SYLLABUS (NEP)

For

M.Sc. Course in Chemistry

To be effective from the session 2026-2027



BANKURA UNIVERSITY

BANKURA - 722155

WEST BENGAL, INDIA

Credits & Evaluation:

Duration of PG course of studies in chemistry will be of two years with four semesters, *viz.*, semester I, semester II, semester III and semester IV - each of six months duration coupled with four examinations *viz*. semester I, semester II, semester III and semester IV in chemistry at the end of each semester. Syllabus is hereby framed according to certain schemes and structures highlighted below schemes:

1. 250 marks in SEM I and SEM II each and 300 marks in SEM III and SEM IV each with a grand total of 1100 marks and 88 credits.
2. 20 credits in SEM I and SEM II each and 24 credits in SEM III and SEM IV each with a total of 88 credits; each theoretical/practical paper of 4 credits.
3. 20% marks allotted for internal assessment in each theoretical and practical paper which will be assessed by written test or viva-voce conducted by the department.
4. Three theoretical papers (common to all students) in each of semester I, semester II. Two theoretical papers (common to all students) in semester III. One theoretical paper (common to all students) in semester IV.
5. Two practical papers (common to all students) in semester I. One practical paper (common to all students) in semester II.
6. In semester II, one extra departmental Generic Elective (Interdisciplinary) paper to be learnt by the students of the other sister departments and the students of this department to be learnt from other sister departments.
7. One special elective theory paper *viz*. inorganic, organic and physical in semester III and two special elective theory papers *viz*. inorganic, organic and physical in semester IV; the number of students in special elective paper will be decided by the department on the basis of marks obtained in earlier semesters.
8. One special elective practical paper *viz*. inorganic, organic and physical in semester III.
9. In semester III, one paper on research thesis/project/patent/term paper on any topic relevant to the subject/paper assigned by the concerned teacher.
10. For thesis/project/patent/term paper- preparation 50: presentation: 25 and Viva-voce: 25.
11. In semester IV, one paper on dissertation on any topic relevant to the subject/paper assigned by the concerned teacher.
12. For dissertation – Project work: 50; thesis writing: 50; presentation: 25 and viva-voce: 25.
13. In semester IV, one non-credit paper (IKS) to be learnt by the students of this department.
14. Duration of examination: each theoretical paper of 2 hours, each practical paper, 6 hours.
15. For each practical paper- experiments: 30, laboratory notebook: 5, and viva-voce: 5 (by external examiner).

COURSE STRUCTURE

SEMESTER-I

Category of Course	Course Code	Course Title	Marks				Credit
			IA	ESE		TOTAL	
				TH	PR		
Theoretical Papers							
DSC	CHEM 101C	Inorganic Chemistry I	10	40	-	50	4
DSC	CHEM 102C	Organic Chemistry I	10	40	-	50	4
DSC	CHEM 103C	Physical Chemistry I	10	40	-	50	4
Practical Papers							
DSC	CHEM 104C(PR)	Inorganic Chemistry Practical	10	-	40	50	4
DSC	CHEM 105C(PR)	Organic Chemistry Practical	10	-	40	50	4
		Total	**250**				**20**

SEMESTER-II

Category of Course	Course Code	Course Title	Marks				Credit
			IA	ESE		TOTAL	
				TH	PR		
Theoretical Papers							
DSC	CHEM 201C	Inorganic Chemistry II	10	40	-	50	4
DSC	CHEM 202C	Organic Chemistry II	10	40	-	50	4
DSC	CHEM 203C	Physical Chemistry II	10	40	-	50	4
Practical Papers							
DSC	CHEM 204C(PR)	Physical Chemistry Practical	10	-	40	50	4
#Generic Elective Paper (Interdisciplinary)							
GE	CHEM 205G	General Chemistry	10	40	-	50	4
		Total	**250**				**20**

SEMESTER-III

Category of Course	Course Code	Course Title	Marks				Credit
			IA	ESE		TOTAL	
				TH	PR		
Theoretical Papers							
DSC	CHEM 301C	Advanced General Chemistry I	10	40	-	50	4
DSC	CHEM 302C	Research Methodology	10	40	-	50	4
DSE	CHEM303E (IS/OS/PS)	Special Theory I	10	40	-	50	4
Practical Paper							
DSE	CHEM304E (IS/OS/PS)	Special Practical	10	-	40	50	4
##Term Paper/Project							
DSC	CHEM 305C	Research thesis/Project/Patent/Term Paper	Project work-50, Presentation-25 Viva-voce-25				8
		Total	**300**				**24**

SEMESTER-IV

Category of Course	Course Code	Course Title	Marks				Credit
			IA	ESE		TOTAL	
				TH	PR		
Theoretical Papers							
DSC	CHEM 401C	Advanced General Chemistry II	10	40	-	50	4
DSE	CHEM 402E (IS/OS/PS)	Special Theory II	10	40	-	50	4
DSE	CHEM 403E (IS/OS/PS)	Special Theory III	10	40	-	50	4
Skill Based Course (Non-Credit)	CHEM 404C	IKS	50				0
##Term Paper/Project							
DSC	CHEM 405C	Dissertation	Project work-50, Thesis writing-50, Presentation-25 and Viva-voce- 25.				12
		Total	**300**				**24**
		Grand Total	**1100**				**88**

IS: Inorganic Special; OS: Organic Special; PS: Physical Special; DSC = Discipline Specific Course; DSE = Discipline Specific Elective; GE = Generic Elective (Interdisciplinary); TH = Theory; PR = Practical; IA = Internal Assessment; IKS= Indian Knowledge System; ESE = End Semester Examination.

*The Non-Credit course (IKS) is to be conducted by the department. The credit earned for these courses shall not be considered while preparing the final result. However, the candidates are required to obtain 'satisfactory' remark to obtain eligible for the award of the PG degree.

Semester I (Total Marks - 250, Credits - 20)

Theoretical Papers

CHEM 101C: Inorganic Chemistry I **Marks: 50, Credits: 4**

1. Chemical Bonding – a quantum chemical approach (15 Lectures)

The Born-Oppenheimer Approximation, Molecular Orbitals of Diatomic Systems (homonuclear and heteronuclear), MO of polynuclear ABn type molecules, Molecular Term Symbol, Koopmans' theorem, Walsh diagram. Isolobal Analogy, Frontier Molecular Orbital (FMO) Interactivity, Molecular term symbols, Hückel Molecular Orbital (HMO) Framework and p-MO profiles of ethylene, allyl system, aromatics and conjugated systems.

2. Coordination chemistry: bonding, stereochemistry and structure (20 Lectures)

Fundamentals of coordination chemistry, Molecular orbital theory of complexes, Jahn-Teller and Renner-Teller effects on energy levels, Term Symbols and Interelectronic Repulsion, Racah Parameters, Nephelauxetic effect. Symmetry-Based Graphical Representations: Orgel diagram, Tanabe-Sugano diagram, Spectral Transition Selection Rules, Vibronic Coupling, band broadening, spin-forbidden transition, intensity stealing, magnetic properties, lowering of symmetry, electronic, steric, Chelation Dynamics and Conformational analysis, Structural equilibrium and implication, Correlation of CFSE with spectroscopy.

3. Molecular Magnetism (25 Lectures)

Fundamentals of Molecular Magnetism, Microstates and Term Symbols, Multiplets and Splitting, Crystal Field Effects, Spin–Orbit Coupling (SOC), Quenching of Orbital Angular Momentum, Magnetic Susceptibility and Van Vleck equation, Temperature-Independent Paramagnetism (TIP), Magnetic Exchange Interactions: Mechanisms of magnetic exchange (direct exchange, superexchange, double exchange and spin polarization); Magnetic interactions in di, polynuclear clusters and cluster system; Bleaney–Bowers equation; Magnetization (magnetization versus temperature (M vs. T) and magnetic field (M vs. H); Curie and Curie-Weiss laws) and Variable Temperature Magnetism, Long-Range Ordering, Single-molecule magnets (SMMs), Single Chain magnets (SCMs) etc., Magnetic material synthesis and their modern applications.

4. Advanced Bioinorganic Chemistry **(20 Lectures)**

Metal ion homeostasis, transport and biological functions; structure and function of metalloproteins and metalloenzymes, including porphyrins, hemoglobin, myoglobin, hemocyanin, hemerythrin, cytochrome c and Cytochrome P450, blue copper proteins, nitrogenase, hydrogenase, superoxide dismutase, catalase and peroxidase; oxygen transport and activation, electron-transfer reactions, role of metallochaperones, siderophores, transferrin, and ferritin. Homeostatic Regulation (e.g., iron-responsive element-binding proteins, zinc fingers). Photosystems and Solar Energy Conversion; Biological Electron Transfer and Proton-Coupled Electron Transfer (PCET) (basic concepts); Biomimetic Inorganic Chemistry, Metal Complexes in Medicine, Bio-inspired Catalysis and Renewable Energy

Reference Books:

- F. A. Cotton, Chemical Applications of Group Theory, 3rd Edn, John Wiley & Sons, New York, 1999.
- F. A. Cotton, G. Wilkinson, C. M. Murillo and M. Bochmann, Advanced Inorganic Chemistry, 6th Edn, John Wiley & Sons, Inc, New York, 1999.
- B. Douglas, D. McDaniel and J. Alexander, Concepts and Models of Inorganic Chemistry, 3rd, Edn, John Wiley & Sons, Inc., New York, 2001.
- J. E. Huheey, E. A. Keiter, R. L. Keiter and O. K. Medhi, Inorgnic Chemistry: Principles of Structures and Reactivity, 4th, Edn, Pearson, New Delhi, 2006.
- H. E. White, Introduction to Atomic Spectra, McGraw-Hill Kogakusha Ltd, Tokyo, 1934.
- B. N. Figgis, Introduction to Ligand Field Theory, Interscience, New York, 1966.
- C. J. Ballhausen, Molecular Electronic Structure of Transition Metal Complexes, McGraw-Hill, London, 1979.
- R. McWeeney, Coulsons' Valence, 3rd Edn, Oxford University Press, Oxford, 1979.
- B. P Lever, Inorganic Electronic Spectroscopy, Elsevier, New York, 1984.
- E. Douglas and C. A. Hollingsworth, Symmetry in Bonding and Spectra, An Introduction, Academic Press, New York, 1985.
- T. A. Albright, J. K. Burdett and M. H. Whangbo, Orbital Interactions in Chemistry, Wiley, New York, 1985.
- V. Heine, Group Theory in Quantum Mechanics: An Introduction to Its Present Usage, Dover Publication, New York, 1991.

- P. Atkins, T. Overton, J. Rourke, M. Weller and F. Armstrong, Shriver & Atkins Inorganic Chemistry, 4th Edn, Oxford, 2006.
- R. L. Carlin, Magnetochemistry, Springer-Verlag, New York, 1986. O. Kahn, Molecular Magnetism,
- VCH, New York, 1993. 66
- P. Day and A. E. Underhill (Eds), Metal-organic and Organic Molecular Magnets, RSC, London, 2000.
- P. M. Lathi (Ed), Magnetic Properties of Organic Materials, Marcel Dekker, New York, 1999.
- J. S. Miller and M. Drillon (Eds), Magnetism: Molecules to Materials, V; Molecule-based Magnets, Wiley-VCH, Weinheim, 2005.
- P. Gutlich and H. A. Goodwin, Spin Crossover in Transition Metal CompoundsI, Springer, Berlin, 2004.
- F. E. Mabbs and D. J. Machin, Magnetismand Transition Metal Complexes, Dover Publications, 2008.
- R. Winpenny (Ed), Single-Molecule Magnets and Related Phenomena, Structure and Bonding Series, Vol. 122, Springer, Berlin, 2010.
- D. Cullity and C. D. Graham, Introduction to Magnetic Materials, 2nd Edn, John Wiley & Sons, New York, 2011.
- K. H. J. Buschow, Handbook of Magnetic materials, Vol 20, Elsevier, New York, 2012.
- Gatteschi, R Sessoli and J. Villain, Molecular Nanomagnets, Oxford University Press, Oxford, 2006.
- Bertini, H. B. Gray, E. I. Stiefel, J. S. Valentine, Biological Inorganic Chemistry: Structure and Reactivity, University Science Books, Sausalito, 2007.
- R. H. Holm, P. Kennepohl, E. I. Solomon (Eds.), Chemical Reviews: Bioinorganic Chemistry, American Chemical Society, Washington, D.C., 1996.
- R. R. Crichton, Biological Inorganic Chemistry: A New Introduction to Molecular Structure and Function, 3rd Edition, Academic Press (Elsevier), London, 2019.
- L. Que Jr., W. B. Tolman (Eds.), Nature's Catalysts: The Science of Metalloenzymes, Royal Society of Chemistry, Cambridge, 2022.
- I. Solomon, R. K. Szilagyi, S. DeBeer George, L. Basumallick, Electronic Structures of Metal Sites in Proteins and Models: Contributions to Function in Blue Copper Proteins and Heme–Copper Oxidases, Chemical Reviews, American Chemical Society, 2004. (Selected review articles.)

Course Objective:

1. Develop a strong theoretical foundation in advanced inorganic chemistry by introducing modern concepts of chemical bonding, molecular orbital theory, and quantum chemical approaches to molecular structure.
2. Provide an in-depth understanding of coordination chemistry, including electronic structure, stereochemistry, spectroscopy, and magnetic properties of coordination compounds using modern ligand field and molecular orbital theories.
3. Introduce the principles of molecular magnetism and familiarize students with magnetic exchange interactions, variable-temperature magnetic behavior, and the design and applications of molecular magnetic materials.
4. Explore the role of metal ions in biological systems by studying the structure, function, and mechanisms of metalloproteins, metalloenzymes, metal homeostasis, biological electron transfer, and oxygen activation processes.
5. Expose students to emerging areas of inorganic chemistry, including biomimetic chemistry, metal-based therapeutics, bio-inspired catalysis, renewable energy, and advanced functional materials.
6. Develop analytical, problem-solving, and research skills by enabling students to interpret spectroscopic, structural, magnetic, and biological data, thereby preparing them for advanced research and professional careers in inorganic chemistry and related interdisciplinary fields.

Course Outcome:

1. Explain the principles of quantum chemical bonding in molecules using molecular orbital theory, Born–Oppenheimer approximation, molecular term symbols, Walsh diagrams, frontier molecular orbital (FMO) theory, and Hückel molecular orbital (HMO) approaches.
2. Analyze the electronic structure, bonding, stereochemistry, and spectroscopic properties of coordination compounds using crystal field theory, molecular orbital theory, term symbols, Tanabe–Sugano and Orgel diagrams, and correlate these with magnetic and structural properties.
3. Evaluate the magnetic behavior of transition metal complexes and molecular magnetic materials by applying concepts of crystal field effects, spin–orbit coupling, magnetic exchange interactions, magnetic susceptibility, and variable-temperature magnetism, including single-molecule and single-chain magnets.

4. Interpret the role of metal ions in biological systems by explaining the structure, function, and mechanisms of metalloproteins, metalloenzymes, metal homeostasis, electron transfer, oxygen activation, and bioinorganic processes relevant to health and energy conversion.
5. Apply advanced concepts of inorganic chemistry to contemporary research problems in molecular magnetism, bioinorganic chemistry, biomimetic catalysis, renewable energy, and metal-based medicinal chemistry.

CHEM 102C: Organic Chemistry I **Marks: 50, Credits: 4**

1. Bonding in Organic Molecules & Structure-Reactivity Relationship (20 Lectures)

Qualitative MO treatment to acyclic and cyclic conjugated systems, Huckel treatment-applications to ethylene, allyl, cyclopropenyl, butadiene, cyclobutadiene and benzene; concept of aromaticity in benzenoid and nonbenzenoid systems, graphical method-Frost diagram, linear free energy relations, Hammett equation; equilibria and rates in organic reactions; separation of polar, steric and resonance effects: Taft equation, Grunwald-Winstein equation.

2. NMR Spectroscopy (20 Lectures)

Principles, instrumentation and different techniques (CW and FT) of NMR spectroscopy, factors influencing chemical shift, spin-spin interactions, coupling constant (J); spin-decoupling; cross polarization, peak integration, first-order and non first-order spectra, spin system notations; introduction to ^{13}C: proton decoupled ^{13}C spectra, NOE, off resonance ^{13}C.

3. Mass Spectroscopy (20 Lectures)

Principles of Mass spectroscopy, instrumentation and applications of mass spectrometry-methods of generation of ions in EI, CI, FD and FAB, MALDI-TOF; detection of ions, ion analysis, ion abundance, molecular ion peak, meta-stable peak, isotope, ion-molecule interaction and analysis of fragmentation patterns; calculation of Molecular Formula from mass, introduction to GC-MS, LC-MS and MS-MS.

Applications of mass, UV-VIS, IR and NMR spectroscopy to structural and mechanistic problems.

4. Stereochemistry and Conformational Analysis (20 Lectures)

Molecular symmetry, chirality and point group; stereoisomerism: definitions, classifications; configuration and conformation; relative and absolute configuration; determination of relative configuration: Prelog's rule, Cram's rule, Sharpless rule; conformations of acyclic and cyclic system (3 to 8 membered rings), fused (5/5 and 6/6), spiro and bridged bicyclo systems; stability, reactivity and mechanism; allylic strain; reactions of 5/6-membered ring containing one or more trigonal carbon(s).

Reference Books:

- E. V. Anslyn, D. A. Dougherty. Modern Physical Organic Chemistry, University Science Books, 2006.
- S. Shaik, P. C. Hiberty. Valence Bond Theory, its History, Fundamentals and Applications: a Primer, Reviews in Computational Chemistry, Volume 20 (Eds. K. B. Lipkowitz, R. Larter, T. R. Cundari), John Wiley & Sons, Hoboken, NJ, USA, 2004.
- F. A. Caroll. Perspectives on Structure and Mechanism in Organic Chemistry, 2nd Edn. Wiley-VCH, 2011.
- E. L. Eliel, S. H. Wilson, L. N. Mander. Stereochemistry of Organic Compounds, John Wiley & Sons, 2003.
- E. L. Eliel. Stereochemistry of Carbon Compounds, Tata McGraw-Hill Edition, New Delhi, 1988.
- D. Nasipuri. Stereochemistry of Organic Compounds (Principles and Applications), 2nd Edn. Wiley Eastern Limited, New Delhi, 1994.
- E. L. Eliel, N. L. Allinger, S. J. Angyal, G. A. Morrison. Conformational Analysis, John Wiley & Sons, 1967.
- J. Eames, J. Peach. Stereochemistry at a Glance, Blackwell Science, 2003.
- K. Mislow, W. A. Benjamin. Introduction to Stereochemistry, New York, 1965.
- B. Testa. Principles of Organic Stereochemistry, Marcel Dekker, New York, 1979.
- E. Juaristi. Stereochemistry and Conformational Analysis, John Wiley & Sons, 1991.
- M. Nogradi. Stereochemistry: Concepts and Applications, Pergamon press, New York, 1981.
- H.-J. Zhu. Organic Stereochemistry: Experimental and Computational Methods, Wiley-VCH, 2015.
- M. B. Smith, J. March. March's Advanced Organic Chemistry (Reactions, Mechanisms and Structure), 5th Edn. John Wiley & Sons, 2001.

- L. N. Ferguson. The Modern Structural Theory of Organic Chemistry, Prentice-Hall of India Pvt. Ltd., New Delhi, 1963.
- R. H. Grubbs, D. J. O'leary. Handbook of Metathesis - Volume 1 & 2, Wiley-VCH, 2015.
- D. L. Pavia, G. M. Lampman, G. S. Kriz. Introduction to Spectroscopy, 3rd Edn. Harcourt, 2001.
- R. M. Silverstein, G. C. Bassler, T. C. Morrill. Spectroscopic Identification of Organic Compounds, 5th Edn. John Wiley & Sons, 1991.
- D. H. Williams, I. Fleming. Spectroscopic Methods in Organic Chemistry, 5th Edn. Tata McGraw-Hill edition, New Delhi, 2004.
- W. Kemp. Organic Spectroscopy, 3rd Edn. Macmillan press Ltd. 1991.
- G. Siuzdak. Mass Spectrometry for Biotechnology, Academic press, 2005.
- H. Budzikiewicz, C. Djerassi, D. H. Williams. Interpretation of Mass Spectra of Organic Compounds. Holden-Day Inc., 1965.
- J. S. Splitter, F. Turećek. Applications of Mass Spectrometry to Organic Stereochemistry, Wiley-VCH, 1994.
- Atta-ur-Rahman, Md. Iqbal Choudhary. Solving Problems with NMR Spectroscopy, Academic press, 1996.
- N. S. Bhacca, D. H. Williams. Applications of NMR Spectroscopy in Organic Chemistry, Holden-Day Inc., 1964.
- L. M. Jackman, S. Sternhell. Applications of Nuclear Magnetic Resonance Spectroscopy in Organic Chemistry, 2nd Edn. Pergamon Press, Oxford, 2nd Edn. 1969.
- R. G. Linington, P. G. Williams, J. B. Macmillan. Problems in Organic Structure Determination: a Practical Approach to NMR Spectroscopy, CRC press, Taylor & Francis group, 2016.
- Y. R. Sharma. Elementary Organic Spectroscopy (Principles and Chemical Applications) S. Chand & Company Ltd., New Delhi, 5th Edn. 2013.

Course Objective:

1. Develop a comprehensive understanding of molecular orbital theory, aromaticity, and structure–reactivity relationships in organic molecules.
2. Explain the principles and applications of modern spectroscopic techniques, particularly NMR and mass spectrometry, for structural elucidation of organic compounds.

3. Apply linear free energy relationships and mechanistic concepts to analyze reaction pathways and predict the influence of electronic, steric, and solvent effects.
4. Acquire advanced knowledge of stereochemistry, molecular symmetry, conformational analysis, and stereochemical principles governing the stability and reactivity of organic molecules.
5. Integrate spectroscopic and stereochemical concepts to solve complex structural and mechanistic problems encountered in organic chemistry and research.

Course Outcome:

Upon successful completion of this course, students will be able to:

1. Explain molecular orbital theory, aromaticity, and structure–reactivity relationships in conjugated organic systems using qualitative MO theory, Hückel theory, and linear free energy relationships.
2. Interpret and analyse 1H and 13C NMR spectra, including chemical shifts, spin–spin coupling, coupling constants, spin systems, and advanced NMR techniques for structural characterization.
3. Demonstrate a thorough understanding of the principles, instrumentation, ionization methods, and fragmentation mechanisms in mass spectrometry, and apply MS, GC–MS, LC–MS, and MS–MS techniques for molecular identification.
4. Solve structural and mechanistic problems by integrating information obtained from UV–Visible, IR, NMR, and mass spectroscopic data.
5. Analyse stereochemical and conformational features of acyclic, cyclic, fused, spiro, and bridged organic systems, predict their stability and reactivity, and apply stereochemical principles to organic reaction mechanisms.
6. Apply advanced concepts of stereochemistry, spectroscopy, and structure–reactivity relationships to interpret experimental data and address research-oriented problems in modern organic chemistry.

CHEM 103C: Physical Chemistry I **Marks: 50, Credits: 4**

1. Quantum Mechanics I **(16 Lectures)**

Introduction, time-dependent Schrödinger equation of motion, conservative systems and time independent Schrödinger equation; particle in a one and three-dimensional boxes with infinite potential walls, important features; particle in one-dimensional box with finite potential walls (or

particle in a rectangular well), step potential and tunnelling; solution of Schrodinger equation of a Harmonic oscillator using the operator method; selection rules for harmonic oscillator; rigid rotator; elementary discussion of the H-atom solution.

2. Symmetry & Group Theory I **(16 Lectures)**

Introduction, symmetry, symmetry elements and symmetry operations, definition of a group, point symmetry groups, group multiplication tables, theorems of groups, conjugate elements and class, symmetry operators and their matrix representation, function space, reducible and irreducible representations, equivalent representations, characters of representations.

3. Electrochemistry **(12 Lectures)**

Introduction, ion-solvent interaction: Born model and Born equation, enthalpy of ion-solvent interaction and its calculation, solvation and solvation number, ion association, Bjerrum equation, fraction of ions associated, ion association constant; electrode kinetics: relation between current and rate of electrode reaction, current-overpotential relationship, Tafel equation and its importance.

4. Biophysical Chemistry **(18 Lectures)**

Introduction, adsorption of solids, micelles, reverse micelles, microemulsion, thermodynamics of micellization, hydrophobic hydration, interaction; stabilization and denaturation of protein, transport of ions, ion channels, configuration and conformation of biological macromolecules, membrane structure; applications of spectroscopic techniques: UV-VIS, CD, fluorescence, separation techniques: gel electrophoresis; macromolecule ligand binding and co-operativity.

5. Chemical Kinetics I **(18 Lectures)**

Introduction, theories of reaction rates: applications to uni-, bi- and ter-molecular reactions, thermodynamic formulation of reaction rate, reactions in solution; cage effect, dielectric effect on ion-ion reaction, electrostriction, volume of activation, effect of pressure on reaction rate, classification of reactions on the basis of volume of activation, Curtin-Hammett principle, linear free energy relationship, Hammett and Taft equations; fast reactions: flow process and relaxation techniques.

Reference Books:

- L. Pauling, E. B. Wilson. Introduction to Quantum Mechanics, McGraw-Hill, New York, 1939.
- H. Eyring, J. Walter, G. F. Kimball. Quantum Chemistry, Wiley, New York, 1944.
- P. W. Atkins. Molecular Quantum Mechanics, Clarendon press, Oxford, 1980.
- L. I. Schiff. Quantum Mechanics, McGraw-Hill, New York, 1985.
- A. K. Chandra. Introductory Quantum Chemistry, Tata McGraw-Hill Publishing, New Delhi, 1989.
- F. L. Pilar. Elementary Quantum Chemistry, Tata McGraw-Hill, New Delhi, 1990.
- D. A. McQuarrie. Quantum Chemistry, Viva books (P) Ltd. New Delhi, 2003.
- S. C. Rakshit. Molecular Symmetry Group and Chemistry, The New Book Stall, Kolkata, 1988.
- F. A. Cotton. Chemical Applications of Group Theory, 3rd Edn. John Wiley & Sons. New York, 1999.
- D. M. Bishop. Group Theory and Chemistry, Oxford University Press, 1993.
- J. Vincent. Molecular Symmetry and Group Theory, John Wiley & Sons. New York, 1998.
- S. Glasstone. An Introduction to Electrochemistry, D. Van Nostrand Company, 1962.
- J. O'M. Bockris, A. K. N. Reddy. Modern Electrochemistry, Volume I, Plenum Press, New York, 1970.
- J. Albery. Electrode Kinetics, Oxford Chemistry Series, Clarendron Press, Oxford, 1975.
- G. W. Castellan. Physical Chemistry, 3rd Edn. Narosa Publishing House, New Delhi, 1995.
- R. A. Alberty, R. J. Silbey. Physical Chemistry, 1st Edn. John Wiley & Sons. New York, 1995.
- R. S. Berry, S. A. Rice, J. Ross. Physical Chemistry, Oxford University Press, London, 1970.
- K. V. Van Holde, W. C. Johnson, P. S. Ho. Principles of Physical Biochemistry, Prentice Hall, 1998.
- D. L. Nelson, M. Cox. Lehninger Principles of Biochemistry, 8th Edn. Macmillan Learning, 2017.
- C. Tanford. Physical Chemistry of Macromolecules, John Wiley & Sons. New York, 1961.
- P. J. Flory. Principles of Polymer Chemistry, Cornell University Press, Ithaca & London, 1995.
- K. J. Laidler. Reaction Kinetics, Volume I & II, Pergamon Press, London, 1970.
- K. J. Laidler. Chemical Kinetics, Tata McGraw-Hill Publishing Company Ltd. New Delhi, 1988.

- M. R. Wright. Fundamental Chemical Kinetics, Horwood Publishing, 1999.

Course Objective:

1. Develop a strong theoretical foundation in quantum mechanics, including time dependent and time-independent Schrödinger equation, particle in 1-D and 3-D boxes with infinite and finite potential wells, harmonic oscillator and rigid rotator.
2. Introduce the principles of symmetry and group theory, symmetry elements and symmetry operations, group multiplication tables, matrix representation of symmetry operators etc.
3. Provide an in-depth understanding of electrochemistry, about ion-solvent interaction, Born model and Born equation, solvation, ion association and electrode kinetics.
4. Expose students to emerging areas of Bio-physical Chemistry, including adsorption, micellization, protein stabilization, applications of UV-VIS, CD, fluorescence spectroscopic techniques, macromolecule ligand binding and co-operativity.
5. Elaborate the theoretical details of kinetics of chemical reaction rates, its thermodynamic formulation, electrostriction, volume of activation, effect of pressure on reaction rate, Curtin-Hammett principle, linear free energy relationship, Hammett and Taft equations; fast reactions etc.

Course Outcome:

After the completion of this course, the students will be able to

1. Learn about time-dependent and time-independent Schrödinger equation, particle in a one and three-dimensional boxes with infinite and finite potential walls. They will also have sound knowledge about solution of Schrodinger equation of a harmonic oscillator, selection rules for harmonic oscillator, rigid rotator, elementary discussion of the H-atom solution.
2. Acquire detail information about symmetry, symmetry elements and symmetry operations, group, group multiplication tables, theorems of groups, conjugate elements and class, symmetry operators and their matrix representation, reducible and irreducible representations, characters of representations etc.
3. Develop in-detail knowledge about ion-solvent interaction, enthalpy of ion-solvent interaction, solvation, ion association, electrode kinetics, current-overpotential relationship etc.
4. Gather extensive knowledge about adsorption of solids, thermodynamics of micellization, stabilization and denaturation of protein, transport of ions, ion channels, configuration and

conformation of biological macromolecules, membrane structure; applications of UV-VIS, CD, fluorescence spectroscopic techniques etc.

5. Collect detailed information about theories and thermodynamic formulation of reaction rate, reactions in solution, electrostriction, volume of activation, effect of pressure on reaction rate, classification of reactions on the basis of volume of activation, Curtin-Hammett principle, Hammett and Taft equations; fast reactions etc.

Practical Paper

CHEM 104C(PR): Inorganic Chemistry Practical **Marks: 50, Credits: 4**

1. Determination of amount of Ca^{2+} in milk by complexometric titration.
2. Estimation of Ca^{2+}, Mg^{2+} and Fe^{3+} in Dolomite by complexometry
3. Estimation of phosphoric acid in cola drinks by molybdenum blue method
4. Estimation of iron in minute quantities by UV-vis spectrophotometry
5. Estimation of fluoride in water by SPADNS Method.
6. Analysis of brass (Cu and Zn) by iodometry and complexometry.
7. Preparation and characterization (FTIR, UV-Vis) of hexamminenickel(II) chloride: estimation of ammonia and nickel by titrimetric and gravimetric methods
8. Computer application in chemistry-Exposure to available standard application packages like: chemdraw, generation of graphs using Origin, data sheet creation, tables using excel programme, etc.

Reference Books:

- Vogel's Textbook of Quantitative Chemical Analysis - Jeffery, Bassett, Mendham and Denney
- Practical Inorganic Chemistry, Preparations, reactions and instrumental methods, Geoffrey Pass, Haydn Sutcliffe, Springer Dordrecht, 2013.
- Experimental Inorganic Chemistry, W. G. Palmer, 1954.
- Advanced Experiments in Inorganic Chemistry-G. N. Mukherjee
- Practical Inorganic Chemistry-Dr. L. Rakesh Sharma

Course Objective:

1. Develop proficiency in quantitative inorganic analysis using classical volumetric, gravimetric, and spectrophotometric techniques for the estimation of metal ions and inorganic species in real samples.
2. Provide hands-on training in instrumental analytical methods, including UV–Visible spectrophotometry and FTIR spectroscopy, for qualitative and quantitative characterization of inorganic compounds.
3. Enhance laboratory skills in the synthesis, purification, characterization, and compositional analysis of coordination compounds using standard experimental protocols.
4. Introduce students to environmental and industrial chemical analysis through the estimation of constituents in milk, dolomite, drinking water, cola beverages, and brass alloys.
5. Develop competence in scientific data acquisition, analysis, interpretation, and reporting with emphasis on accuracy, precision, error analysis, and laboratory safety.
6. Familiarize students with modern computational tools such as ChemDraw, Origin, and Microsoft Excel for chemical structure drawing, graphical data analysis, and scientific documentation.

Course Outcome:

1. Perform quantitative determination of metal ions and inorganic analytes using complexometric, iodometric, gravimetric, and spectrophotometric methods with accuracy and precision.
2. Apply UV–Visible and FTIR spectroscopic techniques for the characterization of coordination compounds and the quantitative estimation of inorganic species.
3. Synthesize, purify, and characterize coordination compounds and determine their composition using appropriate analytical methods.
4. Analyze environmental, biological, and industrial samples such as water, milk, beverages, minerals, and alloys using standard analytical protocols and interpret the experimental results.
5. Utilize computer applications including ChemDraw, Origin, and Microsoft Excel for molecular visualization, data processing, graphical representation, and preparation of scientific reports.
6. Demonstrate good laboratory practices by maintaining safety, accurate record-keeping, critical data interpretation, teamwork, and effective scientific communication, thereby developing skills required for advanced research and industrial laboratories.

CHEM 105C(PR): Organic Chemistry Practical **Marks: 50, Credits: 4**

Chemical separation, purification and identification of organic compounds in binary mixture (two solids) using chemical tests and TLC.

(At least 6 samples are to be worked up during the lab session).

Reference Books:

- B. S. Furniss, A. J. Hannaford, P. W. G. Smith, A. R. Tatchell. Vogel's Textbook of Practical Organic Chemistry, 5th Edn. John Wiley & Sons. New York, 1989.
- A. I. Vogel. A Textbook of Practical Organic Chemistry, 3rd Edn. Longman group ltd. London, 1956.
- R. C. Bhattacharyya. A Manual of Practical Chemistry, 11th Edn. Studies book sellers & publishers, Calcutta, 1992.
- Roberts, Gilbert, Rodewaid, Wingrove. An Introduction to Experimental Organic Chemistry, 3rd Edn. Holt, Rinehart & Winston Publishers, New York, 1969.
- H. T, Clarke. Handbook of Organic Analysis, 4th Edn. Hodder & Stoughton Educational, London, 1926.
- H. Middleton. Systematic Qualitative Organic Analysis, 2nd Edn. Hodder & Stoughton Educational, London, 1943.
- V. K. Ahluwalia, R. Aggarwal. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press, 2001.
- E. Stahl. Thin Layer Chromatography, 2nd Edn. Springer, 1969.
- R. M. Silverstein. Spectrometric Identification of Organic Compounds, 6th Edn. John Wiley & Sons, New York, 1997.

Course Objective:

1. Develop practical skills in the systematic separation, purification, and identification of organic compounds present in binary mixtures.
2. Gain proficiency in the application of classical qualitative organic analysis using chemical tests and chromatographic techniques.
3. Learn the principles and applications of Thin Layer Chromatography (TLC) for monitoring separation and assessing the purity of organic compounds.

4. Enhance laboratory competence in handling chemicals, maintaining accurate experimental records, and following safe laboratory practices.
5. Build analytical and problem-solving skills required for organic synthesis, quality control, and research laboratories.

Course Outcome:

Upon successful completion of this course, students will be able to:

1. Perform the systematic separation of binary mixtures containing two solid organic compounds using appropriate chemical methods.
2. Purify separated organic compounds by suitable laboratory techniques and evaluate their purity.
3. Identify unknown organic compounds through systematic qualitative analysis, including functional group and confirmatory chemical tests.
4. Apply Thin Layer Chromatography (TLC) for monitoring separations, determining purity, and supporting the identification of organic compounds.
5. Demonstrate competency in laboratory techniques, safe handling of chemicals, accurate observation, data recording, and interpretation of experimental results.
6. Develop analytical reasoning and problem-solving abilities for the identification of unknown organic compounds, providing a strong foundation for advanced research and industrial laboratory applications.

Semester II (Total Marks -250, Credits- 20)

Theoretical Papers

CHEM 201C: Inorganic Chemistry II **Marks: 50, Credits: 4**

1. Main Group Chemistry **(20 Lectures)**

Fundamentals of electronic structure, periodic trends, allotropy, synthesis, structure and bonding of main-group compounds; electron-deficient, electron-precise and hypervalent compounds, multicentre bonding and multiple bonding in heavier main-group elements. Boron Cluster Chemistry: boranes, carboranes, Wade–Mingos rules and organoboron compounds; Low-valent main-group compounds: N-heterocyclic carbenes (NHCs), silylenes, germylenes, and phosphinidenes. Frustrated Lewis Pairs (FLPs) and small-molecule activation: Concept,

mechanism of activation and small molecule transformations. Industrially important compounds of boron, silicon and phosphorus, and selected applications in catalysis, materials chemistry and green chemistry.

2. Advanced organometallic Chemistry **(20 Lectures)**

Synthesis, bonding, structure and reactivity of organometallic compounds; metal–ligand bonding, Advanced electron counting methods, the 18-electron rule considering important ligand systems (phosphines, cyclopentadienyl (Cp/Cp*) and N-heterocyclic carbenes (NHCs)); Elementary organometallic reactions including ligand substitution, oxidative addition, reductive elimination, migratory insertion, β-hydride elimination and transmetallation; Principles of homogeneous catalysis and catalytic cycles with applications in hydrogenation, hydroformylation, carbonylation, olefin metathesis and transition-metal-catalysed cross-coupling reactions; Brief overview of heterogeneous catalysis, olefin polymerization (Ziegler-Natta catalysis) and green organometallic catalysis.

3. Nuclear Chemistry **(20 Lectures)**

Introduction to nuclear stability, formulation of semi-empirical binding energy equation, mass parabola and application of binding energy equation; nuclear reactions, Calculation of Q value, threshold energies and cross section of nuclear reaction. The liquid drop model, Fermi gas model, Magic numbers and its derivation from nuclear potential well. Nuclear fission and nuclear fusion. Nuclear reactors and particle accelerators. Interaction of radiation with matter, radio-analytical techniques and activation analysis, dosimetry (physical and chemical dosimetry), Applications of Nuclear Chemistry in Neutron activation analysis (NAA), isotope dilution analysis. Waste management and nuclear safety.

4. Electroanalytical Methods **(20 Lectures)**

Fundamentals of Electroanalytical Chemistry: Electrochemical cells; electrode potentials; reference electrodes, indicator and working electrodes; three-electrode system; electrode–solution interface and electrical double layer; mass transport (diffusion, migration and convection); supporting electrolytes; choice of solvent and electrolyte; electrochemical instrumentation. Dropping mercury electrode (DME) and mercury film electrodes; Cottrell, Ilkovič and Ilkovič–Heyrovský equations; current–potential curves; reversible, quasi-reversible and irreversible electrode processes; DC and AC polarography; linear sweep voltammetry (LSV); cyclic voltammetry (CV); differential pulse voltammetry (DPV); square-wave voltammetry (basic

concepts); stripping voltammetry (anodic and cathodic); interpretation of voltammograms and reaction mechanisms (EE, EC, ECE and CE pathways), determination of diffusion coefficients, electron-transfer kinetics and catalytic rate constants; electrogravimetry and amperometric titrations; electrochemical impedance spectroscopy (EIS) (basic concepts); Electrocatalysis; electrochemical water oxidation (OER), proton reduction (HER), oxygen reduction (ORR) and carbon dioxide reduction (CO_2RR); rechargeable batteries (Li-ion, Na-ion, Ni–Cd, Ni–MH and Ag–Zn).

Reference Books:

- W Henderson, Main Group Chemistry, RSC publishing, 2007
- Thomas Baumgartner, Frieder Jäkle, Main Group Strategies towards Functional Hybrid Materials, Wiley, 2017
- Joseph Casanova, The Borane, Carborane, Carbocation Continuum, Wiley, 1998
- P. Powell, Principles of Organometallic Chemistry, 2nd Edn, Chapman and Hall, London, 1988.
- J. D. Atwood, Inorganic and Organometallic Reaction Mechanisms, 2nd Edn, VCH, New York, 1997.
- R. H. Crabtree, The Organomettalic Chemistry of the Transition Metals, 4th Edn, Wiley, New York , 2005.
- C. Elschenbroich, Organometallics, 3rd Edn, Wiley-VCH, Weinheim, 2006.
- R. A. van Santen and M. Neurock Molecular Heterogenous Catalysis, Wiley-VCH, Weinheim, 2006.
- G. O. Spessard and G. L. Miessler, Organometallic Chemistry, International 2nd Edn, Oxford University Press, Oxford, 2010.
- J. F. Hartwig, Organotransition Metal Chemistry. From Bonding to Catalysis, University Science Books, Sausalito, CA, 2010.
- H. J. Arnikar, Essentials of Nuclear Chemistry, 4th Edn Reprint, New Age International (P) Ltd Publications,New Delhi, 2001.
- R. D. Evans, The Atomic Nucleus, McGraw-Hill, New York, 1979.
- B. Harvey, Introduction to Nuclear Physics and Chemistry, Prentice Hall, 1965.
- S. Glasstone, Source Book of Atomic Energy, East-West Press Pvt. Ltd, New Delhi, 1967.
- S. M. Khopkar, Basic Concepts of Analytical Chemistry, Wiley Eastern Ltd., New Delhi, 1998.

- D. R. Crow, Polarography of Metal Complexes, Academic Press, London, 1979.
- J. Bard and L. F. Faulkner, Electrochemical Methods–Fundamentals and Applications, 2nd Edn, Wiley, New York, 1998.
- G. Zoski (Ed) Handbook of Electrochemistry, Elsevier, New York, 2007.
- Ed. By R.Kellner, J.-M.Mermet, M.Otto,M.Valcarcel,H.M.Widmer, Analytical Chemistry, Wiley VCH

Course Objective:

1. Develop an advanced understanding of main-group and organometallic chemistry, including electronic structure, bonding, reactivity, catalysis, and the synthesis of modern inorganic compounds.
2. Acquire comprehensive knowledge of nuclear chemistry, including nuclear structure, radioactive decay, nuclear reactions, radiation detection, nuclear energy, and their applications in science, industry, and medicine.
3. Understand the principles and applications of electroanalytical methods, including voltammetric, polarographic, electrochemical impedance, and electrocatalytic techniques for chemical analysis and energy conversion.
4. Apply theoretical concepts to contemporary research problems in catalysis, sustainable energy, materials chemistry, green chemistry, and advanced inorganic analytical techniques.

Course Outcome:

1. Explain the structure, bonding, reactivity, and applications of advanced main-group and organometallic compounds, including low-valent species, frustrated Lewis pairs, and homogeneous catalytic systems.
2. Analyze nuclear phenomena by applying concepts of nuclear stability, nuclear reactions, radioactivity, radiation–matter interactions, nuclear reactors, particle accelerators, and radioanalytical techniques.
3. Interpret electrochemical processes using modern electroanalytical methods such as cyclic voltammetry, differential pulse voltammetry, electrochemical impedance spectroscopy, and amperometric techniques, and relate them to reaction mechanisms and energy conversion.
4. Critically evaluate contemporary developments in inorganic chemistry and apply advanced concepts to solve research-oriented problems in catalysis, nuclear science, electrochemistry, materials chemistry, and sustainable technologies.

CHEM 202C: Organic Chemistry II **Marks: 50, Credits: 4**

1. Organic Name Reaction and Reagents **(20 Lectures)**

Moffat oxidation; Swern oxidation; Dess-Martin Periodinane; Shapiro reaction; Barton reaction; McMurry reaction; Peterson reaction; Sharpless asymmetric epoxidation; Luche reduction; Yamaguchi esterification; Woodward and Prevost hydroxylation; Click reaction; Mitsunobu reaction; hydride transfer reagent: Boranes, trialkyl borohydrides, Diimide, Baker's yeast, trialkyl tin hydride; DIBAL-H, $Na(CN)BH_3$, Red-Al; Selectrides; PCC, PDC, Mn(IV) oxide; RuO_4 (TRAP); OsO_4.

2. Heterocyclic Chemistry I **(20 Lectures)**

Systematic nomenclature (Hantzch-Widman system) for monocycle system, general approach to heterocyclic synthesis- cyclisation and cycloaddition routes, heterocycles in organic synthesis-masked functionalities, umpolong, Stork annulations reaction; rearrangement and ring transformation involving 5- and 6- membered heterocycles with one heteroatom.

3. Asymmetric Synthesis I **(15 Lectures)**

Introduction to asymmetric synthesis, preliminary idea about different methods of asymmetric synthesis with special reference to the chiral pool strategy, asymmetric Diels-Alder reaction, enantioselective organocatalysis, biocatalysis

4. Pericyclic Reactions **(25 Lectures)**

The Woodward-Hoffmann selection rules and stereochemistry of electrocyclic reactions, cycloadditions, sigmatropic rearrangements, cheleotropic reactions and group transfer reaction, rationalization based on frontier MO approach, correlation diagrams, Dewer-Zimmermann approach, Mobius and Huckel systems, Sommelet-Hauser, aza-Cope and Ene reaction, Wittig rearrangement, suitable examples of [(2Π+2Π), (4Π+2Π), (4Π+4Π), (2Π+2Π+2Π)] and metal catalysed cycloaddition reactions.

Reference Books:

- T. L. Gilchrist, R. C. Storr. Organic Reactions and Orbital Symmetry, 2nd Edn. Cambridge University Press, 1979.
- N. J. Turro. Modern Molecular Photochemistry, The Benjamin Cummings Publishing, 1978.
- S. Sankararaman. Pericyclic Reactions - A Textbook, Wiley-VCH Verlag, 2005.

- R. E. Gawley, J. Aube. Principles of Asymmetric Synthesis, Elsevier, 1996.
- M. Gruttadauria, F. Giacalone. Catalytic Methods in Asymmetric Synthesis: Advanced Materials, Techniques and Applications, John Wiley & Sons, 2011.
- I. Ojima. Catalytic Asymmetric Synthesis, John Wiley & Sons, 2013.
- G.-Q. Lin, Y.-M. Li, A. C. Chan. Principles and Applications of Asymmetric Synthesis, John Wiley & Sons, 2003.
- M. P. Koskinen, Asymmetric Synthesis of Natural Products, John Wiley & Sons, 2012.
- J. A. Joule, K. Mills. Heterocyclic Chemistry, Blackwell Science Publication, 2000.
- R. K. Bansal. Heterocyclic Chemistry: Synthesis, Reactions and Mechanisms, Wiley Eastern Ltd. New Delhi, 1999.
- T. L. Gilchrist. Heterocyclic Chemistry, Pearson Education, 2008.
- T. Eicher, S. Hauptmann, A. Speicher. The Chemistry of Heterocycles, Wiley-VCH, 2012.
- G. Brahmachari. Green Synthetic Approaches for Biologically Relevant Heterocycles, Elsevier, 2014.
- I. Meyers. Heterocycles in Synthesis, John Wiley & Sons, 1974.
- A. R. Katritzky, Comprehensive Heterocyclic Chemistry, Elsevier Book Series.
- I. Hassner Namboothiri. Organic Synthesis based on Name Reactions, 3rd Edn. Elsevier, 2012.
- L. Kürti, B. Czakó. Strategic Applications of Name Reactions in Organic Synthesis: Background and Detailed Mechanisms, Elsevier Academic Press, 2005.
- Z. Wang. Comprehensive Organic Name Reactions and Reagents, Wiley-VCH, 2009.
- G. Brahmachari. Organic Name Reactions: A Unified Approach, Narosa Publishing House Pvt. Ltd. New Delhi, 2012.
- M. B. Smith, J. March. March's Advanced Organic Chemistry (Reactions, Mechanisms and Structure), 5th Edn. John Wiley & Sons, 2001.
- R. Bruckner. Advanced Organic Chemistry (Reaction Mechanisms), Harcourt Academic Press, 2002.
- J. Clayden, N. Greeves, S. Warren, P. Wothers. Organic Chemistry, Oxford University Press, 2001.
- F. A. Carry, R. J. Sundberg. Advanced Organic Chemistry, 5th Edn. Springer, 2007.
- L. G. Wade, Jr. M. S. Singh. Organic Chemistry, 6th Edn. Pearson Education, 2008.
- T. G. Graham, C. B. Fryhle. Organic Chemistry, 8th Edn. John Wiley & Sons, 2004.
- J. Moody. Reactive Intermediates, Oxford University Press, 1992.

- R. T. Morrison, R. N. Boyd, S. K. Bhattacharjee. Organic Chemistry, 7th Edn. Pearson Education, 2013.
- W. Carruthers, I. Coldham. Modern Methods of Organic Synthesis, Cambridge University Press, 4th Edn. 2012.

Course Objective:

1. Develop an advanced understanding of important organic name reactions, modern synthetic reagents, and their applications in selective organic transformations.
2. Acquire comprehensive knowledge of the nomenclature, synthesis, rearrangements, and synthetic applications of heterocyclic compounds.
3. Understand the principles and strategies of asymmetric synthesis, including chiral pool synthesis, organocatalysis, biocatalysis, and enantioselective reactions.
4. Explain the mechanistic and stereochemical aspects of pericyclic reactions using molecular orbital theory and orbital symmetry conservation principles.
5. Apply advanced synthetic methodologies and mechanistic concepts to the design and execution of efficient and stereoselective organic syntheses relevant to research and industrial applications.

Course Outcome:

Upon successful completion of this course, students will be able to:

1. Explain the mechanisms, stereochemical features, and synthetic applications of important organic name reactions and modern reagents used in selective organic synthesis.
2. Apply advanced synthetic reagents and reaction methodologies to design efficient routes for the preparation and functional group transformation of organic molecules.
3. Classify, name, synthesize, and analyse five- and six-membered heterocyclic compounds, including their rearrangements, ring transformations, and applications in organic synthesis.
4. Demonstrate an understanding of the principles of asymmetric synthesis and apply chiral pool strategy, asymmetric cycloaddition, organocatalysis, and biocatalysis to achieve enantioselective synthesis.
5. Interpret the mechanisms and stereochemical outcomes of electrocyclic reactions, cycloadditions, sigmatropic rearrangements, cheletropic reactions, group transfer reactions, and metal-catalysed cycloadditions using Woodward–Hoffmann rules, frontier molecular orbital theory, correlation diagrams, and Möbius–Hückel concepts.

6. Integrate concepts of modern synthetic methodology, heterocyclic chemistry, asymmetric synthesis, and pericyclic reactions to solve complex mechanistic and synthetic problems encountered in advanced organic chemistry research.

CHEM 203C: Physical Chemistry II **Marks: 50, Credits: 4**

1. Quantum Mechanics II **(14 Lectures)**

Introduction, approximate methods in Quantum Mechanics: variational method; statement and proof of the Rayleigh-Ritz variational principle; evaluation of ground-state energies using trial wave functions on some model QM systems; linear variational method and its applications to simple molecular systems, including linear and cyclic polyenes using the Hückel Molecular Orbital (HMO) approximation; time independent perturbation theory: Rayleigh-Schrödinger perturbation theory for non-degenerate systems; derivation of first-order corrections to energy and wave function, and second-order correction to energy; applications to simple quantum mechanical systems.

2. Photo-excited Processes **(16 Lectures)**

Introduction, Jablonski diagram, photoexcitation, fluorescence, phosphorescence, photosensitization, delayed fluorescence: E- and P-type, quantum yield and its determination, fluorescence quenching: static and dynamic, application of Stern-Volmer equation/plot (linear and non-linear); absorption, emission and excitation spectra - mirror symmetry, excited state processes, Marcus theory, solvent effect in spectroscopy, solvation dynamics, sensing of biologically relevant cations, anions and neutral molecules, chemosensors.

3. Nanotechnology: Principles and Applications **(16 Lectures)**

Introduction, fundamental principles of nanoparticles (0D, 1D, 2D and 3D) and their physical, optical, electronic, magnetic properties; metallic and semiconducting nanoparticles; density of states, some special nanomaterials - quantum wire, thin film, fullerenes, carbon nanotubes and nanodiamonds; nanolithography; material characterization techniques: transmission electron microscopy (TEM), scanning electron microscope (SEM) and atomic force microscopy (AFM); applications of nanotechnology.

4. Thermodynamics and Statistical Mechanics **(16 Lectures)**

Introduction, Legendre transformation with applications; Maxwell-Boltzmann distribution with degeneracy (distinguishable and indistinguishable particles), partition function and its properties, interpretation of thermodynamic laws, thermodynamic functions in terms of partition functions, molecular partition functions (translational, rotational, vibrational and electronic) for ideal gas,

Sackur-Tetrode equation, calculation of thermodynamic functions for mono- and diatomic gases, equipartition principle, equilibrium constant in terms of partition functions.

5. Symmetry & Group Theory II (18 Lectures)

The Great Orthogonality Theorem (GOT) - statement and interpretation, proof of its corollaries; character table and its construction, number of times an irreducible representation occurs in a reducible one; the reduction of reducible representations, notation of irreducible representations, representations and quantum mechanics, the invariance of Hamiltonian operator under symmetry transformations, direct product representation, molecular vibrations, symmetry species of vibrational mode, selection rules for Infrared and Raman spectra, crystal field splitting.

Reference Books:

- L. Pauling, E. B. Wilson. Introduction to Quantum Mechanics, McGraw-Hill, New York, 1939.
- H. Eyring, J. Walter, G. F. Kimball. Quantum Chemistry, Wiley, New York, 1944.
- P. W. Atkins. Molecular Quantum Mechanics, Clarendon Press, Oxford, 1980.
- L. I. Schiff. Quantum Mechanics, McGraw-Hill, New York, 1985.
- A. K. Chandra. Introductory Quantum Chemistry, Tata McGraw-Hill Publishing, New Delhi, 1989.
- F. L. Pilar. Elementary Quantum Chemistry, Tata McGraw-Hill, New Delhi, 1990.
- D. A. McQuarrie. Quantum Chemistry, Viva Books Pvt Ltd, New Delhi, 2003.
- J. R. Lakowicz. Principles of Fluorescence Spectroscopy, 3rd Edn. Springer, 2010.
- N. J. Turro. Modern Molecular Photochemistry, The Benjamin Cummings Publishing, 1978.
- B. Valeur, M. N. Berberan-Santos. Molecular Fluorescence: Principles and Applications, John Wiley & Sons, New York, 2012.
- K. Rohatgi-Mukherjee, Fundamentals of Photochemistry, New Age International (P) Ltd, India, 2007.
- C. Bréchignac, B. P. Houdy, M. Lahmani. Nanomaterials and Nanochemistry, Springer, London, 2006.
- C. N. R. Rao, A. Muller, A. K. Cheetam. The Chemistry of Nanomaterials: Synthesis, Properties and Applications, Wiley-VCH verlog, Germany, 2005.
- G. Cao. Nanostructures and Nanomaterials: Synthesis, Properties and Applications, Imperial College Press, London, 2004.

- R. W. Kelshell, I. W. Hameley, M. Geoghegan. Nanoscale Science and Technology, John Wiley & Sons, England, 2005.
- C. P. Poole, F. J. Owens. Introduction to Nanotechnology, Wiley Interscience, 2003.
- T. Pradeep. A Textbook of Nanoscience and Nanotechnology, Tata McGraw-Hill India, 2012.
- P. Diwan, A. Bharadwaj. The Nanoscope: Encyclopedia of Nanoscience and Nanotechnology. Pentagon Press, 2005.
- N. Levine. Physical Chemistry, Tata McGraw-Hill, New Delhi, 1978.
- K. Denbigh. Principles of Chemical Equilibrium, Cambridge University Press, Cambridge, 1981.
- M. Klotz, R. M. Rosenberg. Chemical Thermodynamics, John Wiley & Sons, New York, 1994.
- G. W. Castellan. Physical Chemistry, 3rd Edn. Narosa Publishing House, 1995.
- N. A. Gokcen, R. G. Reddy. Thermodynamics, Plenum Press, New York, 1996.
- P. W. Atkins. Physical Chemistry, Oxford University Press, Oxford, 1998.
- R. S. Berry, S. A. Rice, J. Ross. Physical Chemistry, Oxford University Press, Oxford, 2000.
- S. C. Rakshit. Molecular Symmetry Group and Chemistry, The New Book Stall, Kolkata, 1988.
- F. A. Cotton. Chemical Applications of Group Theory, 3rd Edn. John Wiley & Sons. New York, 1999.
- D. M. Bishop. Group Theory and Chemistry, Oxford University Press, 1993.
- J. Vincent. Molecular Symmetry and Group Theory, John Wiley & Sons. New York, 1998.

Course Objective:

1. Develop a strong theoretical foundation in advanced quantum mechanics, including variational method; Rayleigh-Ritz variational principle; linear variational method and its applications to simple molecular systems, including linear and cyclic polyenes using the Hückel Molecular Orbital (HMO) approximation**;** time independent perturbation theory etc.
2. Learn in-detail about Jablonski diagram, quantum yield and its determination, fluorescence quenching; absorption, emission and excitation spectra, excited state processes, Marcus theory, solvent effect in spectroscopy, solvation dynamics etc.
3. Provide a basic knowledge about physical, optical, electronic, magnetic properties of nanoparticles, quantum wire, thin film, fullerenes, carbon nanotubes and nanodiamonds;

nanolithography, transmission electron microscopy, scanning electron microscope and atomic force microscopy etc.

4. Expose students towards Maxwell-Boltzmann distribution with degeneracy, partition function and its properties, thermodynamic functions in terms of partition functions, molecular partition functions for ideal gas, Sackur-Tetrode equation, equilibrium constant in terms of partition functions etc.
5. Elaborate the theoretical details of the Great Orthogonality Theorem (GOT), proof of its corollaries, character table and its construction, the reduction of reducible representations, notation of irreducible representations, representations and quantum mechanics, the invariance of Hamiltonian operator under symmetry transformations, direct product representation, molecular vibrations, selection rules for Infrared and Raman spectra etc.

Course Outcome:

After the completion of this course, the students will be able to

1. Gather a strong theoretical foundation in advanced quantum mechanics, including variational method; Rayleigh-Ritz variational principle; linear variational method and its applications to simple molecular systems, including linear and cyclic polyenes using the Hückel Molecular Orbital (HMO) approximation**;** time independent perturbation theory etc.
2. Collect in-detail information about Jablonski diagram, quantum yield and its determination, fluorescence quenching; absorption, emission and excitation spectra, excited state processes, Marcus theory, solvent effect in spectroscopy, solvation dynamics etc.
3. Have a basic knowledge about physical, optical, electronic, magnetic properties of nanoparticles, quantum wire, thin film, fullerenes, carbon nanotubes and nanodiamonds; nanolithography, transmission electron microscopy, scanning electron microscope and atomic force microscopy etc.
4. Allow the students to acquire knowledge about Maxwell-Boltzmann distribution with degeneracy, partition function and its properties, thermodynamic functions in terms of partition functions, molecular partition functions for ideal gas, Sackur-Tetrode equation, equilibrium constant in terms of partition functions etc.
5. Have extensive theoretical knowledge about the Great Orthogonality Theorem (GOT), proof of its corollaries, character table and its construction, the reduction of reducible representations, notation of irreducible representations, representations and quantum mechanics, direct product representation, molecular vibrations, selection rules for Infrared and Raman spectra etc.

Practical Paper

CHEM 204C (PR): Physical Chemistry Practical **Marks: 50, Credits: 4**

1. To determine the rate constant of acid catalyzed hydrolysis of an ester in a micellar media.
2. To verify Ostwald dilution law and determine the K_a of a weak acid.
3. To determine the rate constant and salt effect on the rate constant of the reaction between $K_2S_2O_8$ and KI.
4. To determine the composition of a mixture of acetic acid, sodium acetate and ammonium acetate by conductometry.
5. To study the titration of H_3PO_4 by NaOH using potentiometry.
6. To determine the composition of metal-ligand complex by Job's method.

Reference Books:

- B. Viswanathan, P. S. Raghavan. Practical Physical Chemistry, Viva Books, 2009.
- J. Mendham. Vogel's Quantitative Chemical Analysis, 6th Edn. Pearson Education, 2009.
- D. C. Harris. Quantitative Chemical Analysis, 6th Edn. W. H. Freeman, 2007.
- S. R. Palit, S. K. De. Practical Physical Chemistry, Science Book Agency.
- University Hand Book of Undergraduate Chemistry Experiments, edited by G. N. Mukherjee. University of Calcutta.
- B. P. Levitt. Findlay's Practical Physical Chemistry, 9th Edn. Longman Group Ltd. 1973.
- J. N. Gurtu, R. Kapoor. Advanced Experimental Chemistry, S. Chand & Co. Ltd.

Course Objective:

1. To become skilled at carrying out acid catalyzed hydrolysis reactions.
2. To become experienced to evaluate the k_a of a weak acid and validate the Ostwald dilution law.
3. To become experienced to determine the rate constant and salt effect on the rate constant of the reaction between $K_2S_2O_8$ and KI.
4. To become skilled to determine the composition of a mixture and metal-ligand complex.
5. To investigate the titration of H_3PO_4 by NaOH using potentiometry.

Course Outcome:

After the completion of this course, the students will be able to,

1. Develop proficiency in quantitative analysis of kinetic reaction rate.

2. Provide hands-on training in conductivity meter, pH meter etc.
3. Enhance laboratory skills in potentiometric titrations.
4. Learn to determine the exact composition of a mixture by conductometry and of metal-ligand complex colorimetrically/spectrophotometrically.

CHEM 205G: **General Chemistry** **Marks: 50, Credits: 4**

1. Structure and Properties of Organic Molecules **(35 Lectures)**

Nature of bonding in aliphatic, alicyclic, aromatic and heterocyclic compounds; bond length, bond strength, bond angle and their variations in compounds with sp^3, sp^2 and sp hybridized carbon atoms; orbital pictures of methane, ethane, ethene, ethyne, allene and benzyne; delocalized bonds, inductive effect, resonance, steric inhibition of resonance, hyperconjugation, tautomerism, aromaticity, Huckel's rules, aromatic, nonaromatic and antiaromatic compounds, non-benzenoid aromatic compounds; formation, structure, stability and reactions of classical and non-classical carbocations, carbanions, free radicals, arynes, ylides, carbenes and nitrenes.

2. Atomic Structure **(25 Lectures)**

Bohr's model, Sommerfeld's extension, de Broglie's wave particle duality; Heisenberg's uncertainty principle and Schrödinger's equation (qualitative); significance of ψ and ψ^2; radial density, angular probability, characteristics of s-/p-/d-orbital, Aufbau principle, Pauli's exclusion/antisymmetry principle (statement and implication), Hund's rules, Slater's rules, quantum defect; Mendeleev-Seaborg's periodic table: basis and possible extension; periodic properties: atomic radius, ionic radius, covalent radius, van der Waals radius, ionization energy, electron affinity, electronegativity and its different scales, orbital/group electronegativity, ionic potential, diagonal relationship, work function; aperiodicity.

3. Kinetic Theory of Gases **(20 Lectures)**

Idea of distribution functions, properties of gamma functions, Maxwell's speed and energy distributions in one-, two- and three- dimensions, distribution curves, different types of speeds and their significance, principle of equipartition of energy and its application to calculate the classical limit of molar heat capacity of gases.

Reference Books:

- I. L. Finar. Organic Chemistry, Volume I, 6th Edn, Addison Wesley Longmann, London, 1998.

- I. L. Finar. Organic Chemistry, Volume II, 5th Edn, ELBS, London, 1995.
- W. J. I. Noble. Highlights of Organic Chemistry, Mercel Dekker, New York, 1974.
- J. J. Li. Name Reactions: A Collection of Detailed Reaction Mechanisms, Springer, 2014.
- G. Brahmachari. Organic Name Reactions: A Unified Approach, Narosa Publishing House Pvt. Ltd., New Delhi, 2012.
- M. B. Smith, J. March. March's Advanced Organic Chemistry (Reactions, Mechanisms, and Structure), 5th Edn, John Wiley & Sons Inc. 2001.
- R. Bruckner, Advanced Organic Chemistry (Reaction Mechanisms), Harcourt/Academic Press, 2002.
- J. Clayden, N. Greeves, S. Warren, P. Wothers. Organic Chemistry, Oxford University Press, 2001.
- F. A. Carry, R. J. Sundberg. Advanced Organic Chemistry - Part-A and B, 5th Edn, Springer, 2007.
- L. G. Wade. Jr., M. S. Singh. Organic Chemistry, 6th Edn, Pearson Education, 2008.
- J. Moody. Reactive Intermediates, Oxford University Press, 1992.
- R. T. Morrison, R. N. Boyd, S. K. Bhattacharjee. Organic Chemistry, 7th Edn, Pearson Education, 2013.
- J. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi. Inorganic Chemistry: Principles of Structures and Reactivity, 4th Edn, Pearson, New Delhi, 2006.
- F. A. Cotton, G. Wilkinson, C. M. Murillo, M. Bochmann. Advanced Inorganic Chemistry, 6th Edn, John Wiley & Sons Inc. New York, 1999.
- P. Atkins, T. Overton, J. Rourke, M. Weller, F. Armstrong. Shriver & Atkins Inorganic Chemistry, 4th Edn, Oxford, 2006.
- P. C. Rakshit (Revised by S. C. Rakshit), Physical Chemistry, Sarat Book Distributers, Kolkata.
- P. W. Atkins, Julio De Paula. Physical Chemistry, Oxford University Press, Oxford.
- D. A. Mc-Quarie, J .D. Simon. Physical Chemistry: A Molecular Approach, Viva Book Pvt. Ltd.

Course Objective:

1. Develop a comprehensive understanding of the structure, bonding, and reactivity of organic molecules and the influence of electronic and steric effects on their chemical behaviour.

2. Acquire fundamental knowledge of atomic structure, quantum mechanical principles, periodic properties, and their applications in explaining chemical phenomena.
3. Understand the kinetic theory of gases and the statistical distribution of molecular velocities and energies.
4. Correlate theoretical concepts from organic, inorganic, and physical chemistry to explain molecular structure, stability, and chemical properties.
5. Strengthen analytical and problem-solving skills necessary for advanced studies and interdisciplinary research in chemical sciences.

Course Outcome:

Upon successful completion of this course, students will be able to:

1. Explain the nature of chemical bonding, molecular geometry, electronic effects, aromaticity, and the structure–reactivity relationships of aliphatic, aromatic, and heterocyclic organic compounds.
2. Analyse the formation, stability, and reactivity of reactive intermediates, including carbocations, carbanions, free radicals, carbenes, nitrenes, arynes, and ylides, in organic reaction mechanisms.
3. Apply the principles of atomic structure, quantum mechanics, electronic configuration, and periodic trends to interpret the physical and chemical properties of elements.
4. Explain periodic properties such as atomic and ionic radii, ionization energy, electron affinity, electronegativity, ionic potential, and related concepts, and correlate them with the behaviour of elements.
5. Apply the kinetic theory of gases and statistical distribution functions to analyse molecular speed and energy distributions and explain the principle of equipartition of energy and its application to the heat capacities of gases.
6. Integrate concepts from organic chemistry, atomic structure, and physical chemistry to solve advanced theoretical and quantitative problems relevant to postgraduate studies and chemical research.