**Department of Chemistry**

**COURSE OUTCOMES**

**M. Sc. Chemistry**

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| **S No** | **Class & Semester** | **Course & Course Code** | **COs** | **Course Outcomes** |
| **01** | **M.Sc. & I-Sem.** | **Inorganic Chemistry-I MCH-6101** | CO 1 | Explain the fundamental concepts of VSEPR theory, Walsh diagrams, and bonding features, including dπ-pπ bonds and hybridization energetics. |
| CO2 | Analyze the principles of Crystal Field Theory and Molecular Orbital Theory in various geometries, incorporating π-bonding effects. |
| CO3 | Illustrate electronic spectra and magnetic properties of transition metal complexes using Tanabe-Sugano diagrams and spectroscopic methods. |
| CO4 | Interpret the bonding and structures of metal carbonyls and clusters using vibrational spectroscopy and Wade's rule. |
| CO5 | Describe the principles of radioactive decay, detection methods, and instrumentation in nuclear and radiochemistry. |
| **02** | **M.Sc. & I-Sem.** | **Organic Chemistry-I MCH-6102** | CO 1 | Students will be able to identify and explain the key steps and requirements of various reaction mechanisms, including kinetic and thermodynamic control. |
| CO2 | Students will apply Huckel’s rule and other theoretical frameworks to evaluate the aromaticity or anti-aromaticity of complex molecules. |
| CO3 | Students will interpret and predict stereochemical outcomes of reactions using nomenclature, projection conversions, and rules like Cram’s and Prelog’s. |
| CO4 | Students will classify and analyze nucleophilic and electrophilic substitution reactions, including their mechanisms, regioselectivity, and stereoselectivity. |
| CO5 | Students will use quantitative methods such as the Hammett and Taft equations to predict reaction rates and mechanisms based on molecular structure. |
| **03** | **M.Sc. I-Sem.** | **Physical Chemistry-I MCH-6103** | CO 1 | Students will recall the postulates of quantum mechanics and explain key concepts such as operators (linear, commutator, Hamiltonian), eigenvalues, eigenfunctions, and the Schrödinger equation |
| CO2 | Students will apply Schrödinger's equation to different systems like the particle in a one-dimensional box, the three-dimensional box, the simple harmonic oscillator, the rigid rotor, and the hydrogen atom, including solving for radial and angular wave functions |
| CO3 | Students will analyze the concepts of angular momentum in quantum systems, including the use of ladder operators and the addition of angular momentum. |
| CO4 | Students will evaluate and compare approximation methods such as the variation theorem, linear variation principle, and perturbation theory, applying these methods to the helium atom. |
| CO5 | Students will apply the concepts of surface tension, capillary action, and adsorption isotherms (Langmuir and BET) to real-world systems. They will analyze and interpret the Gibbs adsorption isotherm and electrokinetic phenomena. |
| **04** | **M.Sc. I-Sem.** | **Spectroscopy-I MCH-6105** | CO 1 | Recall the basic principles of stereochemistry, bonding theories, and their applications to the main group and transition metal compounds, including VSEPR theory.. |
| CO2 | Explain the limitations of bonding theories such as VSEPR and crystal field theory. |
| CO3 | Apply concepts of molecular orbital theory to predict bonding, structures, and spectroscopic properties of octahedral, tetrahedral, and square planar complexes, including π-bonding interactions |
| CO4 | Analyze the electronic spectra of transition metal complexes using Orgel and Tanabe-Sugano diagrams, calculate crystal field splitting parameters (Dq, B, and β), and interpret charge transfer spectra. |
| CO5 | Discuss the bonding and structure of metal π-complexes (e.g., 2/3carbonyls of Fe, Co, Ni) and interpret their vibrational spectra to elucidate structural information. |
| **05** | **M. Sc. II-Sem.** | **Inorganic Chemistry-II MCH-6202** | CO 1 | Recall the fundamental concepts of symmetry elements, symmetry operations, and the classification of molecular symmetry into point groups using Schönflies symbols. |
| CO2 | Explain the mechanisms of molecular rearrangement processes, including outer sphere and inner sphere electron transfer, and analyze the role of HOMO and LUMO in these reactions. |
| CO3 | Classify organometallic compounds based on bond types, and describe the types of metal-carbon bonds  and synergic bonding in terms of metal-to-ligand and ligand-to-metal back-donation. |
| CO4 | Apply the 18-electron rule to predict the stability and bonding of organometallic compounds and evaluate the general methods of their synthesis, including transmetallation and oxidative addition. |
| CO5 | Analyze the reactivity patterns and catalytic applications of organometallic compounds in industrial processes such as hydrogenation, hydroformylation, olefin metathesis, and C-C coupling reactions (e.g., Heck, Suzuki, and Stille). |
| **06** | **M.Sc. II-Sem.** | **Organic Chemistry-II MCH-6203** | CO 1 | Students will be able to recall the mechanisms of addition, elimination, and rearrangement reactions and identify key reactions such as Aldol, Michael, and Diels-Alder. |
| CO2 | Students will be able to explain the stereochemical and mechanistic aspects of addition reactions involving electrophiles, nucleophiles, and free radicals, including regio- and chemoselectivity. |
| CO3 | Students will be able to predict the products of pericyclic reactions, including Diels-Alder, sigmatropic rearrangements, and electrocyclic reactions, using molecular orbital symmetry principles. |
| CO4 | Students will be able to analyze the reactivity of substrates and reagents in elimination reactions (E2, E1, and E1cB) and assess the influence of structural and environmental factors on product orientation. |
|  | CO5 | Students will be able to classify rearrangement reactions (e.g.,Pinacol, Baeyer-Villiger, Beckmann) based on their migration mechanisms and analyze the migratory aptitude of substituents to predict outcomes. |
| **06** | **M.Sc. II-Sem.** | **Spectroscopy Chemistry-II MCH-6205** | CO 1 | Students will be able to recall the principles of ultraviolet (UV), visible, and infrared (IR) spectroscopy, including the Beer-Lambert law and characteristic vibrational frequencies for functional groups. |
| CO2 | Students will be able to explain the factors influencing electronic transitions, such as solvent effects and steric hindrance, and describe the fragmentation patterns in mass spectrometry for various organic compounds. |
| CO3 | Students will be able to apply rules like Woodward-Fieser and Karplus relationships to predict UV-Vis absorption maxima and spin-spin coupling constants in proton NMR spectra. |
| CO4 | Students will be able to interpret two-dimensional NMR techniques such as COSY, NOESY, and DEPT for detailed structural elucidation and evaluate the contributions of coupling constants and chemical shifts in both proton and carbon-13 NMR spectra. |
| CO5 | Students will be able to analyze spectral data from UV, IR, NMR, and mass spectrometry to determine the structure of organic molecules, including complex cases with overlapping peaks or functional group interactions. |
| **07** | **M.Sc. II-Sem.** | **Research Methodology-II**  **MCH-6201** | CO 1 | Define the key concepts of scientific inquiry, including induction, deduction, hypothesis, and theory, and explain their role in multidisciplinary and interdisciplinary research in commerce |
| CO2 | Identify and choose appropriate research problems and sampling techniques for designing a research study. |
| CO3 | Apply methods of data collection, including observation, interviews, and questionnaires, to gather primary and secondary data for research purposes.. |
| CO4 | Analyze and interpret data using processing operations, classification, tabulation, and visualization to derive meaningful conclusions |
| CO5 | Use quantitative tools such as measures of central tendency, dispersion, and hypothesis testing to evaluate data trends and relationships. |

**M. Sc. Second Year (Sem-III to Sem-IV)**

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| **S No** | **Class & Semester** | **Course & Course Code** | **COs** | **Course Outcomes** |
| **01** | **M.Sc. III-Sem** | **Solid state and nano materials**  **(MCH-301)** | CO 1 | Students will recall and describe the fundamental concepts of solid-state chemistry, including types of defects (Schottky, Frenkel), lattice imperfections, and the thermodynamics of these defects. |
| CO2 | Students will apply the principles of solid-state reactions, including nucleation, sintering, and co-precipitation. They will also use kinetic concepts to analyze solid-state reactions and understand factors influencing their reactivity. |
| CO3 | Students will analyze the synthesis, structure, and properties of high-temperature superconductors, solid-state lasers, and inorganic phosphors. |
| CO4 | Students will evaluate various X-ray diffraction methods, including Bragg’s condition, Miller indices, and the Debye-Scherrer method. |
| CO5 | Students will analyze the scattering intensity in electron diffraction, apply Wierl’s equation, and evaluate its role in determining the structure of simple gas-phase molecules and surfaces. |
| **02** | **M.Sc. III-Sem** | **Green Chemistry**  **(MCH-302)** | CO 1 | Recall the key principles and concepts of green chemistry, including the twelve principles of green chemistry and their applications in organic synthesis and environmental sustainability. |
| CO2 | Explain the importance of green chemistry in addressing environmental challenges and discuss the role of green reagents, catalysts, and alternative energy sources in sustainable chemical processes.. |
| CO3 | Apply green chemistry principles to design environmentally friendly organic synthesis reactions using non-traditional approaches such as green reagents, nanocatalysts, and biocatalysts |
| CO4 | Analyze the benefits and limitations of microwave-induced synthesis, ultrasound-assisted green synthesis, and electrochemical methods in organic transformations, evaluating their impact on efficiency and sustainability. |
| CO5 | Utilize ionic liquids, aqueous phase reactions, and fluorous solvents in green synthesis to improve selectivity, reduce environmental impact, and enhance reaction efficiency in organic reactions. |
| **03** | **M.Sc. & III-Sem** | **Biophysical Chemistry**  **(MCH-303)** | CO 1 | Define biosensors, bio-receptors, and electrochemical transducers, and describe the components and functions of biosensor systems in various applications, such as glucose monitoring, food analysis, and DNA biosensors. |
| CO2 | Explain the principles of bio-electrocatalysis and nanochemistry, including the role of enzymes as biological catalysts, immobilization techniques, and the synthesis and applications of nanomaterials in medicine, pollution elimination, and industry |
| CO3 | Apply the knowledge of biosensors to identify and monitor glucose levels, blood conditions, and pregnancy through colorimetric and electrochemical strip methods, demonstrating practical applications in healthcare. |
| CO4 | Analyze the structure and functions of cell membranes, including ion transport mechanisms and nerve conduction, and assess the thermodynamic principles underlying membrane transport and active transport systems. |
| CO5 | Define biosensors, bio-receptors, and electrochemical transducers, and describe the components and functions of biosensor systems in various applications, such as glucose monitoring, food analysis, and DNA biosensors. |
| **04** | **M.Sc. III-Sem** | **Natural Product**  **(MCH-B-304)** | CO 1 | Define and classify terpenoids, carotenoids, alkaloids, steroids, plant hormones, insect hormones, natural pigments, and porphyrins. |
| CO2 | Describe the biosynthesis and physiological roles of terpenoids, carotenoids, alkaloids, steroids, and plant hormones. |
| CO3 | Apply the isoprene rule, stereochemistry, and general synthetic methods to study the structure and synthesis of representative terpenoids (such as Citral, Geraniol, Menthol, and β-Carotene). |
| CO4 | Analyze the chemical structures of natural pigments like Luteolin, Quercetin, and Cyanidin chloride, and evaluate their methods of isolation, synthesis, and structural elucidation. Assess the role of these pigments in plant physiology and their applications. |
| CO5 | Synthesize and propose pathways for the biosynthesis of complex compounds such as morphine, nicotine, and cholesterol, integrating the relevant biosynthetic pathways and enzymatic processes. |
| **05** | **M.Sc. III-Sem** | **Organic Synthesis -I**  **(MCH-B-305)** | CO 1 | Students will be able to explain the principles of enolate formation, control mechanisms, and their synthetic applications. |
| CO2 | Ability to design and implement Aldol condensation, Claisen condensation, and other enolate-driven reactions for organic synthesis. |
| CO3 | Students will understand and predict the outcomes of oxidation and reduction reactions in both laboratory and industrial settings. |
| CO4 | Students will explain the design, synthesis, and applications of supramolecular systems and their importance in materials and biological chemistry. |
| CO5 | Utilize advanced methodologies such as catalytic hydrogenations, asymmetric hydroboration, and supramolecular self-assembly to address synthetic problems. |
| **06** | **M.Sc. III-Sem** | **Heterocyclic Chemistry-I**  **(MCH-B-306)** | CO 1 | Define the nomenclature rules for monocyclic, bicyclic, spiro, and bridged Heterocyclics using the Hantzsch-Widman system. Understand the classification of heterocycles based on their structure and heteroatom composition. |
| CO2 | Explain the general chemical behavior of aromatic heterocycles, including the criteria for aromaticity and the factors that influence their stability, such as bond lengths, delocalization energy, and diamagnetic susceptibility. |
| CO3 | Apply the principles of aromaticity and reactivity to predict the behavior of aromatic heterocycles in synthetic reactions. Use this understanding to design and synthesize heterocyclic compounds with desired properties and reactivity profiles. |
| CO4 | Analyze the strain, bond angle, and torsional strain in small-ring heterocycles, such as three- and four-membered heterocycles, and evaluate their impact on reactivity and stability.. |
| CO5 | Synthesize small-ring heterocycles (e.g., aziridines, oxiranes, thiiranes) and five-membered heterocycles with two heteroatoms (e.g., oxazoks, thiazoks, azaphosphoks), using appropriate synthetic strategies. Employ reaction mechanisms to functionalize these heterocycles. |
| **07** | **M.Sc. & IV-Sem** | **Medicinal Chemistry**  **(MCH-B-401)** | CO 1 | Define the key concepts in drug design, including prodrugs, soft drugs, structure-activity relationship (SAR), and quantitative structure-activity relationship (QSAR). Identify factors affecting bioactivity such as resonance, inductive effects, isosterism, and bio-isosterism. |
| CO2 | Explain the principles behind drug-receptor interactions and describe the different theories of drug activity. Discuss the role of pharmacokinetics in drug development, including drug absorption, distribution, metabolism, and elimination, and the key pharmacokinetic parameters used to define drug disposition. |
| CO3 | Apply the concepts of pharmacodynamics to explain enzyme stimulation, enzyme inhibition, and drug metabolism. Illustrate the significance of drug metabolism and biotransformation in medicinal chemistry and the development of new drugs. |
| CO4 | Analyze the mechanisms of action of antineoplastic (anti-cancer), anti-infective, cardiovascular, and psychoactive drugs. Assess the role of different drug classes in treating diseases such as cancer, infections, cardiovascular disorders, and psychiatric conditions. |
| CO5 | Synthesize knowledge of drug chemistry and pharmacology to design new drugs targeting specific receptors or enzymes. Propose new methods for improving the bioactivity and therapeutic effectiveness of existing drugs using structure-activity relationship (SAR) concepts. and improving their environmental sustainability. |
| **08** | **M.Sc. & IV-Sem** | **Organic Synthesis-II]**  **MCH: B-402** | CO 1 | Define key concepts such as synthons, synthetic equivalents, disconnection approach, and functional group inter-conversions.  Recognize the importance of the order of events in organic synthesis and explain the role of chemo selectivity and reversal of polarity in synthesis. |
| CO2 | Explain the principles of protecting groups, specifically for alcohols, amines, carbonyl, and carboxyl groups. Understand the techniques used for  protecting these functional groups in synthetic organic chemistry and apply them to simple practice exercises. |
| CO3 | Apply the disconnection approach to one-group and two-group C-X and C-C disconnections. Demonstrate the use of alkene synthesis, acetylenes, aliphatic nitro compounds, and reactions like Diels-Alder,Michael addition, and Robinson annulation in organic synthesis. |
| CO4 | Analyze stereogenic centers and their role in the planning of asymmetric syntheses. Evaluate the methods for racemization and resolution in the synthesis of chiral compounds. Critically assess regio-selectivity and stereoselectivity in reactions involving alcohols, carbonyl compounds, and other functional groups.. |
| CO5 | Design synthetic pathways using the disconnection approach tosynthesize complex organic molecules. Incorporate knowledge of ring synthesis, pericyclic rearrangements, and the use of cyclization reactions to form 3, 4, 5, and 6-membered rings in organic synthesis. |
| **09** | **M.Sc. & IV-Sem** | **Heterocyclic Chemistry-II**  **(MCH-B-403)** | CO 1 | Define and classify various five-membered heterocycles with more than two heteroatoms, including triazoles, tetrazoles, oxadiazoles, thiadiazoles, and diazaphospholes. |
| CO2 | Explain the concept of meso-ionic heterocycles, including their classification and the chemistry of important meso-ionic heterocycles of types A and B. |
| CO3 | Synthesize and demonstrate the reactions of six-membered heterocycles with one heteroatom, such as pyrylium salts, pyrones, coumarins, chromones, and phosphorines. |
| CO4 | Analyze and compare the synthesis, structure, and reactivity of six-membered heterocycles containing two or more heteroatoms, including diazines, triazines, tetrazines, oxazines, thiazines, and their derivatives. |
| CO5 | Design synthetic routes for large-membered heterocycles, including eight-membered (azocine, diazocine), nine-membered (azonine, oxonine), and ten-membered rings. |