



Savitribai Phule Pune University

(Formerly University of Pune)

Two Year Degree Program in Chemistry

(Faculty of Science & Technology)

Revised Syllabi for

M.Sc. (Chemistry) Part-I

(for Colleges Affiliated to Savitribai Phule Pune University)

Choice Based Credit System Syllabus

To be implemented from Academic Year 2019-2020

Title of the Course: M.Sc. (Chemistry)

Structure of the Course:

Basic structure/pattern (Framework) of the proposed postgraduate syllabus for the two year integrated course leading to M.Sc. (Chemistry) in the colleges affiliated to Savitribai Phule Pune University.

| Semester-I | | | |
|-------------------------------------|--------------------------|--|--------------------------|
| S. N. | Paper No | Subject | Credits |
| 1 | CCTP-1 CHP-110 | Physical Chemistry-I (Fundamentals of Physical Chemistry) | 4 credit (48 L + 12T) |
| 2 | CCTP-2 CHI-130 | Inorganic Chemistry-I (Molecular Symmetry and Chemistry of Main Group Elements) | 4 credit (48 L + 12T) |
| 3 | CCTP-3 CHO-150 | Organic Chemistry-I (Basic Organic Chemistry) | 4 credit (48 L + 12T) |
| 4 | CBOP-1 CHG-190 | Section-I: General Chemistry-I, Theory Course (Any one option) Elective Option-A: Introduction to Solid State of Matter Elective Option-B: Mathematics for Chemists Elective Option-C: Introduction to Chemical Biology-I | 2 credit (24 L + 6T) |
| | | Section-II: General Chemistry Practical (Any one) Elective Option-A : Inorganic Chemistry-Material Analysis, Synthesis and Applications Elective Option-B : Chemical Biology Practical-I | 2 credit (48 L + 12T) |
| 5 | CCPP-1 CHP-107 | Basic Practical Chemistry-I | 4 credit (96 L + 24T) |
| Semester- II | | | |
| 6 | CCTP-4 CHP-210 | Physical Chemistry - II (Molecular Spectroscopy and Nuclear Chemistry) | 4 credit (48 L + 12T) |
| 7 | CCTP-5 CHI-230 | Inorganic Chemistry -II (Coordination and Bioinorganic Chemistry) | 4 credit (48 L + 12T) |
| 8 | CCTP-6 CHO-250 | Organic Chemistry-II (Photochemistry, Pericyclic and Organic spectroscopy) | 4 credit (48 L + 12T) |
| 9 | CBOP-2 CHG-290 | Section-I: General Chemistry-II, Theory (Any one option) Elective Option-A : Material Characterization Technique Elective Option-B : Organometallic and Inorganic Reaction Mechanism Elective Option-C: Introduction to Chemical Biology-II | 2 credit (24 L + 6T) |
| | | Section-II: General Chemistry, Practical (Any one option) Elective Option-A: Electroanalytical Techniques of Analysis Elective Option-B: Chemical Biology Practical-II | 2 credit (48 L + 12T) |
| 10 | CCPP-2 CHP-227 | Basic Practical Chemistry-II | 4 credit (96 L + 24T) |
| Total Credits for First Year | | | 40 |

CCTP- Core Compulsory Theory Paper; CBOP-Choice Based Optional Paper; CCPP- Core Compulsory Practical Paper

2) Equivalence to 2014 pattern

| Course in 2014 pattern | Course in 2019 pattern |
|-------------------------------|-------------------------------|
| CHP-110 | CCTP-1, CHP-110 |
| CHI-130 | CCTP-2, CHI-130 |
| CHO-150 | CCTP-3, CHO-150 |
| CHG-190 | No equivalence |
| CHP-107 | No equivalence |
| CHP-127 | No equivalence |
| CHP-210 | CCTP-4, CHP-210 |
| CHI-230 | CCTP-5, CHI-230 |
| CHO-250 | CCTP-6, CHO-250 |
| CHG-290 | No equivalence |
| CHP-247 | No equivalence |

Detailed Syllabus:**Semester-I****CCTP-1: CHP-110, Physical Chemistry-I, Semester - I****(Fundamentals of Physical Chemistry) (4 Credits)****SECTION - I****(2 Credits, 24 L, 6T)****1. Thermodynamics****(05 L)**

State function, path function, exact differential and inexact differential, internal energy and enthalpy, temperature dependent internal energy and enthalpy, reversible and irreversible adiabatic expansion. The entropy of irreversible changes, the Helmholtz and Gibbs function, Entropy and entropy change in an ideal gas with temperature and pressure, Clausius inequality, chemical potential, chemical potential of a substance in a mixture.

2. Change of State**(04 L)**

Partial molar quantities, methods for determination of molar quantities, ideal solutions, Raoult's and Henry's law, Thermodynamics of Gibbs function of mixing, colligative properties: Elevation in boiling point, depression in freezing point and osmosis.

3. Quantum Chemistry**(08 L)**

Applications of quantum chemistry- blackbody radiation, photoelectric effect, de Broglie hypothesis and uncertainty principle and its experimental evidence. Schrödinger wave equation, particle in one dimensional box, Normalization and orthogonality of wave function, particle in three dimensional box, hydrogen like atoms (no derivation). Operators: algebra of operators, commutative property, linear operators, commutator operator, the operator ∇ and ∇^2 .

4. Chemical Bonding**(07 L)**

Valence bond theory, hybrid orbitals, geometry and hybridization, molecular orbital theory for di and tri atomic molecule, linear variation method, approximations underlying Huckel theory, applications to simple π -systems.

SECTION – II**(2 Credits, 24 L, 6 T)****Chemical Kinetics and Reaction Dynamics****1. Rate Laws****(06 L)**

Recapitulations of basic concept, the temperature dependent reaction rates, reaction moving towards equilibrium, consecutive reaction, parallel reactions, pre-equilibria, unimolecular reactions.

2.

2. Kinetics of Complex Reactions**(03 L)**

Fast reactions: flash photolysis, flow technique, stopped flow technique, relaxation method, the steady state approximation, chain reactions - free radical polymerization reaction between H_2 and Br_2 , explosive reaction.

3. Molecular Reaction Dynamics**(05 L)**

Collision theory of bimolecular gas phase reactions, diffusion controlled and activation controlled reaction in solution, activated complex theory of reaction rate, Eyrings equation.

4. Enzyme Catalysis**(04 L)**

Michaelis mechanism, effect of pH and temperature on enzyme catalyzed reactions, limiting rate, Lineweaverburk and Eadie equation and plots, inhibition of enzyme action, competitive inhibition and non- competitive inhibition.

5. Molecular Thermodynamics**(06 L)**

Molecular energy levels, Boltzmann distribution law, partition functions and ensembles, translational, rotational and vibrational partition function of diatomic molecule, obtaining energy, heat capacity, entropy and equilibrium constants from partition functions, Maxwell- Boltzmann, Fermi-Dirac and Bose-Einstein statistics.

References:

1. Physical Chemistry by P.W. Atkin and De Paul
2. Physical Chemistry by T. Engel and P. Reid
3. Physical Chemistry and molecular approach by D. Mequarie and J. Siman
4. Physical Chemistry for biological sciences by Raymond Chang (Universal books, 2000)
5. Physical Chemistry by Merron and C.F. Prouton
6. Physical Chemistry by G.M. Barrow
7. Quantum Chemistry by I. Levine 8. Quantum Chemistry by R.K. Prasad

Semester-II**CCTP-4: CHP-210, Physical Chemistry-II, Semester - II**
(Molecular Spectroscopy and Nuclear Chemistry) (4 Credits)**SECTION - I (2 Credits, 24 L, 6T)****Molecular Spectroscopy**

- 1) **Microwave Spectroscopy (03 L)**
Types of molecule on the basis of moment of inertia and rotational spectra of di- and poly-atomic molecules.
- 2) **Infra-red Spectroscopy (05 L)**
The vibrating diatomic molecule, harmonic and Anharmonic oscillator, The diatomic vibrating rotator, breakdown of the Born-Oppenheimer approximation, The vibrations of polyatomic molecule, Fourier transform spectroscopy and its advantages, The carbon dioxide laser, Applications.
- 3) **Raman Spectroscopy (05 L)**
Quantum and classical theory of Raman effect, pure rotational Raman spectra, vibrational Raman spectra, polarization of light and Raman effect, structure determination from Raman and Infra-red spectroscopy, applications.
- 4) **Electronic Spectroscopy of molecules (07 L)**
Electronic spectra of diatomic molecules - The Born- Oppenheimer approximation, Vibrational coarse structure, Frank- Condon principle, dissociation energy and dissociation product, Rotational fine structure of electronic-vibration transition, The forttrat diagram, Pre-dissociation, molecular photoelectron spectroscopy.
- 5) **Mossbauer Spectroscopy (04 L)**
Principle, Instrumentation and Applications of Mossbauer Spectroscopy.

SECTION – II (2 Credits, 24 L, 6T)
Nuclear and Radiation Chemistry

- 1) **Radioactivity (04 L)**
Types of radioactive decay, general characteristics of radioactive decay, decay kinetics, general expression for the activity of a daughter nuclide, Geiger- Nuttalis law, α -decay: A problem in classical physics, Internal conversion and the Auger effect.
- 2) **Elements of Radiation (06 L)**
Chemistry: Interaction of radiation with matter, interaction of γ radiation with matter, units for measuring radiation absorption, Radiation dosimetry, Radiolysis of water, free radicals in water radiolysis, Radiolysis of some aqueous solutions.
- 3) **Nuclear Fission: (06 L)**
The discovery of nuclear fission, the process of nuclear fission, fission fragments and their mass distribution, charge distribution, Ionic charge of fission fragments, fission energy,

fission cross-section and threshold, fission neutrons, theory of nuclear fission, Neutron evaporation and spallation.

4) Applications of Radioactivity

(08 L)

Typical reaction involved in the preparation of radioisotopes, The Szillard- Chalmers reaction, Radiochemical principles in the use of tracers, Isotopes in elucidating reaction mechanism and structure determination, physic-chemical research - The solubility of a sparingly soluble substances, surface area of a powder or precipitate rates of diffusion, Analytical applications- Isotope dilution analysis, Neutron activation analysis, Radiometric titrations, Medical applications-Thyroiditis, Assessing the volume of blood in a patient, Industrial applications thickness measurements and control, friction and wear out, gamma radiography.

References:

- 1) Elements of Nuclear Chemistry by H.J.Arnika
- 2) Source book of Atomic energy by S. Glasstone and D. Van
- 3) Chemical applications of radioisotopes by H.J.M. Brown
- 4) Fundamentals of molecular spectroscopy by C.N.Banwell and E.M.McCash

Semester-I**CCTP-2: CHI-130, Inorganic Chemistry-I, Semester - I****(Molecular Symmetry and Chemistry of Main Group Elements) (4 credits)****SECTION-I****(2Credits, 24 L, 6 T)****Molecular Symmetry and its Applications****1) Molecular Symmetry and Symmetry Groups (10L)**

Symmetry elements and operations, Symmetry planes and reflections, the inversion centre, proper axes and proper rotations, improper axes and improper rotation, products of symmetry operations, equivalent symmetry elements and equivalent atoms, general relations among symmetry elements and symmetry operations, classes of symmetry operations, symmetry elements and optical isomerism, symmetry point groups, classification of molecular point groups. Defining properties of a group, group multiplication table, some examples of group, subgroups and classes.

2) Representations of Groups (06 L)

Matrix representation and matrix notation for geometric transformation, The Great Orthogonality Theorem and its consequence, character tables (No mathematical part), wave function as basis for irreducible representations.

3) Symmetry Adapted Linear Combinations (04L)

Projection operators and their use to construct SALC (Construction of SALC for sigma bonding for molecules belonging to point groups: D_{2h} , D_{3h} , D_{4h} , C_{4v} , T_d , O_h), normalization of SALC, transformation properties of atomic orbitals, MO's for sigma bonding, AB_n molecules, tetrahedral AB_4 and O_h AB_6 cases.

4) Application of Group theory to Infrared Spectroscopy (04L)

Introduction, selection rules, polyatomic molecules, possible vibrations in a linear molecule, bending modes, symmetry of vibrations and their IR activity, Group vibration concept and its limitations, IR spectra related to symmetry of some compounds, IR spectra of complex compounds.

References:

- 1) Chemical Applications of Group Theory by F. A. Cotton
- 2) Symmetry and spectroscopy of molecules by K. VeeraReddy
- 3) Group Theory and its Chemical Application, P.K. Bhattacharya
- 4) Inorganic Chemistry by Shriver and Atkins
- 5) Concise Inorganic Chemistry by J. D. Lee
- 6) Inorganic chemistry: principle of structures and reactivity by Huheey, Keiter, Medhi

Learning outcomes:

1. Student should visualize/ imagine molecules in 3 dimensions.
2. To understand the concept of symmetry and able to pass various symmetry elements through the molecule.
3. Understand the concept and point group and apply it to molecules.
4. To understand product of symmetry operations.
5. To apply the concept of point group for determining optical activity and dipole moment.

6. Student should understand the importance of Orthogonality Theorem.
7. They should be able to learn the rules for constructing character table.
8. Using reduction formulae should be able to find out the possible type of hybridization.
9. Student should know the concept of SALC.
10. Student able to find out character for reducible representation.
11. To know about projection operator.
12. Apply projection operator to find out the normalized wave function for atomic orbital.
13. Student should correlate the application of symmetry to spectroscopy.
14. Students able to find out the possible modes of vibration.
15. From the previous knowledge of symmetry student must be able to find out which modes are IR active.

Section-II

(2 Credits, 24 L, 6 T)

Chemistry of Main Group Elements

1. Hydrogen and its compounds:

(02L)

Classification of Hydrides, electron deficient, electron precise and electron rich hydrides.; PH_3 , SbH_3 , AsH_3 , Selenides, Tellurides.

2. Alkali and Alkaline Earth Metals

(02L)

Solutions in non-aqueous media, application of crown ether in extraction of alkali and alkaline earth metal

3. Boron Group

(04L)

Boron Hydrides, preparation, structure and Bonding with reference to LUMO, HOMO, interconversion of lower and higher boranes, metalloboranes, carboranes, reactions of organoboranes, STYX rules and structure of higher boranes.

4. Carbon Group

(03L)

Allotropes of carbon, Diamond, Graphite, Graphene, fullerenes, carbon nanotube with synthesis, properties, Structure- single walled and multi walled and its application, Intercalation compounds of graphite, Silicates, including Zeolites.

5. Nitrogen Group

(03L) Nitrogen activation, Boron nitride, Oxidation states of nitrogen and their

interconversion, PN and SN Compounds, Applications of PN and SN compounds.

6. Oxygen Group

(03L)

Metal Selenides and Tellurides, oxyacid's, and oxoanions of Sulphur and nitrogen. Ring, Cage and Cluster compounds of p-block elements.

7. Halogen Group:

(02L)

Interhalogens, pseudohalogen, Synthesis, Properties and Applications, Structure, Oxyacid's and Oxyanions of Halogens.

8. Noble gases:

(02L)

Occurrence, Compounds of Xenon-with fluorine and Oxygen and its uses

9. Organometallic Compounds**(03L)**

Organometallic Compounds of Li, Mg, Si, Pb, As, with Classification, Nomenclature, Synthesis, Structure Properties and Uses of Li, Mg, Si, Pb, As, with Classification, Synthesis, Structure Properties and Uses

References:

- 1) Inorganic Chemistry by Shriver and Atkins
- 2) Concise Inorganic Chemistry by J. D. Lee
- 3) Inorganic chemistry by Principle of Structures and Reactivity by Huheey, Keiter, Medhi
- 4) Inorganic Chemistry by Catherine Housecraft
- 5) Inorganic Chemistry by Meissler and Tarr
- 6) Organometallics by Christoph Elschenbroich
- 7) Organometallics by A Concise Introduction by Christoph Elschenbroich and Albrecht Salzer
- 8) Basic Organometallic Chemistry by B. D. Gupta and A. J. Elias

Learning outcomes:

1. Student should understand the detail chemistry of S and P block elements w.r.t. their compounds, their reactions and applications.
2. To learn the advance chemistry of boranes, fullerene, zeolites, polymers etc.
3. Organometallic chemistry of some important elements from the main groups and their applications

Semester-II**CCTP-5: CHI-230, Inorganic Chemistry, Semester – II
(Coordination and Bioinorganic Chemistry) (4 Credits)****SECTION-I (2 Credits, 24 L, 6T)
Coordination Chemistry**

1) Concept and Scope of Ligand Fields: (05 L)
Quantum numbers, Free ion Configuration, Terms and States, Energy levels of transition metal ions, free ion terms, microstates, term wave functions, spin-orbits coupling.

2) Ligand Field Theory of Coordination Complexes (07L)
Effect of ligand field on energy levels of transition metal ions, weak cubic ligand field effect on Russell- Saunders terms, Orgel diagrams, strong field effect, correlation diagrams, Tanabe-Sugano Diagrams, Spin-Pairing energies.

3) Electronic spectra of Transition Metal Complexes (06 L)
Introduction, band intensities, band energies, band width and shapes, transition metals spectra of 1st, 2nd and 3rd row ions and complexes, electronic spectra of Lanthanide and Actinide, spectrochemical and nephelauxetic series, charge transfer and luminescence spectra, calculations of Dq, B, β parameters, percentage of covalent character for metal complexes.

4) Magnetic Properties of Coordination Complexes (06 L)
Origin magnetism, types of magnetism, Curie law, Curie-Weiss Law, Magnetic properties of complexes-Para magnetism, 1st and 2nd Ordered Zeeman effect, quenching of orbital angular momentum by Ligand fields, Magnetic properties of A, E and T ground terms in complexes, spin free and spin paired equilibria, temperature dependence of magnetism.

References:

1. Ligand field theory and its applications by B.N. Figgis and M.A. Hitchman
2. Symmetry and spectroscopy of molecules by K. Veera Reddy
3. Elements of Magnetochemistry by R. L. Datta and A. Syamal

Learning outcomes:

1. Student should be able to find out the no of microstates and meaningful term symbols, construction of microstate table for various configuration
2. Hund's rules for arranging the terms according to energy.
3. Student should understand interelectronic repulsion.
4. Student should know the concept of weak and strong ligand field.
5. Student able to find out splitting of the free ion terms in weak ligand field and strong ligand field.
6. To draw correlations diagram for various configurations in Td and Oh ligand field.
7. Student should know basic instrumentation and selection rules and relaxation in rules.
8. Student should know basic d-d transition, d-p mixing, charge transfer spectra.
9. Interpretation of electronic spectra for spin allowed oh and td complexes using Orgel diagram.
10. Understand the concept of spectro chemical series and Nephelauxetic series.

11. Should able to solve numerical based on crystal field parameters.
12. Understand the various terms involved in magnetochemistry.
13. Various phenomenons of magnetism and their temperature dependence.
14. Various experimental methods to find out magnetic moment.
15. Understand the various Quenching of orbital angular momentum.

Section-II:**(2Credits, 24 L, 6 T)****Bioinorganic Chemistry****1) Overview of Bioinorganic Chemistry****(04 L)**

Historical Background and current relevance, role of Cu, Fe, Mn and Mo in metalloprotein, and metalloenzymes.

2) Concepts of Inorganic Chemistry in Bioinorganic Chemistry**(08L)**

Thermodynamic aspects - HSAB concept, chelate effect and Irving-William series, pK_a values of coordinated ligands, Tuning of redox potential, Biopolymer effects. Kinetic aspects- Electron transfer reaction, Electronic substitution reaction. reactions of coordinated ligands and Template effect, concept of spontaneous self-assembly model compounds.

3) Functions and Transport of Alkali and Alkaline Earth Metal Ions**(04L)**

Importance of alkali and alkaline earth metals, Distribution of cationic and anionic electrolytes in blood plasma and intracellular fluid, Ionophores: Natural and Synthetic, Application of ionophores, Different mechanism involved in exchange of ions across cell wall, Na^+/K^+ -ATPase ion pump for active transport of Na^+ and K^+ .

4) Biochemistry of following Elements:**(08L)**

- (a) Ca in Blood coagulation.
- (b) Magnesium in Photosystem I
- (c) Manganese in Photosystem II
- (d) Iron in Ferritin, Transferrin, Fe-S clusters, Porphyrin based system.

References:

1. Principle of Bioinorganic Chemistry by S.J. Lippard and J. M. Berg
2. Bioinorganic Chemistry: Inorganic Elements in Chemistry of Life by W.Kaim and B. Schwederski

Learning outcomes:

- 1) Importance of bioinorganic chemistry.
- 2) Role of metals in Metalloprotein and metalloenzymes.
- 3) Similarities in coordination theory for metal complexes and metal ions complexed with biological ligands.
- 4) Importance and transport of metal ions.
- 5) Passive transport metal ions by ionophores and gramicidin.
- 6) Mechanism for active transport of Na^+ and K^+
- 7) Nerve impulse generation in rod cell of retina.
- 8) Importance and function of Ca, Fe and Mg in metalloprotein
- 9) Catalytic role of Mn in photosynthesis.

Semester-I**CCTP-3:CHO-150, Organic Chemistry-I, Semester – I (4 Credits)****SECTION-I****(2 Credits, 24 L, 6T)****Basic Organic Chemistry****1. Structure and Reactivity:****(04 L)**

Aromaticity: Benzenoid and non-benzenoid compounds, Huckel's rule, antiaromaticity, Application to carbocyclic and heterocyclic systems, annulenes, azulenes, current concepts of aromaticity.

2. Heterocyclic Chemistry**(08 L)**

Five and six membered heterocycles with one and two hetero atoms: Synthesis, reactivity, aromatic character and importance of following heterocyclic compounds, Furan, Pyrrole, Thiophene, Pyrazole, Imidazole, Pyridine, Pyrimidine

3. Stereochemistry:**(12 L)**

- Stereochemical principles, enantiomeric relationship, distereomeric relationship, R and S, E and Z nomenclature in C, N, S, P containing compounds, Prochiral relationship, stereospecific and stereoselective reactions, optical activity in biphenyls, spiranes, allenes, Topicity.
- Conformational analysis of di, tri, tetra-substituted 5 -6 membered rings and decalins.

SECTION-II**(2 Credits, 24 L, 6T)****1. Structure, Stability and Reactions of Reactive Intermediates****(06 L)**

- Carbocation, Carbanion, Free Radical, Carbenes and nitrenes
- NGP : Neighbouring group participation

2. Rearrangements:**(06 L)**

Beckmann, Hofmann, Curtius, Schmidt, Wolff, Lossen, Bayer-villiger, Sommelet, Favorskii, Pinacol-pinacolone, Benzil-benzilic acid, Fries, Tiffeneau Demjanov.

3. Ylides:**(04 L)**

Phosphorus, Nitrogen and Sulphur ylides

4. Oxidation and Reduction Reactions:**(08 L)**

Oxidising agents: CrO₃, PDC, PCC, KMnO₄, MnO₂, Swern, SeO₂, Pb(OAc)₄, Pd-C, RuO₄, OsO₄, m-CPBA, O₃, NaIO₄, HIO₄, TEMPO, IBX, CAN, Dess-Martin, DDQ, Ag₂O

Reducing agents: Boranes and hydroboration reactions, MPV reduction and reduction with H₂/Pd-C, Raney-Ni, NaBH₃CN, Willkinsons catalyst, DIBAL and Wolff-Kishner reduction, Birch, Clemenson, Dissolving metal

References:

- Organic Chemistry–by J. Clayden, N. Greeves, S. Warren and P. Wothers (Oxford)
- Advanced Organic Chemistry –by J. March 6th Edition
- Advanced Organic Chemistry (Part A) –by A. Carey and R.J. Sundberg
- A guidebook to mechanism in organic chemistry – Peter Sykes 6th Ed.
- Stereochemistry of carbon compound-by E.L. Eliel
- Stereochemistry of organic compound-by Nasipuri
- Stereochemistry conformations and mechanism by P.S. Kalsi

8. Modern Synthetic reactions- H.O. House
9. Organic Synthesis – M.B. Smith
10. Organic chemistry –by Cram, Hammond, Pine and Handrickson
11. Mechanism and structure in Organic Chemistry – E. S. Gould
12. Heterocyclic Chemistry -T. Gilchrist
13. An introduction to the chemistry of heterocyclic compounds-R M Acheso
14. Heterocyclic Chemistry- J A Joule and K Mills
15. Principles of modern heterocyclic chemistry- A Paquette
16. Handbook of Heterocyclic Chemistry- A R Katritzky, A F Pozharskii
17. Heterocyclic Chemistry-II- R R Gupta, M Kumar, V Gupta, Springer (India) pvt

Learning outcomes

At the end of the course the students will know and recall the fundamental principles of organic chemistry that include chemical bonding, nomenclature, structural isomerism, stereochemistry, chemical reactions and mechanism.

1. They will understand the criteria for aromaticity in nonbenzenoid molecules and other advanced polycyclic aromatics
2. Understand the chemistry of monocyclic heterocycles, nomenclature and reactions
3. Learn the concept stereochemistry and its importance; their rules and the concept of chirality
4. Understand the role of various reaction intermediates like carbocation, carbanion, carbenes, radicals, and nitrenes in organic reactions; concept of NGP
5. Able to describe mechanism of different rearrangement reactions. Appreciates the various steps involved in the molecular rearrangements.
6. Understand the chemistry of Ylides
7. Use synthetic reagent of oxidation and reduction for solving the problems

Course outcomes

1. To understand some fundamental aspects of organic chemistry, to learn the concept aromaticity, to understand the various types of aromaticity
2. To study heterocyclic compound containing one and two hetero atoms with their structure, synthesis and reactions.
3. To know stereochemistry of organic compounds; able to do interconversion of Fischer to Newmann, Newmann to Sawhorse and vice versa, Able to assign R and S to given molecules; understand stereoselective and stereospecific reactions; acquire knowledge on topicity.
4. To study structure, formation, stability and related name reaction of intermediates like Carbocation, Carbanion, Free Radical, Carbenes and nitrenes; Recognize neighboring group participation
5. To study rearrangement reaction with specific mechanism and migratory aptitude of different groups.
6. To study Ylides and their reaction.
7. To understands the basis of redox reaction; acquire knowledge about the reagents which causes selective oxidation / reduction in various compounds; learn the basic mechanism of oxidation / reduction in organic compounds.

Semester-II**CCTP-6:CHO – 250, Organic Chemistry-II, Semester–II
(4 Credits)****SECTION-I (2 Credits, 24 L, 6T)****Photochemistry and Pericyclic Reactions****1) Photochemistry [12 L]**

Principles of Photochemistry, photochemistry of carbonyl compounds, alkenes, dienes, and aromatic compounds, photo rearrangements, Barton reaction

2) Pericyclic Reactions [12 L]

Cycloaddition reactions, Analysis by correlation diagrams, FMO approach, Electrocyclic, sigmatropic and ene reactions, 1,3-dipolar additions,

References:

1. Advanced Organic Chemistry, Part A by F. A. Carey and R. J. Sundberg
2. Excited states in Organic Chemistry by J.A. Barltrop and J.D. Coyle
3. Organic photochemistry: A visual approach by Jan Kopecky
4. Conservation of orbital symmetry by R. B. Woodward and R. Hoffmann
5. Orbital Symmetry : A problem solving approach- R. E. Lehr and A. P. Marchand
6. Pericyclic Reactions By A. P. Marchand, Roland E. Lehr
7. Organic reactions and orbital symmetry, 2nd Ed. T. L. Gilchrist and R. C. Storr
8. Molecular Orbitals and Organic Chemical Reactions by Ian Fleming
9. Pericyclic Reactions by Ian Fleming
10. Pericyclic Reactions by A Mechanistic and Problem-Solving Approach by Sunil Kumar Vinod Kumar S.P. Singh
11. Essentials of Pericyclic and Photochemical Reactions by Dinda and Biswanath
12. Pericyclic Reactions - A Textbook: Reactions, Applications and Theory by S. Sankararaman, Roald Hoffmann (Foreword by)

SECTION-II (2 Credits, 24 L, 6T)**Spectroscopic Methods in Structure Determination of Organic Compounds****1. UV and IR Spectroscopy [04L]**

UV: Recapitulation of UV spectroscopy, calculations of λ_{max} of aromatic compounds IR spectra of important functional groups 1. With and without conjugation, 2. Ring size effect 3. Effect of H-bonding, 4. Resonance effect, 5. Inductive effect.

2. ¹H-NMR [12L]

Understanding of basic principle, chemical and magnetic nonequivalence, Homotopism, Enantiotopism, diastereotopism, chemical shifts and factors influencing chemical shift: electronegativity, NMR solvent polarity, temperature, anisotropic effect, chemical shifts of acidic protons, D₂O exchange, Multiplicity patterns and Coupling Constants: Pascal's triangle, understanding of tree diagram, complex splitting patterns in aromatic, vinylic, saturated monocyclic compounds, bicyclic compounds (fused and bridged rings), Integration: NMR of racemic mixture, relationship between integration and ee% in diastereotomers.

Problems: complex problems based on multiple coupling constants should be discussed and drawing of expected ¹H-NMR spectrum along with complex multiplicity patterns and coupling constants. Drawing of multiplicity patterns and determination of coupling constants of complex multiplets should be discussed.

3. ^{13}C -NMR**[04L]**

Basic of ^{13}C -NMR: Chemical shift and factors affecting chemical shifts in ^{13}C NMR, off resonance and proton decoupled spectra. Simple problems on ^{13}C -NMR.

4. Mass spectrometry (MS)**[04L]**

Basic principle of MS, significance of M^+ (m/z) in determination of molecular formula, Rule of 13. Genesis of m/z fragments: alkanes (cyclic and acyclic), alcohols, amines

Problems: Based on 2-3 fragments of above mentioned functional groups should be discussed.

Combined problems: Problems based on UV, IR, MS, ^1H -NMR, ^{13}C -NMR should be solved.

References:

1. Introduction to Spectroscopy by Donald L. Pavia and Gary M. Lampman
2. UV-VIS Spectroscopy and Its Applications by Perkampus, Heinz-Helmut
3. Infrared Spectroscopy: Fundamentals and Applications by Barbara H. Stuart
4. Infrared Spectroscopy by James M. Thompson
5. Spectrometric Identification of Organic Compounds by Robert M. Silverstein, Francis X. Webster, David J. Kiemle, David L. Bryce
6. Introduction to Spectroscopy by Donald L. Pavia
7. Understanding NMR Spectroscopy by James Keeler
8. Spin Dynamics: Basics of Nuclear Magnetic Resonance by Malcolm H. Levitt
9. Guide to Spectroscopic Identification of Organic Compounds by Karen Feinstein
10. Principles of Nuclear Magnetic Resonance in One and Two Dimensions by Richard R. Ernst, Geoffrey Bodenhausen, Alexander Wokaun
11. NMR Spectroscopy: Basic Principles, Concepts and Applications in Chemistry by Harald Günther
12. Basic One- and Two-Dimensional NMR Spectroscopy by Horst Friebolin
13. Principles of Nuclear Magnetism by A. Abragam
14. Principles of Magnetic Resonance by Charles P. Slichter
15. Nuclear Magnetic Resonance by Peter Hore
16. Applications of NMR Spectroscopy by Atta-ur-Rahman, M. Iqbal Choudhar
17. Solving Problems with NMR Spectroscopy by Atta-ur-Rahman Muhammad Choudhary Atia-tul- Wahab

Learning outcomes:

1. Students should be able to understand free radicals' formation, stability and reactivity and should also be able to use the basic understanding in writing probable reaction mechanisms.
2. Students should be able to write MO diagram for various olefinic compounds and should be able to predict the products, the stereochemistry as well as should be able to understand the preferred reaction pathways.
3. Students should be able to calculate λ_{max} of organic compounds containing more than one and less than four conjugated systems. Students should be able to correlate IR bands with functional groups using numerical data as well as spectral data.
4. Students should be able to solve ^1H -NMR problems and should also be able to draw the ^1H -NMR spectrum for simple organic compounds mentioning multiplicity pattern and coupling constant with the help of "Tree Diagram" Should be able to predict and analyze the multiplicity patterns with more than one coupling constants.

5. Students should be able to use ^{13}C -NMR data to interpret the structure NMR problems and should also be able to draw the ^1H -NMR spectrum for simple organic compounds mentioning multiplicity pattern and coupling constant with the help of "Tree Diagram" Should be able to predict and analyze the multiplicity patterns with more than one coupling constants.
6. Students should know various key factors responsible for the spectroscopic data acquisition and should be able to solve Problems based on UV, IR, MS, ^1H -NMR, ^{13}C -NMR.

Course outcomes:

Students will be able to understand -

1. MOT and will be able to extend this in predicting reaction mechanism and stereochemistry of electrocyclic reactions.
2. The concepts in free radical reactions, mechanism and the stereochemical outcomes.
3. The basic principle of spectroscopic methods and their applications in structure elucidation of organic compounds using given spectroscopic data or spectra.

Semester-I**CBOP-1: CHG – 190, General Chemistry-I, Semester-I (4 Credits)****SECTION-I: Theory Course (2 Credits, 24 L, 6T)****(Any one option is to be selected by candidate)****Elective Option-A : Introduction to Solid State of Matter****1. Bonding in Solids and Electronic Properties (Ref-1, 4) (05 L)**

Recollect the concepts: Crystalline solids, unit cell, and types of unit cells

Introduction, Bonding in Solids—Free Electron Theory, Electronic Conductivity, Bonding In Solids—Molecular Orbital Theory, Simple Metals, Semiconductors—Si And Ge, Photoconductivity, The *P-N* Junction—Field-Effect Transistors, Bands In Compounds—Gallium Arsenide, Bands In D-Block Compounds—Transition Metal Monoxides.**2. Defects and Non-Stoichiometry (Ref-1, 4) (07 L)**

Introduction, point defects—an introduction, defects and their concentration, intrinsic defects, extrinsic defects the concentration of defects, ionic conductivity in solids, solid electrolytes, fast-ion conductors: oxygen ion conductors, fast-ion conductors: sodium ion conductors, Applications: 1) fuel cells, 2) sensors, 3) electrochromic devices, non-stoichiometric compounds, introduction, non-stoichiometry in wustite, the titanium monoxide structure.

3. Superconductivity (Ref-1, 4) (04 L)

Introduction, Discovery, The Magnetic Properties Of Superconductors, Josephson Effects, The Bcs Theory Of Superconductivity, High Temperature Superconductors, Theory Of High Tc Superconductors, Uses Of High Temperature Superconductors

4. Synthesis of Solids (Ref-2 and 3) (08L)Introduction, Common Reactions Employed in Synthesis, Soft-Chemistry Routes, Ceramic Methods, Decomposition of Precursor Compounds, Combustion Synthesis, Mechano-chemical and Sono-chemical methods, Soft Chemistry Routes(Ion Exchange Reactions, Use of Fluxes, Sol–Gel Synthesis, Electrochemical Methods, Hydrothermal, Solvothermal and Ionothermal Synthesis), Chemical Vapour Deposition and Atomic Layer Deposition, Procedures of synthesis of some nano-materials- Gold and Silver nanoparticles, CdS nanoparticles, ZnO, TiO₂ and Fe₂O₃ nanoparticles and Porous Silica**References**

Ref.-1: Elaine A. Moore, Lesley E. Smart - Solid State Chemistry - an Introduction. Third Ed. / Fourth Ed. CRC Press (2012)

Ref-2: C. N. R. Rao, Kanishka Biswas, Essentials of inorganic materials synthesis, Wiley, 2015

Ref-3: Nanotechnology: Principles and Practices, S. K. Kulkarni, Third Ed. Springer

Ref-4: Anthony R. West, Solid State Chemistry and its Applications Second Edition (Student Edition), Wiley.

Learning outcomes

At the end of course student will understand

1. Bonding in solids – band theory
2. Electronic conductivity
3. Semiconductors, photoconductivity
4. Non-stoichiometry, defects and types of defects in solids
5. Ionic conductivity and their applications
6. Superconductivity and theory of superconductivity

7. Method of synthesis of solids

Elective Option-B: Chemical Mathematics**1. Functions (14 L)**

Differential and integral calculus, limits, derivatives, physical significance, basic rules of differentiation, maxima and minima, application in chemistry, exact and inexact differentiation, Taylor and McLaurin Theorem, curve sketching, partial differentiation, rules of integration, separation of variable, substitution, partial function method to solve to indefinite integrals in chemistry

2. Differential Equations (06 L)

Separation of variables, homogeneous, exact, linear equations of second order, series solution method.

3. Vectors Matrices, and Determinants (04 L)

Vectors, dot, Cross and triple products, introduction to matrix algebra, addition and multiplication of matrices, inverse, adjoints and transport of matrices, unit and diagonal matrices.

References:

- 1) Chemical Maths Book, E. Steiner, Oxford University Press (1996).
- 2) Maths For Chemists Vol. 1 and 2, Martin MCR Cockett and G. Doggett, Cambridge (2003).
- 3) Mathematical Preparation for Physical Chemistry, F. Daniels, McGraw Hill (1972)

Elective Option-C: Introduction to Chemical Biology-I**1. Overview of Biochemical Concepts (03 L)**

Central dogma of cell biology, prokaryotes- eukaryotes and subcellular components, Overview of cell metabolism, Interdisciplinary approach, Biomolecules as potential drug targets

2. Chemistry of Biomembranes (06 L)

Structure, Functions and Composition, Fluid Mosaic Model by Singer and Nicholson, Properties of membrane, Transport of Ions (Na^+ , K^+ , H^+ , Ca^{2+} , Cl^-) and Molecules (Glucose, Amino acids, Proteins), transport across the membrane, Uniport, Symport, Antiport, Active and Passive facilitated transport, Exocytosis and Endocytosis (Pinocytosis, phagocytosis, receptor mediated endocytosis), Drug transport, Amphipathic nature and Significance of liposomes

3. Carbohydrates (04 L)

Classification, Structure and Properties, Derived sugars and their significance, Glycoproteins, glycolipids

4. Lipids (04 L)

Classification, Structure and Properties of lipids, Saponification number, Iodine number, Acid number, Rancidity of lipids, Lipoproteins

5. Amino Acids and Proteins (07 L)

Introduction, Classification of amino acids, Physico chemical properties, Optical properties, Peptide bond, Primary, Secondary, Tertiary and Quaternary structure of proteins, Protein-Ligand interactions, Denaturation of proteins, Oligopeptide synthesis, Concept of proteomics

References:

1. Principles of biochemistry, Albert Lehninger (CBS Publisher and Distributors Pvt. Delhi.
2. Harper's Biochemistry by R.K. Murray, D. I. Granner, P. A. Mayes, (Prentice Hall International Inc.)

3. Biochemistry by U. Satynarayana
4. Biochemistry by J. L. Jain
5. Biophysical Techniques by Upadhyaya Nath

Course Outcomes:

The goal of this course is to introduce students to fundamental concepts in Chemical Biology and methods of chemistry used to solve problems in molecular and cell biology. After completion of this course, successful students will:

- 1) Students will be able to explore new areas of research in both chemistry and allied fields of science and technology.
- 2) Students will be able to function as a member of an interdisciplinary problem solving team.
- 3) To impart the students thorough idea in the chemistry of carbohydrates, amino acids, proteins and nucleic acids etc.
- 4) Be able to describe the chemical basis for replication, transcription, translation and how each of these central processes can be expanded to include new chemical matter.
- 5) Develop skills to critically read the literature and effectively communicate research in a peer setting.

SECTION-II: Practical Course (2 Credits, 48 L 12T)
(Any one option to be selected by candidate)

Elective Option-A: Inorganic Material Analysis, Synthesis and Applications

Time allotted: One practical session of 4 hours per week for one semester

Part-I: Analysis (at least two of the following) (Ref. -1)

1. Determination of Silica and Manganese from pyrolusite ore.
2. Determination of Aluminum and Silica from Bauxite ore.
3. Determination of silica and iron from hematite ore.
4. Determination of copper and iron from Chalcopyrite ore.

Part-II: Alloy Analysis (at least two of the following) (Ref. -1)

5. Determination of tin and lead from solder alloy.
6. Determination of iron and chromium from stainless steel alloy.
7. Determination of copper and nickel from cupranickel alloy.

Part-III: Synthesis of solid state materials / nano-materials (any three) (Ref- 2 and 3)

8. Synthesis of ZnO from zinc oxalate - precursor method and determine band gap by absorption spectroscopy
9. Synthesis of TiO₂ TiCl₄ or Ti-Isopropoxide by Sol-gel method and determine band gap by absorption spectroscopy
10. Synthesis of Colloidal silver nanoparticles and determine band gap by absorption spectroscopy
11. Synthesis of Fe₂O₃ nanoparticles sol-gel/coprecipitation/hydrothermal (any one method)
12. ZnO, TiO₂, Fe₂O₃ nanoparticles powder XRD, SEM, TEM (at least one spectral analysis should be done)

Part-IV: Applications of Solid State Materials

12. Removal and kinetics of photocatalytic dyes, degradation (methylene blue) by ZnO TiO₂ photocatalysis (Ref-2)
13. Study of adsorption of phosphate ion on α -Fe₂O₃ (Ref-2)

References:

1. Text book of Quantitative Analysis by A.I. Vogel 3^{ed} (1963).
2. Experimental Inorganic Chemistry by Mounir A. Malati, Horwood
3. Nanotechnology by S. K. Kulkarni

Examination Scheme:

1. The examination structure will be given before the commencement of examination.
2. 50% students will be assigned experiment on part-I or II while remaining – (analysis of any one component) 50% students will assigned experiment on part-III and IV.
3. Use of only university supplied procedure will be allowed at the time of examination.

Elective Option - B: Chemical Biology-I Practical

Time allotted: One practical Session of 4 hours per week for one semester

1. Statistical treatment of experimental data (calculation of mean and standard deviation for given data and least square method for calibration curve method) - Compulsory

Perform at least 10 Practical from the following

1. Preparation of biological buffers.
2. Qualitative analysis of carbohydrates
3. Qualitative analysis of Lipids
4. Qualitative analysis of amino acids
5. Paper chromatographic / TLC separation of mixture of amino acids and their detection
6. Paper chromatographic separation of mixture carbohydrates and their detection
7. Quantitative estimation of Glucose by dinitro salicylic acid by using calorimetric method
8. Quantitative estimation of proteins by Lowry's method
9. Kjeldahl method of Protein Determination
10. Saponification number of fats
11. Iodine value of oil
12. Isolation Quantitative estimation of DNA by Diphenyl amine method
13. Determination of Inorganic Phosphate in Biological Samples

References:

1. A reference book of biochemistry practicals by Sadashivam
2. Practical approach to biochemistry by Plummer
3. Martin Holtzhauer, Basic Methods for the Biochemical Lab, First Edition, Springer

Examination Scheme:

1. The examination structure will be given before the commencement of examination.
2. Use of only university supplied procedure will be allowed at the time of examination.

Semester-II**CBOP-2: CHG – 290, General Chemistry -II,****(4 Credits)****SECTION-I: Theory Course****(2 Credits, 24 L, 6T)****(Any one option is to be selected by candidate)****Elective Option-A: Material Characterization Technique****1. X-Ray Diffraction Methods (Ref-1) (6 L)**

Miller and Weiss indices, X-Ray Radiation, Generation of X-Rays, X-Ray Absorption, Theoretical Background of Diffraction, Diffraction Geometry, Bragg's Law, Reciprocal Lattice, Diffraction Intensity, Structure Extinction, X-Ray Diffractometry, Instrumentation, System Aberrations, Samples and Data Acquisition, Sample Preparation, Acquisition and Treatment of Diffraction Data, Distortions of Diffraction Spectra, Crystallite Size, Applications, Crystal-Phase Identification, Quantitative Measurement, Wide-Angle X-Ray Diffraction and Scattering, Wide-Angle Diffraction, Wide-Angle Scattering. Problem on XRD (Calculation of d values, assigning planes, calculation of crystal parameters)

2. Transmission Electron Microscopy (Ref-1) (4 L)

Instrumentation, Electron Sources, Thermionic Emission Gun, Field Emission Gun, Electromagnetic Lenses, Specimen Stage, Specimen Preparation, Prethinning, Final Thinning, Electrolytic Thinning, Ultramicrotomy, Image Modes (Mass-Density Contrast, Diffraction Contrast, Phase Contrast), Selected-Area Diffraction (SAD), Selected-Area Diffraction Characteristics.

3. Scanning Electron Microscopy (Ref-1) (4 L)

Instrumentation, Optical Arrangement, Signal Detection, Detector, Probe Size and Current Contrast Formation, Electron-Specimen Interactions, Topographic Contrast, Compositional Contrast, Operational Variables, Working Distance and Aperture Size, Acceleration Voltage and Probe Current, Astigmatism, Specimen Preparation, Preparation for Topographic examination.

4. X-Ray Spectroscopy for Elemental Analysis (Ref-1) (10 L)

Features of Characteristic X-Rays, Types of Characteristic X-Rays, Selection Rules, Comparison of K, L, and M Series, X-Ray Fluorescence Spectrometry, Wavelength Dispersive Spectroscopy, Analyzing Crystal, Wavelength Dispersive Spectra, Energy Dispersive Spectroscopy, Detector, Energy Dispersive Spectra, Advances in Energy Dispersive Spectroscopy, XRF Working Atmosphere and Sample Preparation, Energy Dispersive Spectroscopy in Electron Microscopes, Special Features, Scanning Modes, Qualitative and Quantitative Analysis, Qualitative Analysis, Quantitative Analysis, Quantitative Analysis by X-Ray Fluorescence, Fundamental Parameter Method, Quantitative Analysis in Electron Microscopy, Numerical.

References:

- 1: Yang Leng, Materials Characterization -Introduction to Microscopic and Spectroscopic Methods, Second Ed. Wiley-VCH,
- 2: R. D. Braun, Introduction to Instrumental Analysis, Second Ed.
- 3: Elaine A. Moore, Lesley E. Smart - Solid State Chemistry - an Introduction. Fourth Ed. CRC Press (2012)

Learning outcomes:

At the end of course student will understand / able to explain

1. Different characterization technique of solids.
2. Principle of XRD, instrumentation of powder XRD, Bragg's law, applications of XRD for crystal structure determination, numerical problems.
3. Principle of SEM, instrumentation of SEM and interpretation of surface morphology of solid from SEM.
4. Principle of TEM, instrumentation of TEM and interpretation of TEM images.
5. Basics of X-rays, Principle of XRF, types of XRF, instrumentation, qualitative and quantitative analysis, numerical.

Elective Option - B: Organometallic and Inorganic Reaction Mechanism

1. Organometallic Chemistry (08 L)

Organic ligands and nomenclature, 18 electron rule: counting electrons, ligands having extended pi system, bonding between Metal Atoms and organic pi systems: linear pi system, cyclic pi system, spectral analysis and characterization of organometallic complexes: IR and NMR, examples.

2. Organometallic Reactions and Catalysis (08 L)

Reactions involving gain and loss of ligands: ligand dissociation and substitution, oxidative addition, reductive elimination, nucleophilic displacement, reactions involving modification of ligands: insertion, carbonyl insertion, 1-2 insertion, hydride elimination, abstraction, organometallic catalysis: Hydroformylation, Monsanto acetic acid process, Wacker Process, Hydrogenation by Willkinsons catalyst, Olefin metathesis, heterogeneous catalysis: Ziegler Natta Polymerization, Water gas reduction.

3. Coordination Compounds: Reactions and Mechanism (08L)

History and principles, Substitution reactions: Inert and labile complexes, mechanism of substitution, Kinetics Consequences of reaction pathway: dissociation, interchange, association, Experimental evidences in Octahedral Substitution: dissociation, linear free energy relationship, associative mechanism, the conjugate base mechanism, the kinetic chelate effect, Stereochemistry of reactions: substitution in trans complexes, substitution in cis complexes, isomerisation of chelate rings, substitution reactions in Sq. Pl. Complexes.

Reference

- 1) Inorganic Chemistry: Gary Miessler and Donald A. Tarr, Third Ed., Pearson (Chapter-12, 13 and 14 pages: 422 to 561)
- 2) IUPAC Nomenclature of Organometallic Compounds of Transition Metals by Salzer http://publications.iupac.org/pac/1999/71_08_pdf/7108salzer_1557.pdf

Learning Outcomes:

At the end of course students will be able to explain

1. Valence electron count, back bonding in organometallics, spectral characterization of organometallic compounds.
2. Catalytic reaction involving organometallic compounds and mechanism of these reactions
3. Types of reaction involving organometallic compounds

4. Types of reactions in coordination compounds, inert and labile complexes, substitution reactions in coordination complexes and their mechanism, stereochemistry of reaction, kinetics of reactions.

Elective Option– C: Introduction to Chemical Biology-II

1. Enzymes

(06 L)

Classification w.r.t. reaction catalysis, Theory of Enzyme -Substrate (ES) formation, Active sites and its features, Enzyme specificity, Factors affecting enzyme activity, enzyme Kinetics (MM equation, LBW equation), Allosteric enzymes, Types of enzyme inhibition, Industrial applications of enzymes

2. Nucleic Acid

(06 L)

Central dogma of molecular biology, Differences between DNA and RNA, Overview of replication transcription, Genetic code, translation, Gene cloning, Gene Therapy, Applications of Biotechnology

3. Metabolism of Biomolecules

(06 L)

Aerobic and Anaerobic glycolysis, TCA Cycle, Beta oxidation of fatty acids, Trans amination, deamination, decarboxylation of amino acids, Urea cycle

4. Biochemical Techniques

(06 L)

Protein purification and characterization, Dialysis, Chromatography, Electrophoresis, Native and SDS-PAGE

References:

1. Principals of biochemistry, Albert Lehninger (CBS Publisher and Distributers Pvt. Delhi.
2. Harper's Biochemistry by R.K. Murray, D. I. Granner, P. A. Mayes, (Prentice Hall International Inc.)
3. Biochemistry by U. Satynarayana
4. Biochemistry by J. L. Jain
5. Biophysical Techniques by Upadhyaya Nath

Learning outcomes:

The goal of this course is to introduce students to fundamental concepts in Chemical Biology and methods of chemistry used to solve problems in molecular and cell biology. After completion of this course, successful students will:

- 1) Students will be able to explore new areas of research in both chemistry and allied fields of science and technology.
- 2) Students will be able to function as a member of an interdisciplinary problem solving team.
- 3) To impart the students thorough idea in the chemistry of carbohydrates, amino acids, proteins and nucleic acids etc.
- 4) Be able to describe the chemical basis for replication, transcription, translation and how each of these central processes can be expanded to include new chemical matter.
- 5) Develop skills to critically read the literature and effectively communicate research in a peer setting.
- 6) Describe the importance of chemical biology research and interdisciplinary work.

SECTION-II: Practical Course (2 Credits, 48 L, 12T)
(Any one option to be selected by candidate)

Elective Option-A: Electrochemical Methods of Analysis

Time allotted: One practical Session of 4 hours per week for one semester

Total 11 practical to be conducted

Part-I: Conductometry: (Any three)

1. Hydrolysis of NH_4Cl or CH_3COONa or aniline hydrochloride.
2. Determination of λ_0 or λ_α and dissociation constant of acetic acid.
3. Hydrolysis of ethyl acetate by NaOH .
4. Determination of ΔG , ΔH , and ΔS of silver benzoate by conductometry.
5. Determination of critical micellar concentration (CMC) and ΔG of micellization of sodium Lauryl Sulphate / Detergent

Part-II: Polarography (any one)

6. Determination of half wave potential $E_{1/2}$ and unknown concentration of Cu or Pb or Zn ion.
7. Amperometric titration of $\text{Pb}(\text{NO}_3)_2$ with $\text{K}_2\text{Cr}_2\text{O}_7$.

Part-III: Potentiometry: (Any three)

8. Stability Constant of a complex ion.
9. Solubility of a sparingly soluble salt.
10. To determine the ionic product of H_2O
11. Estimation of halide in mixture.

Part-IV: pH metry (any two)

12. Determination of the acid and base dissociation constant of an amino acid and hence the isoelectric point of the acid.
13. Determination of dissociation constants of tribasic acid (phosphoric acid)
14. Construct pH curve for titration of strong base – strong acid, strong base - weak acid and predict the best indicator in these titrations (methyl orange, methyl orange, brocresol green, phenolphthalein, etc.)

Part-V: Table Work (any two)

15. Analysis of powder XRD of SrTiO_3 and Ag metal or any two compounds (Calculation d, lattice constant, crystal volume and density, and assigning planes to peaks using JCPDS data)
16. Cyclic voltamogram of $\text{K}_3\text{Fe}(\text{CN})_6$ in $\text{KCl}/\text{H}_2\text{O}$ / Ferrocene in TEAP/MeCN
17. Detailed interpretation of Raman spectra of diatomic molecules

References:

1. Practical physical chemistry, A. Findlay, T.A. Kitchner (Longmans, Green and Co.)
2. Experiments in Physical Chemistry, J.M. Wilson, K.J. Newcombe, A.r. Denko. R.M.W. Richett(Pergamon Press)
3. Senior Practical Physical Chemistry, B.D. Khosla and V.S. Garg (R. Chand and Co., Delhi.).
4. Experimental Physical Chemistry by D. P. Shoemaker, Mc. Growhill, 7th Edition, 2003.
5. Physical chemistry by Wien (2001)
6. Advance Physical Chemistry Experiment, Gurtu and Gurtu, Pragati Publication (Meerut)

7. Experiments in Chemistry, D. V. Jahagirdar, Himalaya Publishing House
8. Practical physical Chemistry, B. Vishwanathan and P. S. Raghwan, Viva Books

Examination Scheme:

1. The examination structure will be given before the commencement of examination.
2. Use of only university supplied procedure will be allowed at the time of examination.

Elective Option-B: Chemical Biology-II Practical

Time allotted: One practical Session of 4 hours per week for one semester

Perform at least 11 Practical

1. Dialysis and Reverse dialysis of protein salt solution
2. Separation of protein by Gel filtration method
3. Separation of protein by affinity chromatography method
4. Separation of protein by Ion exchange chromatography
5. Native and SDS PAGE of proteins
6. Separation of amino acids by paper chromatography
7. Separation of nucleic acid by Agarose gel electrophoresis
8. Effect of pH on enzyme activity
9. Effect of Temperature on enzyme activity
10. Effect of substrate concentration on enzyme activity
11. Detection of λ Max of proteins
12. Detection of λ Max of Nucleic acid

References:

1. A reference book of Biochemistry Practicals by Sadashivam
2. Practical approach to biochemistry by Plummer
3. Martin Holtzhauer, Basic Methods for the Biochemical Lab, First Edition, Springer

Examination Scheme:

1. The examination structure will be given before the commencement of examination.
2. Use of only university supplied procedure will be allowed at the time of examination.

Semester-I

CCPP-1: CHP-107: Practical Course – I: Semester -I

Basic Practical Chemistry (Compulsory)

(4 Credits, 96 L, 24T)

Time allotted: Two practical sessions of 4 hours per week for one semester (one practical session for Section-I and one practical session for Section-II per week is compulsory)

Sec-I: Physical Chemistry Practical (11 Experiments)

1. Statistical treatment of experimental data (calculation of mean and standard deviation for given data and least square method for calibration curve method) (compulsory)

Part-I: Chemical Kinetics: (Any three)

2. Kinetic decomposition of diacetone alcohol by dilatometry.
3. Determination of an order of a reaction.
4. Brönsted primary salt effect.
5. Kinetics of oxidation of ethanol by $K_2Cr_2O_7$

Part-II: Non-Instrumental: (Any Three)

6. Determination of surface excess of amyl alcohol or TX-100 surfactant by Capillary rise method.
7. Determination of molecular weight by steam distillation.
8. Glycerol radius by viscosity.
9. Partial Molar Volume (Polynometry) Determination of the densities of a series of solutions and to calculate the molar volumes of the components.

Part-III: Colorimetry and spectrophotometry (Any four experiments)

10. Simultaneous determination of Ni and Co by spectrophotometry (Ref-1)
11. Simultaneous determination of $KMnO_4$ and $K_2Cr_2O_7$ by spectrophotometry. (Ref-7)
12. To study the adsorption of certain dyes such as methyl violet, picric acid or malachite green on charcoal. (Ref-2)
13. To determine the indicator constant of bromocresolpuple by half height method (Ref-8)
14. Estimation of Cu(II) by titration with Na_2 EDTA by colorimetry
15. a. Determination of energy of n to Π^* transition in acetone and study of effect of solvent on energy of this transition by recording absorbance spectra in n-hexane and water. b. To study the effect of the extended conjugation on the λ_{max} of p-nitro phenol by recording spectrum in acidic and alkaline medium (Ref-8).

Part -IV: Radioactivity: (Any one)

10. Estimation of Mn in tea leaves by NAA.
11. Half-life of a radioactive nuclide and counting errors.
12. Determination of E-max of β radiation and absorption coefficients in Al.

References:

1. Practical physical chemistry, A. Findlay, T.A. Kitchner (Longmans, Green and Co.)
2. Experiments in Physical Chemistry, J.M. Wilson, K.J. Newcombe, A.r. Denko. R.M.W. Richett(Pergamon Press)
3. Senior Practical Physical Chemistry, B.D. Khosla and V.S. Garg (R. Chand and Co., Delhi.).

4. Experimental Physical Chemistry by D. P. Shoemaker, Mc. Growhill, 7th Edition, 2003.
5. Physical chemistry by Wien (2001)
6. Advance Physical Chemistry Experiment, Gurtu and Gurtu, Pragati Publication (Meerut),
7. Experiments in Chemistry, D. V. Jahagirdar, Himalaya Publishing House
8. Practical physical Chemistry, B. Vishwanathan and P. S. Raghwan, Viva Books

Sec-II: Organic Chemistry (11 Experiments)

Introduction to Laboratory Safety: Meaning of safety signs on container of chemicals, safety handling of chemicals, MSDS sheets: Detailed explanation at least for 4 different types of substances (e.g. nitric acid, benzene, potassium dichromate, bromine, etc.), Handling of glassware's and care to be taken, handling of organic flammable as well as toxic solvents in laboratory, use of safety goggles, shoes and gloves, fire extinguisher and its use, action to be taken in accidental cases e.g. cleaning of acid spill over, use eye wash station and bath station in emergency, etc. (compulsory)

Part-I: Purification Techniques (Compulsory) (8 Experiments)

- a) Purification of **two** organic solids by recrystallization using solvents other than water
- b) Purification of **two** organic liquids by upward/downward/traditional distillation technique
- c) Column Chromatography technique should be performed for any one of the following preparation
- d) Sublimation by Cold Thumb Method
- e) Thin Layer Chromatography technique **two mixtures**

Part-II: Introduction to Green Chemistry (Compulsory 1 Practical)

Concept of green chemistry, twelve principals of green chemistry, applications of green chemistry for sustainable development, Atom economy, Monitoring of reaction using TLC.

Green Chemistry Experiments (any two)

1. Preparation of Schiff's bases in aqueous medium.
2. Preparation of dihydropyrimidinone under solventfree conditions
3. Preparation of acetanilide from aniline and acetic acid using Zn dust

1. Examination Scheme:

1. The examination structure will be given before the commencement of examination.
2. Use of only university supplied procedure will be allowed at the time of examination.
3. One experiment from Physical chemistry and any one experiment from organic section will be assigned.

Semester-II

CCPP-2: CHP-227: Practical Course-II: Semester -II

Basic Practical Chemistry (Compulsory) (4 Credits, 96 L, 24T)

Time allotted: Two practical sessions of 4 hours per week for one semester (one practical session for Section-I and one practical session for Section-II per week is compulsory)

Section-I: Inorganic Chemistry (11 Experiments)

Part-I: Synthesis of coordination complexes (any three) (Ref. 2)

1. Synthesis and Purity of $[\text{Mn}(\text{acac})_3]$
2. Synthesis and Purity Chloropentaamminecobalt(III) chloride.
3. Synthesis and Purity Nitro pentaamminecobalt(III) chloride.
4. Synthesis and Purity Bis $[\text{TrisCu}(\text{I})\text{thiourea}]$

Part-II: Inorganic Conductometry (any two)

4. Structural determination of metal complexes by conductometric measurement. (Ref-3)
5. To study complex formation between Fe(III) with sulfosalicylic acid by conductometry (Ref-3).
6. To verify the Debye Huckel theory of ionic conductance for strong electrolytes KCl, BaCl_2 , K_2SO_4 and $[\text{K}_3\text{Fe}(\text{CN})_6]$ (Ref-3)
7. Determination of Pb(II) in solution with Na_2SO_4 solution and determination of solubility product of PbSO_4 (Ref-4)

Part-III: Inorganic characterization techniques (any two of the following)

8. Determination of equilibrium constant of M – L systems Fe(III)–Sulphosalicylic acid or Fe(III)– β –resorcinic acid by Job's continuous variation method. (Ref.-3, 5)
9. Solution state preparation of $[\text{Ni}(\text{en})_3]\text{S}_2\text{O}_3$, $[\text{Ni}(\text{H}_2\text{O})_6]\text{Cl}_2$, $[\text{Ni}(\text{NH}_3)_6]\text{Cl}_2$. Record absorption spectra in solution of all three complexes and calculate 10 Dq. Arrange three ligands according to their increasing strength depending on your observations. (Ref. -5)
10. Determination of magnetic susceptibility (χ_g and χ_m) of mercury tetracyanato cobalt or $\text{Fe}(\text{acac})_3$ or Ferrous ammonium sulfate by Faraday or Gouy method. (Ref. -3, 5)

Part-IV: Inorganic Kinetics Experiment (any two)

11. Synthesis and photochemistry of $\text{K}_3[\text{Fe}(\text{C}_2\text{O}_4)_3] \cdot 3\text{H}_2\text{O}$. (Ref-4)
12. Kinetics of substitution reaction of $[\text{Fe}(\text{Phen})_3]^{2+}$ (Ref-3)
13. Kinetics of formation of Cr(III)-EDTA complex (Ref-3)

Part-V: Ion – Exchange Chromatography (Ref. -1 and 3)

1. Separation of mixture of Zn(II) and Mg(II) using Amberlite IRA 400 anion exchanger and quantitative estimation of separated ions Zn(II) and Mg(II)

Part-VI: Solvent Extraction and colorimetric (any one experiment) (Ref. -1 and 3)

2. Determination of Cu(II) by solvent extraction as Dithiocarbamate complex (Ref-1)
3. Determination of iron by solvent extraction techniques in a mixture of Fe(III) +Al(III) or Fe(III) + Ni(III) using 8-hydroxyquinoline reagent. (Ref. -1)

References:

1. Vogel's Textbook of Inorganic quantitative analysis
2. Experimental Inorganic Chemistry, Mounir A. Malati, Horwood Series in Chemical Science (Horwood publishing, Chichester) 1999.

3. Experiments in Chemistry, D. V. Jahagirdar, Himalaya Publishing House
4. General Chemistry Experiments, Anil. J Elias, University Press (2002)
5. Practical physical Chemistry, B. Vishwanathan and P. S. Raghwan, Viva Books

Section -II: Organic Chemistry (11 Experiments)

1. Base catalyzed aldol condensation using LiOH.H₂O as a Catalyst.
2. Bromination of *trans*-stilbene using sodium bromide and sodium bromate
3. [4+2] cycloaddition reaction in aqueous medium at room temperature
4. BenzilBenzilic acid rearrangement under solvent free condition
5. Clay catalyzed solid state synthesis of 7-hydroxy-4-methylcoumarin
6. Ecofriendly nitration of phenols and its derivatives using Calcium nitrate
7. Bromination of acetanilide using ceric ammonium nitrate in aqueous medium
8. Green approach for preparation of benzopinacolone from bezopinacol using iodine catalyst,
9. Preparation of 1, 1-bis-2-naphthol under grinding at room temperature.
10. Solvent free aldol condensation between 3,4-dimethoxybenzaldehyde and 1-indanone
11. Preparation of azlactone from hippuric acid
12. Preparation of thioamide from benzaldehyde in water.

Note: Students should perform a) Relevant chemical analysis. b) Column chromatography. c) Elemental analysis. d) Spectroscopic interpretation. e) How to draw schemes and mechanism using Chem Draw / ISIS Draw etc.

N B. :

1. Use molar concentrations for volumetric /estimations/synthesis experiments.
2. Use optimum concentrations and volumes
3. Two burette method should be used for volumetric analysis (Homogeneous mixtures)
4. Use of microscale technique is recommended wherever possible

References:

1. Comprehensive Practical Organic Chemistry by V.K. Ahluwalia and Renu Aggarwal
2. Monograph on Green Chemistry Laboratory Experiments by Green Chemistry TaskForce Committee, DST

Learning Outcomes:

1. This course is designed to make students aware of how to perform organic compounds in laboratory.
2. The course includes synthesis of some derivatives and organic compounds, which will help them while working in research laboratory in future.
3. Making derivatives of organic compounds will help them in industry or while doing research in medicinal chemistry for Drug development.
4. This practical course is also designed to make student aware of green chemistry and role of green chemistry in pollution reduction.
5. The students learn how to avoid solvents and do solvent free reaction.
6. Also the work-up procedure in many experiments is made more eco-friendly to environment.

Course Outcomes:

1. Students are trained to different purification techniques in organic chemistry like recrystallization, distillation, steam distillation and extraction.
2. Students are made aware of safety techniques and handling of chemicals.

3. Students are made aware of carrying out different types of reactions and their workup methods.
4. This practical course is designed to make student aware of green chemistry and role of green chemistry in pollution reduction.

Examination Scheme:

1. The examination structure will be given before the commencement of examination.
2. Use of only university supplied procedure will be allowed at the time of examination.
3. Any one experiment from inorganic chemistry and any one experiment from organic section will be assigned time the time of examination.

Pattern of Question Paper

For theory courses, end semester question papers will be set by the University and centralized assessment for theory papers done as per the rules laid down by the University. Questions will be designed to test the conceptual knowledge and understanding of the basic and advanced concepts of the subject. There will be **two sections** for each paper. Each section will be of **35 marks** and the pattern of question paper shall be:

| | |
|--------------------------|---|
| Question 1 (10 Marks) | 5 compulsory sub-questions, each of 2 marks; precisely answerable in 2-5 sentences (such as define, short problem, draw the structure / neat labelled diagram, short reasons, characteristics, applications, etc.) |
| Question 2 (10 Marks) | 2 out of 4 – descriptive answer type questions of 5 marks each; answerable in sufficient length with graph or diagram or flow sheet if necessary. |
| Question 3 (10 marks) | 2 out of 4 – Critical analysis / differentiation / evaluative / summarize interpret, write notes, numerical problem type of questions of 5 marks each; answerable in 15 lines with graph or diagram if applicable. |
| Question 4 (5 Marks) | 1 out of 2 – numerical problem type question; spectral analysis, <u>For descriptive course</u> critical notes, decryption of technique, how you will apply your knowledge to solve particular problem, etc. types of question. |

In question paper setting wattage for each chapter will be proportional to number of theory lectures assigned to that chapter.