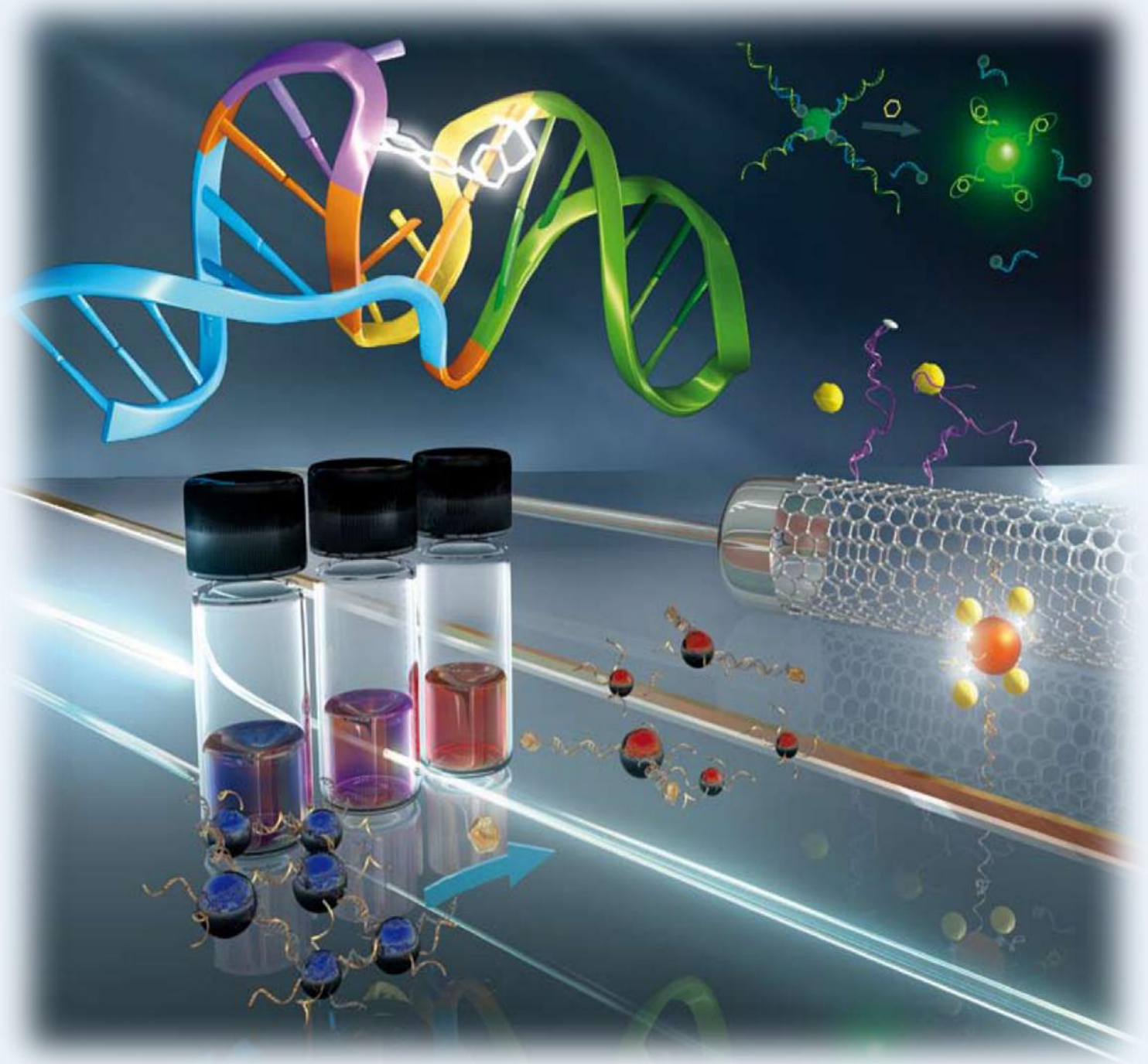
Integrated M.Sc Chemistry



Department of Chemistry
Central University of Tamil Nadu
Thiruvarur 610 101

Name of the course	:	**Integrated M. Sc. (Chemistry)**
Duration	:	10 semesters
Intake	:	30
Eligibility	:	Plus two examination or equivalent of any recognized board in India with 60% marks (Chemistry, Mathematics, Physics and Computer Science/Biology) for general category, 55% marks for OBC (Non-creamy layer) and 50% marks for SC/ST candidates. The candidates should not have completed 20 years of age as on 01-07-2015.

Course Structure

The five year program is spread into ten semesters where in first four semesters are designed for broad subject based understanding. Later six semesters will have increased focus on chemistry.

The subject courses in the early stage of iM.Sc programme are simplified and of basic level that bolsters the inter-disciplinary way of learning. The third and subsequent year courses have been designed on advanced theories in chemistry with emphasis on concurrent modern laboratory techniques. Further the iM.Sc (Chemistry) programme has been included with experiments that provide exhaustive hands on experience on various sophisticated instruments, experimental techniques to enable the students secure jobs in corporate. The final semester is dedicated to specialization within the subject with research level training.

The rules and regulations of Choice Based Credit System (CBCS) are applicable to this program. Generally, a student takes ten semesters to complete the program. The courses offered under CBCS, has certain credit number (2, 3 or 4). Core requirements of the programs are clearly defined. In the first two years of the program, a student has common course load with students from other departments. From fourth semester onwards, students will have courses more tuned towards chemistry. Apart from courses offered by the Department of Chemistry, student shall take prescribed number of elective courses either from parent department or from other departments

CENTRAL UNIVERSITY OF TAMIL NADU, THIRUVARUR
iM.Sc CHEMISTRY SYLLABUS CREDIT DISTRIBUTION

Course Code	Title of the Course	Credits
CY1101	General Chemistry I	3
CY1201	General Chemistry II	3
CY1202	General Chemistry Practical – I	2
CY2101	General Chemistry III	3
CY2102	General Chemistry Practical – II	2
CY2201	General Chemistry IV	3
CY2202	General Chemistry Practical – III	2
CY3101	Inorganic Chemistry I	4
CY3102	Organic Chemistry I	4
CY3103	Physical Chemistry I	4
CY3104	Analytical Chemistry: Instrumental methods of analysis	4
CY3105	Analytical and Inorganic Chemistry Laboratory	3
CY****	ELECTIVE	3
CY3201	Inorganic Chemistry II	4
CY3202	Organic Chemistry II	4
CY3203	Physical Chemistry II	4
CY3204	Physical Chemistry Laboratory I	3
CY3205	Organic Chemistry Laboratory I	3
CY****	ELECTIVE	3
CY4101	Advanced Inorganic Chemistry I	4
CY4102	Advanced Organic Chemistry I	4
CY4103	Advanced Physical Chemistry I	4
CY4104	Advanced Physical Chemistry Laboratory I	3
CY****	ELECTIVE	3
CY4201	Advanced Inorganic Chemistry II	4
CY4202	Advanced Organic Chemistry II	4
CY4203	Advanced Physical Chemistry II	4
CY4204	Physical methods in Chemistry	4
CY4205	Advanced Organic Chemistry Laboratory I	3
CY****	ELECTIVE	3
CY5101	Advanced Inorganic Chemistry III	4
CY5102	Advanced Organic Chemistry III	4
CY5103	Advanced Physical Chemistry III	4
CY5104	Seminar and Literature Review	3
CY5105	Advanced Inorganic Chemistry Laboratory I	3
CY****	ELECTIVE	3
CY5201	Research Project	9
CY****	ELECTIVE	3
TOTAL CREDITS		**134**

Semester: 1 **Subject Code: CY1101** **Credits: 3** **2-1-0-3**

Title: General Chemistry I

Introduction: Units, dimensions, Stoichiometry, concept of mole

Electronic Structure and Periodic Properties: Hydrogen atomic orbitals and their description. Quantum numbers – principal, azimuthal, magnetic and spin quantum numbers and their significance - radial and radial distribution functions-angular functions – principles governing the occupancy of electrons in various quantum levels – Pauli's exclusion principle – Aufbau principle – Screening effect– an effective nuclear charge – Hund's rule – (n+1) rule – stability of half-filled and fully-filled orbitals.
Periodic properties – variation of atomic volume, atomic and ionic radii, ionization potential, electron affinity and electronegativity along periods and groups – factors affecting the periodic properties.

Chemical Bonding: Ionic bond – lattice energy and Born-Haber cycle (no derivation) - Fajan's rule Crystal structures: fcc, bcc and simple cubic lattices. Covalent bond –hybridization, polarity of bonds – Ionic character of covalent bond and electronegativity- coordinate bond. Molecular orbital theory-diatomic and polyatomic molecules. Qualitative MO theory - Sigma, Pi and Delta bonds, Octet and EAN rules.

VSEPR theory - shapes of simple inorganic molecules containing lone pair and bond pairs of electrons ($BeCl_2$, NH_3, H_2O, PCl_3, XeF_4, SF_4, BrF_5, ClF_5, PCl_5, SF_6, I_3^-). Intermolecular forces – non-covalent interaction, van der Waals forces and hydrogen bonding.

Introductory Organic Chemistry: IUPAC nomenclature: Alkanes, cycloalkanes, alkenes, alkynes, halogen compounds, alcohols, ethers, aldehydes, ketones and carboxylic acids; Hybridization and geometry of molecules: methane, ethane, ethylene, acetylene; Electronic effects: Inductive – resonance - hyperconjugation and steric effect; Cleavage of bonds: Homolytic and Heterolytic bond fission; Reaction Intermediates and their stability: Carbocations, carbanions and free radicals.

Gaseous State: Gas laws, Kinetic theory of gases

Prescribed Books

1. Whitten, K. W; Davis, R. E; Peck, L; Stanley, G. G; Chemistry, C engage Learning; 9th edition, **2009**.
2. Chang, R.; Goldsby, K. Chemistry, Mc-Graw Hill, 11th edition, **2012**.
3. Mahan, B. H.; Myers, R. J. University Chemistry, Benjamin-Cummings Publishing Company; 4th Sub edition, **2000.**
4. Morrison, R. T.; Boyd, R. N.; Organic Chemistry, 6th edition, **2000.**
5. Lee, J. D. *Concise Inorganic Chemistry*, Blackwell Science, 5th edition, **1996.**
6. Atkins, P. W. Paula, J.; Physical Chemistry, Oxford Publications, 8th edition, **2009**.
7. Sharpe, A.G. *Inorganic Chemistry*, 3rd Edition, Pearson, **2010**.

Reference Books

1. Shriver, D. Atkins, P. W.; Inorganic Chemistry, W. H. freeman and Company, 5th edition, **2009.**

2. Miessler, G. L. Tarr, D. A. Inorganic Chemistry, Prentice Hall, 5th edition, **2013.**
3. Rao, C. N. R. *Understanding Chemistry*, University Press (India) Ltd., **2001**.
4. Castellan, G. W. Physical Chemistry, Narosa Publishing House, 3rd edition, **2004.**
5. Raff, L. M. Principles of Physical Chemistry, Prentice Hall, **2001.**
6. Shillady, D. Essentials of Physical Chemistry, CRC Press, **2012.**
7. Huheey, J. E. Keiter, E. A. Keiter, R. L. Inorganic Chemisry - Principles of Structure and Reactivity, Pearson Education, 4th edition, **2006.**
8. Douglas, B. McDaniel, D. Alexander, J. Concepts and Models of Inorganic Chemistry, 3rd edition, John Wiley & Sons, **2010.**
9. Volhardt, K.P. C. Schore, N. E. Organic Chemistry, W. H. Freeman and Company, **1990.**
10. Pine, S. H. Organic Chemistry, Tata McGraw Hill, 5th edition, **2008.**
11. Finar, I. L. Organic Chemistry, Pearson education India, 6th edition, *vol-1*, **2011.**

Semester: 2 **Subject Code: CY1201** **Credits: 3** **2-1-0-3**

Title: General Chemistry II

Chemical Thermodynamics: Terminology, state and path functions. Concept of heat and work. First Law of thermodynamics, energy and enthalpy, spontaneity, entropy and free energy.

Equilibria: Chemical, Ionic and Phase: Chemical equilibrium; law of mass action; Kp, Kc and Kx; Le Chatelier's principle, solubility product, Concepts of a strong, weak acids and bases; pH scale; Henderson-Hasselbach equations; Buffer solutions, Acid-base indicators; Phase Equilibria - Phase, Components, Degree of freedom, Phase rule, one component system and two component system.

Solution: Ideal solutions and Raoults law; Henrys law; colligative properties, completely miscible and partially miscible binary liquids, van't Hoff equation and van't Hoff factor.

Chemical Kinetics: Rate of reaction and rate laws; molecularity and order of reactions – zero, first, second and pseudo first order reactions.

Electrochemistry: Arrhenius theory of electrolytic dissociation, classification of electrolytes Conductance concepts; Cell constant; Galvanic cells, Applications of conductance measurements.

Prescribed Books

1. Silbey, R. J.; Albert , R. A.; Bawendi, M. G.; Physical Chemistry, Wiley, 4thedition, **2004.**
2. R. Chang, Chemistry, 1st Indian Edition, Tata-McGraw Hill, **2007**.
3. Atkins, P. W.; Paula, J.; Physical Chemistry, Oxford Publications, 8th edition, **2009**.

Reference Books

1. Castellan, G. W.; Physical Chemistry, Narosa Publishing House, 3rd edition, **2004.**
2. Kapoor K. L.; Textbook of Physical Chemistry: Thermodynamics and Chemical Equilibrium, Vol 3, 2nd edition, Macmillan Publishers India Ltd, **2009**.
3. Raff, L. M.; Principles of Physical Chemistry, Prentice Hall, **2001.**
4. Laidler, K. L.; Chemical Kinetics, Pearson Education Inc, 3rd edition, **2011.**
5. McQuarrie, D. A.; Simon, J. D.; Physical Chemistry: A Molecular Approach, University Science Books, **2011.**
6. Levine, I. N.; Physical Chemistry, McGraw-Hill Science/Engineering/Math, 6th edition, **2008.**
7. Shillady, D.; Essentials of Physical Chemistry, CRC Press, **2012.**

Semester: 2 **Subject Code: CY1202** **Credits: 2** **0-0-3-2**

Title: General Chemistry Practical - I

1. Demonstration and concept of good lab practices including safety, glassware handling, chemical nature understanding, chemical handling, chemical/glassware waste management, Error Analysis, notebook maintenance.

2. Calibration and handling of balances, pipettes and burettes, basic principles and experiments related to sample and reagent preparation: practical concept of Molarity, Molality, Normality, equivalence, weight %, vol. %, Preparation of standard solutions.

I. Acidimetry and Alkalimetry

1. Estimation of NaOH using standard Na_2CO_3 solution and link HCl solution
2. Estimation of HCl using standard H_2SO_4 solution and link NaOH solution

II. Permanganometry

3. Estimation of FAS (Mohrs salt) using standard $FeSO_4$ solution and link $KMnO_4$ solution
4. Estimation of hydrogen peroxide using standard oxalic acid solution and link $KMnO_4$ solution

III. Iodo and Iodimetry

5. Estimation of copper by using standard $K_2Cr_2O_7$ solution and link Sodium thiosulphate solution

IV. Complexometric

6. Estimation of zinc by using standard zinc sulphate solution and link EDTA solution

Qualitative Analysis

Semi-micro analysis of a mixture containing two anions (Interfering anions) and two cations.

Reference Books

1. Jeffery, G. H., Bassett, J., Mendham, J., Denney, and R. C., Vogel's quantitative chemical analysis, 5th edition, Longman Scientific and Technical, **1989**.
2. Svehla, G: *Vogel's qualitative inorganic analysis*, 7th Edition, Prentice Hall, **1996**
3. Mendham, J., Denney, J. C., Barnes, J. D., and Thomas, M. J. K., : *Vogel's Prescribed book of qualitative chemical analysis*, 6th Edition, Prentice Hall, **2000**.
4. Morris Hein, Judith N. Peisen and Robert L. Miner, Foundations of College Chemistry in the Laboratory, John Wiley and Sons, **2011**
5. Woollins, J. D; *Inorganic experiments*, 3rd Edition, Wiley-VCH Verlag GmbH Co. KGaA, **2012**.

Semester: 3 **Subject Code: CY2101** **Credits: 3** **2-1-0-3**

Title: General Chemistry III

Oxidation and Reduction Reactions: Oxidation and reduction reactions – oxidation number concept, balancing redox equations by oxidation number method and ion-electron method – equivalent weight of oxidizing and reducing agents

Nuclear Chemistry: Introduction – composition of nucleus and nuclear forces. Nuclear stability – n/p ratio, mass defect, binding energy, packing fraction and magic numbers, shell and drop models. Isotopes – detection and separation. Isotopic constitution of elements and whole number rule. Deviation of atomic weights from whole numbers. Isobars, isotones and isomers.

Radioactivity and Nuclear Transformations: Radioactivity – discovery, detection and measurements (Wilson cloud chamber). Radioactive emanations. Disintegration theory – modes of decay – Group displacement law – Rate of disintegration – Half life and average life – Radioactive series. Nuclear transformations – use of projectiles – nuclear reactions – fission and fusion. Nuclear reactors.

Hydrogen, Hydrides and Alkali and Alkaline Earth Metals: Hydrogen: Electronic structure, abundance, preparation and properties, isotopes, ortho- and para hydrogens. Hydrides: ionic, covalent, metallic and intermediate hydrides; Hydrogen bonding. Alkali metals: Introduction, halides, oxides and hydroxides, salts of oxoacids and aqueous solution chemistry. Alkaline earth metals: Introduction, halides, oxides and hydroxides, salts of oxoacids, and aqueous solution chemistry

Prescribed Books

1. Lee J. D., Concise Inorganic Chemistry, 5th Edition, Blackwell Science, **1996**.
2. Sharpe G., Inorganic Chemistry, 3rd Edition, Pearson, **2010**
3. Atkins P., Overton T., Rourke J., Weller M., and Armstrong F., Inorganic Chemistry, 5th Edition, Oxford University Press, **2010**.
4. Arnikar, H. J., Essentials of Nuclear Chemistry, 4th edition, New Age International Publishers Ltd., New Delhi, **1995.**
5. Loveland, W. D., Morrissey, D. J., Seaborg, G. T., *Modern Nuclear Chemistry*, Wiley-VCH Verlag GmbH Co. KGaA, **2006**.
6. Huheey, J. E., Keiter, E. A., Keiter, R. L., and Medhi, O. K.; Inorganic Chemistry - Principles of Structure and Reactivity, 4th edition, Pearson Education, **2006**.
7. Glasstone, Source Book on Atomic Energy, 3rd edition, Affiliated East West Press, **1979.**

Reference Books

1. Greenwood N. N. and Earnshaw A., Chemistry of the Elements, 2nd edition, Elsevier, **2005**.
2. Housecraft C. E. and Sharpe A. G., Inorganic Chemistry, 4th edition, Pearson, **2012**.
3. Chang R., Chemistry, 1st Indian edition, Tata-McGraw Hill, **2007**.
4. Douglas B., McDaniel D. and Alexander J., Concepts and Models of Inorganic Chemistry, 3rd edition, John Wiley & Sons, **2010**.
5. Cotton F. A., Wilkinson G., Murillo C. A. and Bochmann M., Advanced Inorganic Chemistry, 6th edition, John Wiley & Sons, **2008**.

Semester: 3 **Subject Code: CY2102** **Credits: 2** **0-0-3-2**

Title: General Chemistry Practical - II

1. Melting point determination.
2. Crystallization, decolorization using charcoal.
3. Qualitative analysis of simple organic compounds.
4. Single step preparation of organic compounds.

Reference Books

1. Vogel's Practical Organic Chemistry, 5th edition, Pearson Publishers.
2. Experimental Organic Chemistry Vol. 1 and 2, Singh, P. R., Gupta, D. S., Bajpai, K. S., Tata McGraw Hill.
3. Bansal R. K., Laboratory Manual in Organic Chemistry, New Age International Pvt Ltd Publishers, **2009.**
4. Monograph on Green Chemistry Laboratory Experiments, Ranu, B. C., (Ed.) Green Chemistry Task Force Committee, DST, New Delhi, **2012**.

Semester: 4 **Subject Code: CY2201** **Credits: 3** **2-1-0-3**

Title: General Chemistry IV

Basic Organic Chemistry: Alkanes: preparation by reduction of alkyl halides, Wurtz reaction and Kolbe's electrolytic method with mechanism; Alkenes: preparation by dehydration of alcohols, dehydrohalogenation of alkylhalides, dehalogenation of vicinal dihalides and by Kolbe's electrolytic method; Alkynes: Preparation by dehydrohalogenation of vic-dihalides and gem-dihalides, dehalogenation of tetrahalides; Cycloalkanes, preparations and properties.

Reactions: Mechanism of free radical halogenation of alkanes, Addition reactions with halogens, hydrogen halide (Markovnikov's rule, peroxide effect), hydroboration, ozonolysis, hydroxylation with $KMnO_4$, allylic substitution by NBS; Types of dienes - Conjugated dienes: 1,3-butadiene-preparation, stability- 1,2 & 1,4 - addition, Diels- Alder reaction.

Stereochemistry: Introduction, Concept of Isomerism, Classification of Stereoisomers, Optical isomerism, Chirality & elements of symmetry, Wedge formula, Fischer projection, Newman projection. Relative and absolute configurations, sequence rules, D & L, R & S systems of nomenclature. Understanding with examples for enantiomers, meso form, diastereoisomers, inversion, retention, and racemization. Geometrical Isomerism: About C=C, E-Z notation-determination of configuration. Conformational analysis: Ethane, 1,2 – dihalo and dihydroxyethanes and butane.

Aromaticity and Aromatic substitutions: Introduction to Aromaticity, Basic aspects of Aromaticity, Huckel's rule, aromaticity of benzenoid compounds. Electrophilic substitution reactions, directing groups, orientation and reactivity.

Prescribed books

1. Morrison R. T., Boyd R. N. and Bhattacharjee S. K., *Organic Chemistry*, Seventh Edition, Pearson Prentice Hall, **2011**.
2. Finar I.L., *Organic Chemistry, Volume 1, 6th edition, Pearson education India,* **2011**.
3. Carey, F.A., and Sundberg R.J., Advanced Organic Chemistry, Part A: Structure and Mechanisms, 5thedition, **2007**.
4. Nasipuri, D., *Stereochemistry* of Organic Compounds: Principles and Applications, 4th edition, New Academic Science Publisher. **2012**.
5. Ernest L Eliel, Samuel H. Wilen, Stereochemistry of organic compounds, Wiley India edition, **2008**.

Reference books

1. Peter K., Vollhardt, C., and Schore N. E., *Organic Chemistry,* W. H. Freeman and Company, **2010**.
2. Pine S. H., *Organic Chemistry,* Tata McGraw Hill, 5th edition, **2008**.
3. R. Chang, Chemistry, 1st Indian Edition, Tata-McGraw Hill, **2007**.
4. Guidebook to Mechanism in Organic Chemistry (6th Edition), Peter Sykes, Longman Scientific & Technical, **1985**.
5. March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, Michael B. Smith, Jerry March John Wiley & Sons, 6th edition, **2007**.

Semester: 4 **Subject Code: CY2202** **Credits: 2** **0-0-3-2**

Title: General Chemistry Practical – III

Understanding error, accuracy and precision by measuring physical parameters
Determination of physical properties of materials
Experiments involving colligative properties, chemical equilibria, chemical kinetics and electrochemistry

Reference Books

1. Halpern, A. M., and McBane, G. C. Experimental Physical Chemistry: A Laboratory Prescribed Book, W. H. Freeman, 3rd edition, **2006.**
2. Hein, M.; Peisen, J. N., and Miner, R. L. Foundations of College Chemistry in the Laboratory, John Wiley & Sons Inc., **2011.**
3. Dave, R. K. Experiments in Physical Chemistry, Campus Books International, **2011.**

Semester: 5 **Subject Code: CY3101** **Credits: 4** **4-0-0-4**

Title: Inorganic Chemistry I

Acids and Bases, Chemistry in Aqueous and Non-aqueous Solvents: Theory of Acid-bases: Bronsted-Lowry theory, Lewis theory, Lux-Flood definition, Usanovich definition, HSAB theory and symbiosis - Gas phase acid-base chemistry – Solvent levelling effects. Chemistry in aqueous and Non-aqueous Solvents - super acids - molten salts.

Boron Group: Introduction; hydrides, halides, oxides, oxoacids, hydroxides, oxoanions and nitrogen derivatives. Boron family, metal borides and hydrides of boron group. Al, Ga, In and Tl, oxides, oxoacids, oxoanions and hydroxides; nitrogen derivatives; Al, Ga, In and Tl salts of oxoacids and aqueous solution chemistry, organometallic compounds.

Carbon Group: Introduction, Intercalation compounds of graphite, hydrides, carbides and silicides, halides and complex halides; oxides and oxoacids of carbon; oxides and oxoacids and hydroxides of Si, Ge, Sn and Pb; Silicates; Silicones; Cyanogen, its derivatives and silicon nitride; aqueous solution chemistry and oxoacid salts of Sn and Pb.

Nitrogen Group: Introduction; hydrides; nitrides, phosphides and arsenides; halides, oxohalides and complex halides; Oxides, Oxoacids and sulfides of N, P, As, Sb and Bi; Phosphazenes; Aqueous solution chemistry; Organic derivatives.

Oxygen Group and Halogen Family: Oxygen group: Introduction – Hydrides; Halides, Oxohalides and complex halides – Oxides, Oxoacids and their salts – Sulphur-nitrogen compounds – Aqueous solution chemistry of S, Se and Te – Organic derivatives. Halogen family: comparative study of halogens and their compounds – Oxides and oxoacids of halogens (structure only) – Basic properties of halogens – Inter-halogen compounds – preparation, properties and uses – Pseudohalogens – Preparation, properties and uses of cyanogens and thiocyanogen comparison with halogens – Anomalous properties of fluorine.

Noble gases: Introduction – compounds of Xe, Kr and Rn – Preparation, structure and bonding – Reactivity

Prescribed Books

1. Huheey J. E., Keiter E. A. and Keiter R. L. and Medhi O. K., *Inorganic Chemistry - Principles of Structure and Reactivity*, 4th edition, Pearson Education, **2006**.
2. Atkins P., Overton T., Rourke J., Weller M. and Armstrong F., *Inorganic Chemistry*, 5th edition, Oxford University Press, **2010**
3. Lee J. D., *Concise Inorganic Chemistry*, 5th Eeition, Blackwell Science, **1996**.
4. Miessler G. L. and Tarr D. A., Inorganic Chemistry, 3rd edition, Pearson, **2004**.
5. Sharpe A. G., *Inorganic Chemistry*, 3rd edition, Pearson, **2010**

Reference Books

1. Greenwood, N. N., and Earnshaw, A., *Chemistry of the Elements*, 2nd edition, Elsevier, **2005**.
2. Housecraft, C. E. and Sharpe, A. G., *Inorganic Chemistry*, 4th edition, Pearson, **2012**.
3. Massey, A. G., Main Group Chemistry, 2nd edition, John and Wiley & Sons, LTD, **2000**.

4. Cotton, F. A., Wilkinson, G., Murillo, C. A. and Bochmann, M.; Advanced *Inorganic Chemistry*, 6th Edition, John Wiley & Sons, **2008**.
5. Douglas, B., McDaniel, D. and Alexander, J., *Concepts and Models of Inorganic Chemistry*, 3rd Edition, John Wiley & Sons, **2010**.

Semester: 5 **Subject Code: CY3102** **Credits: 4** **4-0-0-4**

Title: Organic Chemistry I

Nucleophilic substitutions: Mechanisms for nucleophilic substitution – structural and solvation effects on reactivity – Neighboring-Group Participation (NGP) – structure and reactions of carbocation intermediates.

Carbanion and other carbon nucleophile: Acidity of hydrocarbons – carbanion character of organometallic compounds – carbanions stabilized by functional groups – enols, enamines and imines – carbanions as nucleophiles in SN2 reactions.

Polar addition and elimination reactions: Addition of hydrogen halides to alkenes – acid catalysed hydration and related addition reactions addition to halogens – sulfenylation and selenylation reactions – addition reactions involving epoxides, E1, E2, E1cb and pyrolytic eliminations.

Rearrangements: Classification – pinacol-pinacolone, benzidine, Beckmann and Bayer-Villiger.

Biomolecules: Chemistry of amino acids and proteins

Heterocycles: Nomenclature – synthesis and reactions of pyrrole, furan, thiophene and pyridine.

Prescribed Book

1. Carey, F.A., and Sundberg, R.J., Advanced Organic Chemistry, Part A: Structure and Mechanisms, 5th edition, **2007**.

Reference Books

1. Morrison, R. T., Boyd R. N., and S. K. Bhattacharjee, Organic Chemistry, 7th edition, Pearson Prentice Hall, **2011**.
2. Pine, S. H., Organic Chemistry, Tata McGraw Hill, 5th edition, **2008**.
3. Smith M. B., and Jerry March, March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, John Wiley & Sons, 6th edition, **2007**.
4. Finar I. L., Organic Chemistry, Vol. I & II, 5th edition, Longman Ltd., New Delhi, **1975**.
5. Peter Sykes, Guidebook to Mechanism in Organic Chemistry (6th edition), Longman Scientific & Technical, **2003**.
6. Joule, J.A., Mills, K, Heterocylic Chemistry, 5th edition, John Wiley and Sons, **2010**.

Semester: 5 **Subject Code: CY3103** **Credits: 4** **4-0-0-4**

Title: Physical Chemistry - I

Chemical Thermodynamics: Thermodynamic processes, state and path functions, Internal energy, Enthalpy, Heat capacities. Calculation of w, q, dU & dH for the expansion of ideal gases under

isothermal and adiabatic condition for reversible process. Introduction to Thermo-chemistry, Kirchhoff's equation and applications: Entropy, entropy changes in reversible and irreversible processes, physical concept of entropy, entropy changes of an ideal gas in different processes, entropy of an ideal gas, Free energy concept, Gibbs and Helmholtz free energies, variation of free energy with temperature and pressure. Gibbs-Helmholtz equations, Criteria for reversible and irreversible processes based on entropy and free energy. Fundamentals of open and closed systems, partial molar properties, Gibbs-Duhem equations, concepts of activity, fugacity, Non-ideal solutions, Azeotropic mixtures. Third law and concept of absolute entropy.

Kinetics: Elementary, parallel, opposing and consecutive reactions, mechanism of complex reactions, chain reactions. Theories of reaction rates: basic collision theory, conventional transition state theory, thermodynamic treatment.

Electrochemistry: Reversible and irreversible cells, cell EMF, Reactions in reversible cells, free energy and EMF of reversible cell. Single electrode potential (Nernst equation), Standard electrode potential. EMF of reversible cell from electrode potentials. Types of reversible electrode, reference electrodes. Applications of current and potential measurement. Theory of activity co-efficient of strong electrolytes.

Prescribed Books

1. McQuarrie, D. A.; Simon, J. D.; Physical Chemistry: A Molecular Approach, University Science Books, **2011.**
2. Silbey, R. J.; Albert , R. A.; Bawendi, M. G.; Physical Chemistry, Wiley, 4thedition, **2004.**
3. R. Chang, Chemistry, 1st Indian Edition, Tata-McGraw Hill, **2007**.
4. Atkins, P. W.; Paula, J.; Physical Chemistry, Oxford Publications, 8th edition, **2009**.

Reference Books

1. Castellan, G. W.; Physical Chemistry, Narosa Publishing House, 3rd edition, **2004.**
2. Kapoor K. L.; Textbook of Physical Chemistry: Thermodynamics and Chemical Equilibrium, Vol. 3, 2nd edition, Macmillan Publishers India Ltd, **2009**.
3. Raff, L. M.; Principles of Physical Chemistry, Prentice Hall, **2001.**
4. Laidler, K. L.; Chemical Kinetics, Pearson Education Inc, 3rd edition, **2011.**
5. Levine, I. N.; Physical Chemistry, McGraw-Hill Science/Engineering/Math, 6th edition, **2008.**
6. Shillady, D.; Essentials of Physical Chemistry, CRC Press, **2012.**

Semester: 5 **Subject Code: CY3104** **Credits: 4** **4-0-0-4**

Title: Analytical Chemistry: Instrumental methods of analysis

Chromatographic methods: General principles - classification of chromatographic methods - nature of partition forces. Chromatographic behavior of solutes- column efficiency and resolution, HPLC.
Gas chromatography: detector, optimization of experimental conditions. Ion-exchange chromatography, thin layer chromatography, coating of materials, preparative TLC.
Solvents used and methods of detection - Column chromatography: Adsorption and partition methods. Nature of column materials-preparation of the column.

Thermo Gravimetric Analysis and Differential Scanning Calorimetry: Effect of heat on materials, Chemical decomposition and T, G curves, Analysis of TG curve to show nature of decomposition reactions, the product and qualities of compounds expelled, applications, instrumentation.
DSC- theory, instrumentation and applications - thermometric titrations and applications.

AAS and ICP: Atomic Absorption Spectroscopy- Introduction, Principle, differences between AAS and FES. Instrumentation - single and double beam AAS, detection limit and sensitivity, Interferences - applications.
Inductively coupled Plasma Spectroscopy - Nebulization Torch, Plasma, Instrumentation, Interferences, and Applications.

Spectroscopy and spectrometry: Basic principles and applications of UV, Fluorescence, IR and NMR spectroscopy – Mass spectrometry.

Prescribed Books

1. Willard, H. H., Merritt, L. L., and Dean, J. A., Instrumental Methods of analysis, CBS Publishers & Distributors, Shahdara, Delhi, 7th edition, **2004**.
2. Skoog, D. and West, D., Principles of Instrumental Analysis, Cengage Learning; 6th edition, **2006**.
3. Donald L. Pavia , Gary M. Lampman , George S. Kriz , James A. Vyvyan , Introduction to spectroscopy, Cengage Learning; 4 edition, **2008**.

Reference Books

1. Gary D., Christian, Analytical Chemistry, John Wiley & Sons, 6th edition, **2007**.
2. Bobbitt, J. M., Roy Gritter, Introduction to chromatography, Holden Day; 2nd edition, **1985**.
3. Gurdeep R. Chatwal, Sham K. Anand, Instrumental Methods of Analysis, Himalaya Pub., **1979**.
4. Svehla, G. : *Vogel's qualitative inorganic analysis*, 7th edition, Prentice Hall, **1996**.
5. Strobel, H. A., Heineman, W. R., Chemical Instrumentation: A Systematic approach, Wiley-Interscience; 3rd edition, **1989**.
6. Morf, W.E., The principles of ion-selective electrodes and membrane transport, Elsevier Science Ltd, **1981**.
7. Atkins, P. W.; Paula, J.; Physical Chemistry, Oxford Publications, 8th edition, **2009**.
8. Kolthoff , I.M., Treatise on Analytical Chemistry, Wiley Interscience, Vol. 1 to 7 .

Semester: 5 **Subject Code: CY3105** **Credits: 3** **0-1-5-3**

Title: Analytical and Inorganic Chemistry Laboratory

1. Semi-micro qualitative analysis of a mixture containing two common and two rare cations.

2. Estimation of inorganic compound in a mixture by Volumetric and Gravimetric analysis.

Reference Books

1. Svehla, G.: *Vogel's qualitative inorganic analysis*, 7th edition, Prentice Hall, **1996**
2. Mendham, J., Denney, R. C., Barnes, J. D., and Thomas, M. J. K.: *Vogel's Prescribed book of qualitative chemical analysis*, 6th edition, Prentice Hall, **2000**.
3. Woollins, J. D.; *Inorganic experiments*, 3rd edition, Wiley-VCH Verlag GmbH @Co. KGaA, **2012**.
4. Hein, M., Peisen, J. N., and Miner, R. L.; *Foundations of College Chemistry in the Laboratory*, John Wiley and Sons, **2011**

5. Jeffery G H, Bassett J. Mendham J, Denney R C, *Vogel's Prescribed Book of Inorganic Quantitative Analysis*, Longman, **1984**.
6. A. J. Elias, *A Collection of Interesting General Chemistry Experiments*, Universities Press, Sangam Books Ltd, **2002**.
7. In-house manual prepared by Department of Chemistry, CUTN, Thiruvarur.

Semester: 5 **Subject Code: CYxxxx** **Credits: 3** **3-0-0-3**

Semester: 6 **Subject Code: CY3201** **Credits: 4** **4-0-0-4**

Title: Inorganic Chemistry II

Solid State Chemistry: Classification of solids – Isotropic and anisotropic crystals. Laws of crystallography representation of planes – Miller indices, space lattice, crystal systems – seven primitive, unit cells –X –ray diffraction – derivation of Bragg's equation – determination of structure of NaCl by Debye Scherrer (powder method) and rotating crystal method determination of Avogadro's number – discussion of structure of KCl & CsCl – defects in crystals – stoichiometric and non-stoichiometric – methods of growing crystals – from melt and from solution (hydrothermal method, Gel method) – packing of ions in crystals radius ratio rules and its limitations.

Coordination Chemistry I: Basic coordination chemistry: ligands, IUPAC nomenclature – coordination geometries, isomerism. Theories of coordination compounds - Werner's theory – Valence band theory and crystal field theory d-orbital splitting (octahedral and tetrahedral only) – spectrochemical series.

Coordination Chemistry II: Studies of coordination compounds in solution – detection of complex formation in solution – Stability constants – stepwise and over-all formation constants – simple methods (Potentiometric, pH metric and photometric methods) of determining the formation constants - factors affecting stability – statistical and chelate effects – forced configurations.

Metallurgy: Various processes involved in extraction of metals: Concentration of ores – froth floatation, magnetic separation, calcinations, roasting, smelting, flux, aluminothermic process – purification of metals – electrolysis, zone refining, van Arkel de Boer–.Alloys and their properties. Latimer and Pourbaix diagrams, applications of redox reactions to extraction of elements from their ores: Ellingham diagrams.

Prescribed Books

1. Huheey, J. E., Keiter, E. A., Keiter, R. L. and Medhi, O. K., *Inorganic Chemistry - Principles of Structure and Reactivity*, 4th edition, Pearson Education, **2006**.
2. Atkins, P., Overton, T., Rourke, J., Weller M., and Armstrong, F., *Inorganic Chemistry*, 5th edition, Oxford University Press, **2010**
3. Lee, J. D., Concise Inorganic Chemistry, 5th edition, Wiley-India, **2010**.
4. Azaroff, L.V., Introduction to Solids, Mc.Graw hill, New York. **1960**
5. West, A. R., Solid State Chemistry and Its Applications, John Wiley & Sons, **1984**.
6. Chakrabarty, K., Solid State Chemistry, New Age Publishers, **1996.**

Reference Books

1. Miessler, G. L., and Tarr, D. A., Inorganic Chemistry, 3rd edition, Pearson, **2004**.
2. Gilreath, E. S., *Fundamental concepts of Inorganic Chemistry*', International students edition. Mcgraw-Hill Kogakusha, Ltd., **1958**.
3. Chatwal G., and Yadu, M.S., 'Co-ordination Chemisty', 1st edition, Himalaya Publishing House, **1992**.
4. Douglas, B., McDaniel, D., and J. Alexander, *Concepts and Models of Inorganic Chemistry*, 3rd edition, John Wiley & Sons, **2010**.
5. Cotton, F. A., Wilkinson, G., Murillo, C. A., and Bochmann, M., *Advanced Inorganic Chemistry*, 6th edition, John Wiley & Sons, **2008**.
6. Day Jr, M. C., and Selbin, J. Theoretical Inorganic Chemistry, Literary Licensing, LLC, **2012**
7. Boyer, H. E., and Gall, T. L., *Metals Handbook*, Desk edition, **1984**

Semester: 6 **Subject Code: CY3202** **Credits: 4** **4-0-0-4**

Title: Organic Chemistry II

Addition, condensation and substitution reactions of aldehydes and ketones: Reactivity of carbonyl compounds towards addition – hydration and addition of alcohols to aldehydes and ketones – condensation reactions of aldehydes and ketones with nitrogen nucleophiles – intramolecular catalysis of carbonyl substitution reactions – addition of organometallic reagents to carbonyl groups – addition to enolates and enols to carbonyl compounds: Aldol addition and condensation reactions, corssed aldol, cannizaro reaction, Perkins reaction.

Organic transformations based on carbanions: Dicarboxylic acids, dicarbonyls, diesters**,** Acidity of α-hydrogens, alkylation of diethyl malonate and ethyl acetoacetate. Synthesis using diethyl malonate and ethyl acetoacetate, Claisen condensation. Knoevenagel condensation, Reformatsky reactions.

Alkaloids and terpenoids: Occurrence, importance, general methods of structural elucidation and biosynthesis.
Alkaloids: Structure and synthesis of nicotine and piperine, morphine, cocaine.
Terpenes: classification, Isoprene rule, structure and synthesis of citral, geraniol and α-terpineol.

Carbohydrates: Structural elucidation of glucose, inter-conversion of aldoses to ketoses and vice-versa, stepping up and stepping down reactions. Epimer, Anomer, optical properties, elementary stereochemistry. Structure of sucrose, maltose, cellulose and starch.

Vitamins and Co-enzymes: structure and biological activity of retinol, riboflavin, ascorbic acid, pyridoxine, lipoic acid, NAD, NADH.

Prescribed Books

1. Carey, F.A., and Sundberg, R.J., Advanced Organic Chemistry, Part A: Structure and Mechanisms, 5th dition, **2007**.
2. March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, Michael B. Smith, Jerry March John Wiley & Sons, 6th edition, **2007**.
3. Thomson, R.H., The Chemistry of Natural Products, Publisher- Springer, Netherlands; 2nd edition. **1993**.

Reference Books

1. Morrison, R. T., Boyd, R. N. and Bhattacharjee, S. K., Organic Chemistry, 7th edition, Pearson Prentice Hall, **2011**.
2. Pine, S. H., Organic Chemistry, Tata McGraw Hill, 5th edition, **2008**.
3. Guidebook to Mechanism in Organic Chemistry (6th Edition), Peter Sykes, Longman Scientific & Technical, **1985**.
4. Grossman, R. B. The Art of Writing Reasonable Organic Reaction Mechanisms, 2nd edition, Springer, **2010**.
5. P.S. Kalsi, Organic Reactions and Their Mechanisms, 1st edition, New Age International Pub., New Delhi, **1996**.
6. Finar, I. L., Organic Chemistry, Vol. I & II, 5th edition, Longman Ltd., New Delhi, **1975**.

Semester: 6 **Subject Code: CY3203** **Credits: 4** **4-0-0-4**

Title: Physical Chemistry II

Surface Chemistry: Adsorption, Absorption, Types of adsorption, Freundlich-Langmuir adsorption isotherms, BET theory- Surface area determination, catalytic activity at surfaces, transition state theory of surface reactions: rates of chemisorption and desorption, unimolecular and bimolecular surface reactions, comparison of homogeneous and heterogeneous reaction rates, surface heterogeneity, Thermodynamics of surfaces : Gibbs adsorption isotherm, heat and entropy of adsorption.

Enzyme kinetics and catalysis: Enzyme kinetics (steady-state kinetics, pre-steady-state kinetics). Reaction mechanisms (ligand binding; catalytic groups: acid/base, nucleophiles, electrophiles, co-factors, metals and entropic effects). Experimental analysis of catalytic and kinetic mechanisms (spectrometry, stopped flow, isotope effects, structure/reactivity relationships). Experimental data analysis.

Macromolecules: types of polymers, conformation of polymers, number average, weight average molecular weight, determination of molecular mass of macromolecules- viscometry, ultracentrifugation, gel permeation chromatography and light scattering,.

Colloids and interface: classification, preparation and purification of colloids; properties of colloidal systems; electrical properties – charge, electrical double layer; DVLO theory, electro kinetic properties: electrophoresis, electroosmosis; Optical and Physical properties, determination of size of colloidal particles involving microscopy, scattering (ILS, DLS, x-ray, neutron), micelles, emulsions and membranes.

Gels - definition - Thermoreversible and Irreversible physical gels - inorganic gels - Small molecule organo gelators - associating polyelectrolyte gels - electrical behaviors and mechanical responses of polyelectrolyte gels.

Prescribed Books

1. Silbey, R. J.; Albert , R. A.; Bawendi, M. G.; Physical Chemistry, Wiley, 4thedition, **2004.**
2. R. Chang, Chemistry, 1st Indian edition, Tata-McGraw Hill, **2007**.
3. Atkins, P. W.; Paula, J.; Physical Chemistry, Oxford Publications, 8th edition, **2009**.

4. Odian G., Principles of polymer chemistry, 4th edition, Wiley-Blackwell, **2004**.
5. Laidler, K. L.; Chemical Kinetics, Pearson Education Inc, 3rd edition, **2011.**

Reference Books

1. Castellan, G. W.; Physical Chemistry, Narosa Publishing House, 3rd edition, **2004.**
2. Raff, L. M.; Principles of Physical Chemistry, Prentice Hall, **2001.**
3. Levine, I. N.; Physical Chemistry, McGraw-Hill Science/Engineering/Math, 6th edition, **2008.**
4. Shillady, D.; Essentials of Physical Chemistry, CRC Press, **2012.**

Semester: 6 **Subject Code: CY3204** **Credits: 3** **0-1-5-3**

Title: Physical Chemistry Laboratory I

Experiments involving chemical thermodynamics, chemical equilibria, chemical kinetics and electro chemistry

Reference Books

1. Halpern, A. M.; McBane, G. C. Experimental Physical Chemistry: A Laboratory Prescribed Book, W. H. Freeman, 3rd edition, **2006.**
2. Viswanathan, B.; Raghavan, P. S.; Practical Physical Chemistry, Viva Books, **2010.**
3. Hein, M.; Peisen, J. N.; Miner, R. L.; Foundations of College Chemistry in the Laboratory, John Wiley & Sons Inc., **2011.**
4. Dave, R. K.; Experiments in Physical Chemistry, Campus Books International, **2011.**

Semester: 6 **Subject Code: CY3205** **Credits: 3** **0-1-5-3**

Title: Organic Chemistry Lab I

Preparations:

Two-step preparations involving acetylation, methylation, condensation, rearrangements and photochemical reactions.

Estimations:

1. Estimation of phenol and aniline - volumetric method.
2. Estimation of glucose by Betrands method.
3. Estimation of methyl ketone – iodimetric method
4. Determination of the percentage or number of hydroxyl groups in organic compounds by acetylation method.
5. Determination of iodine and saponification value of an oil sample.

Reference Books:

1. Vogel, A. I., Elementary Practical Organic Chemistry: Small Scale Preparations, Qualitative Organic Analysis, Quantitative Organic Analysis, Pearson Education, **2011**.
2. Leonard , J., Lygo G. B., Procter, Advanced Practical Organic Chemistry, 3rd edition, CRC press, **2013**.

3. Singh, P. R., Gupta, D. S., and Bajpai, K.S., Experimental Organic Chemistry, Vol. 1 and 2, Tata McGraw Hill, **1981**.
4. Bansal R. K., Laboratory Manual in Organic Chemistry, New Age International Pvt Ltd Publishers, **2009**.

Semester: 6 **Subject Code: CYXXXX** **Credits: 3** **3-0-0-3**

Semester: 7 **Subject Code: CY4101** **Credits: 4** **4-0-0-4**

Title: Advanced Inorganic chemistry I

The Chemistry of the Main Group Elements: Inorganic Rings, chains and cages **-** Catenation and Heterocatenation, Heterocyclic ring system- Borazines, Phosphazines- Monomer and Polymer, S-N ring compounds, Homocyclic rings of S, Se and Te. Silicate minerals, Isopolyanions, Boranes: boron cage compounds-*closo, nido, arachno*, carboranes; cage compounds of S and P.

Advanced Solid State Chemistry: Ionic solids, close packing, radius ratio rules, Structures of ionic crystals – AX and AX_2 type crystal structures – layer structures - lattice energy - Born-Lande, Born-Mayer and Kapustinskii equations – Derivations and applications – Decomposition of ionic solids – solubility of ionic solids. Defects and Non-stoichiometric - Intrinsic and extrinsic defects - point, line and plane defects; vacancies, Stoichiometric defects - Schottky and Frenkel defects - Non-stoichiometry – Metal excess and Metal-deficiency. Thermodynamic and structural aspects. n- and p-type semiconductors–photovoltaic cell – Superconductivity.

Theories of Metal-Ligand Bond: VB theory and its limitations – crystal field theory - splitting of d-orbitals under various geometries – factors affecting splitting – CFSE and evidences for CFSE (Structural and thermodynamic effects) – Spectrochemical series – Jahn-Teller distortion – Spectral and magnetic properties of complexes – site preferences - limitations of CFT – ligand field theory – MO theory – sigma – and pi-bonding in complexes and evidences for pi-bonding – nephelauxetic effect – angular overlap model.

Coordination Chemistry – Reaction Mechanism: Kinetics and mechanism of reactions in solution – labile and inert complexes – ligand displacement reactions in octahedral and square planar complexes – acid hydrolysis, base hydrolysis and anation reactions – trans effect – theory and applications. Electron transfer reactions – complementary and non-complementary types – inner sphere and outer sphere processes – Excited state outer sphere electron transfer reactions - isomerisation and racemisation reactions of complexes – reactions of four and six-coordinate complexes – interconversion between stereoisomers. Spectral and magnetic properties of lanthanides and actinides.

Prescribed Books

1. Huheey J. E., Keiter E. A. and Keiter R. L. and Medhi O. K., *Inorganic Chemistry - Principles of Structure and Reactivity*, 4th edition, Pearson Education, **2006**.
2. Atkins, P. W.; Paula, J.; Physical Chemistry, Oxford Publications, 8th edition, **2009**.
3. B. Douglas, D. McDaniel and J. Alexander, *Concepts and Models of Inorganic Chemistry*, 3rd edition, John Wiley & Sons, **2010**.

4. F. A. Cotton and G. Wilkinson, *Advanced Inorganic Chemistry*, 3rd ed., Wiley-Eastern Company, New Delhi, **1990**.
5. Azaroff, L.V., Introduction to Solids, McGraw hill, New York. **1960**
6. West, A. R., Solid State Chemistry and Its Applications, John Wiley & Sons, **1984**.
7. Chakrabarty, K., Solid State Chemistry, New Age Publishers, **1996.**
8. Keer, H. V., Principles of the Solid State, Wiley Eastern Limited, **1993**.

Reference Books

1. Day, M. C., and Selbin, J., *Theoretical Inorganic Chemistry*, Affiliated East West Press Pvt. Ltd. 2nd edition, **1985**.
2. Kettle, S. F. A., Physical Inorganic Chemistry – *A Coordination Chemistry Approach*, Spectrum Academic Publishers, Oxford University Press, **1996**.
3. Basolo, F., and Pearson, R. G., *Mechanism of Inorganic Reactions*, John Wiley, New York, **1967**.
4. Miessler, G. L., and Tarr, D. A., *Inorganic Chemistry*, 3rd edition, Pearson, **2004**.
5. Housecraft, C. E., and Alan G. Sharpe, *Inorganic Chemistry*, 4th edition, Pearson, **2012**.
6. Purcell, K. F., and Kotz, J. C., *Inorganic Chemistry*, Cengage Learning, **2012**.
7. Day Jr ,M. C., and Selbin, J, *Theoretical Inorganic Chemistry*, Literary Licensing, LLC, **2012**
8. Wilkinson, G., Gillars, R. D., and Mccleverty, J. A., *Comprehensive Co-ordination Chemistry*, Pergamon Press, **1987**.
9. Wulfberg, G., *Inorganic Chemistry*, University Science Books, **2000**.

Semester: 7 **Subject Code: CY4102** **Credits: 4** **4-0-0-4**

Title: Advanced Organic Chemistry I

Advanced Stereochemistry: Configuration - conformation of cycloalkanes, conformation and reactivity -stereochemistry of allenes, spiranes, biphenyls, molecules with chiral planes, Topicity stereoselective and stereospecific reactions - enantioselective reactions - double stereo differentiation, asymmetric synthesis, chiral auxiliaries, chiral catalysts and reagents.

Introductory physical organic chemistry: Thermodynamic stability – general relationship between thermodynamic stability and reaction rates – electronic substituent effects on reaction intermediates – kinetic isotope effects – linear free energy relationships – principles of microscopic reversibility – substituent effects – solvent and solvent effects – methods of determination of reaction mechanism.

Aromaticity: Criteria of aromaticity - Craig's rule – non-benzenoid aromatic compounds – anti-aromaticity, homo aromaticity – fused-ring systems –hetero aromatic systems.
Nucleophilic aromatic substitution reactions – VNS - transition metal- catalyzed aromatic substitution reactions – aromatic substitution reactions involving radical intermediates.

Advanced Heterocycles: Nomenclature, heterocyclics with two hetero atoms – fused five and six membered heterocyclics – preparation and reactions of indole, quinoline, isoquinoline and carbozole.

Prescribed books:

1. Nasipuri, D., *Stereochemistry* of Organic Compounds: Principles and Applications, 4th edition, New Academic Science Publisher. **2012**.
2. Eliel, E. L., and Wilen, S. H. Stereochemistry of Organic Compounds, Wiley, **1994**.
3. F.A.Carey and R.J.Sundberg, Advanced Organic Chemistry, Part A: Structure and Mechanisms, 5thedition, **2007**.
4. Heterocyclic Chemistry- J. A. Joule, K. Mills, G. F. Smith, Blackwell publishing Ltd, 5th edition, **2010.**

Reference books:

1. Morrison, R. T., Boyd, R. N. and Bhattacharjee, S. K., Organic Chemistry, 7th edition, Pearson Prentice Hall, **2011**.
2. Pine, S. H., Organic Chemistry, Tata McGraw Hill, 5th edition, **2008**.
3. Carruthers, W., and Coldham, I., Modern methods of Organic Synthesis, Cambridge University Press, First South Asian edition, **2005**.
4. J. March and M. B. Smith, March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, 6th edition, Wiley, **2007**.

Semester: 7 **Subject Code: CY4103** **Credits: 4** **4-0-0-4**

Title: Advanced Physical Chemistry I

Quantum Chemistry I: Wave particle duality and uncertainty principle, wave equation, wave functions, properties of wave functions, Normalization of wave functions, orthogonality of wave functions, one dimensional wave equation, separation of variables for solving wave equation, general solutions to wave equations, two dimensional wave equations.

Postulates of quantum mechanics, Wave function of a particle - Schrödinger equation, Eigen value problem, linear operator's classical mechanical quantities in quantum mechanics, wave function normalization, Particle in one dimensional and three dimensional box, Harmonic oscillator.

Group Theory: A systematic procedure for symmetry classification of molecules. Symmetry elements, symmetry operations, concepts of groups, Sub-groups, classes of symmetry operations, group multiplication tables. Abelian and non-Abelian point groups. symmetry criterion of optical activity, symmetry restrictions on dipole moment, representation of groups, matrix representation of symmetry operations, reducible and irreducible representations, application of orthogonality theorem.

Construction of character tables for point groups C2v, C3v and D2h, structure of character tables, determination of symmetry species for translations and rotations.

Atomic term symbols and electronic configuration for multi electron systems, Russel-Saunders coupling, J-J coupling.

Prescribed Books

1. Cotton, F. A.; Chemical Applications of Group Theory, John Wiley & Sons Inc., 3rd edition, **2009.**
2. Veera Reddy, K., Symmetry and spectroscopy of molecules, New Age International, 2nd edition, **2009**

3. McQuarie, D.; Quantum chemistry, University Science Publishers, **2007.**
4. McQuarie, D. A.; Simon, J. D.; Physical Chemistry: A Molecular Approach, University Science Books, **2011.**

Reference Books

1. Jaffe, H. H.; Orchin, M.; Symmetry in Chemistry, John Wiley & Sons Inc., **2002**.
2. Atkins, P. W.; Paula, J.; Physical Chemistry, Oxford Publications, 8th edition, **2009**.
3. Levine, I. N.; Physical Chemistry, McGraw-Hill Science/Engineering/Math, 6th edition, **2008.**
4. Raff, L. M.; Principles of Physical Chemistry, Prentice Hall, **2001.**
5. I. N. Levine, Molecular Spectroscopy, John Wiley, **1975.**
6. Harris, D. C.; Bertolucci, M. D.; Symmetry and Spectroscopy: An Introduction to Vibrational and Electronic Spectroscopy, Dover Publications, **1989.**
7. Lowe, J. P., Peterson, K.A., Quantum Chemistry, Academic press, **2011**.

Semester: 7 **Subject Code: CY4104** **Credits: 3** **0-1-5-3**

Advanced Physical Chemistry Laboratory I

Advanced experiments on thermodynamics, kinetics, catalysis, electrochemistry, spectroscopy, photochemistry and macromolecules.

Reference Books

1. In-house laboratory manual, Department of Chemistry, CUTN.
2. Halpern, A. M.; McBane, G. C. Experimental Physical Chemistry: A Laboratory Prescribed Book, 3rd ed.; W. H. Freeman, **2006**.

Semester: 7 **Subject Code: CYXXXX** **Credits: 3** **3-0-0-3**

Semester: 7 **Subject Code: CYXXXX** **Credits: 3** **3-0-0-3**

Semester: 8 **Subject Code: CY4201** **Credits: 4** **4-0-0-4**

Title: Advanced Inorganic Chemistry II

Structure and bonding in organometallics: 18-Electron rule - metal carbonyls – bonding – spectra – metal alkyls, aryls, hydrides and dihydrogen complexes - ligands – metallocenes - electronic structure and bonding in ferrocene - synthesis, physical and spectroscopic properties of metallocenes – fluxional molecules.σ–bonded ligands: metal- phosphines / metal- nitrosyls: structures, reactivity and bonding. Carbenes: N-heterocyclic carbenes, Fischer carbenes, Schrock carbenes, carbynes. Isolobal analogy, metal-metal bond, transition metal clusters.

Reaction mechanism and catalysis: oxidative addition, reductive elimination, insertion, hydride elimination, abstraction; hydrogenation of olefins, hydroformylation, Wacker process, Ziegler-Natta polymerisation, cyclo oligomerisation, Isomerization reactions, olefin metathesis, Monsanto acetic acid synthesis, Fischer-Tropsch process, hydrosilylation, carbonylation, and CH functionalization reactions. Applications of organometallics in organic synthesis: C-C coupling reactions (Heck, Sonogoshira, Suzuki etc).C-N bond coupling reactions and asymmetric hydrogenations.

Electronic Spectroscopy : Microstates, terms and energy levels for d^1- d^9 ions in cubic and square fields – Intensity of bands – group theoretical approach to selection rules - Effect of distortion and spin-orbit coupling on spectra – Evaluation of 10Dq and β for octahedral complexes of cobalt and nickel – applications to simple coordination compounds – charge transfer spectra – electronic spectra of $[Ru(bipy)_3]^{2+}$. Optical rotatory dispersion, circular dichroism and Magnetic circular dichroism – applications to metal complexes.

Infrared and Raman Spectroscopy: Vibrations in simple molecules (H_2O, CO_2) and their symmetry notation for molecular vibrations – combined uses of IR and Raman spectroscopy in the structural elucidation of simple molecules - effect of coordination on ligand vibrations – uses of groups vibrations in the structural elucidation of metal complexes. Applications of IR and Raman spectroscopy to inorganic compounds.

Prescribed Books

1. Powell, P., *Principles of Organometallic Chemistry*, 2nd ed., Springer, **1998**.
2. Purcell, K. F., and Kotz, J. C., *Inorganic Chemistry*, Saunders Golden Sunburst Series, W. B. Saunders Company, Philadelphia, **1977**.
3. Huheey, J. E., Keiter, E. A. and Keiter, R. L. and Medhi, O. K., *Inorganic Chemistry - Principles of Structure and Reactivity*,4th edition, Pearson Education, **2006**.
4. Mehrotra, R. C., and Singh, A., Organometallic Chemistry, A Unified Approach, New Age International, **2006**.
5. Crabtree, R. H., *Organometallic Chemistry of the Transition Metals*, Wiley, New York, **1988**.
6. Gupta, B. D., and Elias, Anil. J., Basic Organometallic Chemistry: Concepts, Syntheses, and Applications of Transition Metals, 1st edition, Universities Press, CRC Press, **2010**.
7. Drago, R. S., *Physical Methods for Chemistry*, 2nd edition, Saunders College Publishing, **1992**.
8. Lever, A. B. P., *Inorganic Electronic Spectroscopy*, 2nd Sub. edition, Elsevier Science, **1986**.

Reference Books

1. Elschenbroich , C., and Salzer, A., *Organometallics: A Concise Introduction*, 3rd edition, **1999**.
2. Greenwood, N. N., and Earnshaw, A., *Chemistry of the Elements*, 2nd edition, Elsevier, **2005**.
3. Jolly, W. L., *Modern Inorganic Chemistry*, McGraw Hill, New York, 2nd Edition., **1991**.
4. Douglas, B., McDaniel, D, .and Alexander, J., *Concepts and Models of Inorganic Chemistry*, John Wiley, New York, 3rdedition., **1993**.
5. Kegley, S. E., and Pinhas, A. R., *Problems and Solutions in Organometallic Chemistry*, University Science Books, Oxford University Press, **1986**.
6. Douglas, B., McDaniel, D. H., and Alexander, J. J., Concepts and Models of Inorganic Chemistry, 2nd edition, John Wiley & sons, New York, **2006**.
7. Bochmann, M., Organometallics 1: Complexes with transition metal-carbon s-bonds;
8. Oxford Chemistry Primers Series,No. 13 Oxford Chemistry Primers Series, No. 12, **1994**.; Bochmann, M., Organometallics 2:Complexes with transition metal-carbon p-bonds, **1994.**
9. Collman, J. P., Hegedus, L. S., Nortan, J. R. and Finke, R. G., Principles and Applications of Organotransition Metal Chemistry, University Science Books. Mill Valley, California, **1987**.

Semester: 8 **Subject Code: CY4202** **Credits: 4** **4-0-0-4**

Title: Advanced Organic Chemistry II

Pericyclic Reactions: Pericyclic reactions – orbital correlation diagram – FMO. Diels-Alder reactions – 1,3-dipolar cycloaddition reactions – [2+2] cycloadditions and related reactions leading to cylcobutanes – [3,3] and [2,3]-sigmatropic rearrangements –unimolecular thermal elimination reactions.

Organic photochemistry: Photochemistry of alkenes, dienes and polyenes – photochemistry of carbonyl compounds – photoreductions, photooxidations and photorearrangement reactions - photochemistry of aromatic compounds.

Application of molecular Rearrangements in organic synthesis: Classification – electrophilic, nucleophilic and free radical rearrangements, mechanisms of the following rearrangements – pinacol – pinacolone, Wagner – Meerwin, Tiffenev-Demjanov, Dienone- Phenol, Favorskii, Hofmann, Schmidt, Lossen, Curtius, Beckmann, Fries, Baeyer – Villager, Stevens, Benzil – Benzilic acid, Brook and Benzidine rearrangements.

Selected name reactions in organic synthesis: Wittig Reaction, Baylis-Hillman reaction, Henry reaction, Nef reaction, Kulinkovich reaction, Ritter reaction, Sakura reaction, Tishcheko reaction and Ugi reaction.

Prescribed books

1. Carey F.A., and Sundberg, R.J., Advanced Organic Chemistry, Part B: Reactions and synthesis, 5th edition , **2007**.
2. Fleming, Pericyclic Reactions, Oxford University Press, Oxford, **1999**.
3. Mukherjee, S.M. and Singh, S.P., Pericyclic Reactions, MacMillan India, New Delhi.
4. Sankararaman, S., Pericyclic Reactions - Applications and Theory, Wiley – VCH, **2005**.
5. Turro , N. J., Scaiano, J. C., and Ramamurthy, V., Modern Molecular Photochemistry of Organic Molecules, University Science Books, **2010.**

Reference books

1. Morrison, R. T., Boyd, R. N., and Bhattacharjee, S. K., Organic Chemistry, 7th edition, Pearson Prentice Hall, **2011**.
2. Pine, S. H., Organic Chemistry, Tata McGraw Hill, 5th edition, **2008**.
3. March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, Michael B. Smith, Jerry March John Wiley & Sons, 6th edition, **2007**.
4. Finar, I. L., Organic Chemistry, Vol. 1 & 2, 5th edition, Longman Ltd., New Delhi, **1975**.
5. Guidebook to Mechanism in Organic Chemistry (6th Edition), Peter Sykes, Longman Scientific & Technical, **1985**.
6. Mukherjee, S.M., and Singh, S.P., Reaction Mechanism in Organic Chemistry, 1st edition, Macmillan India Ltd., New Delhi, **1990**.
7. Lowry, T. H., and Richardson, K. S., Mechanism and Theory in Organic Chemistry, 3rd edition, Addison – Wesley Longman Inc., **1998**.

Semester: 8 **Subject Code: CY4203** **Credits: 4** **4-0-0-4**

Title: Advanced Physical Chemistry II

Quantum Chemistry II: Rigid rotor, energy levels of a rigid rotor, spherical harmonics, Schrödinger equation for the hydrogen atom – solutions, s orbitals, p orbitals, energy levels of a hydrogen atom in magnetic field, Schrödinger equation for Helium atom. Perturbation theory, Variational methods, Hartree-Fock equations, Self-consistent field methods for solving Hartree-Fock equations, Born-Oppenheimer approximation-molecular Hamiltonian operators, Valence bond treatment for chemical bonding in molecules, molecular orbitals, molecular orbital theory for different diatomic molecular systems, photoelectron spectra, SCF-LCAO-MO wave functions, electronic states of diatomic molecules, sp, sp^2 and sp^3 hybrid orbitals, molecular term symbols, Hückel molecular orbitals, bonding in polyatomic molecules.

Molecular spectroscopy: Characterization of electromagnetic radiation, energy quantization, atomic and molecular spectra, emission and absorption spectra; Fourier transformed spectroscopy, Lasers. Microwave spectroscopy, rotation spectra of di – and poly- atomic molecules; Stark effect; Applications of microwave spectra**.** Vibrational spectra of diatomic molecules; Rotation-vibration spectra of diatomic molecules; Vibrational spectra of diatomic and ploy atomic molecules; breakdown of Born-Oppenheimer approximation. Electronic spectra of diatomic and polyatomic molecules.

Photochemistry: Basics of Photochemistry and Photophysics, Jablonski diagram. Electronically excited states: electronic, vibrational and spin levels, unimolecular and bimolecular photophysical processes. photochemical reactions and kinetics – energy transfer, electron transfer, excited state quenching – eximer and exiplex.

Prescribed Books

1. McQuarie, D.; Quantum chemistry, University Science Publishers, **2007.**
2. McQuarrie, D. A.; Simon, J. D.; Physical Chemistry: A Molecular Approach, University Science Books, **2011.**
3. Prasad, R. K.; Quantum Chemistry, New Age International Publishers, 4th edition, **2010.**
4. Banwell, C. N.; McCash, E. M.; Fundamentals of Molecular Spectroscopy, Tata McGraw-Hill, 4th edition, **2010**.
5. Rohatgi Mukherjee K K , Fundamentals of Photochemistry, Wiley Eastern Ltd., **1992**.

Reference Books

1. Raff, L. M.; Principles of Physical Chemistry, Prentice Hall, **2001.**
2. Atkins, P. W.; Paula, J.; Physical Chemistry, Oxford Publications, 8th edition, **2009**.
3. Levine, I. N.; Physical Chemistry, McGraw-Hill Science/Engineering/Math, 6th edition, **2008.**
4. Kreyszig, Advanced Engineering Mathematics, 9th edition, **2012**.
5. Harris, D. C.; Bertolucci, M. D.; Symmetry and Spectroscopy: An Introduction to Vibrational and Electronic Spectroscopy, Dover Publications, **1989.**
6. Turro T J, Ramamurthy V, Scaiano J C, Principle of molecular photochemistry – An Introduction, University Science books, 1st edition, **2008**.

Semester: 8 **Subject Code: CY4204** **Credits: 4** **4-0-0-4**

Title: Physical methods in chemistry

Infra-Red Spectroscopy: Principle, instrumentation and sampling techniques, types of stretching and bending vibration – Factors influencing the vibrational frequency, vibrational frequencies of alkane, alkenes, alkynes, aromatic compounds, alcohols, ethers, phenol, carbonyl compounds, amines and heterocyclics– related problems.

NMR Spectroscopy: ^{1}H NMR, Spectral parameters – intensity, chemical shift, multiplicity, coupling constant, factors affecting chemical shift. Analysis of first order and second - order spectra – shift reagents - structure determination of organic compounds by ^{1}H NMR spectra. Chemical shifts and coupling constants (spin-spin coupling) involving different nuclei (^{1}H,^{13}C) interpretation and applications to inorganic compounds – Effect of quadrupolar nuclei (^{10}B) on the ^{1}H NMR spectra, Satellite spectra - examples for different spin systems –Systems with chemical exchange - study of fluxional behavior of molecules.

^{13}C NMR: Proton coupled; off–resonance decoupled; proton noise decoupled ^{13}C NMR spectra. Assignment of chemical shifts, additively effect, characteristic chemical shifts of common organic compounds and functional groups, APT, DEPT and INEPT spectra. NMR of common heteroatoms present in organic compounds - 2D NMR techniques ^{1}H – ^{1}H COSY, ^{1}H – ^{13}C COSY – HMBC, NOESY and INADEQUATE.

Elementary idea about mass spectrometry, interpretation of data and solving problems with spectroscopic techniques.

EPR spectroscopy and Magnetic Properties

Theory of EPR spectroscopy - Spin densities and McConnell relationship – Factors affecting the magnitude of g and A tensors in metal species - Zero-field splitting and Kramers degeneracy – Spectra of VO(II), Mn(II), Fe(II), Co(II), Ni(II) and Cu(II) complexes.

Applications of EPR to a few biological molecules containing Cu(II) and Fe(III) ions.

Magnetic properties -Determination of Magnetic moments and their applications to the elucidation of structures of inorganic compounds – temperature independent paramagnetism. Magnetic properties of lanthanides and actinides. Spin crossover in coordination compounds – Single molecule magnets.

Elementary idea about Mössbauer spectroscopy and NQR spectroscopy.

Prescribed books

1. Silverstein, R. M., and Webster, F. X., Spectrometric identification of organic compounds, John Wiley and Sons. Inc., 6th edition, **1997**.
2. W. Kemp, Organic Spectroscopy, 3rd edition, MacMillon, **1994**.
3. Jag Mohan, Organic Spectroscopy: Principles & Applications, Narosa Publishers, **2012**.
4. Drago, R. S., *Physical Methods for Chemistry*, 2nd Edition, Saunders College Publishing, **1992**.
5. Lever, A. B. P., *Inorganic Electronic Spectroscopy*, 2nd Sub. Edition, Elsevier Science, **1986**.

Reference Books

1. Pavia, Lampman and Kriz, Introduction to Spectroscopy, Brooks/Cole Pubs Co, 5th edition, **2015**.
2. Williams, D. H., and Ian Fleming, Spectroscopic methods in organic chemistry, Tata McGraw Hill, **1998**.
3. William Kemp, NMR in chemistry: A multinuclear introduction, MacMillan, **1988**.
4. Organic Spectroscopy by L. D. S. Yadav, Kulwer academic publishers, **2004**.
5. Gerson, F., and Huber, W., Electron Spin Resonance Spectroscopy for Organic Radicals, Wiley-VCH, 1st edition, **2001**.
6. Cotton, F. A., and Wilkinson, G., *Advanced Inorganic Chemistry*, 3rd edition, Wiley-Eastern Company, New Delhi, **1990**.
7. J. AND Wilkins Lewis, R. G., *Modern Coordination Chemistry Principles and Methods*, Interscience Publishers, Inc., **1967**.
8. Ebsworth, E. A. V., Structural Methods in Inorganic Chemistry, 3rd edition, ELBS, Great Britain, **1987**.
9. Scott, R. A., and Lukehart, C. M., Applications of Physical Methods to Inorganic and Bioinorganic Chemistry, John and Wiley & Sons, LTD, **2007**.
10. Solomon, E. I., Lever, A. B. P., Inorganic Electronic Structure and Spectroscopy, Vol., 2, Applications and Case Studies, Wiley-Interscience, **2006**.
11. Satyanarayana, D. N., Electronic Absorption Spectroscopy, Universities Press, **2000**.
12. Jordon, R. B., Reaction Mechanisms of Inorganic and Organometallic Systems, 3rd edition, Oxford University Press, **2007**.
13. Ballhausen, C. J., and Gray, H. B., Molecular Orbital Theory, Benjamin/Cummings Pub. Co, **1965**.
14. Figgis, B. N., and Hitchman, M. A., *Ligand Field Theory and Its Applications*, 1st edition, Wiley VCH, **1999**.
15. Huheey, J. E., Keiter, E. A. and Keiter, R. L., and Medhi, O. K., *Inorganic Chemistry - Principles of Structure and Reactivity*,4th Edition, Pearson Education, **2006**.
16. Purcell, K. F. and Kotz, J. C., *Inorganic Chemistry*, Cengage Learning, **2012**.

Semester: 8 **Subject Code: CY4205** **Credits: 3** **1-0-5-3**

Title: Advanced Organic Chemistry Laboratory I

Multistep organic synthesis- conventional synthesis - microwave assisted synthesis - photochemical reactions. Purification of the compounds using column chromatography and characterization of the compounds using MS, IR, ^{1}H and ^{13}C NMR techniques.

Qualitative Analysis: Separation and analysis of organic mixture containing two components and preparation of suitable derivatives.

Reference Books

1. Singh, P. R., Gupta, D. S., Bajpai, K. S., Experimental Organic Chemistry Vol 1 and 2, Tata McGraw Hill
2. Bansal, R. K., Laboratory Manual in Organic Chemistry, Wiley, **2006**.
3. Vogel , A.I., Tatchell, A.R., Furnis , B.S., Hannaford , A.J., Smith, P.W.G., Vogel's Practical Organic Chemistry, 5th edition, Pearson education Ltd, **1996**.

Reference Books:

1. Leonard, J., Lygo, B., Procter, G., Advanced Practical Organic Chemistry, , 3rd edition, CRC press, **2013**.
2. Singh, P. R., Gupta, D. S., Bajpai, K. S., Experimental Organic Chemistry Vol 1 and 2, Tata McGraw Hill
3. Laboratory Manual in Organic Chemistry, R. K. Bansal, Wiley. **2006**.
4. Silverstein, R. M. and Webster, F. X., Spectrometric identification of organic compounds, John Wiley and Sons.Inc., 6th edition, **1997**.

Semester: 8 **Subject Code: CYXXXX** **Credits: 3** **3-0-0-3**

Semester: 9 **Subject Code: CY5101** **Credits: 4** **4-0-0-4**

Title: Advanced Inorganic Chemistry III

General Principles of Bioinorganic Chemistry: Occurrence and availability of Inorganic elements in biological systems. Basics of Biomineralisation.

Function and Transport of Alkali and Alkaline earth metals: Uptake, transport and storage of metal ions by organisms - structure and functions of biological membranes - the generation of concentration gradients (the Na^+ -K^+ pump) - mechanisms of ion-transport across cell membranes – bleomycin - siderophores (e.g. enterobactin and desferrioxamine) - transport of iron by transferring - storage of iron by ferritin - bio chemistry of calcium as hormonal messenger. Metals at the Center of Photosynthesis: Primary Processes in Photosynthesis – Photosystems I and II.

Metalloporphyrins/Metalloenzymes: Dioxygen transport and storage - hemoglobin and myoglobin: electronic and spatial structures - hemeythrin and hemocyanine - synthetic oxygen carriers, model systems - blue copper proteins (Cu) - iron-sulfur proteins (Fe)- cytrochromes electron transport chain - carbon monoxide poisoning - iron enzymes - peroxidase, catalase and cytochrome P-450, copper enzymes - superoxide dismutase, vitamin B_{12} and B_{12} coenzymes, nitrogen fixation. Medicinal bioinorganic chemistry: platinum complexes in cancer therapy – cis-platin and its mode of action.

Advanced Nuclear Chemistry: Radioactive equilibrium: Transient and secular -nuclear reactions: energetics and types - nuclear fission- liquid drop model-shell model - nuclear spin calculation - Nordheim's rule - nuclear fusion - essential features of nuclear reactors - application of radioisotopes**:** Probing by isotopes, reactions involved in the preparation of radioisotopes, the Szilard-Chalmer's reaction - radiochemical principles in the use of tracers - applications of radioisotopes as tracers - chemical investigations, analytical applications, agricultural and industrial applications - neutron activation analysis - carbon and rock dating - use of nuclear reactions - radioisotopes as source of electricity - nuclear medicines. Radiolysis of water and hydrated electron.

Prescribed Books

1. Lippard, S. J., and Berg, J. M., *Principles of Bioinorganic Chemistry*, Panima Publishing Company, New Delhi, **1997**.

2. Kaim W., and Schewederski, B., *Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life*, John Wiley & Sons, New York, USA, **2013**.
3. Bertini, I., Gray, H. B., Lippard, S. J. and Valentine, J. S., *Bioinorganic Chemistry*, 1st South Asia edition, Viva books Pvt. Ltd., **2007**.
4. Huheey, J. E., Keiter, E. A. and Keiter, R. L., and Medhi, O. K., *Inorganic Chemistry - Principles of Structure and Reactivity*,4th edition, Pearson Education, **2006**.
5. Behrens, P., Bauerlein, E., *Hand Book of Biomineralization*, 1st edition, Vol. 1& 2, Wiley-VCH, **2007**.
6. Arnikar, H. J., Essentials of Nuclear Chemistry, 4th edition, New Age International Publishers Ltd., New Delhi, **1995**.
7. Loveland, W. D., Morrissey, D. J., Seaborg, G. T., *Modern Nuclear Chemistry*, Wiley-VCH Verlag GmbH Co. KGaA, **2006**.
8. Glasstone,'*Source Book on Atomic Energy'*, 3rd edition, Affiliated East West Press, **1979.**

Reference Books

1. Purcell, K. F. and Kotz, J. C., Inorganic Chemistry, Cengage Learning, **2012**.
2. Cotton, F. A., Wilkinson, G., Carlos A. Murillo, Manfred Bochmann, Advanced Inorganic Chemistry, 6th ed., A Wiley - Interscience Publication, John –Wiley & Sons, USA, **2007**. Chem. Education, 62, No. 11, Bioinorganic Chemistry, State of the Art. **1985.**
2. Eichorn, G. L., Inorganic Biochemistry, Volumes 1 & 2, 2nd ed., Elsevier Scientific Publishing Company, New York, **1973**.
3. Atkins, P., Overton, T., Rourke, J., Weller M., and Armstrong, F., Inorganic Chemistry, 5th edition, Oxford University Press, **2010.**
4. Lehninger, A., Nelson, D. L., Cox, M. M,. Principles of Biochemistry, 5th edition, W.H Freeman, **2008.**
5. Alessio, E., Bioinorganic Medicinal Chemistry, 1st Edition, Wiley-VCH Verlag GmbH Co. KGaA, **2012**.

Semester: 9 **Subject Code: CY5102** **Credits: 4** **4-0-0-4**

Title: Advanced Organic Chemistry III

Oxidations and reductions: oxidation: Ozone, CrO_3, DCC, DDQ, 9-BBN, lead tetra acetate, phenyl iodoso acetate, dimethyl sulphoxide, SeO_2, PCC, Yeast in organic synthesis and functional group transformations. Phase transfer catalysis – benzyltriethylammonium halides- crown ethers. Reduction**:** Addition of hydrogen at carbon-carbon multiple bonds – catalytic hydrogenation of carbonyl and other functional groups – group-III hydride-donor reagents – group-IV hydride donors – reduction reactions involving hydrogen atom donors – dissolving-metal reductions – reductive deoxygenation of carbonyl groups – reductive elimination and fragmentation.

Organometallic reagents: B, Mg, Li, Si, Pd, Cu, Zn, Ru, Rd, Sm, In, Sn, Cd, Hg, Ce, homogeneous hydrogenation - Willkinson's catalyst – umploung synthesis.

Protection and deprotection of organic functional groups – alcohol, amines and carbonyl compounds.

Planning Organic Synthesis: An introduction to reterosynthesis - synthon – synthetic equivalent – target molecule, functional group interconversion. Disconnection approach- one group disconnection- disconnection of alcohols, olefins and ketones.Logical and illogical disconnections.

Two group disconnection-1,2, -1,3, 1,4, 1,5 and -1,6 dioxygenated skeletons and dicarbonyls. Green chemical synthesis.

Recommended Books:

1. Carey F. A., and Sundberg, R. A., Advanced Organic Chemistry, Part B: Reactions and Synthesis, 5th edition, Springer, New York, **2007**.
2. Carruthers , W., and Coldham, I., Modern methods of Organic Synthesis, 1st South Asian Edition, Cambridge University Press, **2005**.
3. March, J., and Smith, M. B., March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure 6th edition, Wiley, **2007**.
4. Warren, S., Wyatt, P., Organic Synthesis: The Disconnection Approach, Wiley, **2008**.
5. Willis, C. L., Wills, M., Organic Synthesis, Oxford Chemistry Primers, 31, Oxford Science Publications, **1996**.
6. Paquette, L. A., Crich , D., Fuchs, P. L., Molander, G. A., Encyclopedia of Reagents for Organic Synthesis, 14 Volume Set, Wiley, **2009**.
7. Warren, S., Wyatt, P., Wiley, Workbook for Organic Synthesis: The Disconnection Approach, 2nd edition, **2010**.
8. Starkey, L., S., Introduction to Strategies for Organic Synthesis, Wiley, **2012**.
9. Anastas, P. T., Green Chemistry: Theory and Practice, Oxford University Press, USA, **2000**.

Semester: 9 **Subject Code: CY5103** **Credits: 4** **4-0-0-4**

Title: Advanced Physical Chemistry III

Statistical Thermodynamics: Statistical entropy, microcanonical and canonical ensembles, Maxwell-Boltzmann distribution, Thermodynamic quantities and canonical partition function, molecular partition functions, translational, rotational, vibrational and electronic partition functions. Ideal monoatomic and diatomic gases. Heat capacities - Einstein theory and Debye theory. Applications of statistical thermodynamics to activated complex theory.

Chemical Kinetics: Theories of unimolecular gaseous reactions: Lindmann, Lindmann-Hinselwood, RRK, RRKM theories. Kinetics of fast reactions: flow and relaxation methods; ultrafast reactions.

Solids, Surface growth and characterization: Growth and structure of solid surfaces, surface analytical techniques and characterization. Solid solutions, solubility limit, phase rule, binary phase diagrams, intermediate phases, intermetallic compounds, Alloys

Principles of electrochemistry and techniques: Theory of strong electrolytes; electrified interfaces: theories and models; basics in electro-catalysis and bio-electrochemistry; kinetics of electrode reactions; irreversible electrode processes. Cyclic voltammetry, differential pulse voltametry and square wave voltammetry, polarography, amperometry.

Prescribed Books

1. McQuarrie, D. A.; Simon, J. D.; Physical Chemistry: A Molecular Approach, University Science Books, **2011.**
2. Atkins, P. W.; Paula, J.; Physical Chemistry, Oxford Publications, 8th edition, **2009**.
3. McQuarrie, D. A.; Statistical mechanics, University Science Publishers, **2000.**
4. J.O'M Bockris and A.K.N Reddy, Modern Electrochemistry 2A: Fundamentals of Electrodics, Vol II, **2001**.

5. D. Skoog and D.West , Principles of Instrumental Analysis, Cengage Learning; 6th edition, **2006**

Reference Books

1. Hill, T. A.; An Introduction to Statistical Thermodynamics, Dover Publications Inc., **1987**.
2. Levine, I. N.; Physical Chemistry, McGraw-Hill Science/Engineering/Math, 6th edition, **2008**.
3. Laidler, K. J.; Chemical Kinetics, Pearson Education, 3rd edition, **2011**.
4. D.R. Crow, Principles and Applications of Electrochemistry, John Wiley & Sons (New York) 2nd edition, **2001.**
5. Bard, A. J.; Faulkner, L. R.; Electrochemical Methods: Fundamentals and Applications, Wiley, 2nd edition, **2000.**

Semester: 9 **Subject Code: CY5104** **Credits: 3** **1-0-3-3**

Title: Seminar and Literature Review

Students are required to take two seminars of one hour duration. 45 minutes presentation and 15 minutes of questions and discussion. Evaluation will be based on content of the material, presentation and depth of knowledge in the topic presented.

The student will be required to make a literature survey for the project that will be carried out in the subsequent semester assigned to a teacher.

Semester: 9 **Subject Code: CY5105** **Credits: 3** **0-0-3-3**

Title: Advanced Inorganic Chemistry Laboratory I

Estimation of copper, iron and nickel using spectrophotometry method.

Preparation of the following compounds and their Characterization

1. Tetramminecopper(II) sulphate.
2. Potassium trioxalatochromate(III).
3. Potassium trioxalatoaluminate(III).
4. Trithioureacopper(I) chloride.
5. Dibenzyltin dichloride.
6. Nitro and nitrito linkage isomers
7. Mn_3 clusters

1. Synthesis and study of Tris(oxalato)iron(III) potassium salt by Cyclic Voltammetry (CV) and Differential Pulse Voltammetry (DPV), and determination of the following: the formal reduction potential ($E^{o'}$); the number of electrons transferred in the redox process (n); the diffusion coefficient (D); electrochemical reversibility; and the effects of varying concentration (C) and scan rate.
2. Synthesis and study of Mn^{III}(Salen)Cl by Cyclic Voltammetry and Differential Pulse Voltammetry (DPV), and determination of the following: the formal reduction potential ($E^{o'}$); the number of electrons transferred in the redox process (n); the diffusion coefficient (D); electrochemical reversibility; and the effects of varying concentration (C) and scan rate.
4. Preparation and determination of the effective magnetic moment and number of unpaired electrons in $Mn(acac)_3$.

5. Preparation and determination of the aquation rate of $[Co(NH_3)_5Cl]Cl_2$.
6. Preparation and resolution of the optically active compound $[Co(en)_3]^{3+}$.
7. Preparation and characterization of (Mesitylene) tricarbonylmolybdenum(0) by solution infrared spectrum.
8. Bioanalytical techniques – Monitoring the cleavage of DNA and protein by metal complexes using Gel electrophoresis techniques – Agarose and PAGE

Reference Books

1. Elias, A. J., *A Collection of Interesting General Chemistry Experiments*, Universities Press, Sangam Books Ltd, **2002**.
2. Woollins, J. D., *Inorganic experiments*, 3rd edition, Wiley-VCH Verlag GmbH @Co. KGaA, **2012**.
3. Hein, M., Peisen, J. N., and Miner, R. L., *Foundations of College Chemistry in the Laboratory*, John Wiley and Sons, **2011**.
4. Girolami, G. S., Rauchfuss,T. B., and Angelici, R. J., Synthesis and Technique in Inorganic Chemistry: A Laboratory Manual, 3rd edition, University Science Books, **1999**.
5. Jolly, W. L., The Synthesis and Characterization of Inorganic Compounds, Prentice-Hall, Inc.**1970**.
6. In-house Laboratory Manual, Department of Chemistry, CUTN.

Semester: 9 **Subject Code: CYXXXX** **Credits: 3** **3-0-0-3**

Semester: 10 **Subject Code: CHE5201** **Credits: 9** **0-3-12-9**

Title: Research Project

Research project is carried out under the supervision of a faculty in the chosen field of research by the student. Normally it will be continuation of literature survey carried out from the yester semester.

Semester: 10 **Subject Code: CYXXXX** **Credits: 3** **3-0-0-3**

List of Electives

Mathematics for chemists and biologists, Introductory Biology, Advanced Spectroscopy Techniques, Principles of Fluorescence, Medicinal Inorganic Chemistry, Supramolecular Chemistry, Molecular Electronics, Chemistry of Soft matter, Carbon nanomaterials, Advances in Carbohydrate Chemistry, Fundamentals of Polymer Chemistry, Advances in Polymer Chemistry, Organophosphorus Chemistry and Applications, Chemistry of Biotransformations, Asymmetric Catalysis, Asymmetric Synthesis, Medicinal Chemistry and Drug design, Chemistry of C-H Activation, Chemistry of Materials, Imaging Techniques.

Mathematics for Chemists and biologists

Subject Code: CY0001 **Credits: 3** **3-0-0-3**

Scalars and Vectors: Scalars, Vectors, Vector Products, Vector Spaces, linear independence, basis, curvilinear coordinates, Tensors. Applications: Two body problem, Center of Mass and Relative coordinates.

Vector Integration and Differentiation: Gradient, Divergence and Curl, Line Integrals, Surface integrals, volume integrals, Greens theorem, Stokes Theorem. Applications: Force, Work and Potentials. Path integrals.

Matrix Algebra: Matrices, Rank, Determinants, Eigenvalues, Eigenvectors, System of Equations. Applications: Slater Determinants, Huckel MO theory.

1st order ODEs: Differential Equations of 1st order. Separation of variables, integrating factor, exact differentials, system of ODEs. Applications: Reaction rates. 2nd order differential equations: 2nd order differential equations with constant coefficients, general solution, particular solution, power series method. Applications: Angular Momentum Eigen functions for a single particle.

Numerical Methods: Taylor series, numerical differentiation and integration, matrix diagonalization methods. Applications: Perturbation method for radiation-matter interaction

Reference books:

1. Kreyszig, Advanced Engineering Mathematics, 9th edition, **2012**.
2. Peter Tebbutt, Basic Mathematics for Chemists, 2nd Edition, Wiley, **1998.**

Introductory Biology

Subject Code: CY0002 **Credits: 3** **3-0-0-3**

Objectives :

1. To enable the student to develop a sound knowledge of fundamental concepts in biology.

2. To enumerate the molecular motif of a living cell, structural and functional hierarchy of biomolecules.

3. To emphasis on the various aspects of metabolism and interrelationship of metabolic events.

UNIT 1: Amino acids and Proteins

Living Cell – Plant and Animal cell. Cell membrane – organelles – functions of major subcellular components.

Amino acids – Classification –Synthesis of α-amino acids and their identification. Peptide bond-stereochemistry, synthesis of peptides.

Proteins – Classification – properties-3D structure-determination of amino acid sequence – denaturation and renaturation of protein molecules.

UNIT 2 : Enzymes & lipids

Nomenclature, classification and properties-specificity, factors influencing enzyme action. Mechanism of enzyme action – Lock and Key model and induced fit models. Coenzymes – cofactors – prosthetic groups of enzymes (TPP, NAD, NADP, FAD, ATP).

Classification and properties of lipids. Hydrolysis-acid number, saponification number. Metabolism: Oxidation of glycerol – β-oxidation of fatty acids; biosynthesis of lipids – synthesis of fatty acids and synthesis of triglycerides.

UNIT 3: Carbohydrates

Carbohydrates of the cell membrane – starch, cellulose and glycogen. (Structure and utility) Metabolism: Glycolysis and its reversal; TCA cycle. Relation between glycolysis and respiration. Principles of bioenergetics, electron transport chain and oxidative phosphorylation. Self study: Gluconeogenesis, pentose phosphate pathway.

UNIT 4: Nucleic Acids

Nucleosides and nucleotides – purine and pyrimidine bases. Nucleic acids Difference between DNA and RNA. Classification of RNA. Biosynthesis of DNA: Replication. Biosynthesis of mRNA: Transcription. Genetic code – mutations and mutants. DNA repair. Biosynthesis of proteins. DNA sequencing and PCR, recombinant DNA technology, DNA polymorphism.

Text books

1. David L. Nelson and Michael M. Cox Lehninger, Principles of Biochemistry, Fourth Edition, , Worth Publishers, New York, **2005**.

2. Lubert Stryer, Biochemistry, W. H. Freeman and company, New York, **1975**.

3. Robert L.Caret, Katherine J. Denniston, Joseph J. Topping, Principles and Applications of organic and biological chemistry, WBB publishers, USA, **1993.**

4. A. Mazur and B. Harrow, Text book of biochemistry, 10th Edition, W.B. Saunders Co., Philadelphia, **1971.**