M.Sc. (Semester-I)

Each theory course of Credit 3 (3 hour per week over a semester)

Each practical course of Credit 3 (9 hour per week over a semester)

1. Course Outcome (CO): (SOS/C001-**Inorganic Chemistry - I)**

CO1: Stereochemistry, bonding of inorganic molecules using VSEPR and hybridization theory is explained.

CO2: Metal-ligand complex formation and various factors that affect the rate and stability of complex formation is explained.

CO3: The formation of various types of inorganic complex and the mechanism using valence bond and crystal field theories including electron transfer and conjugate mechanism are explained.

CO4: In this section, using crystal field theory, Jahn-Teller distortion, Molecular Orbital Theory, the metal-ligand complex formation and application to octahedral, tetrahedral and square planar complexes is explained.

2. Course Outcome (CO) : (SOS/C002-**Organic Chemistry - I)**

CO1: Aromaticity in organic molecules using Huckel's theory is explained.

CO2: Stereochemistry and stereoisomers (conformational and configurational isomer), in organic molecules such as cyclohexane, carbohydrate and its derivatives containing heteroatoms and synthesis and reactivity of stereoisomer is explained.

CO3: Organic reactions and their mechanism using Hammond's postulate and Curtain-Hammett principle is explained. This includes the structure and reactivity of a substrate molecule with respect to transition states and intermediates.

CO4: Aliphatic nucleophilic substitution reactions and their mechanism, the effect of substrate, solvent, nucleophile and leaving group on the rate and yield of an aliphatic nucleophilic substitution reaction is explained.

CO5: Aliphatic electrophilic substitution reactions and their mechanism, the effect of substrate, solvent, electrophile and leaving group on the rate and yield of an aliphatic electrophilic substitution reaction is explained.

3. Course Outcome (CO) : (SOS/C003-**Physical Chemistry - I)**

CO1: **"Quantum Chemistry:Introduction to Exact Quantum Mechanical Results",** describes quantum mechanics, theory and principle using Eigen function, Schrodinger wave equation and by taking examples of hydrogen and helium atom. To develop a basic foundation of quantum chemistry which at advanced level is required for developing computational methods to explain or predict results from an experimental route.

CO2: **Quantum Chemistry: Approximate Methods** To stepwise approach the solutions for wave functions for hydrogen and hydrogen like atoms through advanced arithmatics.To develop a basic foundation of quantum chemistry which at advanced level is required for developing computational methods to explain or predict results from an experimental route.

CO3: **"Quantum Chemistry: Angular momentum"** To introduce the concept of spin and angular momentum amongst students.

CO4: **" Quantum Chemistry: Electronic Structure of Atoms"** To learn the electronic structure of atoms.

CO5: **Surface Chemistry: Adsorption"** describes surface chemistry of micelle and macromolecules. The course intends to equip the students to pursue research oriented studies in the field of nanotechnology and in designing catalytic and kinetic experiments with Surface Chemistry :Adsorption.

CO6: **"Thermodynamics: Classical Thermodynamics"** contains introduction to classical thermodynamics, laws of thermodynamics, non-ideal solution It is designed to build a better understanding of the world around us with topics in Thermodynamic like spontaneous processes, non spontaneous processes, chemical potential and free energy change.

4. Course Outcome (CO) : (SOS/C004-**Group Theory & Spectroscopy)**

CO1: Symmetry in organic and inorganic molecules, point group, various symmetry elements and character tables is explained.

CO2: Electromagetic radiation (EMR), and their different types of interaction with matter such as absorption, emission, transmission, reflection, refraction, dispersion, polarization and scattering properties of EMR is explained.

CO3: Application of EMR, atomic electronic spectroscopy is explained with suitable examples such as hydrogen and alkali metal atoms.

CO4: Microwave spectroscopy, principle and application, effect of substituent on the transition frequency, intensity of a molecule is explained.

CO5: Infrared spectroscopy, principle and selection rule for a vibrational transition, type of

vibrational stretching, effect of bond strength and functional group on the vibrational frequency and intensity of a molecule is explained.

5. Course Outcome (CO) : (SOS/C005-**Laboratory Course-IA)**

CO1: In Inorganic Chemistry laboratory course, student will perform qualitative analysis of mixture of six cation and six anions.

CO2: In Organic Chemistry laboratory course, student will separate, purify binary mixture of organic compounds using chromatography techniques and identify through chemical and spectroscopy methods

6. Course Outcome (CO) : (SOS/C006-**Laboratory Course-IB)**

CO1: In Inorganic Chemistry laboratory course, student will learn and perform various separation techniques such as paper, thin layer and ion exchange chromatography that are used to separate cations and anions from the inorganic mixture.

CO2: In Organic Chemistry laboratory course, student will learn and perform the synthesis of few organic compounds using acetylation, oxidation, Grignard reaction and Sandmeyer reaction.

COs of the course Lab "SOS/ C005 (Laboratory Course-IA and SOS/ C006 (Laboratory Course-IB): Physical Chemistry Paper-I"

CO 1 To train the students in handling laboratory equipments like conductivity meter through experiments in conductance measurements.

CO 2 To learn quantitative methods of analysis like determining the strength of strong and weak acids in a given mixture conductometrically.

CO 3 To obtain the rate constant of acid hydrolysis of an ester through volumetric titrations.

CO 4 To understand the concept of solubility product by finding the solubility product of sparingly soluble salts like barium sulphate and lead sulphate conductometrically.

CO 5 To introduce them to scientific writing and collecting data from handbooks.

Programme Specific Outcome (PSO) :

PSO1: From Inorganic Chemistry-I, student will learn, the importance of stereochemistry of

inorganic compounds, structure, reactivity and mechanism, various theories of Metal-ligand complex formation and its various limitations.

PSO2: From Organic Chemistry-I, student will learn, the importance of stereoisomer, structure, reactivity and mechanism in aliphatic compound (cyclic and acyclic).

PSO3: From Physical Chemistry - I, student will learn, quantum mechanics, classical thermodynamics, their importance and applications, surface phenomena of micelle and macromolecules.

PSO4: From Group Theory & Spectroscopy, student will learn, the nature of EMR and its interaction with matter. Further, how this interaction is used to characterized various vibrational, rotational and electronic transition of an atom and a molecule using Atomic electronic spectroscopy, Microwave spectroscopy and Infrared Spectroscopy. Student also learn, how EMR-matter interaction is highly dependent upon the symmetry of a molecule.

PSO5: From Lab IA, student will learn, how to identify inorganic and organic compounds by qualitative analysis and acquainted with various physical methods of determining kinetic parameters of a chemical reaction. The students are introduced to scientific writing and collecting data from handbooks.

PSO6: From Lab IB, student will learn and used, various separation techniques to separate mixture of inorganic cations and anions, Also acquainted with synthesis of organic compounds, and gain knowledge of determining kinetic parameters of a chemical reactions using conductance methods.

M.Sc. Semester-II

Each theory course of Credit 3 (3 hour per week over a semester)

Each practical course of Credit 3 (9 hour per week over a semester)

1. Course Outcome (CO) : (SOS/C007-Inorganic Chemistry - II)

CO1: Student will learn electronic spectra and amp, magnetic properties of transition metal Complexes,

CO2: Bonding, preparation and properties of metal-π-complexes and organometallic Compounds,

CO3: Reactivity, bonding and topology of boranes,

CO4: Wade's rules for the classification of Carboranes, metalloboranes and metallocarboranes and their properties,

CO5: Principles of silicates their structure, classification and use in the development of technology.

2. Course Outcome (CO) : (SOS/C008-**Organic Chemistry - II)**

In this course, students will learn

CO1: Different types of aromatic electrophilic substitution reaction and the factors that affect the reaction

CO2: Different types of aromatic nucleophilic substitution reaction with examples and the factors that affect the reaction

CO3: Free radical substitution reaction with examples.

CO4: C=C and C=X addition reactions with examples.

CO5: Different types of pericyclic reactions, their mechanism and reactivity.

3. Course Outcome (CO) : (SOS/C009-Physical Chemistry - II)

CO1: "Chemical Dynamics", This course will introduce advance theories in Chemical Kinetics to students including Unimolecular Theory.- Hinshelwood, Lindmann, RRK and RRKM theories. teaches students about steps involved in various chain mechanisms and deriving their rate constants.

CO2: "Statistical Thermodynamics", is designed to undersand a system of many molecules and deriving their microstates and thermodynamic properties through statistical treatment. To learn

Fermi dirac statistics, Bose Einstein Statistics and Maxwell Boltzmann statistics with their applications

CO3: "Non-Equilibrium Thermodynamics" aims to introduce the principles of nonequilibrium thermodynamics with examples.

CO4: "Electrochemistry" aims to learn the various spheres of application of electrochemistry like double layers in colloids, electrocatalysis, corrosion, polarography etc.

4. Course Outcome (CO) : (SOS/C010- **Spectroscopy and Separation methods)**

In this course students will learn

CO1: Principle and application of Molecular electronic spectroscopy and their application.

CO2: Principle and application of Raman spectroscopy their application.

CO3: Principle and application of Nuclear magnetic resonance spectroscopy and their application in characterizing organic molecules

CO4: Principle and application of chromatography methods such as gas liquid chromatography.

5. Course Outcome (CO) : (SOS/C011-**Laboratory Course-IIA)**

CO1: In Inorganic Chemistry Laboratory course, student will learn and perform qualitative analysis of two metal ions using volumetric and gravimetric analysis.

CO2: In Organic Chemistry Laboratory course, student will learn to synthesize organic compounds based on aromatic electrophilic substitution reactions such as nitration, bromination, etc.

CO3: In Physical Chemistry Laboratory course, student will learn how to determine molecular weight of non-volatile electrolyte and degree of ionization of electrolyte.

6. Course Outcome (CO) : (SOS/C012-**Laboratory Course-IIB)**

CO1: In inorganic chemistry laboratory course, students will synthesize selected inorganic complexes

CO2: In organic chemistry laboratory course, student will perform quantitative analysis to determine number of hydroxyl groups in a organic compounds, presence of phenol, amine, saponification values etc.

CO3: In physical chemistry laboratory course, student will determine strength of acids, dissociation constant, thermodynamic parameters using potentiometry methods.

Programme Specific Outcome (PSO) :

PSO1: Inorganic Chemistry-II: This course will help the students to understand the important properties of transition metal complexes, properties of metal-carbon bond and applications of silicates in technology. Student will get opportunity to absorb in industry.

PSO2: Inorganic Chemistry-II: This course will be also useful for students to extend their basic concepts of inorganic chemistry to a more advance level.

PSO3: Organic Chemistry-II: Students will learn organic reaction, their mechanisms, reactivity and help them to absorb in pharmaceutical industry.

PSO4: Spectroscopy and Separation methods :This course help to learn various spectroscopic and chromatography techniques for characterizing and separating organic and inorganic molecules. This help student to get absorb in analytical chemical industry.

PSO5:From laboratory course, students will able to analyze metal ions using volumetric and gravimetric analysis, synthesize simple organic compounds, synthesize inorganic complexes and able to determine the functional group in organic compounds using quantitative

M.Sc. (Semester-III)

Each theory course of Credit 3 (3 hour per week over a semester)

Each practical course of Credit 3 (9 hour per week over a semester)

1. Course Outcome (CO) : (SOS/E002-**Bioinorganic, Bioorganic, Biophysical Chemistry-I)**

CO1: Bioinorganic Chemistry-I, describes the role metal ion in biology, particularly Na/K pump, chlorophylls, photo system I and photo system II and Heme proteins.

CO2: Bioorganic Chemistry-I, describes various enzymes with mechanism of action such as chymotrypsin, ribonuclease, Enzyme catalyzed carboxylation and decarboxylation, nucleophilic displacement reaction, isomerization, etc.

CO3: Biophysical Chemistry-I, introduces, structure, function of cell membrane and ion transport mechanism. Understanding the biological reaction such as ATP hydrolysis through various biophysical parameters.

2. Course Outcome (CO) : (SOS/E005-**Spectroscopy and Solid State)**

CO1: Students will learn various electronic transition of organic compounds such as carbonyls and olefin compounds and the effect of solvent and substituent on the electronic transition of organic molecules.

CO2: Students will learn about the vibrational frequencies of aliphatic and aromatic compounds such as hydrocarbons, amine, carbonyls compound and the effect of solvent and hydrogen bonding on their vibrational frequency is studied.

CO3: This course introduces two new spectroscopy, Optical Rotatory Dispersion (ORD) and Circular Dichroism (CD) to students, which help them to characterize organic molecules.

CO4: Students will learn theory of various solid state reaction and kinetics parameters. This includes organic solids, fullerene and molecular devices such as organic superconductors, molecular rectifiers, transistors, artificial photosynthetic devices, molecular memory, switches and sensors using organic charge transfer, magnetism, doped methods, etc.

3. Course Outcome (CO) : (SOS/E006-Organometallic Reagents and Organic Synthesis)

CO1: Students will learn various reagents based on organometallic compounds that are used in organic synthesis. The metals used are Li, Hg, Pd, Ni, Cr, Si and B.

CO2: Students get information about the application of organometallic reagents as an oxidizing agents in organic synthesis. This includes oxidation of carbonyls, carboxylic acids using

organometallic compounds with Th, Ru metal ions.

CO3: In this course, various reducing reagents will be explained to students that are used in the synthesis organic compounds such as carbonyls, alkene, alkynes, nitro, azo compounds.

CO4: This describes synthesis of organic compounds through rearrangement reactions.

CO5: Synthesis and reactions of some polycyclic organic compounds such as non-benzenoid and polycyclic aromatic compounds are explained.

4. Course Outcome (CO) : (SOS/C018-**Organic Synthesis and Photochemistry)**

CO1: Retro-synthesis of organic compounds will be explained to the students. This includes C-X disconnection approach, order of events, selectivity and specificity in synthesis.

CO2: Various protecting groups for alcohol, carboxylic acid, carbonyl compounds and their importance in organic synthesis is explained.

CO3: Retro-synthesis of organic compounds with C-C disconnection approach is explained. This includes synthesis of target molecule using acetylene and nitro compounds.

CO4: Various photo-processes and their mechanism is explained. It also contain various photochemical reaction and determination of parameters such as rate of reaction, rate constant, etc.

CO5: Various photochemical reaction of olefin and carbonyl compounds such as 1,4-and 1,5-dienes, saturated cyclic and acyclic, β,γ-unsaturated and α,β-unsaturated compounds is explained to the students.

5. Course Outcome (CO) : (SOS/C016-**Laboratory Course-Org IIIA)**

CO1: From **Laboratory Course-Org IIIA,** students will learn various separation techniques such as chromatography methods and purify and identify organic components.

6. Course Outcome (CO) : (SOS/C017-**Laboratory Course-Org IIIB)**

CO1: **Laboratory Course-Org IIIB**, students will learn multi-step synthesis of organic compounds based on their syllabus.

CO2: This includes Benzopinacolone and Benzanilide from Benzophenone,

CO3: Benzilic acid from Benzoin, Quinoline from aniline and indole from phenylhydrazine,

CO4: Alkylation of diethylmalonate using microwave in presence of alkyl and benzyl halide.

Programme Specific Outcome (PSO) :

PSO1: From **Bioinorganic, Bioorganic, Biophysical Chemistry-I**, student will gain knowledge of role of metal ion in the structure, function of metalloprotein, mechanism of action of various enzymes through their kinetic studies and understand the biological processes through various biophysical parameters.

PSO2: From **Spectroscopy and Solid State**, student will learn, principle and theory of electronic and vibrational transitions in organic molecules, solid state reaction and application of organic material in molecular devices such as memory, switches, sensors, conductors, etc.

PSO3: From **Organometallic Reagents and Organic Synthesis**, student will learn, the application of organometallic reagents in various oxidative and reductive reaction in organic synthesis. Student also learn various synthetic method to obtained benzenoid and non-benzenoid aromatic compounds.

PSO4: From **Organic Synthesis and Photochemistry**, student will learn, how to synthesized a organic molecules using retro-synthetic techniques and use of protection and deprotection of functional group. In 2nd part, student will learn various photochemical reaction and their mechanism. This will help them to synthesize organic molecule through photochemical reaction.

PSO5: From **Laboratory Course-Org IIIA**, student will learn, how to separate and identify organic compound from three mixtures of compounds by chromatography and spectral analysis.

PSO6: From **Laboratory Course-Org IIIB**, student will learn, how to work with multi-step organic synthesis and acquainted with various reagents and reaction conditions. This will help then to get absorn in pharmaceutical/ chemical industry.

M.Sc. Semester-IV

Each theory course of Credit 3 (3 hour per week over a semester)

Each practical course of Credit 3 (9 hour per week over a semester)

Organic Chemistry

1. Course Outcome (CO) : (SOS/E009- Spectroscopy)

Students will learn

CO1: The principle, theory, function and application of electron spin resonance spectroscopy

CO2: The principle, theory, function and application of nuclear magnetic resonance spectroscopy,

CO3: The principle, theory, function and application of mass spectrometry

CO4: The principle, theory, function and application of photoelectron spectroscopy.

CO5: In this course, student develop ability to characterize organic and inorganic molecules using above spectroscopy techniques.

2. Course Outcome (CO) : (SOS/E010- Bioinorganic, Bioorganic, Biophysical Chemistry-II)

CO1: In Bioinorganic Chemistry-II, the role of electron transfer, nitrogen fixation in biology is explained by giving suitable example of metallo proteins.

CO2: In Bioorganic Chemistry-II, student will learn about the function and action of various enzymes and co-enzymes and enzyme models.

CO3: In Biophysical Chemistry-II, student will learn the structure, function of biopolymer and forces involve in their interactions.

CO4: This course provides students, an understanding about the biological sciences, and its biotechnological application. Students will get opportunity to absorb in pharmaceutical and biochemical industries.

3. Course Outcome (CO) : (SOS/C027-Natural Products)

In this course, students will learn the

CO1: Isolation, properties, and structure determination of natural products in the series of terpenoids and carotenoids (abietic acid and β-carotene)

CO2: Isolation, properties, and structure determination of natural products in the series of alkaloids (ephedrine, quinine),

CO3: Isolation, properties, and structure determination of natural products in the series of steroids (cholesterol and bile acids).

CO4: Synthesis of few natural products such as Prostaglandins (PGE_2 and PGF_{2a}), haemin

pigments.

CO5: By completion of this course, student develop ability to understand the isolation and characterization of natural product. This also help to develop research ability in natural product for higher study.

4. Course Outcome (CO) : (SOS/E013- Heterocyclic Chemistry**)**

In this course, students will learn

CO1: The nomenclature of aromatic and non-aromatic heterocyclic compounds (small ring, five, six, seven and large member heterocycles).

CO2: The synthesis, reaction and properties of heterocyclic compounds (small ring, five, six, seven and large member heterocycles).

5. Course Outcome (CO) : (SOS/C025-**Laboratory Course-Org IVA)**

CO1: In Laboratory Course-Org IVA, student will extract organic compounds from natural sources such as isolation of caffeine from tea leaves, casein and lactose from milk, piperine from black pepper, lycopene from tomatoes, b-carotene from carrots, etc.

CO2: Develop ability to isolate and characterize the natural product.

CO3. Student gain knowledge of separating organic compounds using paper chromatography.

6. Course Outcome (CO) : (SOS/C026-**Laboratory Course-Org IVB)**

CO1: In Laboratory Course-Org IVB, through spectral data, (1H NMR, FTIR, Mass, etc), student will identify the unknown organic compounds

CO2: Student will estimate the concentration of natural products such as amino acids, proteins, carbohydrate, etc using spectrophotometric methods (UV/Vis).

Programme Specific Outcome (PSO) :

PSO1: Students will learn the principle, theory, function and application various spectroscopic techniques and their used in characterizing organic and inorganic molecules.

PSO2: Students gain knowledge in biological sciences. This help them in working with the biotechnological application.

PSO3: The ability to understand the structure, function and isolation of natural products.

PSO4: Students gain knowledge of synthesis and properties of aromatic and non-aromatic heterocycles compounds.

PSO4. Ability to identify and develop future drugs molecule in pharmaceutical industry

Inorganic Chemistry

1. Course Outcome (CO): SOS/C022-Laboratory Course-Inorganic. IVA

CO1: This course includes: Spectrophotometric determinations of

(a) Manganese/chromium/vanadium in steel sample.

(b) Nickle/molybdenum/tungsten/vanadium/uranium by extractive Spectrophotometric method.

(c) Fluoride/nitrite/phosphate.

(d) Iron-phenanthroline complex: Job's Method of continuous variation.

(e) Zirconium-alizarin Red-S complex: Mole-ratio method.

(f) Copper-ethylene diamine complex: Slope –ratio method.

CO2: Flame photometric determinations of

(a). Sodium and Potassium when present together.

(b). Lithium/Calcium/barium/strontium.

(c). Cadmium and magnesium in tap water.

2. Course Outcome (CO): SOS/C023-Laboratory Course-Inorganic. IVB

CO1: This course describes the following practicals: Nephelometric determinations of

(a). Sulphate

(b). Phosphate

(c). Silver

CO2: Chromatographic separations: Paper or TLC and determination of Rf values of

(a). Cadmium and Zinc.

(b). Silver, Lead and Mercury.

(c). Nickel, Magnesium, Cobalt and Zinc.

3. Course Outcome (CO) : (SOS/C024-Inorganic polymers)

CO1: This course is designed to describe Inorganic polymer synthesis and their characterization by various methods,

CO2: Synthesis of main group polymer by various condensation methods and polymerisation.

CO3: It also includes applications of inorganic polymers in various fields.

Programme Specific Outcome (PSO):

PSO1: Inorganic polymers: This course demonstrates various aspects of inorganic polymers used in different areas. Being an exciting research field, It will be able to attract the mind of young students to explore the usefulness of inorganic polymers.

PSO2: Inorganic laboratory course- IVA, This course will enhance the practical ability of students with an understanding of spectrophotometric and flame photometric techniques

PSO3: Inorganic laboratory course-IVB, This course will give an understanding of Nephelometric technique and Chromatographic separations methods.

Physical Chemistry

Course Outcome (CO) : (ADVANCED QUANTUM CHEMISTRY)

CO1 To develop a knowleddge of quantum chemistry which at advanced level is required for developing computational methods to explain or predict results from an experimental route.

CO2 To stepwise approach the solutions for wave functions for hydrogen and hydrogen like atoms through advanced arithmatics.

CO3 To learn the electronic structure theories like Hartree-Fock and self consistent field theory

CO4 Introduction to correlated methods: Configuration Interaction (CI), Many-body perturbation theory (MBPT) and Coupled-cluster theory

Programme Specific Outcome (PSO) : (Advanced Quantum Chemistry)

PSO1: To introduce advanced aspects of quantum mechanics, theory and principle which can help the students in pursuing higher research.