Course: B. Sc. in Chemistry(Major)

B. Sc. in Chemistry is an undergraduate program which covers topics in physical, organic, quantum, analytical and inorganic in all years of study. It is of three years duration course having six semesters. B. Sc. in Chemistry graduate has many career opportunities in scientific research related places. Other popular areas of work included education, technical occupations, business and finance, commercial, industrial and public sector management.

Course outcomes:
Students successfully completing the following courses should have developed the ability to:

Course Outcomes	**Paper M 1.1 Physical Chemistry**
CO1	Describe various thermodynamics terms, the laws of thermodynamics and be able to explain how they are derived.
CO2	Explain the concept of state function, thermodynamic reversibility, heat capacity, enthalpy and its significance.
CO3	Use the thermodynamics laws to calculate the heat and work in various processes.
CO4	Define the terms and determine the enthalpy and entropy change associated with a reaction.
CO5	Determine the Gibbs energy change associated with a reaction and explain and the concept of thermodynamic equilibrium.
CO6	The chemical potential as a driving force in chemical reactions: Gibbs-Duhem equation.
CO7	Discuss the concept of rate laws, rate constants, reaction order, half-lives and the Arrhenius equation in chemical kinetics.
CO8	Draw an energy *vs* reaction coordinate diagram, predict the dependence of rate constants on temperature, calculate the activation energy and pre exponential factors.
CO9	Apply the notion of steady state approximation and derive the rate law of a complex mechanism such as that found in unimolecular reactions.
CO10	Describe the concept of catalysis most notably homogeneous catalysis, acid-base catalysis, enzyme catalysis and zeolites and its uses in petroleum.

Course Outcomes	**Paper M 1.2 Organic Chemistry**
CO1	Recognize and name a wide range of organic molecules according IUPAC and common naming system.
CO2	Describe the structure (including electronic configuration) of organic molecules in terms of orbitals, hybridization and can also explain the concept of electron delocalization effects in organic compounds.
CO3	Predict the relative acidity and basicity of organic molecules, and describe these properties with the concepts of pK_a.
CO4	Explain the concept of aromaticity and identify both aromatic and non-aromatic molecules.
CO5	Identify electron rich and electron poor centres within molecules, by using the concepts of electronegativity, inductive effects and mesomeric (resonance) effects.
CO6	Draw representations of the chemical structure of organic molecules using a concise notation.
CO7	Understand the relative stability of conformations of linear and cyclic organic molecules.
CO8	Understand and use sawhorse and Newman projections, 3D structures of organic molecules including cyclic structures.
CO9	Explain the concept of activation energy, transition state, energy profile diagrams, concept of kinetic and thermodynamic control of reactions, and reaction intermediates like carbocations, carboanions, carbenes, free radicals, nitrenes, and arynes.
CO10	Describe mechanism of the following reactions *viz.* Addition, Substitution, and Elimination and also explain the factors that influence them.

Course Outcomes	**Paper M 1.3 Practical**
CO1	The preparation for each experiment by studying laboratory manual.
CO2	Skillful in standard methods and be able to perform physico-chemical experiments with precision and accuracy.
CO3	Capable to undertake basic safety assessments of experiments and carry out practical work safely and professionally.
CO4	Proficient of interpreting and manipulating analytical data and using it to draw conclusions.
CO5	Capable of recording and reporting findings from these experimental processes to a basic, scientific standard.
CO6	Expertise in physical chemistry experiment like solubility of a given salt at different temperatures, water of crystallization by ignition and weighing, kinetics of the reaction between H_2O_2 & I^- and Clock reaction between $S_2O_3^{2-}$ & HCl, adsorption of $H_2C_2O_4$ on activated charcoal, Estimation acetic acid in vinegar by conductometry, Column chromatographic, TLC and Paper chromatographic techniques for separation of pigments and identification of sugars

Course Outcomes	**Paper M 2.1 Physical Chemistry**
CO1	Describe and explain the main intermolecular interactions and to discuss their relative magnitude in qualitative terms and compressibility factor.
CO2	Understand and apply the van der Waals equation of state to perform calculations on real gases.
CO3	Evaluation of kinetic theory of gases and distribution of molecular speeds like mean, root mean square and most probable speeds.
CO4	Explain the concept of collision cross section, transport properties and degrees of freedom.
CO5	Describe Flux and Fick's law of diffusion, Principle of equipartition of energy, molecular basis of heat capacity and be able to explain how they are derived.
CO6	Understand the structure of liquid and determination of physical properties like vapour pressure, capillary action, surface tension and viscosity.
CO7	Elementary idea of structure, physical properties and uses of liquid crystals.
CO8	Thermodynamic treatment of lowering of vapour pressure, osmotic pressure, elevation of boiling point and depression of freezing point.
CO9	Explain the concept of van't Hoff's factor, abnormal colligative properties and real solution – activity, activity coefficient.
CO10	Calculate the ionic strength, molar conductance, and transport number of ions.
CO11	Proficient to understand the use of electrochemical techniques/data analysis to obtain information on a redox system.
CO12	Describe the concept of electrochemical cells, measurement of emf, different types of electrodes, electrochemical potential measurement, and buffer solution *etc*.

Course Outcomes	**Paper M 2.2 Organic Chemistry**
CO1	Describe the structure (including electronic configuration) of organic molecules in terms of orbitals, hybridisation and conformation, including stereoisomerism
CO2	Understand the relative stability of conformations of molecules like ethane, butane, cyclohexane and their relative stability.
CO3	Understand the concept of topocity of groups, atoms, and faces.
CO4	Recognize the reactive sites within molecules, by using various concept.
CO5	Apply the curly arrow notation to describe both resonance and reaction mechanisms
CO6	Describe mechanism of electrophilic aromatic substitution and nucleophilic aromatic substitution reactions.
CO7	Understand the general methods of preparation, physical properties, chemical reactions and functional group transformation of various aliphatic and aromatic compounds.

Course Outcomes	**Paper M 2.3** **Organic Practical**
CO1	General methods of analysis of an organic compound and identification by detection of N, S, Halogen, test for functional groups, determine solubility, melting point, boiling point and preparation of a derivative & determination of its melting point.

Course Outcomes	**Paper M 3.1** **Structure and Bonding**
CO1	Understand the Particle character of radiation (Black body radiation).
CO2	Describe the Wave character of radiation (Electron diffraction).
CO3	Explain the concept of dual nature of matter - de Broglie hypothesis
CO4	Understand the Heisenberg's uncertainty principle and necessity of quantum mechanical equation
CO5	Describe the Schrodinger equation, eigen functions, eigen values, expressions of radial and angular parts for different orbitals.
CO6	Significance of quantum numbers.
CO7	Establish the concept of spin and spin quantum numbers, Pauli's exclusion principle, Aufbau principle and electronic configuration of many electron atoms.
CO8	Explain the valence bond approach to bonding in diatomic molecules and resonance.
CO9	Elaborate the concept of bond moments, dipole moments and electronegativity.

Course Outcomes	**Paper M 3.2**
CO1	Apply VSEPR theory to a range of molecules and ions to predict the potential shape and geometry.
CO2	Describe the concept of hybridization and to apply it to produce a conceptual model of bonding in simple organic and inorganic molecules.
CO3	Describe the influence of hybridization on bond length, bond angle and other properties of molecules including shapes and dipole moments.
CO4	Describe the basic properties of molecular orbitals and molecular bonds based on their current understanding.
CO5	Describe the construction of homonuclear diatomic molecules MOs from LCAOs, to populate these with electrons and to predict bond order.
CO6	Demonstrate the applications of MO theory to simple triatomic system and to derive the MOs.
CO7	Explain the structure of metals, the concept of band gap energy, and how this band gap determines the electronic properties (insulator, conductor, and semiconductor) of solid materials.
CO8	Describe basic solid state structures for elements in terms of crystal systems, Bravais lattices, unit cells and Miller indices.
CO9	Calculate lattice enthalpy using the Born-Haber cycles

Course Outcomes	**Paper M 3.3 Practical**
CO1	Expertise in analysis of a mixture of salts containing various cations and anions including insoluble salts and interfering anions.
CO2	Students also able to interpret written instructions and perform inorganic chemistry laboratory experiments safely and effectively.

Course Outcomes	**Paper M 4.1**
CO1	Understand group wise and period wise trends in physical and chemical properties of elements and their compounds of groups 1, 2 and 13-17.
CO2	Explain the factors affecting trends like electronic configuration, ionization energy, electron affinity, electronegativity, melting point and boiling point of elements and their compounds, solubility of salts, and electrode potentials.
CO3	Apply the concept of Fajan's rule to understand the polarizing power of cations, polarisability of anions.
CO4	Applications of Pearson's HSAB concept.
CO5	Understand Latimer and Frost diagram and their uses.
CO6	Describe preparation, properties, bonding and structure of hydrates, clathrates, Diborane and higher boron hydrides, allotropes of carbon
CO7	Understand allotropes of phosphorous & sulphur, hydrides, oxides and oxoacids of nitrogen and phosphorous, hydrazine, super oxide and oxygen fluorides.
CO8	Explain mechanism of formation and depletion of ozone layer.

Course Outcomes	**Paper M 4.2**
CO1	Explain preparation, structure and properties of interhalogen compounds, pseudo halogen, oxides and oxoacids of halogens.
CO2	Describe preparation, structure, properties and uses of noble gas compounds.
CO3	Elaborate inorganic chains, ring and cages: silicate, aluminosilicates, zeolites, silicones, borazine, phosphazine *etc*.
CO4	Use band theory to explain metal, semiconductor and insulator.
CO5	Describe occurrence and principles of extraction of Ni, Cr, Mn, Au, V and Mo.
CO6	Discuss a series of aspects of Sn, Pb and Tl, in terms of crystal and electronic structures, synthesis methods, structure-property relationships and applications.
CO7	Understand period wise trends in physical and chemical properties of transition elements and their compounds
CO8	Explain synthesis methods, structure-property relationships and applications of oxides, hydroxides and halides of transition elements.
CO9	Understand the basis of coordination chemistry of the 3*d*, 4*d* and 5*d* series
CO10	Interpret and predict chemical structure, reactivity and electronic properties of co-ordination complexes

Course Outcomes	**Paper M 4.3 Practical**
CO1	Determine the water of crystallization of green vitriol.
CO2	Determine temporary and permanent hardness of water by EDTA titration.
CO3	Elaborate key concepts of inorganic and organometallic chemistry including those related to synthesis, reaction chemistry.
CO4	Basic laboratory procedures used in inorganic synthesis for identification and characterization of synthesized molecules.

Course Outcomes	**Paper M 5.1** **Quantum Chemistry**
CO1	Proficient to the foundations of quantum mechanics to remind the difference between classical and quantum world.
CO2	Concept of operator and its used to solve simple eigenvalue problems.
CO3	Hamiltonian and Schrodinger equation for hydrogen atom, energy levels and quantum numbers, the radial and angular part of the wave function.
CO4	Explain the concept of a particle in a box and the solutions to the Schrödinger equation for particles in 1D, 2D and 3D boxes.
CO5	Perform simple quantum-chemical calculations.
CO6	Concept of degeneracy, energy level diagrams, plot of wave functions and their squares vs displacement from origin, zero point energy, quantum mechanical tunneling, harmonic oscillator, moment of inertia in 3D *etc*.
CO7	Determine Russel-Saunder's coupling, and Term symbols.
CO8	Use of approximation methods in solving molecular problems.
CO9	Explain molecular orbital theory in diatomic and polyatomic molecules.

Course Outcomes	**Paper M 5.2** **Physical Chemistry**
CO1	Describe collision theory, activated complex theory and Erying equation and it thermodynamic formulation.
CO2	Explain the Lindemann theory of unimolecular reactions.
CO3	Elementary idea to lasers and flash photolysis.
CO4	Describe the laws of photochemical equivalence, quantum yield, photostationary equilibrium.
CO5	Elaborate luminescence phenomenon like fluorescence, phosphorescence, and Jablonski diagram.
CO6	Explain photochemistry of air and air pollution
CO7	Describe phase diagram of one and two component system.
CO8	Define Clausius Clapeyron equation, Gibbs-Duhems equation and their derivation
CO9	Derivation of adsorption isotherms – Langmuir, Freundlich, and BET equation.

Course Outcomes	**Paper M 5.3** **Organic Chemistry**
CO1	Recognize and name a wide range of organic molecules according IUPAC system.
CO2	Describe mechanism of the following reactions *viz.* Molecular Rearrangements, Oxidation – reduction, and Pericyclic Reactions.
CO3	Understand the methods of preparation, structure, bonding, properties and reactivity of polynuclear aromatics, nitro and amino compounds, organo S and organo P compounds, active methylene compounds and heterocyclic compounds.

Course Outcomes	**Paper M 5.4** **Inorganic Chemistry**
CO1	Visualization of molecules and determination of various symmetry elements.
CO2	Use of group theory to recognize and assign symmetry characteristics to molecules and objects, and to predict the appearance of compounds (coordination 2-8).
CO3	Understand the shape and various symmetry elements of s, p and d orbital.
CO4	Understand the concept of crystal field theory and factors affecting 10 *Dq* value.
CO5	Describe molecular orbital theory of octahedral complexes.
CO6	Describe metal-metal bonding including $[Re_2Cl_8]^{2-}$.
CO7	Explain synthesis, structure and bonding of organometallic complexes with olefins, acetylene, allyl, cyclopentadiene and arenas.
CO8	Proficient to homogeneous catalysis by transition metal complexes namely isomerzation, hydrogenation, hydroformylation & Ziegler-Natta Polymerization.
CO9	Importance on biological role of various elements.
CO10	Understand the structure and function of hemoglobin, synthetic dioxygen carriers, and dioxygen toxicity.

Course Outcomes	**Paper M 5.5** **Inorganic Practical**
CO1	Methods for calibration and sampling applied to quantitative analysis
CO2	The application of statistical methods for the evaluation of laboratory data
CO3	Separation and estimation of inorganic ions in one-component systems and two-component systems by volumetric, complexometric, gravimetric, redox & precipitation methods.
CO4	Separation of cations by using paper or thin layer chromatographic technique.

Course Outcomes	**Paper M 5.6 Organic Practical**
CO1	Basic laboratory procedures used in organic synthesis and purification.
CO2	Determination of melting point of the synthesized organic molecules.
CO3	Perform quantitative analysis of organic compounds and mixtures.

Course Outcomes	**Paper M 6.1 Spectroscopy**
CO1	Explain electromagnetic radiation its mechanism of interaction with matter.
CO2	Use of spectroscopic methods for qualitative and quantitative analysis.
CO3	Identify the theoretical basis of different spectroscopic techniques, and show their application in analyzing/interpreting experimental data.
CO4	Identify the terms in and describe deviations to Beer's Law.
CO5	Rationalize transitions between quantum states as a result of an absorption, emission or scattering event have a more than zero probability of taking place.
CO6	Describe the selection rule for infrared-active transitions and determine the vibrations for molecule.
CO7	Explain the difference between Stokes and anti-Stokes lines in a Raman spectrum.
CO8	Determine the effect of solvent on the energy of n-π^* and π-π^* transitions.
CO9	Evaluate the utility of UV/Vis spectroscopy as a qualitative and quantitative method.
CO10	Explain the basic working principle of magnetic resonance and mass spectroscopic techniques and their application in chemistry analysis.

Course Outcomes	**Paper M 6.2** **Physical Chemistry**
CO1	Describe specific crystal structures by applying basic crystallographic concepts.
CO2	Give an account of the generation of X-ray radiation and its effects on matter.
CO3	Description of basic structure and properties of solid surfaces (solid structures, unit cells, Miller indices symmetry in solids).
CO4	Describe basic solid state structures for elements in terms of crystal systems, Bravais lattices, unit cells.
CO5	Describe the concept of electrical property of solids, piezo and ferro electricity.
CO6	Explain dia-, para-, ferro- and antiferro magnetism.
CO7	Describe structure, surface and stability of colloids, formation of micelle, electrical double layer and Electrokinetic phenomena.
CO8	Determination of molecular weight of macromolecules and various polymerization techniques.
CO9	Elementary idea on statistical thermodynamics of monatomic and diatomic gases and its application for calculation of heat capacity, residual entropy and equilibrium constants.

Course Outcomes	**Paper M 6.3 Organic Chemistry**
CO1	Explain photochemical and photophysical process takes place on organic molecules.
CO2	Discuss photoreactions reactions for organic compounds.
CO3	Thoroughly know the theory of synthetic macromolecules, their synthesis and characterization, the rules of polymerization, the principles of polymer science, the treatments for polymer processing.
CO4	Know the structure and properties of important polysaccharides.
CO5	Describe structure of cell and cell membrane.
CO6	Explain the chemistry of carbohydrates, proteins and nucleic acids.
CO7	Thorough idea on the structures of amino acids, peptides and polypeptides.
CO8	Importance of enzyme and their function as catalyst.
CO9	Elementary idea on the synthesis and structure of terpenes.
CO10	Proficient to Relevant chemical reactions or synthetic pathways for selected drugs

Course Outcomes	**Paper M 6.4** **Inorganic Chemistry**
CO1	Understand how the *d*-orbitals are split in the presence of ligand.
CO2	Establish Orgel diagram of $d^1 - d^9$ system.
CO3	Recognize thermodynamic stability, kinetic lability and inertness.
CO4	Elementary idea of metalloproteins and their role in photosynthesis, respiration, and nitrogen fixation.
CO5	Understand the toxicity due to Metal ions.
CO6	Describe the properties of an atomic nucleus that make it unstable and undergo nuclear decay.
CO7	Explain the theory of radioactive disintegration.
CO8	Describe nuclear reactors and their use and methods of measurement of radioactivity.
CO9	Understand the fundamental chemistry and physical properties of the 4f and 5f elements.

Course Outcomes	**Paper M 6.5** **Practical**
CO1	From this course, the students will understand physical chemistry from experimental point of view. Moreover, they will learn some modern methods of analysis required in different area of research.

Course Outcomes	**Paper M 6.6 Project Work**
CO1	Develop chemical understanding in a moderately specific area of chemistry beyond the classroom.
CO2	Identify key elements of the scientific literature that are relevant to a research area.
CO3	Know how to handle regarding safety issues (in a responsible way) in relation to practical experiments.
CO4	Maintain a record of practical work to a professional standard.
CO5	Collect and analyze data obtained from various experiment.
CO6	Communicate the results of an open ended investigation with clarity, both verbally and in writing, using appropriate scientific terminology.

Course: B. Sc. in Chemistry (General)

Course outcomes:

Students successfully completing the following courses should have developed the ability to:

Course Outcomes	**Paper E 101 General Chemistry**
CO1	Understand the black body radiation, photoelectric effect.
CO2	Explain the concept of dual nature of matter - de Broglie hypothesis
CO3	Describe the Schrodinger equation, eigen functions, eigen values, expressions of radial and angular parts for different orbitals.
CO4	Can write the electronic configuration of atoms by applying aufbau principle, Pauli's principle, Hund's rule.
CO5	Explain the valence bond approach to bonding in diatomic molecules and resonance.
CO6	Apply the concept of Fajan's rule to understand the polarizing power of cations, polarisability of anions.
CO7	Evaluation of kinetic theory of gases and distribution of molecular speeds like mean, root mean square and most probable speeds.

Course Outcomes	**Paper E 201 General Chemistry**
CO1	Recognize and name a wide range of organic molecules according IUPAC and common naming system.
CO2	Describe the structure (including electronic configuration) of organic molecules in terms of orbitals, hybridization and can also explain the concept of electron delocalization effects in organic compounds.
CO3	Understand the general methods of preparation, physical properties, chemical reactions and functional group transformation of various alkanes, cycloalkanes, alkenes, alkynes and alkadienes.
CO4	Explain reactive intermediates: carbocations and carbanions – their shape, generation, stability and reactions.
CO5	Preparation, chemical properties and synthetic uses of diazomethane, ketene, Aromatic hydrocarbons.
CO6	Describe various thermodynamics terms, the laws of thermodynamics and be able to explain how they are derived.
CO7	Explain the concept of state function, thermodynamic reversibility, heat capacity, enthalpy and its significance.
CO8	Use the thermodynamics laws to calculate the heat and work in various processes.
CO9	Describe phase diagram of water and sulphur systems.

Course Outcomes	**Paper E 301** **General Chemistry**
CO1	Explain groupwise study of physical, chemical properites of elements and their important compounds- oxides and hydroxides, oxyacids, halides, hydrides (Groups 1,15,16,17).
CO2	Understand synthesis, structure and reactions of silicones, borazine and Diborane.
CO3	Explain preparation, structure and properties of interhalogen compounds, pseudo halogen, oxides and oxoacids of halogens.
CO4	Describe preparation, structure, properties and uses of noble gas compounds.
CO5	Explain synthesis methods, structure-property relationships and applications of oxides, hydroxides and halides of transition elements.
CO6	Importance on biological role of various elements.
CO7	Proficient to understand the use of electrochemical techniques/data analysis to obtain information on a redox system.

Course Outcomes	**Paper E 302 Practical**
CO1	The preparation for each experiment by studying laboratory manual.
CO2	Skillful in standard methods and be able to perform physico-chemical experiments with precision and accuracy.
CO3	Capable to undertake basic safety assessments of experiments and carry out practical work safely and professionally.
CO4	Proficient of interpreting and manipulating analytical data and using it to draw conclusions.
CO5	Capable of recording and reporting findings from these experimental processes to a basic, scientific standard.
CO6	Capable of performing qualitative organic analysis.
CO7	Separation of cations by using paper or thin layer chromatographic technique.

Course Outcomes	**Paper E 401** **General Chemistry**
CO1	Understand the general methods of preparation, physical properties, chemical reactions and functional group transformation of various aliphatic and aromatic compounds.
CO2	Explain the preparation, physical properties, chemical reactions Benzyl alcohol
CO3	General methods of preparation, physical properties, chemical reactions and functional group transformation of various aliphatic amines and aniline.
CO4	Understand the general methods of preparation, physical properties, chemical reactions of carbonyl compounds, carboxylic compounds.
CO5	Elementary idea of amino acids, carbohydrates, fats and oils.
CO6	Discuss the concept of rate laws, rate constants, reaction order, half-lives and the Arrhenius equation in chemical kinetics.

Course Outcomes	**Paper E 402 Practical**
CO1	Expertise in analysis of a mixture of salts containing various cations and anions including insoluble salts and interfering anions.
CO2	Estimation of Fe (II), Fe (III), and Cu (II) by standard KMnO4 solution, standard K2Cr2O7 solution, Iodometric method respectively

Course Outcomes	**Paper E 501** **General Chemistry**
CO1	Explain the structure of metals, the concept of band gap energy, and how this band gap determines the electronic properties (insulator, conductor, and semiconductor) of solid materials.
CO2	Explain electromagnetic radiation its mechanism of interaction with matter.
CO3	Use of spectroscopic methods for qualitative and quantitative analysis.
CO4	Identify the theoretical basis of different spectroscopic techniques, and show their application in analyzing/interpreting experimental data.
CO5	Identify the terms in and describe deviations to Beer's Law.
CO6	Rationalize transitions between quantum states as a result of an absorption, emission or scattering event have a more than zero probability of taking place.
CO7	Explain the basic working principle of magnetic resonance and mass spectroscopic techniques and their application in chemistry analysis.
CO8	Explain the theory of radioactive disintegration.
CO9	Describe nuclear reactors and their use and methods of measurement of radioactivity.

Course Outcomes	**Paper E 502** **Practical**
CO1	From this the students will understand physical chemistry from experimental point of view. Moreover, they will learn some modern methods of analysis required in different area of research.
CO2	Determination of melting point of the synthesized organic molecules.

Course Outcomes	**Paper E 601** **General Chemistry**
CO1	Thoroughly know the theory of synthetic macromolecules, their synthesis and characterization, the rules of polymerization, the principles of polymer science, the treatments for polymer processing.
CO2	Know the industrial and environmental importance of various chemicals.
CO3	Know the structure and properties of important polysaccharides.
CO4	Describe structure of cell and cell membrane.
CO5	Explain the chemistry of carbohydrates, proteins and nucleic acids.
CO6	Thorough idea on the structures of amino acids, peptides and polypeptides.
CO7	Elementary idea on the classification, synthesis and structure of terpenes.

Course Outcomes	**Paper E 602** **Practical**
CO1	From this the students will understand a handful of physical chemistry experiment from the experimental point of view.
CO2	Basic laboratory procedures used in inorganic synthesis for identification and characterization of synthesized molecules.