M.Sc. CHEMISTRY SYLLABUS- COURSE OBJECTIVES AND OUTCOMES

(Effective from academic year 2023-2024 for Campus, Constituent and Affiliated colleges)

SEMESTER –I

Semester-I and Semester-II syllabus is common for all specializations i.e., Inorganic, Organic, Physical, Physical- Organic, Analytical and Pharmacoinformatics.

Paper-I CH 101 (Inorganic Chemistry) **Course Objectives:**

Paper 1: CH 101 (Inorganic Chemistry)

IC 01: Symmetry of molecules

IC 02: Bonding in Metal Complexes-I

IC 03: Coordination equilibria

- The learners should be able to recognise the symmetry in molecules and understand its role in chemistry, understand the concept of symmetry elements, symmetry operations and point groups.
- They will be able to learn the concept of Crystal field theory of bonding and apply it to understand magnetic properties, structures, stability and reactivity of transition metal complexes.
- They will be able to understand the stability of metal complexes by the use of stability constants, factors affecting the stability constants, different methods for the determination of stability constants and formation of ternary metal complexes..

Learning Outcomes:

- **Classify and recognize** the symmetry elements and their operations as required to specify molecular symmetry, possible point groups from symmetry elements and identify the point group of molecules by systematic procedure.
- **Explore** the role of symmetry in determining molecular properties like optical activity and dipole moment.
- **Understand** different splitting patterns of d-orbitals in various crystal fields.
- **Identify** the strong and weak field ligands and evaluate the extent of splitting in octahedral complexes.
- **Calculate** crystal field stabilisation energy and magnetic properties of transition metal complexes and apply it to study their properties.
- **Study** stepwise and overall stability constants of metal complexes and identify the relation between .
- **Evaluate** the factors affecting the stability of complexes.
- **Explore** different methods for the determination of stability constants.

Paper-II: CH 102 (Organic Chemistry)

OC-01: Stereochemistry

OC-02: Reaction mechanism-1

OC-03: Conformational analysis (Acyclic systems)

Paper-II: CH 102 (Organic Chemistry) Course objectives:

- To learn and apply the various concepts of stereochemistry, conformational analysis and fundamentals of reaction mechanism.
- To know about determination of reaction mechanism and, Stereochemistry of addition to C=C bond, elimilination and aromatic nucleophic substitution reactions.

Learning outcomes:

At the end of the course, the students should be able to:

- Identify chirality and differentiate chirality centers, axis, planes and helices, E,Z-isomers and determine the absolute configuration. Know about racemic modification and their resolution methods.
- Elucidate the reaction mechanism by trapping intermediates, using isotope effects, IR and NMR
- Predict the stereochemical course of addition, eliminate and to identify types of Aromatic Nucleophilic substitution reactions.
- Evaluate the stability of various conformers of acyclic systems using steric, electronic and stereoelectronic effects and correlate them to reactivity.

Paper-III: CH 103 (Physical Chemistry)

PC-01: Thermodynamics

PC-02: Electrochemistry

PC-03: Quantum Chemistry-I

Paper-III: PHYSICAL CHEMISTRY Course Objectives:

- The learners should be able to understand and apply the third law of thermodynamics and evaluation of absolute entropies from heat capacity data.
- They can understand the significance and conditions of equilibrium in terms of chemical potential and the temperature dependence of equilibrium reactions, partial molar properties and their significance, to calculate thermodynamic properties of ideal gases, real gases, distinguish the real and ideal behaviour with the introduction of activity and fugacity concepts and application of equilibrium thermodynamics to multicomponent systems.
- They can learn about various types of electrochemical cells and electrodes and their applications in measuring EMF of a cell and its applications analysing various solutions in determining their concentrations, solubility products, determining their pH etc. Further they can have insight of understanding the behaviour of strong electrolytes through the Debye-Huckel theory.
- The learners understand the evolution and basic concepts of quantum mechanics, understanding about various types of operators, eigen functions, Solve elementary model problems in quantum mechanics, particle in a potential-free box.

Learning Outcomes:

- **Calculat**e change in thermodynamic properties, equilibrium constants, partial molar quantities, chemical potential. Identify factors affecting equilibrium constant.
- **Explain** dependence of heat capacity of solids at low temperatures and evaluate absolute entropies.
- **Construct** various electrochemical cells and **understand** the use of various electrodes
- **Eliminate** liquid junction potential and understand the over potentials of different systems
- **Estimate** the concentrations of various analytes by EMF measurements, potentiometric titrations and pH measurements.
- **Apply** particle in a box model to evaluate energies of conjugated systems.
- **Calculate** mean ionic activity coefficients and ionic strengths using Debye-Huckel limiting law
- **Use** mathematical techniques in linear algebra for eigenvalues and eigenvectors
- **Solve** the Schrodinger equation for exactly solvable problems for bound states such as particle-in-a-box.

Paper-IV: CH 104 (Analytical Techniques and Spectroscopy – I)

ASP 01: Techniques of Chromatography & Electronic spectroscopy

ASP 02: NMR spectroscopy-I

ASP 03: Vibrational spectroscopy

Paper-IV: CH 104 (Analytical Techniques and Spectroscopy – I: Course outcome

- To understand underlying principles of chromatographic separation techniques and gain knowledge about GC, HPLC principles, instrumentation, detectors, and practical applications.
- To explore the principles of UV-Visible Spectroscopy and learn to analyze various unsaturated organic compounds.
- To develop an understanding of the principles, instrumentation of NMR spectroscopy and to analyse organic molecular structure, understand reaction mechanisms, isomerism, conformational analysis, and hydrogen bonding of NMR spectroscopy.
- Gain insight into the interaction of electromagnetic radiation with matter, to understand the fundamental principles of Infrared (IR) Spectroscopy for diatomic and polyatomic molecules.
- Gain knowledge about Raman spectroscopy, its theories, selection rules, and instrumentation, and its complementary nature to IR spectroscopy.

Learning Outcomes:

- **Knowledge Acquisition**: Overall, students should equip with the theoretical knowledge needed to perform chromatographic separations, interpret spectroscopic data, and apply these techniques in various analytical and research contexts within the field of chemistry.
- **Analytical Skills**: Develop the ability to analyze and interpret chromatographic data and UV-Visible, NMR and IR spectra effectively.
- **Instrumentation Proficiency**: The student gains skill to use chromatographic and spectroscopic instruments, including gas chromatographs, high-performance liquid chromatographs, UV-Visible spectrometers, and NMR instruments

Paper CH 151: Inorganic chemistry Lab Course Objectives: 4 hrs / **week**

The learners should be able to handle and calibrate laboratory glassware, learn the synthesis of the complexes and estimate the ions through titrimetric and gravimetric analysis techniques.

Learning Outcomes:

- **Apply** procedures from literature sources to synthesize given complexes.
- **Calibrate** the laboratory glassware to be used in titrimetric analysis.
- **Estimate** the concentration of the analyte by titrimetric and gravimetric techniques.
- **Perform** stoichiometric calculations using titration and gravimetric data.

Paper CH 152: Organic Chemistry Lab course Course objectives:

The laboratory course is aimed at

- To improve skills in synthesizing organic compounds using various chemical techniques
- Understand the reaction mechanisms of various organic reactions,
- learn techniques – melting points, purification-recrystallization, extraction

Learning outcomes:

- Acquire skills to observe and record scientific experiments.
- Familiarize with the laboratory equipments, various chemicals, and would be able to use their knowledge of chemical reactivity
- to plan and execute the preparation of compounds using various C-C and C-hetero bond-forming reactions and various organic transformations from commercially available starting materials

Paper CH 153 Physical Chemistry Lab Course Objectives:

- The learners should be able to validate the conceptual understanding acquired from the theory classes

Learning Outcomes: At the end of the course, the learners should be able to

Explain the principle behind the experiments performed in the laboratory

- **Plan** and **Perform** experiments and
- **Interpret** experimental results

Paper CH 154: Analytical Chemistry-I Lab course objectives

- Introduce students to common analytical techniques,
- To develop proficiency in performing various chemical estimations using titration and complexometric methods.
- To teach students the principles and practice of thin layer chromatography
- To demonstrate the estimation of drug content in pharmaceutical preparations
- To provide hands-on experience in determining physical properties of solutions and with colorimetric techniques

Learning Outcomes:

- Helps to perform accurate estimations and to conduct drug assays
- To understand and apply thin layer chromatography.
- To determine physical properties of solutions.
- To apply colorimetry principles for quantitative analysis.

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SEMESTER –II

Semester-I and Semester-II syllabus is common for all specializations i.e., Inorganic, Organic, Physical, Physical- Organic, Analytical and Pharmacoinformatics.

Paper-I: CH 201 (Inorganic chemistry)

IC 04: Reaction mechanisms of transition metal complexes
IC 05: Bonding in metal complexes-II
IC 06: Metal clusters and Ligational Aspects of Diatomic molecules

Paper-I **CH 201 Inorganic chemistry** Course Objectives:

- The learners should be able to learn the basic concepts of inorganic reaction mechanism, different mechanisms for octahedral and square planar complexes, trans effect and its application in the synthesis of different metal complexes and also learn about different types of electron transfer reactions.

- They will be able to gain knowledge on the nature of the energy levels of the free metal ion, different types of electronic interactions such as spin-spin, orbital-orbital and spin orbital categorised by term symbols. They can also learn the importance of Orgel diagrams to show the energy levels of octahedral and tetrahedral transition metal ions.

  They will be able to understand classification and structural patterns of metal clusters, bonding modes of metal carbonyl, metal nitrosyl and metal halide clusters. They can learn to differentiate low and high nuclearity carbonyl clusters and understand capping rules in metal clusters.

Learning Outcomes:

- **Understand** the relationship between the type of mechanism and geometric shape of the complex.
- **Compare** different mechanisms for octahedral and square planar complexes
- **Learn** to identify possible reaction mechanisms from suitable rate data.
- **Recognise** the different types of mechanism like substitution, electron transfer.
- **Calculate** the number of microstates for a particular configuration.
- **Identify** the ground state term predicted by Hund's rules.
- **Analyse** electronic transitions in metal complexes through orgel diagrams.
- **Understand** the bonding modes of metal carbonyl and metal nitrosyl clusters.
- **Identify** low nuclearity and high nuclearity carbonyl clusters.
- **Recognise** the structural types in dinuclear metal-metal systems.

Paper-II: CH 202 (Organic Chemistry) Course objectives:

- To learn the involvement of neighboring group participation, reactive intermediates and understand their structure and reactivity through various organic reactions
- To know about types of rearrangement and the mechanisms of rearrangements..
- To learn and understand the orbital interactions (Woodward Hoffmann rules) in concerted reactions and Learn the fundamental ideas of photochemical excitation/de-excitation events, and the molecular events that can intervene at different levels and their applications.

Learning outcomes:

At the end of the course, the students should be able to:

- Understand the structure-reactivity pattern of reactive intermediates involved in organic reactions and rearrangements. Write he tmechanism of organic reactions involving reactive intermediates
- Comprehend the orbital interactions and orbital symmetry correlations of various pericyclic reactions and apply these reactions in organic synthesis
- Apply photochemistry concepts for photochemical application of specific interest and predict the course of an organic photochemical reaction and identify the product with the type of functional group present on the molecule

Paper-III: CH 203 (Physical Chemistry)

PC-04: Chemical Kinetics and Photochemistry ;

PC-05: Quantum Chemistry-II;

PC-06: Solid State Chemistry:

Paper-III: CH 203 Physical Chemistry Course Objectives:

- The learners should be able to apply elementary laws of chemical kinetics and formulate thermodynamic properties of activated complexes
- They can understand the characteristics of various types of reactions and apply staeady state treatment in deriving their rate laws. And can get an insight of the linear free energy relationships and their dependence on electronic effects and analyze reaction mechanisms.
- They can understand the differences and applications of photophysical and photochemical processes, derive expressions for quantum yields of processes & life times of the species involved.
- The process of photosensitization and its significance, quenching phenomenon can be understood by the learners. Further, can understand the photochemical reaction set up to study the reactions in presence of light and also the principle of flash photolysis in studying fast reactions and short lived species.
- They are introduced to mathematical coordinate systems and their inter relations, representation of Schrodinger wave equation and its separation to different variable in deriving and solving expression to get various quantum numbers, physical interpretation of wave functions, probability of wave functions.
- Certain approximation methods such as variation method are also introduced to learners to teach them to set up a trial wave function, evaluate energies of various hydrogen-like systems.
- Introduction of molecular orbital theory and building molecular orbitals wave functions and evaluating their energies is covered for learners in this paper.
- They are introduced to the band theory in understanding the electronic properties of solids. The application of semiconductors in p-n junctions, the concept of photoconductivity and photovoltaic effect and their significance were also covered in this paper.
- The learners get a detailed knowledge of basic concepts of superconductivity and types of superconductors and their behaviour, structure, preparation and applications of 1-2-3 super conductor.
- They learn about basics of nanomaterials, methods of synthesis of nanomaterials, their characterization by XRD and electron microscopic techniques and the applications of nanomaterials.

Learning Outcomes:

At the end of the course, the learners should be able to:

- **Solve** problems on rate/rate constants/efficiency for (i) complex reactions (ii) unimolecular and bimolecular reactions, and (iii) electronically excited state dynamics
- **Estimate** thermodynamic properties of activated complexes
- **Derive** the expressions for quantum yields of processes and estimate the quantum yields, rate constants and life times of the excited species involved.
- **Build** molecular orbitals, **Set up** trial wave functions, **Evaluate** energies of systems using approximation methods.
- **Prepare, evaluate** the properties of superconductors and understanding the phenomenon of superconductivity and its applications.
- **Synthesize** nanomaterials, characterize and learn to explore their applications.

Paper-IV: CH 204 (Analytical Techniques and Spectroscopy – II) 15 hrs

ASP 04: Electro and Thermal Analytical Techniques
ASP 05: NMR-II and ESR Spectroscopy
ASP 06: Mass spectrometry

Paper-IV: CH 204 (Analytical Techniques and Spectroscopy – II) Course objectives

- To introduce students to various electroanalytical and thermal techniques
- To Make the student familiarize with polarography, amperometric titrations, cyclic voltammetry, thermogravimetry, DTA and DSC.
- To extend students understanding of NMR to multinuclear NMR and solid-state NMR.
- Explore advanced NMR techniques such as discrimination of enantiomers, nuclear Overhauser enhancement (NOE), and applications of 19F and 31P NMR.
- Introduce Electron Spin Resonance (ESR) spectroscopy for the study of free radicals.
- To introduce the principles of mass spectrometry (MS) and the origin of mass spectra.
- To teach students about electron impact (EI) mass spectrometry and the determination of molecular formula.
- To explore advanced MS topics, including high-resolution mass spectrometry, fragmentation patterns, and various ionization methods.
- To introduce the applications of MS in conjunction with chromatography techniques (GC-MS and LC-MS).

Learning Outcomes:

- To understand the principles and instrumentation of polarography and amperometric titrations and apply for qualitative and quantitative analysis,
- To Perform cyclic voltammetry and interpret results for chemical analysis.
- Gain knowledge of thermal analysis methods and their applications in studying materials.
- Interpret multinuclear NMR spectra, including first-order and non-first-order spectra.
- Understand techniques for simplifying complex NMR spectra.
- Apply 19F and 31P NMR spectroscopy to study various compounds.
- Gain knowledge of solid-state NMR and its applications.
- Understand the principles and applications of ESR spectroscopy in studying free radicals.
- Understand the principles of EI mass spectrometry and the interpretation of mass spectra.
- Identify and interpret different types of fragments and isotopic peaks.
- Explore advanced MS topics like fragmentation patterns and ionization methods.
- Understand the principles and applications of Gas Chromatography-Mass Spectrometry (GC-MS) and Liquid Chromatography-Mass Spectrometry (LC-MS) techniques

Paper CH 251 : Inorganic chemistry Lab Course Objectives:

- The learners should be able to synthesise the metal complexes, learn to separate the ions from a mixture and estimate the ions by titrimetric and gravimetric analysis techniques.
- They should be able to determine the capacity of an ion exchange resin and learn separation of ions on an anion exchange resin and their estimation.

Learning Outcomes:

- **Apply** procedures from literature sources to synthesize the given complexes.
- **Separate the ions from a mixture and estimate** by titrimetric and gravimetric techniques.
- **Perform** stoichiometric calculations using titration and gravimetric data.
- **Separate** ions on an anion exchange resin and estimate the ions.

Paper CH 252: Organic Chemistry Lab Course objectives:

The laboratory course is aimed at

- To recognize organic compounds based in the principal functional groups.
- To enable the students to analyze the functional group in the organic compound through qualitative analysis

Learning outcomes:

- Use different types of solvents and reagents in analyzing the functional group of the organic compounds

Paper CH 253: Physical Chemistry Lab Course Objectives:

- The learners should be able to validate the conceptual understanding acquired from the theory classes

Learning Outcomes: At the end of the course, the learners should be able to:

- **Explain** the principle behind the experiments performed in the laboratory
- **Plan** and **Perform** experiments and **Interpret** experimental results
- **Analyze and correlate** the data obtained with error analysis.

Paper CH 254: Analytical Chemistry -II & Spectrscopy Lab course Objectives:

- Applied Analysis: To Perform accurate chemical estimations through titration methods.
- Apply analytical techniques to estimate real-world problems which include antacid alkali content and milk, calcium estimations.
- Spectral Analysis: To interpret IR, UV, 1H NMR, and MS spectra of representative organic compounds.
- Instrumental Analysis: To apply conductometry, potentiometry, and pH metry techniques in titration and redox reactions.

Learning Outcomes

- This lab course aims to provide practical skills in chemical analysis, spectral interpretation, and instrumental techniques for applications in analytical chemistry and spectroscopy.