 hours 08 hours 08 hours 06 hours 06 hours
Pedagogy:	Lectures, assignments, presentations will be acquired methods for learning.	
References/Readings	1. Allen Popvich & Ansel, *Ansels Pharmaceutical Dosage forms and Drug Delivery System,* B.I. Publication Pvt . Ltd, 2005,	

	Indian Ed. 2. Lachman, *The Theory and Practice of Industrial Pharmacy,* Varghese Publishing House, Mumbai,1976. 3. Gilbert. Banker, *Modern Pharmaceutics*, Marcel Dekker, Inc, 2002. 4. S.J.Carter, *Dispensing for Pharmaceuticals Students*, CBS publishers & Distributors, Delhi, 2007. 5. Joseph P. Remington, *Remington's Pharmaceuticals Sciences*, Mack Publishers, 1990. 6. Michael E. Aulton, *Pharmaceutics Science of Dosage Forms and Design*, Kevin Taylor Elsevier - Health Sciences Division, 2001.	

Programme: M. Sc. (Pharmaceutical Chemistry)
Course Code: HCC-503
Title of the Course: Drug Design and Development
Number of Credits: 3 **Effective from AY:** 2018-19

Prerequisites for the course:	Should have knowledge of the concept of drug design and the need for it.	
Course Objective:	To make the students well versed with theories of drug action. To make the students understand the Structure Activity Relationship studies with respect to various examples.	
Course Outcome	• Students should be able to explain the theories of drug action. • Students should be able to apply Quantitative Structure Activity Relationship knowledge in drug designing • Students should be able to analyze the effect of different functional groups on the biological activity of drugs • The students will have a clear understanding of concepts on SAR analysis. • The students should be able to illustrate an example of drug designing by molecular modeling. • The students will be able to understand the terms in patents.	
Content:	**1. Introduction to Drug design, Lead compounds and Pro-Drug Concept.** Development of new drugs: Introduction, procedure followed in drug design, the search for lead compounds, molecular modification of lead compounds, prodrugs and soft drugs, prodrug; introduction, prodrug formation of compounds containing various chemical groups, multiple prodrug formation, soft drugs; design of soft drugs. **2. SAR and QSAR Studies in drug discovery** Structure-Activity Relationship (SAR): Factors effecting bioactivity, resonance, inductive effect, isoterism, bioisosterism, spatial considerations, biological properties of simple functional groups. 4-5 illustrative examples depicting structural activity relationship studies. Theories of drug activity, occupancy theory, rate theory, induced-fit theory. Quantitative structure-activity relationship (QSAR): history and development of QSAR, drug receptor interactions, the additivity of group contributions, physico-chemical parameters, lipophilicity parameters, electronic parameter, ionization constants, steric parameters, chelation parameters, redox potential, indicator-variables, quantitative models. **3. QSAR Approaches in drug designing and modern methods in discovery** Hansch analysis- Advantages and drawbacks. Free-Wilson	08 hours 08 hours 08 hours

	analysis, Advantages and drawbacks. Their application, relationship between Hansch and Free-Wilson analysis (the mixed approach), non-linear relationship, Introduction to other QSAR approaches**-** Free Topliss Method-Postulates and Illustration. Introduction to molecular modeling using computers and docking, uses of molecular modelingmanual use, further computer programming. **4. Designing of Enzyme Inhibitors** Structure-based drug design: Process of structure based drug design, deactivation of certain drugs necessary for T cell functioning, determination of the active site with special reference to chymotryspin, design of inhibitors**.** Design of Enzyme Inhibitors, 9-alkylpurines, 9-mercaptopurines and allopurines, active side directed irreversible enzyme inhibition, suicide enzyme inactivators. **5. Development of New drugs** High throughput screening. Drug Design softwares and its applications. Intellectual property rights, patents, industrial designs, geographical indications, trademarks, trade secrets. Patentable inventions. Patentable drugs. Role of patents in Pharmaceutical industry. trade related aspects (TRIPS), international & regional agreements. Examples of new drugs developed.	06 hours 06 hours
Pedagogy:	Lectures assignments presentations and case studies will be acquired methods for learning.	
References/Readings	1. S.S. Pandeya & J.R. Dimmock, *An Introduction to Drug Design,* New Age International (P) Ltd. Publishers, 2007. 2. M.E. Wolff, *Burgers Medicinal Chemistry and Drug Discovery, Vol I,* John Wiley,1997. (Chapter 9 & 14) 3. Alen-Gringauz, *Introduction to Medicinal Chemistry,* Wiley-VCH, 1997. 4. D. Lednicer & L.A. Mitscher, *The Organic Chemistry of Drug Synthesis, Vol. I to V*, John Wiley, 2005. 5. R.B. Silverman, *Organic Chemistry of Drug Design and Drug Action*, Acad. Press, 2004. 6. A. Leach, *Molecular Modelling, Principles and applications* Longman, 1998. 7. Norman Bailey, *Statistical methods in Biology*, Cambridge, 1995. 8. G. Jolles & R. H. Wooldridge, *Drug Design – Fact of Fantasy?*, Academic Press, 1984 . 9. E.B.Roche, *Design of Biopharmaceutical Properties Through Prodrug and Analogs*, Am. Pharm. Assoc. Academy of Pharm. Sci. 1977. 10. Grahan L. Patrick, *An Introduction to Medicinal Chemistry,* Oxford university press ,2001, 2nd Ed.	

	11. N.R. Subbaran, *What Everyone Should Know About Patent,* Pharma Book Syndicate, 2005. 12. Current Patent Acts of various countries. 13. Philip W Grubb, *Patents for Chemicals Pharmaceuticals & Biotechnology, O*xford University Press, 2005, 4th Ed.	

Programme: M. Sc. (Pharmaceutical Chemistry)
Course Code: HCC-504
Title of the Course: Drug Quality and Regulatory Affairs
Number of Credits: 3 **Effective from AY:** 2018-19

Prerequisites for the course:	Should have the knowledge of drug quality management at TYBSc. Level	
Course Objective:	To learn quality management concepts in pharmaceutical industries. To understand the roles of quality control and quality assurance in pharmaceutical industries. To understand quality control processes essential in pharmaceutical industries. To study the fundamentals of regulatory affairs. To learn the ICH guidelines for drug product efficacy and safety.	
Course Outcome	A student will be able to explain the role and responsibilities of quality management. A student will be able to analyze various quality control documentation procedures. Student will be able to apply the knowledge of regulatory affairs in understanding company rules and regulations. A student will be able to relate ICH guidelines to drug product efficacy and safety.	
Content:	1. **Quality Management I** Concept of Total quality management, Philosophy of c-GMP & GLPs. Organization and Personnel, Responsibilities, training, hygiene, personal records. Premises: Location, Design, Plant layout, construction, maintenance, sanitation, environmental control, utilities & services like gas, water, electricity, Maintains of sterile areas, control of contamination. Equipment; selection, purchase specifications Raw material; purchase specifications, stores, selection of vendors, controls on raw materials, Manufacture of and controls on dosage forms, documents, Master formula batch formula records, standard operating procedure, quality audits of manufacturing processes and facilities. In process quality controls on various dosage forms sterile & non sterile standard operating procedures for various operations like cleaning, filling, drying compression, coating polishing, sterilization Quality control laboratories responsibilities good laboratory practices. Data generation and storage. Quality control documentation, retention of sample records, audits of quality control facilities. 2. **Quality Management II** Finished products release, Quality reviews, Quality audits, batch release documents Ware housing, good ware housing practices, Materials & Management. Distribution & selection of records, Handling of returned good, recovered materials & reprocessing.	08 hours 08 hours

	Complaints & recalls, evaluation of complaints, recall procedures & selected record, documents, waste disposal, scrap disposal procedures & records. Pharmaceutical process validations. Quality Management of cosmetics i) Preparations for facial skin: - Vanishing cream, cold & moisturizing cream, face powder ii) Preparations for Oral hygiene: - Dentifrices, mouthwashes iii) Preparations for hair: - Shampoos, Hair dyes, & Conditioners.iv) Body cosmetics: - Antiperspirants & deodorants, talcum Powder 3. **Validation Procedures** Qualification, Validation and calibration of equipment. Validation of process like mixing, granulation, drying, compression. Filtration filling etc. Validation of sterilization methods and equipment, Dry heat sterilization, Autoclaving, membrane filtration. Validation and audits of analytical procedures, Validation and personnel. Validation and security measures for electronic data processing. 4. **Fundamentals of Regulatory affairs** International Conference On Harmonisation: Technical Requirements for Registration of Pharmaceuticals for Human Use: History, structure and process for hormonisation. ICH guidelines on quality: Stability Testing of New Drug Substances and Products Stability Testing: Photostability Testing of New Drug Substances and Products, Stability Testing for New Dosage Forms, Bracketing and Matrixing Designs for Stability Testing of New Drug Substances and Products, Evaluation of Stability Data, Impurities in New Drug Substances, Impurities in New Drug Products, Impurities: Guideline for Residual Solvents. **5. Product efficacy and safety** ICH guidelines on efficacy: ICH guidelines on clinical trial and Good Clinical Practice. ICH Guidelines on safety: Carcinogenicity Studies - Need for Carcinogenicity Studies of Pharmaceuticals and Testing for Carcinogenicity of Pharmaceuticals. Genotoxicity: A Standard Battery for Genotoxicity Testing of Pharmaceuticals. Detection of Toxicity to Reproduction for Medicinal Products & Toxicity to Male Fertility. Preclinical Safety Evaluation of Biotechnology-Derived Pharmaceuticals.	08 hours 06 hours 06 hours
Pedagogy:	Lectures, assignments, presentations and case studies will be acquired methods for learning.	
References/Readings	1. Drug & Cosmetics Act 1945 Rules (Govt. of India) 2. B. T. Laflus & Rabert A. *Nash Pharmaceutical Process Validation in Durgs & Pharmaceutical Sciences Vol 23*, Marcel & Deckker. 3. S. H. Willing , M. M. Tukerman, *Good Manufacturing Practices for Pharmaceutical - A plan for total quality control*, Vol – 162, Marcel Dekker.	

	4. A. F. Hirsch, *Good Laboratory Practices Regulations in Drugs and The Pharmaceutical Sciences*,Volume -38 , Morce :- Dekker 5. P. P. Sharma, *Preparations & Evaluation of Cosmetics* 6. Web Resources in Pharmacy, Inpharma Publication, Bangalore. 7. Mueen Ahmed K.K. "Web Resources in Pharmacy" 8. ICH Guidelines available at www.ich.org	

Programme: M. Sc. (Pharmaceutical Chemistry)
Course Code: HCC-505
Title of the Course: Laboratory Course in Pharmaceutical Chemistry
Number of Credits: 3 E**ffective from AY:** 2018-19

Prerequisites for the course:	Should have undergone practical course in pharmaceutical chemistry at TYBSc. Level.	
Course Objective:	To apply the theoretical knowledge of pharmaceutical chemistry for synthesis.	
Course Outcome	A Student should be able to apply synthetic organic chemistry knowledge for synthesis of drug like compounds.	
Content:	1. **Methods for synthesis of pharmaceutical compounds.** a) Acetylation of p-aminophenol to acetanilide b) Esterification of salicylic acid c) Benzoylation of alanine/L-Cysteine d) Diazotisation of m-nitroaniline and coupling to give azo dye e) Schiff bases from 2-aminophenol and p-bromobenzaldehyde f) Sulphonylation of aniline/phenol 2. **Synthesis of bioactive heterocycles** a) 2-Methyl Benzimidazole from o-phenylene diamine b) 2,3-DiphenylQuinoxaline from Benzil c) Dilantin from Benzil and urea d) 7-Hydroxycoumarin from ethylacetoaceatate e) Barbiturate from diethyl-n-butylmalonate f) Flavone from 2-hydroxyacetophenone g) Benzoxazole from 2-aminophenol h) Synthesis of Phenothiazine derivative 3. **Synthesis of medicinal compounds** a) Synthesis of Propranolol from α-Naphthol b) Synthesis of Sorbic acid from crotonaldehyde c) Synthesis of Dichloramine-T and Chloramine-T d) Synthesis of Eosin from Fluorescein e) Synthesis of Gramine from Indole	16 hours 36 hours 20 hours

Pedagogy:	Laboratory work well understood by pre-lab and post-lab assignments.	
References/Readings	1. K.A. Connors, *Text book of Pharmaceutical analysis*, Wiley Interscience Publication 1990, 3rd Ed. 2. J. Bassett, J. Mendhan, R.C. Denny, *Vogel's Text Book of Quantitative Chemical Analysis* revised by G.H. Jeffery, Pearson Education Publication, 2007, 6th Ed. 3. Indian Pharmacopoeia., United States Pharmacopoeia, British Pharmacopoeia. European Pharmacopoeia. 4. JEF Reynolds, Martindale, The Extra Pharmacopoeia, The Pharmaceutical Press, London, 1989. 5. M. Jahangir, *Pharmaceutical Laboratory Procedures*, New Delhi Cengage Learning India Pvt. Ltd. 2010, 1st Ed. 6. A. Kar, *Advanced Practical Medicinal Chemistry,* New Age International Limited Publishers, 2004	

Programme: M. Sc. (Pharmaceutical Chemistry)
Course Code: HCO-501
Title of the Course: Pharmacological and Toxicological Screening Techniques
Number of Credits: 3 **Effective from AY:** 2018-19

Prerequisites for the course:	Should have knowledge of Biological Chemistry	
Course Objective:	To learn screening methods of biological Assay. To learn terms involved in Toxicology. To learn methods of analysis for Toxicology.	
Course Outcome	A student will be able to apply the role of various screening methods in bioassay. A student will be able to create various in vivo and in vitro assay methods for various targets. A student will be able to evaluate various effects of toxicology.	
Content:	**1. Principles of Biological Standardisation, Screening methods** Statistical treatment of model problems in evaluation of drugs-methods of biological assay, principles of biological assays-methods used in bioassay of vitamins, hormones, vaccines, cardiac drugs and other pharmacopoeial preparations. Organisation of Screening for the pharmacological activity of new substances. Anti-inflammatory agents-carrageenan induced paw oedema, cotton pellet method. Anticonvulsants: Convulsions induced by chemicals, induced by electroshock, combined procedures. Sympatomimetic agents: Mydriasis, the uterus and ascending colon of the rat. **2. Introduction to Toxicology**: Definition and types of toxicology, Basic principles of toxicology, Carcinogenicity, mutagenicity, teratogenicity, acute, sub acute and chronic toxicity. Detailed toxicity(mild/moderate/severe toxicology wherever applicable) and treatment of drugs such as salicylates/ paracetamol, opium, quinine, ethyl alcohol, etc**.** Toxic chemicals in the environment, impact of toxic chemicals on enzymes. Biochemical effects of arsenic, lead mercury, cadmium, carbon monoxide, pesticides and carcinogens**.** **3. Essentials of Analytical Toxicology** Physicochemical, biochemical & genetic basis of toxicity; Principles of toxicokinetics, mutagenesis and carcinogenesis – Behavioural, inhalation toxicity, hypersensitivity and immune response, range finding tests – Acute, subacute and chronic toxicity studies. Classification of Toxins: Acute toxicity tests, Determination of LD_{50} value, Subacute tests - Histopathological and biochemical estimations on toxicity induced in animal models – Modern methods of analysis for Toxins-Barbiturate poisoning, Amphetamine poisoning.	12 hours 12 hours 12 hours

Pedagogy:	Lectures, assignments, presentations and case studies will be acquired methods for learning.	
References/Readings	1. S.K. Gupta, Uma Singh & T. Velpandian, *Analytical Toxicology for Poisoning Management and Toxicovigilance*, Varosa Publishing House, 2002. 2. Clarke, *Isolation and Identification of Drugs*, The Pharmaceutical Press, 1986. 3. A.K. De, *Environment Chemistry,* Wiley Eastern Ltd., New Delhi, 2003. 4. R.K. Trivedy & P.K. Goel, *Chemical and Biological Methods for Water, Pollution Studies*, Environment Publications, Karad (India), 1984. 5. B. K. Sharma, *Industrial Chemistry*, Narosa Publishing House, 1998, 1st Ed. 6. William Andrew, *Pharmaceutical Manufacturing Encyclopaedia* Vol I and II, 2007, 3rd Ed. 7. Profiles Bulk Drug manufacture. 8. Robert .A. Turner & Peter Hebborn, *Screening Methods in Pharmacology, Vol.-1 &2*, Elsevier Science & Technology Books, 1971. 9. H. G. Vogel & W. H. Vogel, *Drug Discovery and Evaluation*, Springer, 2006. 10. S.K. Kulkarni, *Handbook of Experimental Pharmacology,* Vallabh Prakashan, Delhi, 1993. 11. R.S. Satoskar & S.D. Bhandarkar, *Pharmacology and Pharmacotherapeutics*, Popular Prakashan Ltd, 2006. 12. Louis S. Goodman & Alfred Gillman, *The Pharmacology Basis of Therapeutics,* McGraw-Hill Professional Publishing, 2010 13. H.P. Rang & M.A. Dale, *Pharmacology,* Elsevier - Health Sciences Division, 2011.	

Programme: M. Sc. (Pharmaceutical Chemistry)
Course Code: HCO-502
Title of the Course: Calibration and Validation
Number of Credits: 3 **Effective from AY:** 2018-19

Prerequisites for the course:	Should have studied practical course involving calibration of analytical instruments	
Course Objective:	To learn principles of calibration and validation of analytical instruments. To learn validation procedures for analytical instruments. To learn qualification of various analytical instruments.	
Course Outcome	A student will be able to apply calibration techniques to analytical instruments. A student will be able to validate analytical instruments. A student will be able to evaluate qualifications of analytical instruments.	
Content:	**1. Calibration and Validation of Analytical Instruments** Validation and calibration of various instruments used for drug analysis such as UV-Visible Spectrophotometer, IR Spectrophotometer, Spectrofluorimeter, HPLC, HPTLC and GC. Regulatory requirements for analytical method validation. International conference on harmonization (ICH) guideline Q2A: **2. Validation of analytical procedures** Linearity and range criteria and their role in instrumental method validation Detailed discussion on accuracy and precision role in the method validation Role of quantification limit and specificity -Limit of Detection (LOD) and Limit of Quantification (LOQ) Robustness & method validation Ruggedness of chromatographic method Ruggedness of sample preparation procedure Complete method validation package, analytical data, protocol, plan, revisions, and change controls. **3. Qualification of analytical instruments** Overview of qualification of some instruments. Overview of installation, operation, and performance qualification (IQ, OQ, PQ) of analytical equipment.	12 hours 12 hours 12 hours
Pedagogy:	Lectures, assignments, presentations and field visits will be the acquired methods for learning.	
References/Readings	1. WHO guidelines (2014-2018) 2. Michael E. Swartz, *Analytical Method Development & Validation,* CRC Press,1997. 3. Loftus & Nash, *Pharmaceutical Process Validation*, Dekker Incorporated, Marcel, 1984.	

	4. J. Mendham, R.C. Denny, J.D. banes, *Vogel's Textbook of Quantitative Chemical Analysis* Thomas. ELBS, 2007, 6th Ed. 5. Alfred H. Wachter, *Pharmaceutical Process Validation,* Informa Health Care, 2003.	

Programme: M. Sc. (Pharmaceutical Chemistry)
Course Code: HCO-503
Title of the Course: Polymers in Pharmaceuticals and novel drug delivery systems
Number of Credits: 3 **Effective from AY:** 2018-19

Prerequisites for the course:	Should have studied the topic on polymers in the TYBSc. Level	
Course Objective:	To learn classification synthesis and properties of polymers. To learn the role of polymers in drug delivery systems. To learn new innovations in drug delivery systems.	
Course Outcome	A student will be able to identify the type of polymers that can be used for drug delivery systems. A student will be able to get the knowledge of innovative drug delivery systems and apply it for their lab project.	
Content:	**1. Introduction and Types of Polymers in Pharmaceuticals** Classification, General methods of synthesis, properties, characterization and evaluation: Biodegradable polymers - Classification - Mechanism of biodegradation in the body. Polymer processing with respect to novel formulation design: Applications of polymers in novel drug delivery systems. Introduction to Novel Drug delivery systems, drug delivery carriers, routes of administration. **2. Polymers as Novel Drug Delivery systems** Recent advances in drug delivery systems. Theory of controlled release drug delivery systems. Microencapsulation – Methods of encapsulation. Transdermal drug delivery systems – Theory, formulation, production and evaluation. Targeted drug delivery systems – concept of drug targeting, importance in therapeutics. **3. Recent Innovations in drug delivery systems** Recent innovations in conventional dosage form like tablets, capsules, sterile dosage forms, pellets, Mucoadhesive system, GRDDS, peptide drug delivery, supercritical fluid technique, PEGylation, Nanoparticulate drug delivery. Future opportunities and challenges.	12 hours 12 hours 12 hours
Pedagogy:	Lectures, assignments, presentations and mini-projects will be the acquired methods for learning.	

References/Readings	1. U.S. Beans, A.K. Beckett & J.E. Caralem, *Advances in Pharm Sci*,Vol 1-4, Elsevier, 2009. 2. G.S. Banker, *Modern Pharmaceutics*, Dekker Incorporated, Marcel, 2002. 3. Lisbeth Lliun & Stanley S Davis, *Polymer in Controlled Drugs Delivery*, Wright, Bristol, 1987. 4. J. R .Crompton, *Analysis of Polymer- An Introduction,* Pergamon Press, Oxford, 1989. 5. Malcolm P. Steven, *Polymer Chemistry An Introduction,* New York, Oxford, Oxford University Press, 1990. 6. M. Charin, *Biodegradable Polymers as Drug Delivery Systems,* Informa HealthCare, 1990. 7. Beckett & Stenlake, *Practical Pharmaceutical Chemistry Vol I &II*, CBS Publishers, 2005 8. Martins, Patrick J. Sinko, Lippincott, *Physical Pharmacy and Pharmaceutical Sciences,* William and Wilkins, 2006. 9. S.J. Carter, *Cooper and Gunn's Tutorial Pharmacy,* CBS Publisher Ltd, 2008, ,6th Ed. 10. Indian Pharmacopoeia, British Pharmacopoeia. 11. J.R. Robinson & Vincent H.L. Lee, *Controlled Drug Delivery,* Drugs and Pharm. Sci. Series, Vol. 29, Marcel Dekker Inc. N.Y, 987. 12. J.R. Juliano, *Drug Delivery Systems*, Oxford University Press, Oxford, 1980. 13. M.I. Gutcho, *Microcapsules and Microencapsulation Techniques*, Noyes Data Corporation, 1976.	

Programme: M. Sc. (Pharmaceutical Chemistry)
Course Code: HCO-504
Title of the Course: Biopharmaceutics
Number of Credits: 3 **Effective from AY:** 2018-19

Prerequisites for the course:	Should have studied the concepts of drug metabolism at T Y B Sc level.	
Course Objective:	To learn ADMET. Drug absorption drug distribution Drug Action Drug metabolism and excretion To learn how bioavailability is important understanding the efficacy of a drug product.	
Course Outcome	A student will be able to relate drug absorption to bioavailability. A student will be able to get an in-depth knowledge of drug metabolism concept.	
Content:	1**. Drug absorption, Dissolution and Distribution** Based on cell membrane Gastro-intestinal absorption of drugs, mechanisms of drug absorption, factors affecting drug absorption: Biological, physiological, physico-chemical and pharmaceutical. Noyes-Whitney's dissolution rate law, study of various approaches to improve dissolution of poorly soluble drugs, In-vitro dissolution testing models, In-vitro-in-Vivo correlation. Factors affecting drug distribution, volume of distribution, protein binding – factors affecting, significance and kinetics of protein binding. 2. **Drug Metabolism and Excretion** Metabolism of drugs, Xenobiotics, Drug metabolizing organs and enzymes (microsomal & nonmicrosomal), Chemical pathways - Phase I reactions (Oxidative, reductive and hydrolytic reactions) and Phase II reactions (Conjugation), Significance of cytochrome P_{450} oxidation – reduction cycle, Factors affecting biotransformation of drugs. Renal excretion – Glomerular filtration, Active tubular secretion, Active (or) passive tubular reabsorption. Factors affecting renal excretions of drugs. Non renal excretions – Biliary, pulmonary, salivary, mammary, skin/dermal, gastrointestinal and genital excretions of drugs (Any two types) 3. **Bioavailability and Bioequivalency studies** Objectives and considerations in bioavailability studies, Concept of equivalents, Measurements of bioavailability, Determination of the rate of absorption, Bioequivalence studies and its importance,. Biopharmaceutical classification of drugs.	12 hours 12 hours 12 hours
Pedagogy:	Lectures assignments presentations and group discussion will be the acquired methods for learning.	
References/Readings	1. Milo Gibaldi, *Biopharmaceutics and Clinical Pharmacokinetics,* Philadelphia, Lea & febiger, 1991, 4th Ed.	

	2. A. Treatise, D.M. Brahmankar & Sunil B.Jaiswal., *Biopharmaceutics and Pharmacokinetics,* Vallabh Prakasan, Pitambura, Delhi, 1998. 3. Sharjel. L & Yu ABC, *Applied Biopharmaceutics and Pharmacokinetics,* Connecticut, Appleton Century Crofts, 1985, , 2nd Ed 4. Swarbrick.J, Lea & febiger, *Current Concepts in Pharmaceutical Sciences: Biopharmaceutics,* Philadelphia, 1970. 5. Hamed M. Abdou. *Dissolution, Bioavailability and Bioequivalence*, Mack Publishing Company, Pennsylvania, 1989. 6. Robert. E. Notari, *Biopharmaceutics and Clinical Pharmacokinetics, An Introduction*, Marcel Dekker Inc, New York and Basel, 1987, 4th Ed. 7. John.G. Wagner and M.Pernarowski, *Biopharmaceutics and Relevant Pharmacokinetics*, Drug intelligence Publications, Hamilton, Illionois, 1971, 1st Ed. 8. James Swarbrick, James.C. Boylan, *Encyclopedia of Pharmaceutical Technology, Vol.I,* Marcel Dekker Inc, New York, 2002, 2nd Ed.	

Programme: M. Sc. (Pharmaceutical Chemistry)
Course Code: HCO-505
Title of the Course: Pharmaceutical Technology
Number of Credits: 3 **Effective from AY:** 2018-19

Prerequisites for the course:	Should have some knowledge on pharmaceutical technology.	
Course Objective:	To learn unit processes involving various chemical reactions. To learn industrial synthesis of selected list of drugs. To learn the need for pilot plant in industry and also the flowchart on various manufacturing methods of drugs.	
Course Outcome	A student will be able to explain unit processes for various chemical reactions. A student will be able to apply industrial synthesis knowledge for the synthesis of drug like molecules in laboratory. A student will be able to apply the knowledge of effluent treatment methods.	
Content:	**1. Unit Processes** Concept of unit processes in systematization of chemical reactions, explanation of one example each for unit processes: Alkylation, amination, (by ammonolysis, reduction), carbonylation, carboxylation, condensation, dehydration, diazotization, disproportionation, esterification, halogenation, hydration, hydroformylation, hydrogenation, hydrolysis, hydroxylation, nitration, oxidation and reduction. **2. Industrial Synthesis** Introduction to pharmaceutical manufacturing – raw materials, detailed manufacturing procedure, therapeutic function, common name, chemical name, structural formulae of the following drugs :Acyclovir, alprazolam, propanolol, naproxen, ibuprofen, aspirin, levodopa and cimetidine.Lidocaine, ethambutal hydrochloride, 5-fluorouracil, amoxycillin sodium. **3. Process Development & Process Optimization** a) Pilot- plant – Introduction – Appraisal for the need of pilot – plant – pilot plant (Vs) Small scale plant – Benefits of Pilot plant – Broad guidelines of process development. b) Industrial manufacturing method and flow charts of Sulphamethoxazole, Ciprofloxacin, and Rifampicin. Environment Health & Safety: Introduction to industrial effluents. Classification of effluents. Classification of basic methods of purifying effluents.	12 hours 12 hours 12 hours
Pedagogy:	Lectures assignments presentations and group discussion will be the acquired methods for learning.	
References/Readings	1. B.K. Sharma, *Industrial Chemistry*, Narosa Publishing House, 1998, 1st Ed. 2. B.K. Sharma, *Environmental Chemistry*. Narosa Publishing House , 1998, 1st Ed	

	3. Groggins , *Unit processes in Chemical Engineering,* McGraw-Hill, 1958, 1st Ed. 4. Drydens, *Unit processes in chemical engineering*, McGraw-Hill Higher Education , 2004. 5. William Andrew, *Pharmaceutical Manufacturing Encyclopedia Vol.I & II*., William Andrew, 2007, 3rd Ed. 6. W.W.M. Wenland, *Thermal Analysis*, John Willey & Sons, New York, 1974, 2nd Ed. 7. S.B. Chandalia, *Hand Book of Process Development*, Multitech Publishing Company, Mumbai, 1998. 8. Kumar G. Gadamasetti, *Process Chemistry in Pharmaceutical Industries*, Taylor & Francis Group , 1999, 1st Ed. 9. Shreve's, *Chemical Process Industries*, McGraw Hill Book Company, 2000, 5th Ed. 10. M.V. Krishnan, *Safety Management in Industries*, Jaico Publishers, Mumbai, 2002.	

Programme: M. Sc. (Pharmaceutical Chemistry)
Course Code: HCO-506
Title of the Course: Pharmaceutical Stability
Number of Credits: 3 **Effective from AY:** 2018-19

Prerequisites for the course:	Should have studied some knowledge on stability of drugs	
Course Objective:	To learn to predict shelf life and half life of pharmaceutical formulations. To learn various stability protocols and also stability terminologies as given in ICH guidelines I To learn ICH guideline II that is thorough investigation into stability labs.	
Course Outcome	A student will be able to explain fundamentals of stability studies. A student will be able to determine stability requirements for OTC drug products. A student will be able to make a stability labs ready for FDA inspection.	
Content:	**1. Fundamentals of Stability** Basic concept and objectives of stability study. Fundamentals of stability testing requirements. Order of reaction and their applications in predicting shelf life and half-life of Pharmaceutical formulations. **2. ICH Guidelines-I** Review ICH process and ICH updates on stability Common terminology and acronyms. Review current Q1A, Q1B, Q1D, Q1F, Q2, Q3 and Q6 guidelines Determine stability requirements for OTC products Stability SOPs Stability protocols and data Design of a compliant bracketing and matrixing. **3. ICH Guidelines-II** ICH guidelines on bracketing and matrixing Stability testing laboratory Design and validation stability test procedures Stability data management system Investigation procedures of OOS stability results FDA inspection of stability labs.	12 hours 12 hours 12 hours
Pedagogy:	Lectures assignments presentations and group project will be the acquired methods for learning.	
References/Readings	1. J.T.Carstensen, *Drug Stability: Principles & Practices*, Drugs & Pharm Sci. series ,Vol 43, Marcel Dekker Inc., N.Y, 2000. 2. G. S. Banker, *Modern Pharmaceutics*, CRC Press, 2002. 3. Sumie Yoshika & Valenino,J. Stella, *Stability of Drugs & Dosage Forms,* Springer, 2006, Int. Ed. 4. Jens T. Carstensen, *Drug Stability*, Informa HealthCare, 2006 3rd Ed. 5. Stds Boldon , *Pharmaceutical Statistics*, Marcel Dekker Inc	

	2005. 6. James E. De Muth, *Basics Statistics & Pharmaceutical Statistical Applications,* Marcel Dekker Inc, 1999.	

Programme: M. Sc. (Pharmaceutical Chemistry)
Course Code: HCO-507
Title of the Course: Laboratory Course in Natural Product Analysis
Number of Credits: 2 **Effective from AY:** 2018-19

Prerequisites for the course:	Should have studied the theory topics in natural products at TYBSc. Level.	
Course Objective:	To introduce the practical component in natural product analysis. To learn various methods involved in the analysis of natural products.	
Course Outcome	A student will be able to Isolate natural products. A student will be able to synthesize natural products. A student will be able to characterize natural products by physical methods of analysis.	
Content:	1) Isolation of Caffeine from tea, coffee etc. and purification by microscale sublimation. Characterization of pure caffeine by IR. 2) Isolation of Cinnamaldehyde from Cinnamon by microscale steam distillation. Characterization and interpretation of isolated Cinnamaldehyde by IR. 3) Enzymatic reduction of ethylacetoacetate using Baker's yeast. 4) Thin layer Chromatography for separation of mixtures of natural products/Market Formulations. 5) Column chromatography of two component mixture of natural products/Market Formulations. 6) Conversion of camphene to isobornyl acetate 7) Hydrolysis of isobornyl acetate to isoborneol 8) Oxidation of isoborneol to Camphor. 9) Transformation of Benzaldehyde to Benzoin using thiamine B12 as a coenzyme. 10) Isolation of cholesterol from gallstones 11) Determination of Acid Value of Fixed Oil. 12) Determination of Saponification Value of Fixed Oil. 13) Determination of Eugenol in Clove Oil. 14) Qualitative analysis of natural products (Comprises of amino acids, carbohydrates, proteins, alkaloids, glycosides, steriods, flavonoids) 15) Isolation of piperine from black pepper powder. Characterization and interpretation of isolated Cinnamaldehyde by IR. 16) Isolation of calcium citrate from lemon juice.	48 hours
Pedagogy:	Laboratory work.. pre-lab and post-lab exercises mini-projects will be given to students.	
References/Readings	1. D.W.Mayo, R.M. Pike & P.K. Trumper, *Microscale Organic laboratory*, John Wiley and Sons, 1994, , 3rd Ed.	

	2. D.L. Pavia, G.M. Lampman & G.S. Kriz, *Introduction to Organic Laboratory Techniques,* Saunders College published, 1995, 2nd Ed. 3. O.R. Rodig, C.E. Bell, Jr. A.K. Clark, *Organic Chemistry Laboratory*, Saunders College Publishing, 1990.	

Programme: M. Sc. (Pharmaceutical Chemistry)
Course Code: HCO-508
Title of the Course: Laboratory Course in Drug Product Formulation and Development
Number of Credits: 4 **Effective from AY:** 2018-19

Prerequisites for the course:	Should have knowledge of drug dosage forms and drug formulations	
Course Objective:	To learn preparations of variety of pharmaceutical formulations. To learn quality control evaluation methods of tablets. To learn the principle instrumentation and working of dissolution apparatus.	
Course Outcome	A student will be able to prepare various drug formulations and analyze them. A student will be able to evaluate tablets qualitatively using analytical instruments. A student will be able to handle dissolution apparatus and carry out various dissolution experiments to evaluate bioavailability.	
Content:	**1) Preparation of pharmaceutical dosage forms and Quality Control Analysis other than Assays:** i) Concentrated Dill Water ii) Aqueous Iodine Solution I. P iii) Merbromin solution NF 11 iv) Cresol with soap solution I.P. v) Calamine Lotion IP vi) Calamine Cream aqueous BPC. vii) Elixir, Paediatric B.P.C. and Pain balm viii) Cough Expectorant and Antacid suspension ix) Simple ointment IP and Sulphur Ointment IP x) Non-Staining Iodine Ointment BPC and Non-staining iodine ointment with methyl salicylate (BPC) xi) Liniment (BPC) **2) Quality Control Evaluation of Tablets and Capsules** 6 experiments using different types of tablets and capsules of 4 hours each **3) Dissolution Experiments** i) Validation, qualification, Calibration of dissolution Test Apparatus. ii) Carbamazepine tablets iii) Paracetamol tablets iv) Diclofenac sodium tablets v) Combination drugs	42 hours 24 hours 30 hours
Pedagogy:	Laboratory work. pre-lab and post-lab exercises mini-projects will be given to students.	
References/Readings	1. K.A Connors, *Text Book of Pharmaceutical Analysis*, Wiley Interscience Publication 1990, 3rd Ed.	

	2. G.H. Jeffery, J. Bassett, J. Mendhan, R.C. Denny, *Vogel's Text Book of Quantitative Chemical Analysis,* Pearson Education Publication, 2007, 6th Ed. 3. Indian Pharmacopoeia., United States Pharmacopoeia, British Pharmacopoeia. European Pharmacopoeia. 4. JEF Reynolds, Martindale, The Extra Pharmacopoeia, The Pharmaceutical Press, London (1989) 5. Mohini Jahangir, *Pharmaceutical Laboratory Procedures*, New Delhi Cengage Learning India Pvt. Ltd. 2010, 1st Ed.	

Programme: M. Sc. (Pharmaceutical Chemistry)
Course Code: HCO-509
Title of the Course: Laboratory Course in Drug Design, Molecular Docking and Patents
Number of Credits: 2 **Effective from AY:** 2018-19

Prerequisites for the course:	Should have knowledge of structure drawing at T Y B Sc level.	
Course Objective:	To learn drug designing through drug discovery experiments (drug simulations) To learn to use molecular docking software packages. To learn about patenting in pharmaceuticals.	
Course Outcome	A student will be able to synthesize drug molecules carry out in vitro bioassay and drug simulation studies. A student will be able use various molecular docking softwares for designing certain drug targets. A student will be able to know the procedure to pharmaceutical patent can be filed.	
Content:	**1) Drug Design and Discovery experiments** 1. Synthesis of Aspirin and Oil of Winter green and its physical properties, *in vitro* biological assays and drug simulation studies. 2. Synthesis of Sulphacetamide and Sulphamethoxazole and its physical properties, *in vitro* biological assays and drug simulation studies. 3. Synthesis of acetanilide and paracetamol and its physical properties, *in vitro* biological assays and drug simulation studies. **2) Molecular Docking Experiments** Use of software packages in chemistry for the following: To write a computer program to obtain a slope and intercept for linear data using least square fit. 1. Use of ChemDraw, ISISDraw for drawing structures, chemical reactions, equations. 2. Molecular docking softwares such as Hex software or autodocking. 3. Energy minimization of molecules and finding interm interactions of small molecule with macromolecule such a inhibitor, thymidilate synthase, glycogen synthase, E.Coli prote 4. Viewing Tools and Graphics Tools • Rasmol (http://www.umass.edu/microbio/rasmol/) • VMD (http://www.ks.uiuc.edu/Research/vmd/) • Molscript (http://www.avatar.se/molscript/) 6. The use of molecular dynamics techniques for drug discovery using NAMD (http://www.ks.uiuc.edu/Research/namd/). Tutorials are at http://www.ks.uiuc.edu/Training/Tutorials/. 7. Docking of small molecules to protein targets using Autodock	16 hours 24 hours

	(http://autodock.scripps.edu/). Tutorials are at http://autodock.scripps.edu/faqshelp/tutorial/using-autodock-4-with-autodocktools. **3) Patents** i) Prior Art Search on Target Drug (Any 2) ii) Patent Filing procedures (Any two case studies)	8 hours
Pedagogy:	Laboratory work.. pre-lab and post-lab exercises presentations will be given to students.	
References/Readings	1. M. E. Wolff, J *Burger's Medicinal Chemistry and Drug Discovery,* Vol. 1., John Wiley & Sons: New York, 1995**,** , 5th Ed. 2. W.O. Foye, T.L. Lemke, & D. A. Williams, *Principles of Medicinal Chemistry* , Williams and Wilkins: Philadelphia, 1995. 4th Ed. 3. F.D. King, *MCPP – Medicinal Chemistry: Principles and Practice*, Royal Society of Chemistry: Cambridge, 1994. 4. K.V. Raman, *Computers in Chemistry*, Tata Mc.Graw-Hill, 1993. 5. S.K Pundir, Anshu Bansal, *Computers for Chemists,* Pragati Prakashan, 2010. 6. Andrew Leach, *Molecular Modelling, Principles and applications*, Longman, 1998.	

Programme: M. Sc. (Pharmaceutical Chemistry)
Course Code: HCO-510
Title of the Course: Laboratory Course in Quality Control and Quality Assurance
Number of Credits: 4 **Effective from AY:** 2018-19

Prerequisites for the course:	Should have studied the analysis of pharmaceuticals at TYBSc. Level.	
Course Objective:	To learn quality control analysis of drugs using analytical instruments. To learn to perform quality assurance experiments	
Course Outcome	A student will be able to use UV spectrophotometer dissolution apparatus high performance liquid chromatograph (HPLC) and Infra Red spectrophotometer. For quality control analysis of drugs. A student will be able to perform quality assurance experiments.	
Content:	**I) Quality Control Analysis Experiments** **Spectrophotometric Analysis** 1) Determination of % purity of a given sample of Chloramphenicol capsules IP. 2) Determination of % purity of a given sample of Furosemide injection IP. 3) Determination of % purity of a given sample of Allopurinol tablets IP. 4) Determination of % purity of a given sample of Propranolol HCl tablets IP. **Dissolution Analysis (Any 2)** 1) Dissolution rate study of sustained release Theophylline tablets IP. 2) Dissolution rate study of sustained release Diclofenac tablets IP. 3) Analysis of Diclofenac sodium and paracetamol in combined dosage form. **Chromatographic Techniques in Pharmaceuticals:** 1) To identify the given drug amongst the paracetamol, aspirin and caffeine citrate with the help of thin layer chromatography and calculate its *Rf* value. 2) To identify the given sulpha drug among the sulphadiazine, sulphamethoxazole and trimethoprim with the help of thin layer chromatography and calculate its *Rf* value. 3) To perform the Separation of amino acids by paper chromatography. 4) To identify the given sample of sugar with the help of ascending paper chromatography and calculate its *Rf* value. 5) To demonstrate high Performance liquid chromatography and analyse Diazepam Tablets by High Pressure Liquid Chromatography.	16 hours 12 hours 24 hours

	6) To develop and validate the analytical method of any one drug using high performance liquid chromatography. 7) To analyze the given tablets of paracetamol/ibuprofen-paracetamol combination HPTLC method. 8) Separation of mixture of o-nitroaniline and p-nitroaniline using column chromatography. **Infrared Spectroscopic analysis** **Demonstration of Instrumentation and Interpretation of Representative Spectra** a) To differentiate between analgesic-NSAIDs :Aspirin, Ibuprofen, Paracetamol. b) To differentiate between Acetophenone, p-Nitroacetophenone, Benzamide. c) To interpret the I.R. spectra of the following compounds: Benzyl alcohol, Benzaldehyde, Acetanilide, Ethylacetate, Ethyl methyl ketone, m-nitroaniline. **II) Quality Assurance Experiments (Any 9)** 1) Evaluation of Riboflavin/Ibuprofen tablets I .P. to characterize and evaluate the effect of different concentrations of binders and disintegrant. 2) Design and fabrication of theophylline sustained release formulation and comparison of its release profile with the conventional dosage form. 3) Formulation and evaluation of micronized disperse system for parenteral delivery of drugs including test for pyrogens and sterility testing etc. 4) Preparation of solid dispersions of poorly water soluble drugs using different carriers and to study the release profile and compare with conventional dosage forms. 5) Disintegration and dissolution of per oral tablets. 6) Influence of vehicle on drug availability from topical dosage forms in-vitro. 7) Design and preparation of a suspension and its evaluation. 8) Development of moisture resistant coating formulation for Amoxycillin tablets/ Ranitidine tablets. 9) Quality control of paper, Plastic and glass container. 10) Quality control of labels and label adhesives. 11) Microbial limit test in oral products. 12) Validation of sterilization equipments e.g. Hot air oven, Autoclave. 13) Validation of Analytical procedure.	8 hours 36 hours
Pedagogy:	Laboratory work.. pre-lab and post-lab exercises presentations and case studies will be given to students.	
References/Readings	1. K.A Connors, *Text book of Pharmaceutical Analysis*, Wiley	

	Interscience Publication, 1990, 3rd Ed. 2. G.H. Jeffery, J. Bassett, J. Mendhan, R.C. Denny, *Vogel 's Text Book of Quantitative Chemical Analysis*, Pearson Education Publication, 2007, 6th Ed. 3. Indian Pharmacopoeia., United States Pharmacopoeia, British Pharmacopoeia. European Pharmacopoeia. 4. JEF Reynolds, Martindale, The Extra Pharmacopoeia, The Pharmaceutical Press, London (1989) 5. Mohini Jahangir, *Pharmaceutical Laboratory Procedures*, New Delhi Cengage Learning India Pvt. Ltd., 2010, 1st Ed.	

Programme: M. Sc. Part-II (Chemistry)
Course Code: CGO-501
Title of the Course: Selected Experiments in Chemistry
Number of Credits: 8 **Effective from AY:** 2019-20

Prerequisites for the course:	Should have studied the theory and practical courses in Analytical, Inorganic, Organic and Physical Chemistry at MSc-I level so as to have basic knowledge of experiments in chemistry.	
Course Objectives:	*This course is in lieu of Dissertation (8 credits) and is to be opted by those students who are not opting the dissertation at part-II level. Consequently, the course will be taught over two semesters (III and IV, 4 credits in each semester). The objectives and outcomes are thus defined considering the requirements of experimental Analytical, Inorganic, Organic and Physical Chemistry.* 1. Introduction of various instrumental techniques for analysis. 2. Learning data analysis, handling and interpretation of spectra. 3. To learn techniques of crystallization of ligands and synthesis of coordination compounds. 4. To learn characterization of compounds using different instruments. 5. To introduce analysis of ores for metal content. 6. To translate certain theoretical concepts learnt earlier into experimental knowledge by providing hands on experience of basic laboratory techniques required for organic syntheses. 7. To train the students in application of theoretical concepts related to organic spectroscopy by interpreting various spectra (UV, IR, NMR, Mass, 2D NMR etc.) of organic compounds. 8. To impart experimental knowledge regarding computational and theoretical concepts in physical chemistry. 9. To Introduce synthesis methods of nanomaterials and nanoporous materials. 10. To introduce computational techniques in physical chemistry.	
Course Outcomes:	1. Students should be in a position to use different instruments for qualitative and quantitative analysis. 2. To gain experience with some statistics to analyse data in lab. 3. Students will be able to understand the methods of syntheses and characterization of coordination compounds 4. Students will be in a position to synthesis, characterize and measure the solid state properties of oxide materials. 5. Students shall gain the understanding of: i. Stoichiometric requirements during organic syntheses. ii. Safe and Good laboratory practices, handling laboratory glassware, equipment and chemical reagents. iii. Common laboratory techniques including reflux, distillation, steam distillation, vacuum distillation, aqueous extraction, thin layer chromatography (TLC), reactions under dry conditions, use of	

	microwave, photochemistry, low temperature synthesis etc. iv. Use of organic spectroscopic techniques in monitoring the organic syntheses. 6. Students should be in a position to understand mathematical and theoretical methods in chemistry. 7. Students will be able to understand different methods for syntheses and characterization of nanomaterials and nanoporous materials. 8. Students will understand the concepts of phase rule and adsorption.	
Content:	**Unit-I: Analytical Chemistry- Instrumental methods of analysis.** **(Minimum 08 experiments to be performed.)** 1. Potentiometric determination of dissociation constant of Cu-ammonia complex. 2. Potentiometric titration of Zn^{2+} against $[Fe(CN)_6]^{4-}$ and determination of the empirical formula of the complex formed. 3. To record and interpret the cyclic voltammogram for potassium ferricyanide $[K_3Fe(CN)_6]$ 4. Kinetic investigation for Fe^{2+}/Fe^{3+} system using cyclic voltammetry 5. To study the fluorescence spectroscopy by recording spectra for following compounds (Quinine sulphate and Anthracene) and compare the data of two compounds 6. Quantitative determination of amount of anthracene/quinine sulphate using fluorescence spectroscopy 7. Fractionation (based on polarity) of given mixture by Solvent extraction protocol followed by recovery of separated analyte using rotary evaporator and determination of purity by TLC analysis 8. Separation of a mixture of o- and p- nitro anilines on an alumina column chromatography and recovery, reuse of mobile phase using rotary evaporator. 9. Calibration of IR spectrophotometer using polystyrene film and to check the performance of the instrument. 10. Estimation of aspirin and caffeine from APC tablet by UV-Visible spectrophotometry. **Unit-II: Inorganic Chemistry** **Group–1**: *Preparation of ligands (including distillation/ recrystallization) / metal-ligand compounds / inorganic compounds / crystal structure analysis: (**Any 4** experiments)* 1) Preparation of Schiff base and characterization. 2) Preparation of substituted benzoic acids and characterization. 3) Preparation of acetylacetonate complexes of Co(II) and Co(III) and estimation of cobalt. 4) Preparation of a polyoxometallate and characterization 5) Preparation of aluminium(III)tris(acetylacetonate) and estimation of aluminium. 6) Preparation of potassium dihydroxodioxalatotitanate(IV) and estimation of titanium.	**48 hours** **24 Hours**

	7) Preparation of manganic acetate and estimation of manganese 8) Preparation of chromium(II)acetate hydrate and estimation of Chromium. 9) Preparation of $K_2ON(SO_3)_2$ (Fremy's salt). Note: Wherever possible IR and other spectral studies should be undertaken for prepared compounds **Group–2**: *Syntheses, characterization and solid state study of ABO_3/AB_2O_4 oxides: (**Any 4** experiments)* 1) Preparation of Perovskite/Spinel oxide by oxalate precursor method 2) Characterization of precursor using CHN Analyser and estimation of metals in the precursors and oxides by gravimetric and volumetric analysis. 3) Characterization of precursor by i) IR ii) Thermal analysis (TG/DTA) and iii) Isothermal Mass Loss Studies. 4) X-ray diffraction studies of Perovskite/Spinel oxide prepared 5) Electrical resistivity measurement of the prepared oxide by Two probe / Four Probe method. 6) Dielectric studies of prepared oxide: Dielectric constant and dielectric loss V/s I) Frequency and II) Temperature 7) Magnetic Characterization of prepared Spinel oxide by: i) Hysteresis loop data (Ms, Mr, Hc) and ii) A.C Susceptibility **Unit-III: Organic Chemistry** 1. Elucidation of structures of organic compounds using spectral Combination of UV, IR, PMR, CMR, 2D NMR, Mass spectra (reported or predicted) of a single compound to be used to identify the structure of the compound. (Minimum 6 experiments of 2 hr duration each to be performed taking at least four type spectra together). Depending upon available instrumental facilities, students be asked to record spectra (UV, IR, PMR, CMR etc.) of at least 3 products from any of the organic preparations carried out by the students and the structure may be elucidated. *Note: Spectral analysis assessment (max. 20 marks) be conducted as follows: It is recommended that the candidate be given a combination of spectra (UV, IR, PMR, CMR, 2D NMR, Mass; at least four type spectra together) from which s/he will have to deduce preliminary information within first half an hour of the examination without referring to any book/reference material. (This shall carry not more than half of the maximum marks assigned to this exercise). The complete structure of the compound may then be elucidated by the candidate by referring to any standard text-book/reference material etc., (This shall carry remaining marks).* 2. Organic synthesis- ((**Minimum 6** experiments) i. Triphenyl carbinol from benzophenone or ethyl benzoate (Grignard reaction).	**24 Hours** **12 Hours** **36 hours**

	ii. Benzidine from hydrazobenzene (benzidine rearrangement). iii. Methyl orange/red from sulphanilic acid/anthranilic acid (diazotization). iv. Benzil to hydrobenzoin ($NaBH_4$ reduction). v. Photochemical transformation of benzophenone to Benzpinacol. vi. 2-(4-Methyl benzoyl) benzoic acid from phthalic anhydride and toluene (F-C reaction). vii. 2-(4-Methyl benzoyl) benzoic acid to methyl anthraquinone (PPA cyclisation). viii. Resolution of racemic phenyl ethylamine using tartaric acid. ix. Trans-Stilbene by Wittig reaction. x. Enamine alkylation :2- methyl cyclohexanone pyrrolidine enamine with CH_3I. **Unit IV: Physical Chemistry** **I. Computational Chemistry (Any Three Experiments.)** 1. Plotting various types of graphs viz. straight lines, exponential, Gaussians, orbitals, first and second derivative plots. 2. Working with molecular coordinates: Distance matrix, center of mass, bond angles, dihedral angles, bond lengths, moment of inertia. 3. Electronic Structure of Diborane using the nwchem default density functional and basis sets. 4. Vibrational Spectroscopy of Transition Metal Nitrosyls complexes using ab initio calculations. **II. Experimental physical chemistry (Any Five Experiments)** 1. Preparation of a transition metal oxide (ZnO / NiO) by three different precursors and their characterization by IR and XRD. 2. Synthesis of a photo catalyst (TiO_2 / ZnO) by two different precursors and study kinetics of adsorption and photocatalytic degradation of a suitable azo dye as pollutant. 3. Adsorption studies on the porous adsorbents and fitting the adsorption data using Freundlich and Langmuir adsorption isotherms. 4. To study the thermodynamics of the adsorption process and to determine thermodynamic parameters such as ΔS and ΔG of the adsorption process. 5. Synthesis of spherical and rod shaped colloidal silver nanoparticles and to perform stability and surface plasmon resonance (SPR) analysis using UV-vis spectrophotometer. 6. To study the three component system such as chloroform, acetic acid and water and to obtain tie lines and plait point. Plotting the composition of mixture on a ternary phase diagram.	**18 hrs** **30 hrs**
Pedagogy:	Prelab exercises/assignments/ presentations/ lab hand-out or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning.	

Text Books/ References / Readings	1. J. H. Kennedy, *Analytical Chemistry Practice*, Saunders College Publishing, 1990, 2nd Ed. 2. *Vogel's Text book of Quantitative Inorganic Analysis*, Pearson Education, Asia, (2000), 6th ed. 3. A. J. Elias, *Collection of Interesting Chemistry Experiments*, University Press, 2002. 4. A R West, *Solid State Chemistry and its Applications*, John Wiley & Sons, 1987. 5. R. A. Day, L. Underwood, Quantitative Analysis, Prentice Hall, 2001, 6th Ed. 6. J. Kenkel, *Analytical Chemistry for technicians*, Lewis publishers, 2002. 3rd Ed. 7. G. H. Jeffery, J. Bassett, J. Mendham, R. C. Denney, *Vogel's Textbook of quantitative chemical analysis*, 5th Ed. 8. G. Brauer "Handbook of Preparative Inorganic chemistry" 2nd Ed., Vol. 1 and 2, Academic Press New York 1967. 9. G. Marr and B. W. Rockett, "Practical Inorganic Chemistry", Van Nostrnad Reinhold, London, 1972. 10. G. Pass and H. Sutcliffe, "Practical Inorganic Chemistry" 2nd Ed. Chapman and Hall, 1985. 11. J. D. Woolins, "Inorganic Experiments" Wiley – VCH Verlag GmbH and Co, 2003 12. N.K. Vishnoi, *Advanced Practical Organic Chemistry*, Vikas Publishing, 2009, 3rd Ed. 13. A. I. Vogel, *Elementary Practical Organic Chemistry: Part 1- Small Scale Preparations*, Pearson, 2010, 2nd Ed. 14. A. I. Vogel, *Elementary Practical Organic Chemistry: Part 2 - Qualitative Organic Analysis*, Pearson, 2010, 2nd Ed. 15. A. I. Vogel, *Elementary Practical Organic Chemistry: Part 3- Quantitative Organic Analysis*, Pearson, 2010, 2nd Ed. 16. F G Mann & B C Saunders, *Practical Organic Chemistry*, Pearson, 2009, 4th Ed. 17. A.R. Tatchell, B.S. Furnis, A.J. Hannaford, P.W.G. Smith, *Vogel's Textbook of Practical Organic Chemistry*, Longman, 1989, 5th Ed., 18. John C. Gilbert, Stephen F. Martin, *Experimental Organic Chemistry: A Miniscale and Microscale Approach*, Brooks Cole, 2011, 5th Ed. 19. Kenneth L. Williamson, Katherine M. Masters, *Macroscale and Microscale Organic Experiments*, Brooks Cole, 2011, 6th Ed. 20. Donald L. Pavia, Gary M. Lampman, George S. Kriz, Randall G. Engel, *Microscale and Macroscale Techniques in the Organic Laboratory*, Thomson, 2002. 21. B. N. Campbell, Jr., M. M. Ali, *Organic Chemistry Experiments*, Brooks Cole, 1994. 22. D. L. Pavia, G. M. Lampman & G. S. Kriz, *Introduction to Organic Laboratory Techniques: A Contemporary Approach*, W. B. Saunders, 1976. 23. J W. Lehman, *Operational Organic Chemistry - A laboratory Course*, Allyn and Bacon,2008, 4th Ed.	

	24. Koichi Tanaka, *Solvent Free Organic Synthesis*, WILEY - VCH, 2003. 25. D. W. Mayo, R. M. Pike & S. S. Butcher, *Microscale organic laboratory*, John Wiley and Sons, N. York, 1989 26. H. Dupont Durst, George W. Gokel, *Experimental organic Chemistry*, McGraw-Hill, 1987. 27. L. Cademartiri and G.A.Ozin, Concepts of Nanochemistry, 2009, Wiley-VCH 28. H J Butt, K. Graf and M. Kappl, Physics and Chemistry of Interfaces, Wiley-VCH, 2006.	

Note: The course would be taught over entire academic year with practicals from any two specializations in odd semester (III) and remaining two in the even (IV) semester. The ISA and SEA would be conducted in each of the semesters and final marks will be computed only at the end of even semester. Thus, students opting the course will be divided in to four batches and two of them together will undertake practicals in two specializations in one semester and remaining two in the next semester.