Vidyasagar University

Dept. of Chemistry and Chemical Technology

Syllabus 2025

For

M.Sc. in Chemistry

Under NEP 2020
(Semester Program)

[w. e. f. 2025-26 sessions]

Preamble

The M.Sc. in Chemistry programme at Vidyasagar University, offered by the Department of Chemistry and Chemical Technology, has been designed in accordance with the National Education Policy (NEP-2020) to meet the current academic and industrial needs of chemical sciences. The programme aims to equip students with a deep understanding of fundamental and advanced concepts of Chemistry, while fostering analytical thinking, experimental competence, and research innovation.

The curriculum integrates both theoretical and applied aspects of chemistry, offering students the flexibility to specialize in Physical, Inorganic, or Organic Chemistry during the advanced stages of the programme. The inclusion of project work, electives, and practical training ensures a holistic development of scientific knowledge, professional skills, and ethical awareness. In alignment with the principles of the National Education Policy (NEP-2020), students are also encouraged to enroll in Massive Open Online Courses (MOOCs) offered through SWAYAM, thereby accessing diverse learning resources and perspectives beyond the department. In addition, courses on the Indian Knowledge System (IKS), Intellectual Property Rights (IPR), and the Life and Philosophy of Pandit Iswar Chandra Vidyasagar have been integrated into the curriculum to promote holistic academic development, ethical consciousness, and an appreciation of India's rich educational heritage.

The syllabus has been structured to reflect the latest developments in chemical research and technology, emphasizing outcome-based learning, interdisciplinary collaboration, and societal relevance. Learners are encouraged to explore modern frontiers of chemical science, including nanotechnology, pharmaceutical chemistry, green chemistry, polymer science, and computational chemistry.

The students get exposure to state-of-the-art instruments like 400 MHz NMR Spectrometer, Scanning Electron Microscope (SEM), FTIR Spectrometers, Fluorescence and UV–Vis Spectrophotometers, Polarizing Microscope with Fluorescence Attachment, Digital Polarimeter, HPLC, Rheometer, Gel Electrophoresis System, Atomic Force Microscope (AFM), Isothermal Titration Calorimeter (ITC), and Circular Dichroism Spectrometer, etc.

Through rigorous coursework, research projects, and practical exposure, the programme strives to develop competent chemists who can contribute effectively to academia, research institutions, industries, and environmental and healthcare sectors. Graduates of this programme are expected to emerge as critical thinkers, skilled and responsible researchers, and capable of addressing scientific challenges with creativity and ethical integrity.

PROGRAMME OUTLINES

	Type of Program	This is a regular mode M.Sc. programme, based on the guidelines of NEP 2020.
	Duration and Eligibility Criteria	The department offers two types of M.Sc. programmes in Chemistry Students who have completed a 3-year Honours degree in Chemistry are eligible for admission to the two-year M.Sc. programme**,** while those who have completed a 4-year Honours degree in Chemistry (with or without research) are eligible for admission to the one-year M.Sc. programme**.**
	Intake capacity	The current intake capacity of the programme is 75 students. Admission is carried out in accordance with the prevailing government norms, and the reservation rules for EWS, OBC, SC, ST, PWD, and other applicable categories are strictly followed.
	Admission procedure	The university conducts a written admission test as part of the selection process. Admission is based primarily on the performance in the written test, along with consideration of marks obtained in the Undergraduate

		(UG) programme or in the Higher Secondary (HS) examination, as applicable. The Admission Committee oversees the entire admission process, ensuring that all rules and regulations are properly followed.
	Evaluation Process	• The students will be assessed through a combination of continuous evaluation and end-semester examination. **Continuous Evaluation (CE)** carries **20% weightage**, while the **End-Semester Examination** accounts for **80%** of the total marks. • Two CEs will be conducted for each paper/course, and the average of these two will determine the final CE marks. The CEs may be conducted in diverse formats such as multiple-choice questions (MCQs), open-book examinations, take-home exercises, case studies, assignments, or small projects. • The end-semester examination will comprise short-answer, medium-answer, and long-answer type questions to evaluate the students' understanding and analytical skills comprehensively.
	Teaching Methods	To achieve the intended learning outcomes, the following teaching–learning methods will be employed: • **Lecture-based Learning** – Structured delivery of core concepts through classroom lectures. • **Group Learning** – Collaborative discussions and group activities to promote teamwork and idea-sharing. • **Individual Learning** – Independent study and self-paced learning to strengthen conceptual clarity. • **Technology-based Learning** – Use of digital tools, software, and online resources to support interactive learning. • **Peer Teaching** – Students explaining concepts to peers, encouraging active participation and reinforcement of knowledge. • **Problem-solving Approach** – Learning through real-world problems, case studies, and exercises to develop analytical and critical thinking skills.
	Special Instructions	To align the syllabus with the National Education Policy (NEP) 2020, several general courses such as Indian Knowledge System (IKS), Intellectual Property Rights (IPR), Research Methodology and Ethics, Social Service/Community Engagement, Internship/Industry Visit or Industry-related Project, Field Visit, Research Project, and Life and Philosophy of Vidyasagar have been made compulsory. Alongside these, a set of core courses has been included to strengthen subject foundations. The syllabus also offers elective papers to provide flexibility and choice. In Semesters I and II, all papers are core papers, while in Semesters III and IV, elective papers provide three options (Organic / Inorganic / Physical). Students are required to choose one elective paper from the available options.

Program Outcomes (POs)

On successful completion of the M. Sc in Chemistry program, the students will be able to learn the following topics	
PO1	**Advanced Knowledge and Understanding:** Comprehensive understanding of advanced concepts in Physical, Inorganic, and Organic Chemistry, including spectroscopy, thermodynamics, kinetics, and quantum chemistry, is expected to be demonstrated by the learners.
PO2	**Application of Chemical Principles:** Chemical theories, models, and experimental techniques are expected to be applied for the analysis, interpretation, and resolution of real-world chemical problems in academic, industrial, and research settings.

PO3	**Laboratory and Instrumental Competence:** Practical skills in chemical synthesis, qualitative and quantitative analysis, and the use of modern instrumental techniques such as NMR, IR, UV–Vis, and Mass spectroscopy are to be acquired and demonstrated.
PO4	**Research and Innovation Skills:** The ability to design and execute independent research projects, analyze data critically, and contribute to innovative solutions in emerging areas of chemical sciences is to be developed.
PO5	**Interdisciplinary Integration:** Knowledge from allied fields such as nanotechnology, pharmaceutical chemistry, food processing, and computer applications is to be integrated for addressing multidisciplinary scientific challenges.
PO6	**Scientific Communication and Documentation:** Proficiency in communicating scientific information effectively through oral presentations, reports, and publications is expected to be achieved.
PO7	**Ethical and Environmental Awareness:** Professional ethics, laboratory safety, and environmental sustainability are to be practiced and promoted in all chemical activities and research endeavors.
PO8	**Computational and Analytical Skills:** Computational tools, data analysis methods, and statistical techniques are to be employed for the interpretation of chemical phenomena and validation of experimental results.
PO9	**Lifelong Learning and Professional Development:** The importance of continuous learning for staying updated with new developments in chemistry and related sciences is to be recognized and adopted as a professional habit.
PO10	**Teamwork and Leadership:** The ability to work collaboratively in multidisciplinary teams and to demonstrate leadership and responsibility in professional and research environments is expected to be cultivated.

Programme Specific Outcomes (PSOs)

After the successful completion of M. Sc. in Chemistry program, the students are expected to:	
PSO1	Acquire specialized knowledge, practical competence, and research-oriented skills in their chosen branch of chemistry — Physical, Inorganic, or Organic Chemistry. Each specialization aims to develop analytical thinking, experimental expertise, and interdisciplinary understanding aligned with modern scientific and industrial needs.
PSO2	Learners are equipped with in-depth understanding of quantum mechanics, thermodynamics, kinetics, and spectroscopy to interpret physical and molecular behavior. Emphasis is placed on mastering experimental and computational techniques, simulation, and modeling of chemical systems. The specialization prepares students to apply theoretical and experimental principles in materials science, nanotechnology, and pharmaceutical research.
PSO3	Students gain mastery in reaction mechanisms, stereochemistry, pericyclic reactions, and retrosynthetic analysis. The program enhances skills in designing multi-step organic syntheses using green and sustainable chemistry approaches. Emphasis is given to spectroscopic and chromatographic techniques for molecular characterization, and to understanding the significance of organic chemistry in pharmaceuticals, food science, and biological systems.
PSO4	Gain advanced knowledge of coordination chemistry, organometallics, bioinorganic systems, and solid-state chemistry. Learners are trained in group theory applications, synthesis of transition metal complexes, and analysis of reaction mechanisms. It nurtures understanding of inorganic chemistry's role in catalysis, materials science, and

	environmental chemistry, enhancing both theoretical insight and laboratory competence.
PSO5	The learners will be acquainted with the historical and cultural development of chemistry in the context of Indian knowledge system.

M.Sc. in CHEMISTRY

SEMESTER	COURSE NO.		Marks	Lecture hours	Credit (L+T+P)
I	CEMC 401X0	Organic Chemistry - I	40 + 10	40	4 (3-1-0)
	CEMC402X0	Inorganic Chemistry- I	40 + 10	40	4 (3-1-0)
	CEMC403X0	Physical Chemistry - I	40 + 10	40	4 (3-1-0)
	CEMC404X0	Research Methodology and Ethics	40 + 10	40	4 (3-1-0)
	CEMC405X8(INORGANIC) CEMC405X9(PHYSICAL)	Practical (Inorganic Chemistry and Physical Chemistry)	25 + 25	50 + 50	2 + 2 (0-0-2, 0-0-2))
	CEMC406VC	Indian Knowledge System (IKS)	25	20	2 (2-0-0)
	CEMC407NC	Life and Philosophy of Vidyasagar	Compulsory non-credit course		
	TOTAL		275	280	22
II	CEMC451X0	Organic Chemistry - II	40 + 10	40	4 (3-1-0)
	CEMC452X0	Inorganic Chemistry- II	40 + 10	40	4 (3-1-0)
	CEMC453X0	Physical Chemistry - II	40 + 10	40	4 (3-1-0)
	CEMC454X0	Advanced Spectroscopic Technics for Structure and Property	40 + 10	40	4 (3-1-0)
	CEMC455X8(ORGANIC) CEMC455X9(COMPUTER AND FOOD PROCESSING)	Practical (Organic, Computer and Food Processing)	25 + 25	50 + 50	2 + 2 (0-0-2, 0-0-2)
	CEMC456X9	Field visit / Industry visit / Case Study / Hands on Practical / Skill Enhanced Course	25	40	2 (0-1-1)
	TOTAL		275	300	22
III	*SPECIALISATION: ORGANIC / INORGANIC / PHYSICAL CHEMISTRY*				
	CEMC501X0(MOOC)	MOOC	40 + 10	40	4 (3-1-0)
	CEME502A0(ORGANIC)/ CEME502B0 (INORGANIC) / CEME502C0(PHYSICAL CHEMISTRY)	ADVANCED ORGANIC / INORGANIC / PHYSICAL CHEMISTRY-I	40 + 10	40	4 (3-1-0)
	CEME503A0(ORGANIC)/ CEME503B0 (INORGANIC) / CEME503C0(PHYSICAL CHEMISTRY)	ADVANCED ORGANIC / INORGANIC / PHYSICAL CHEMISTRY-II	40 + 10	40	4 (3-1-0)
	CEME504A9(ORGANIC)/ CEME504B9(INORGANIC)/ CEME504C9(PHYSICAL)	Research Project 1, Dissertation	100	200	8 (0-0-8)
	CEMO505X9	Social Service / Community Engagement	25	50	2 (0-0-2)
	TOTAL		275	370	22
IV	*SPECIALISATION: ORGANIC / INORGANIC / PHYSICAL CHEMISTRY*				
	CEME551A0(ORGANIC)/ CEME551B0 (INORGANIC) / CEME551C0(PHYSICAL CHEMISTRY	ADVANCED ORGANIC / INORGANIC / PHYSICAL CHEMISTRY-III	40 + 10	40	4 (3-1-0)
	CEME552A0(ORGANIC)/ CEME552B0 (INORGANIC) / CEME552C0(PHYSICAL CHEMISTRY	ADVANCED ORGANIC / INORGANIC / PHYSICAL CHEMISTRY-IV	40 + 10	40	4 (3-1-0)
	CEME553A9(ORGANIC)/ CEME553B9(INORGANIC)/ CEME553C9(PHYSICAL)	Research Project 2, Dissertation	100	200	8 (0-0-8)
	CEMC554X0	Internship / Capstone Project / Applied Field or Industry Project / Innovation / Incubation / Entrepreneurship /Start up	50	100	4 (0-0-4)

		Proposal or Practice			
	CEMO555X0	Intellectual Property Right / Skill Enhanced Course	25	30	2 (1-0-1)
	TOTAL		275	410	22
	ALL TOTAL		1100	1360	88

Overview of the Syllabus

Semester	Paper	No of Papers	Full Marks of Each Paper	Credit Point of each paper	Total Marks	Credit Points	Total Credit Points
1st	Theory	4	40+10 = 50	4	200	16	22
	Practical	1	25 +25	2 +2	50	4	
	IKS	1	25	2	25	2	
	Life and Philosophy of Vidyasagar	1	25	0	25	0	
2nd	Theory	4	40+10 = 50	4	200	16	22
	Practical	1	25 + 25	2 +2	50	4	
	Field visit / Industry visit / Case Study / Hands on Practical / Skill Enhanced Course	1	25	2	25	2	
3rd	Theory	3	40+10 = 50	4	150	12	22
	Project	1	100	8	100	8	
	Social Service / Community Engagement	1	25	2	25	2	
4th	Theory	2	40+10 = 50	4	100	8	22
	Project	1	100	8	100	8	
	Internship / Capstone Project / Applied Field or Industry Project / Innovation / Incubation / Entrepreneurship /Start up Proposal or Practice	1	50	4	50	4	
	Intellectual Property Right / Skill Enhanced Course	1	25	2	25	2	
Grand Total 88 Credit Points							

DETAILS OF THE COURSES

SEMESTER-I

Course code	CEMC401X0	Organic Chemistry –I	Credit 4 (3-1-0) Full Marks: 50
Core/Elective/Other		Core	Compulsory

Course Objectives:

1. Provide a comprehensive understanding of the fundamental concepts governing pericyclic reactions, including orbital symmetry and molecular orbital theory.
2. Enable students to analyze the biogenetic pathways and structural diversity of terpenoids, emphasizing mechanisms of cation–olefin cyclization and synthetic strategies for triterpenoids.
3. Introduce the principles and applications of modern organic transformations, such as fragmentation, phase-transfer catalysis, multi-component reactions, and olefin metathesis.
4. Develop the ability to design efficient synthetic routes using retrosynthetic analysis and functional group interconversions.
5. Strengthen problem-solving and mechanistic reasoning skills in the context of complex organic synthesis.

Course Outcomes (COs):

• CO 1: Explain the mechanisms and stereochemical outcomes of pericyclic reactions using molecular orbital and frontier orbital theories.
• CO 2: Apply Woodward–Hoffmann rules and correlation diagrams to predict the feasibility and stereochemical course of pericyclic reactions.
• CO 3: Analyze and classify terpenoids based on the biogenetic isoprene rule and their structural features.
• CO 4: Design and rationalize synthetic routes for complex terpenoid structures using cation–olefin cyclization mechanisms.
• CO 5: Utilize modern organic transformations (e.g., metathesis, multi-component reactions, and phase-transfer catalysis) in synthesis.
• CO 6: Employ retrosynthetic analysis and functional group interconversion strategies to design multi-step organic syntheses.
• CO 7: Demonstrate critical thinking and problem-solving skills through mechanistic and synthesis-based exercises.

Syllabus:

Unit-01

Pericyclic reaction I:

Pericyclic reactions characteristic features, conservation of orbital symmetry MO of different polyenes, electrocyclic, cycloaddition, sigmatropic reactions, Rationalisation of different electrocylcic reactions on the basis of frontier orbital interaction, Woodward Hofmann symmetry rules for electrocylcic reactions, exceptions to symmetry rules, correlation diagram and perturbation molecular orbital theory (PMO) of different electrocylcic reactions, Nazarov cyclisation. Problems relating to these reactions.

Unit-02

Natural products-I Terpenoids:

Cation-olefin cyclization reaction: application to the synthesis of tritepenes: biogenetic isoprene rule: monocyclic, bicyclic, tricyclic, tetracyclic and pentacyclic ring systems. Synthesis of triterpenoids containing the following ring systems: 6-6-6-5 rings (dammaranes), 6-6-6-6-5 rings (lupyl), 6-6-6-6-6 rings (germanecyl) (at least 5 examples in each system).

Unit-03

Organic transformations/ Reagent Chemistry/Synthesis-I:

Fragmentation reaction, Phase transfer catalyst. Multi-component reactions: Definition, early examples, Passerine reaction, Ugi reaction. Olefin metathesis reaction: Definition, Ring closing metathesis reaction, examples.

Unit-04

Organic transformations/ Reagent Chemistry/Synthesis-II:

Remote functionalization: biomimetic reactions / template effect, examples. Functional groups inter conversion. Retro-synthetic analysis with examples.

CO–PO Mapping (Numerical Weightage Table)										
COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	3	3	2	3	–	–	–	–	–	2
CO 2	3	3	2	2	–	–	–	–	–	1
CO 3	3	2	–	2	3	–	2	–	–	2
CO 4	3	3	3	3	2	–	–	–	–	2
CO 5	3	3	3	3	3	2	–	–	–	2
CO 6	3	3	3	3	2	–	–	2	–	3
CO 7	2	3	2	3	2	–	–	3	3	3
Legend: 1 = Low correlation 2 = Medium correlation 3 = High correlation – = No significant correlation										

Summary of Attainment

This course contributes strongly to the following Program Outcomes:
- PO1: Knowledge of Chemistry
- PO2: Problem Analysis
- PO4: Investigation of Complex Problems
- PO5: Modern Tool Usage
- PO7: Environment and Sustainability
- PO9: Communication Skills
- PO10: Lifelong Learning

Course code	CEMC402X0	Inorganic Chemistry – I	Credit 4 (3-1-0) Full Marks: 50
Core/Elective/Other		Core	Compulsory

Course Objectives:

1. Provide a thorough understanding of the fundamentals of group theory, including symmetry elements, operations, and matrix representations relevant to molecular systems.

2. Enable students to apply group theoretical principles to predict molecular symmetry, construct character tables, and analyze bonding and spectroscopy.

3. Familiarize students with the role of metal ions in biological systems, emphasizing the structure, function, and models of metalloproteins and metalloenzymes.

4. Introduce the principles of bioenergetics and metal ion transport, highlighting the physiological and toxicological roles of metals.

5. Develop knowledge of crystallography, including lattice theory, symmetry elements, crystal classes, Bragg's law, and X-ray diffraction methods.

6. Strengthen analytical and conceptual skills for interpreting crystal structures, symmetry relationships, and bioinorganic phenomena in real systems.

Course Outcomes (COs):

CO 1: Explain the fundamental concepts of group theory and classify molecules based on symmetry elements and operations.
CO 2: Construct and interpret matrix representations, reducible and irreducible representations of molecular point groups.
CO 3: Apply group theory to predict molecular properties such as bonding, hybridization, and selection rules in spectroscopy.
CO 4: Describe the structure, function, and coordination environment of oxygen-carrying and electron-transport metalloproteins.
CO 5: Explain the mechanisms of metal ion transport, storage proteins. Toxicity of metals in biological systems, and the medicinal roles of metals.
CO 6: Demonstrate understanding of crystallographic concepts such as lattice, unit cell, Bravais lattice, and Miller indices.
CO 7: Analyze X-ray diffraction data using Bragg's law, identify crystal systems, and interpret point and space group symmetries.

Syllabus:

Unit 1: Group Theory-I

Concept of groups; subgroups, classes and the related theorems; commutative (Abelian) groups, cyclic groups; group multiplication tables and the rearrangement theorem; Symmetry elements and operations, products of symmetry operations, equivalent symmetry elements and equivalent atoms, molecular point groups; platonic solids; the matrix representations of symmetry operations; Matrix representation of point groups; similarity transformation; reducible and irreducible representations; the Great Orthogonality Theorem (no derivation) and its corollaries.

Unit 2: Bioinorganic chemistry-I:
Metal-protein interaction; Bioenergetic principle and role of ATP; Oxygen–uptake proteins: haemoglobin, myoglobin, hemerythrin and hemocyanin: structure, function and model study; Synthetic oxygen carriers, Metal ions in electron transport proteins: Fe-S proteins, Blue copper proteins, cytochromes; Metal ions transport and storage proteins: ferritin, transferrin, ceruloplasmin, hemosiderin; Transport across biological membrane: Ion pumps, ionophores; Hydrolytic enzymes: carbonic anhydrase, carboxy peptidase, urease;; Toxic effects of metal: Copper toxicity and Wilson’s disease, Arsenic poisoning, Aluminium toxicity and Alzheimer disease; Heavy metal toxicity; Metals in medicines.

Unit 3: Crystallography:
Crystalline solid –single crystal and polycrystal (twining problem), process of crystallizations, lattice; unit cell – primitive and non-primitive unit cells, Unit cell parameters and crystal systems Concepts of crystal structure-Bravais lattice, Indexing of lattice planes; Miller indices ,Reciprocal lattice and its relation to direct lattice; Bragg equation, Bragg reflection in terms of reciprocal lattice – sphere of reflection and limiting sphere; relation between dhkl and lattice parameters translational and rotational symmetry, symmetry elements and their symbols (both numerical and graphical), point group, screw axis, glide plane. X-ray, Generation of X-ray, Cu K□ and Mo K□ radiation; X-ray diffraction;
Crystal symmetry – (i) point group elements and (ii) space group elements; 32 crystal classes, HM notations, distribution in different systems and stereographic projections; Isogonal symmetry groups Space group – HM notation, space groups in triclinic and monoclinic systems. Methods of growing single crystals.

CO–PO Mapping (Numerical Weightage Table)										
COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	3	3	–	–	–	–	–	–	–	–
CO 2	3	3	3	2	–	–	–	–	–	–
CO 3	3	3	–	3	–	–	–	–	–	–
CO 4	3	2	–	–	3	–	2	–	–	–
CO 5	3	2	–	2	–	–	3	–	–	3
CO 6	3	3	–	3	3	–	–	–	–	–
CO 7	3	3	–	3	2	–	–	–	3	2
Legend: 1 = Low correlation 2 = Medium correlation 3 = High correlation – = No significant correlation										

Summary of Attainment

This course contributes strongly to the following Program Outcomes:
- PO1: Knowledge of Chemistry
- PO2: Problem Analysis
- PO4: Investigation of Complex Problems
- PO5: Modern Tool Usage
- PO7: Environment and Sustainability
- PO9: Communication Skills
- PO10: Lifelong Learning

Course code	CEMC403X0	Physical Chemistry – I	Credit 4 (3-1-0) Full Marks: 50
Core/Elective/Other		Core	Compulsory

Course Objectives:

1. To introduce the thermodynamics of real gases and binary solutions, including fugacity, activity coefficients, and partial molar properties.

2. To develop a microscopic understanding of thermodynamic principles using statistical mechanics.

3. To explain the derivation and significance of Boltzmann, Bose–Einstein, and Fermi–Dirac statistics.

4. To impart knowledge of molecular spectroscopy, focusing on rotational, vibrational, and Raman spectra and their applications.

5. To explain photophysical processes through potential energy diagrams and Jablonskii transitions.

6. To provide a foundational understanding of quantum mechanics and its applications to simple systems.

Course Outcomes (COs):

CO 1: Explain the thermodynamics of real gases, binary solutions, and partial molar quantities.
CO 2: Apply statistical mechanics to derive thermodynamic relationships and evaluate partition functions.
CO 3: Discuss the significance of entropy, molecular distribution functions, and the concept of negative temperature.
CO 4: Interpret molecular rotational and vibrational spectra using quantum principles.
CO 5: Analyze Raman and infrared spectra to determine molecular structure and symmetry.
CO 6: Explain photophysical processes such as fluorescence, phosphorescence, and intersystem crossing using Jablonskii diagrams.
CO 7: Apply quantum mechanical formalism to simple systems (particle in a box, harmonic oscillator, hydrogen atom).

Syllabus:

Thermodynamics:

Thermodynamics of real gases in pure state and mixtures. Thermodynamics of ideal and non-ideal binary solutions: excess functions; partial molar properties. Fugacity, Different scales of activity co-efficients for solutes and solvents

Statistical Mechanics -I:

Basic concepts of statistical mechanics, Connection between microscopic and macroscopic description;
Boltzmann definition of entropy, Derivation of the MB distribution, concept of negative absolute temperature, Bose-Einstein and Fermi-Dirac statistics formulae from the expressions of thermodynamic weight, Different types of Partition functions, Evaluation of molecular partition functions, Thermodynamic quantities in terms of partition function, Gibbs paradox and the Sackur-Tetrode equation.

Spectroscopy-I

Rotational-vibrational spectroscopy of linear molecules. P, Q, R branches. Applications of rotational-vibrational spectroscopy.

Raman spectroscopy: Classical treatment of Raman spectroscopy, Rayleigh, Stokes and anti-Stokes lines, Polarizabilty and polarizabilty ellipsoids, Quantum theory of Raman spectroscopy (qualitative idea only), Vibrational Raman spectroscopy, Mutual exclusion principle. Applications of Raman spectroscopy.

Photophysical Processes: Potential energy surface (diatomic molecules),Types of different electronic states (stable, unstable, singlet, triplet etc.), Types of light absorbing process, Pre-dissociation, Frank-Condon principle and vibrational structure of electronic spectra; Decay of excited states by radiative and non-radiative paths; 1st order photophysical processes; Fluorescence, phosphorescence, internal conversion and intersystem crossing, Jablonskii diagram, Kasha's rule.

Quantum mechanics-I: Basic formalism of quantum mechanics, Bra ket notations, overview of exactly solvable problem (PIB, Rigid rotator, particle in circular ring, SHO, H-atom). Many electron system: construction of Hamiltonian operator, eigen function (slater determinant notation), Energy eigen value problem of ground and excited He-atom.

CO–PO Mapping (Numerical Weightage Table)

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	3	3	–	–	–	–	–	–	–	–
CO 2	3	3	–	3	–	–	–	–	–	–
CO 3	3	–	–	3	–	–	–	–	–	3
CO 4	3	3	–	–	3	–	–	–	–	–
CO 5	3	–	–	–	3	–	3	–	–	–
CO 6	3	–	–	3	3	–	–	–	–	3
CO 7	3	3	–	3	–	–	–	–	3	–

Legend: 1 = Low correlation 2 = Medium correlation 3 = High correlation – = No significant correlation

Summary of Attainment

This course contributes strongly to the following Program Outcomes:
- PO1: Knowledge of Chemistry
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- PO9: Communication Skills
- PO10: Lifelong Learning

Course code	CEMC404X0	Research Methodology and Ethics	Credit 4 (3-1-0) Full Marks: 50
Core/Elective/Other		Core	Compulsory

Course Objectives:

1. To introduce the fundamental concepts of research planning and design.

2. To develop the ability to identify, formulate, and define research problems and hypotheses.

3. To provide knowledge about sampling techniques, data collection, and analysis methods.

4. To enhance understanding of report writing, referencing styles, and documentation.

5. To impart awareness of research and publication ethics, including plagiarism and scientific misconduct.

6. To familiarize students with scientific databases and research metrics for assessing scientific impact.

Course Outcomes (COs):

CO 1: Define and explain the key concepts of research methodology and its scope in scientific investigation.
CO 2: Formulate a research problem and hypothesis based on relevant literature and research gaps.
CO 3: Design and plan effective research projects, applying appropriate sampling and data collection methods.
CO 4: Analyze and interpret research data, and present findings clearly and logically.
CO 5: Prepare research reports and dissertations following proper documentation and citation standards.
CO 6: Demonstrate an understanding of research ethics, publication ethics, and the avoidance of plagiarism.
CO 7: Use scientific databases and bibliometric tools to evaluate journals, articles, and author performance.

Syllabus:

Planning of Research: Essentials of a Good Research Problem, Sources of Research Problem, Factors Affecting Selection of Research Problem, Hypothesis, Features of Good Hypothesis, Types of Hypotheses, Role of Hypothesis, Sources of Hypothesis

Sample design/Sampling: What is sampling? Advantages/merits of Sampling, Methods or Techniques of Sampling, Steps in Sample Design, Principles/essentials of Sampling, Process of Sample Survey,

Research Design: Introduction, Meaning and Definitions, Essentials of Good Research Design, Steps of Research Design, Evaluation of Research Design.

Processing and Analysis of data: Introduction, Stages of Processing of Data, Analysis of Data, Interpretation of Data, Transcription of Data.

Preparation of Report: What is Research Report? Types of Report, contents of Report, Layout of the Research Report, Principles of Report Writing, Steps in Report Writing, Steps Involved in Drafting a Research Report, Documentation, Footnotes, Bibliography.

Ethics and Research: Importance of Ethics in Research, Principles of Research Ethics. Intellectual Honesty and Research Integrity, Integrity of the Individual Scientist, Integrity at Institutional Level, Scientific Misconduct.

Publication Ethics: Definition and Importance of publication ethics, Regulatory Organisations for Publication Ethics, Best Practices/Standards Setting Initiative and Guidelines, Guidelines for Authors, Editors and Reviewers, set by COPE, Conflict of Interests, Publication Misconduct, Types of Publication Misconduct, Plagiarism.

Databases: Definition and Types of Databases, Indexing, Benefits of Indexing, Citation Index Database, Major Citation Indexing Services, Web of Science, Scopus, Google Scholar, PubMed Central (PMC) Database, Indian Citation Index (ICI) Database

Research Metrics: Bibliometrics, Journal Metrics, Journal Impact Factor, Cite Score, Difference between Cite Score and Impact Factor, Source Normalised Impact Per Paper (SNIP), Scimago Journal Rank (SJR),
Impact Per Publication (IPP), Author Metrics, H-Index, Advantages of H-Index, Drawbacks of H-Index, i10/20 Index.

CO–PO Mapping (Numerical Weightage Table)

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	3	3	–	–	–	–	–	–	–	–
CO 2	3	3	3	–	–	–	–	–	–	–
CO 3	3	3	–	3	–	–	–	–	–	–
CO 4	3	2	–	–	3	–	–	–	3	–
CO 5	3	–	–	–	–	–	–	–	3	3
CO 6	3	–	–	–	–	–	–	3	–	3
CO 7	3	–	–	–	3	–	–	–	3	3

Legend: 1 = Low correlation 2 = Medium correlation 3 = High correlation – = No significant correlation

Summary of Attainment

This course contributes strongly to the following Program Outcomes:
- PO1: Knowledge of Chemistry
- PO2: Problem Analysis
- PO3: Design/Development of Solutions
- PO4: Investigation of Complex Problems
- PO5: Modern Tool Usage
- PO8: Ethics
- PO9: Communication Skills
- PO10: Lifelong Learning

Course code	CEMC405X8 CEMC405X9	Inorganic and Physical Chemistry Practical	Credit 2+2 (0-0-4) Full Marks: 50
Core/Elective/Other		Core	Compulsory

Course Objectives:

1. To train students in quantitative and qualitative analysis of inorganic compounds and metal complexes.
2. To develop laboratory skills in classical and modern physical chemistry experiments.
3. To impart practical experience in equilibrium, kinetic, and electrochemical systems.
4. To familiarize students with synthesis and characterization of inorganic compounds.
5. To enable students to correlate experimental data with theoretical principles of chemistry.

Course Outcomes (COs):

CO1: Perform accurate quantitative inorganic analyses using gravimetric and volumetric methods.

CO2: Demonstrate synthesis and characterization of inorganic complexes.

CO3: Apply electrochemical, conductometric, and spectrophotometric techniques to determine chemical parameters.

CO4: Analyze chemical kinetics and equilibrium experimentally and interpret data statistically.

CO5: Synthesize and study the photophysical behavior of nanoparticles.

CO6: Correlate experimental results with theoretical chemical principles to draw scientific conclusions.

Syllabus:

Unit I: Inorganic Chemistry (Marks: 25; Credit: 2)

A. Laboratory work **Marks:15**

1. Quantitative estimation of alloys and ores using Gravimetric / titrimetric methods:

(a) Gravimetric estimation of Cu(II) as CuSCN

(b) Gravimetric estimation of Ni(II) as $Ni(DMGH)_2$

(c) Volumetric estimation of Mn(II)/Fe(III)

(d) Quantitative estimation of Zn(II) and Cu(II) in brass sample by volumetry and gravimetry

(e) Quantitative estimation of manganese in pyrolusite

2. Physicochemical experiments:

(a) Determination of composition of Fe(III)-sulfosalicylate complex in solution by Job‟s method of continuous variation.

(b) Colourimetric estimation of Fe(III) (as thiocyanate complex)

3. Syntheses and crystallization of coordination compounds:

(a) Reinkey‟s salt

(b) $K_3[Fe(ox)_3]$

(c) $K_3[Cr(ox)_3]$

B. Sessional Work: 5

To be awarded by the class teacher on the basis performance of the students during the practical classes.

C. Viva Voce: **5**

To be jointly conducted by the external and internal examiners during the examination.

Unit II: Physical Chemistry (Marks: 25; Credit : 2)

A. Laboratory work **Marks:15**

1. Determination of concentration of Glucose and fructose in a mixture using polarimeter.
2. Conductometric determination of concentrations of KCl, HCl and NH_4Cl in a mixture.
3. Verification of Onsagar equation using KCl, K_2SO_4 and $BaCl_2$ as electrolytes and determine their Λ^0 values.
4. Determination of CMC of a surfactant in aqueous solution by conductometric method.
5. Potentiometric titration of halide mixture (Chloride, Bromide and Iodide).
6. Determination of the E^0 value of Ag^+ /Ag electrode and activity coefficients of different aqueous $AgNO_3$ solutions potentiometrically.
7. Determination of the standard potential of *$Fe(CN)6^{3-}$/ *$Fe(CN)6^{4-}$ electrode by potentiometer.
8. Determine the dissociation constants (K_1, $K_{2,}$ and K_3) of H_3PO_4 by pH meter.
9. Study the kinetics of Iodination of acetone spectrophotometrically.
10. Determination of composition of complexes (Ferric-salicylate complex/Ferrous-orthophenanthroline complex) by Job's method.
11. Determine the rate constant and the order of the reaction of $KBrO_3$ & KI in acid medium.
12. Study of the kinetic of alkaline hydrolysis of crystal violet. Determine the order with respect to alkali and salt effect on the system.
13. Spectroscopic experiments relating to quenching of fluorescence.
14. Experiment for the measurements of activation barrier of some model chemical reactions.
15. Synthesis of metal/semiconducting nanoparticle and their photophysical study.

B. Sessional Work: 5

To be awarded by the class teacher on the basis performance of the students during the practical classes.

C. Viva Voce: 5

To be jointly conducted by the external and internal examiners during the examination.

CO–PO Mapping (Numerical)										
CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	2	2	1	3	2	1	1	2
CO2	3	3	2	3	2	3	2	1	1	2
CO3	3	2	3	2	2	3	3	1	1	2
CO4	3	3	3	3	2	2	3	2	2	3
CO5	3	3	2	3	3	3	2	2	2	3
CO6	3	3	3	3	2	3	3	3	2	3
Legend: 1 = Low correlation 2 = Medium correlation 3 = High correlation – = No significant correlation										

Summary of Attainment

This course contributes strongly to the following Program Outcomes:
- PO1: Knowledge of Chemistry
- PO2: Problem Analysis
- PO3: Design/Development of Solutions
- PO4: Investigation of Complex Problems
- PO5: Modern Tool Usage
- PO8: Ethics
- PO9: Communication Skills
- PO10: Lifelong Learning

Course code	CEMC406VC	Indian Knowledge System	Credit 2 (2-0-0) Full Marks: 25
Core/Elective/Other		Core	Compulsory

Course Objectives:

1. To introduce students to the foundational concepts, principles, and philosophical underpinnings of the Indian Knowledge System (IKS) and its historical development.
2. To explore the contributions of IKS in various scientific domains, including chemistry, Ayurvedic medicine, and environmental sciences.
3. To develop the ability to handle challenges via stress management practices, yoga and pranayam.

Course Outcomes (COs):

CO1: Understand the foundational concepts, philosophical principles, and historical evolution of the Indian Knowledge System.

CO2: Contributions of IKS to various scientific domains such as chemistry, Ayurveda, surgery, naturopathy.

CO3: Apply knowledge of IKS for stress management and life skills.

Course content:

The fundamentals of Indian Knowledge System. The discoveries of the Indian Acharyas such as Charaka, Sushruta, Dhanvantari, Kanada, Kautilya, Aryabhatta, Patanjali for the fundamental understanding of Natural Sciences and Ayurveda (including Chemistry, Mathematics, Health). Holistic approaches to health balancing body, mind and spirit via Yog and Pranayam.

Course code	CEMC407NC	Life and Philosophy of Vidyasagar	Credit 0 Full Marks: 25
Core/Elective/Other		Compulsory non–credit course	
Course Objectives:			
Course Outcomes (COs):			
Course content:			

- Early life and Education of Vidyasagar.
- Vidyasagar and Indian Education.
- Vidyasagar and Women Emancipation.
- Philanthropist Vidyasagar.
- Vidyasagar: Traditions and modernity.
- Relevance of Vidyasagarian thoughts and values.

SEMESTER-II

Course code	CEMC451X0	Organic Chemistry – II	Credit 4 (3-1-0) Full Marks: 50
Core/Elective/Other		Core	Compulsory

Course Objectives:

1. To provide an advanced understanding of pericyclic reactions and their mechanistic aspects using FMO and PMO approaches.
2. To introduce modern organic transformations and reagents used in synthesis, including organometallic and organocatalytic methods.
3. To impart knowledge on the structural elucidation and synthesis of natural products such as alkaloids, flavonoids, and terpenoids.
4. To develop understanding of stereochemical concepts including chirality, conformational analysis, and asymmetric synthesis.
5. To apply stereochemical principles and models for predicting reaction outcomes and molecular behavior.

Course Outcomes (COs):

1. CO1: Understand the mechanistic principles of pericyclic reactions using molecular orbital theory and symmetry rules.
2. CO2: Apply modern organic reagents and transformations for multistep organic synthesis.
3. CO3: Analyze structural features and biosynthetic pathways of natural products such as terpenoids and alkaloids.
4. CO4: Demonstrate understanding of chirality, conformational effects, and stereochemical reactivity in complex systems.
5. CO5: Apply models of asymmetric induction to predict stereochemical outcomes in synthesis.
6. CO6: Correlate molecular symmetry and stereoelectronic effects with chemical reactivity and product selectivity.

Course content

Unit - 01
Pericyclic reaction II:

Energy diagram of ethylene and butadiene system with different substitutions and study of their cycloaddition reactions, FMO approach and correlation diagram of cycloaddition reactions, Perturbation molecular orbital theory (PMO) and Woodward Hofmann symmetry rules for cycloaddition reaction, Regioselectivity, endo rule, secondary interactions in pericyclic reactions, cycloreversion reactions, 1,3-dipolar cycloaddition reactions, cheletropic reactions, Problems relating to these reactions.

Unit-02

Organic transformations/ Reagent Chemistry/Synthesis-III:

Oxidations reactions: Hydroxylation reagents, use of peroxy acids, Woodward prevost hydroxylation, Sharpless asymmetric expoxidation, AD-mix, Transformation of expoxides. Organophosphorus reagents, organo sulfer reagents, organo boranes, organo silanes, organostannanes, Organo catalytic reaction, metal hydrides, Birch reduction, Robinson annulation, Umpolung, Merrifield resin: solid phase synthesis.

Unit 03

Natural Products

Alkaloids, Flavanoids Terpenoids: Definition, Classification, Structure, Synthesis.

Use of retro-synthetic analysis for the synthesis of natural products.

Unit 04 Stereochemistry I:

Symmetry and molecular chirality, Axial chirality, Atropisomerism, Stereochemical features : polysubstituted cyclohexane, conformation and physical properties.Computation of stereoisomers of different systems. Conformation and relative reactivity of diastereomers. 2-, 3, and 4- Alkyl ketone effects.

Unit 05 Stereochemistry II:

Asymmetric synthesis : Addition of a chiral reagents to chiral ketones and aldehydes, models of stereochemical control : Cram, Karabatsos. Felkin model (torsional strain), Burgi Dunitz trajectory, Molecular rearrangements with Neighbouring group participations.

CO–PO Mapping (Numerical)

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	3	2	2	2	3	2	2	3
CO2	3	3	2	3	2	3	3	2	2	3
CO3	3	2	2	3	3	3	2	1	2	3
CO4	3	3	3	3	3	2	2	2	2	3
CO5	3	3	2	3	3	3	3	3	3	3
CO6	3	3	3	3	2	3	3	2	3	3

Legend: 1 = Low correlation 2 = Medium correlation 3 = High correlation – = No significant correlation

Summary of Attainment

This course contributes strongly to the following Program Outcomes:

- PO1: Knowledge of Chemistry
- PO2: Problem Analysis

- PO3: Design/Development of Solutions
- PO4: Investigation of Complex Problems
- PO5: Modern Tool Usage
- PO8: Ethics
- PO9: Communication Skills
- PO10: Lifelong Learning

Course code	CEMC452X0	Inorganic Chemistry – II	Credit 4 (3-1-0) Full Marks: 50
Core/Elective/Other		Core	Compulsory

Course Objectives:

1. To develop a comprehensive understanding of Electron Spin Resonance (ESR) spectroscopy and its applications to transition metal complexes.
2. To strengthen conceptual understanding of group theory, character tables, and their use in molecular spectroscopy and symmetry analysis.
3. To introduce organometallic chemistry with emphasis on structure, bonding, and reactivity of metal-carbon bonded compounds.
4. To provide insights into supramolecular chemistry and non-covalent interactions in metal-organic assemblies.
5. To understand the bonding and structural diversity of boron hydrides, carboranes, and metalloboranes through modern theories.

Course Outcomes (COs):

CO1: Interpret ESR spectra and understand hyperfine interactions in paramagnetic systems.

CO2: Apply group theoretical principles to molecular symmetry and vibrational spectroscopy.

CO3: Explain bonding, reactivity, and fluxionality in organometallic compounds using electron counting rules.

CO4: Describe supramolecular interactions and metal-directed self-assembly in inorganic systems.

CO5: Analyze structure, bonding, and reactivity of boron clusters using Wade's and MO theories.

CO6: Evaluate the chemical and medicinal relevance of boron-based compounds including BNCT applications.

Course content

Unit 1: Electron Spin Resonance (ESR) spectroscopy
Principle of ESR and comparison to NMR spectroscopy, energy of free electron spin state, energy levels of a free electron in an external magnetic field, intensity of ESR lines and factors affecting it, representation of ESR spectrum, X-band and Q-band spectra, external standard, line-width, nuclear hyperfine interactions, prediction of expected number of lines and their relative intensities, hyperfine splitting in various systems, zero-field splitting and Kramer's degeneracy; determination of oxidation state of metal ion in samples.

Unit 2: Group Theory-II
Character tables, construction of character tables (C_{2v}, C_{3v}, C_{4v}, D_4); direct product, the standard reduction formula; the direct product representation and its decomposition.
Wave functions as bases for Irreducible Representations, spectral transition probabilities, polarization effect, Metal based Electronic Excitations in $[Mo_2Cl_8]^{4-}$, allowedness – forbiddenness of n-π* and π-π* transitions; Study of normal modes, IR and Raman activity (H_2O molecule only).

Unit 3: Organometallic Chemistry – I: Application of 18-electron and 16-electron rules to transition metal organometallic complexes; Ligands in organometallic chemistry; Synthesis, structure, bonding and chemistry of Metal-alkyl, -alkene, -alkyne, - allyl, -carbene, -carbyne and -carbide complexes; Agostic interaction; Stereochemical non-rigidity and fluxional behaviour of organometallic compounds with typical examples.

Unit 4: Supramolecular Chemistry of Inorganic Molecules: Basic concept and principles of supramolecular chemistry, molecular recognition and hydrogen bonding; Secondary Electrostatic Interactions in Hydrogen Bonding Arrays. Different non-covalent interactions, Metal directed self-assembly, design of supramolecular host molecules. Examples of Host-guest complexes. Catalytic applications of molecular hosts. Metal Organic Frameworks (MOFs) and their applications, covalent organic frameworks (COFs).

Unit 5: Boranes: Boron cluster classification, skeletal electron counting. Wade's rules. Boron hydrides (Boranes) – Structure and bonding (MO description of B_2H_6 and $B_2H_6^{2-}$) in higher boranes based on Lipscomb's topological concept. "styx" system of numbering; Nomenclature. Carboranes, Metalloboranes and Metallocarboranes– Synthesis and structure; Borohydride B_nH_{n-2} anion, carboranes, metalloboranes, hydroboration reactions. NMR spectroscopy of typical inorganic boron hydride compounds (^{10}B, ^{11}B). Boron compound of potential medicinal interest. Boron neutron capture therapy (BNCT).

CO–PO Mapping (Numerical)

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	2	3	2	3	3	2	2	3
CO2	3	3	3	3	2	3	3	2	2	3
CO3	3	3	3	3	3	3	3	3	2	3
CO4	3	3	2	3	3	2	3	2	2	3
CO5	3	3	3	3	2	3	3	3	3	3
CO6	3	3	3	3	3	3	3	3	2	3

Legend: 1 = Low correlation 2 = Medium correlation 3 = High correlation – = No significant correlation

Summary of Attainment

This course contributes strongly to the following Program Outcomes:
- PO1: Knowledge of Chemistry
- PO2: Problem Analysis
- PO3: Design/Development of Solutions
- PO4: Investigation of Complex Problems
- PO5: Modern Tool Usage
- PO8: Ethics
- PO9: Communication Skills
- PO10: Lifelong Learning

Course code	CEMC453X0	Physical Chemistry – II	Credit 4 (3-1-0) Full Marks: 50
Core/Elective/Other		Core	Compulsory

Course Objectives:

1. To develop a comprehensive understanding of advanced chemical kinetics, including fast reaction techniques and complex reaction mechanisms.
2. To explore the concepts of surface chemistry and interfacial phenomena in heterogeneous systems.
3. To familiarize students with the principles and applications of photophysical processes and laser spectroscopy.
4. To introduce magnetic resonance spectroscopic techniques (NMR and EPR) and their applications in structural elucidation.
5. To strengthen the foundation in quantum mechanics, focusing on approximation methods like variation and perturbation theories.

Course Outcomes (COs):

CO1: Apply advanced kinetic methods to study fast chemical reactions and understand enzyme catalysis and inhibition mechanisms.

CO2: Analyze surface phenomena, micellization, and adsorption processes using relevant thermodynamic models.

CO3: Explain photophysical processes, excited-state interactions, and understand laser principles and their applications.

CO4: Interpret nuclear magnetic resonance (NMR) and electron paramagnetic resonance (EPR) spectra of simple systems.

CO5: Use approximation methods in quantum mechanics (variation and perturbation theories) to solve non-trivial problems in molecular systems.

Course content

Chemical Kinetics-I:

Kinetics of Fast reactions: flow method, relaxation method, flash photolysis. Shock tube method, Molecular beam technique: Method and mechanism.

Kinetics of redox reaction: inner sphere and outer sphere mechanism.

Reactions between ions: influence of solvent dielectric constant (double sphere model), single sphere activated complex model, influence of ionic strength, Enzyme catalysis and Enzyme inhibition in details

Autocatalytic reaction, oscillating reaction.

Surface Chemistry:

Curved surfaces: Young-Laplace and Kelvin equations, Adsorption on solids: BET eqn. Micelles, reverse micelles; micellization equilibrium; thermodynamics of micellization; micro and macro emulsions.

Spectroscopy-II:

Photophysical processes: Photophysical processes of unimolecular processes, Delayed fluorescence, Kinetics of bimolecular processes: collision quenching, Stern-Volmer equation, Concentration dependence of quenching and excimer formation, Excited state electron transfer processes: Exciplex, Twisted intramolecular charge transfer processes, proton couple electron transfer processes (both intra and intermolecular).

Laser and its applications: General feature and properties of LASER, Method of obtaining population inversion, Laser cavity modes, Q-switching, Mode locking, Example of LASER: Ruby laser, Nd-YAG laser, diode laser, He-Ne laser, N2 laser, Ar laser, excimer and exciplex laser, Dye laser.

(VI) Magnetic Resonance Spectroscopy: Principles of Nuclear Magnetic Resonance (NMR) spectroscopy, Larmor precession, chemical shift and low-resolution spectra, different scales, spin-spin coupling and high-resolution spectra, interpretation of PMR spectra of organic molecules. Basic idea of FT-NMR.

Quantum mechanics-II: Approximate methods in QM, Variation principle: Statement and proof on Rayleigh-Ritz variation principle, Linear variational principle and its applications.

Perturbation Theory: Rayleigh-Schrodinger perturbation theory for nondegenerate and time independent case. Expression of first order correction of energy and wave function, second order correction of energy. Examples.

CO–PO Mapping (Numerical)										
CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	2	3	2	3	3	2	2	3
CO2	3	3	3	3	2	3	3	2	2	3
CO3	3	3	3	3	3	3	3	3	2	3
CO4	3	3	2	3	3	2	3	2	2	3
CO5	3	3	3	3	2	3	3	3	3	3
CO6	3	3	3	3	3	3	3	3	2	3
Legend: 1 = Low correlation 2 = Medium correlation 3 = High correlation – = No significant correlation										

Summary of Attainment

This course contributes strongly to the following Program Outcomes:
- PO1: Knowledge of Chemistry
- PO2: Problem Analysis
- PO3: Design/Development of Solutions
- PO4: Investigation of Complex Problems
- PO5: Modern Tool Usage
- PO8: Ethics
- PO9: Communication Skills
- PO10: Lifelong Learning

Course code	CEMC454X0	Advanced Spectroscopic Techniques for Structure and Properties	Credit 4 (3-1-0) Full Marks: 50
Core/Elective/Other		Core	Compulsory

Course Objectives:

1. To provide an in-depth understanding of the principles and applications of advanced nuclear magnetic resonance (NMR) spectroscopy.
2. To familiarize students with the principles and techniques of mass spectrometry and its use in molecular structure elucidation.
3. To develop the ability to combine multiple spectroscopic techniques (UV, IR, NMR, MS) for structure determination.
4. To introduce the principles and applications of Mössbauer spectroscopy, Circular Dichroism (CD), and Optical Rotatory Dispersion (ORD).
5. To build analytical and interpretative skills in determining structures of complex organic and inorganic compounds using modern spectroscopic tools.

Course Outcomes (COs):

CO1: Interpret and analyze ^{1}H and ^{13}C NMR spectra, understanding CW and FT techniques.

CO2: Explain NMR relaxation phenomena, coupling constants, NOE effects, and spectrum simplification techniques.

CO3: Understand principles, techniques, and fragmentation patterns in mass spectrometry.

CO4: Integrate data from UV, IR, NMR, and MS spectra to elucidate molecular structures.

CO5: Describe the principles, instrumentation, and applications of Mössbauer, CD, and ORD spectroscopy.

Course content

Unit-01

Detailed study of ^{1}H NMR and preliminary aspects of ^{13}C NMR, CW and FT techniques.
Ring current: Aromaticity, Antiaromaticity, Homoaromaticity, Annulene systems.

Unit-02

NMR spectroscopy: Principles, Relaxation phenomenon, factors influencing chemical shifts and coupling constants, simplification of complex spectrum, NOE, Rotating frame of reference.

Unit-03

Mass-spectrometry combined applications of spectroscopic methods to organic molecules : Principles of Mass spectrometry, Different techniques, fragmentation modes.

Unit-04

Combined application of spectroscopic techniques (UV, IR, NMR, MS) in elucidation of structure and study of reactions of organic compounds.

Unit 05: Mössbauer Spectroscopy and CD ORD

Mössbauer Spectroscopy: Gamma ray emission and absorption by nuclei, principle, line-width, chemical shift, quadrupole interaction, magnetic interaction; spectra of Mössbauer active nuclei (iron, tin); information of spin, oxidation states and structure.

CD ORD: Circular dichroism spectroscopy (CD) and optical rotatory dispersion(ORD) basic principle, instrumentation and application.

CO–PO Mapping (Numerical)										
CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	3	2	3	2	3	3	2	2	3
CO2	3	3	3	3	2	3	3	2	2	3
CO3	3	3	3	3	3	3	3	3	2	3
CO4	3	3	2	3	3	2	3	2	2	3
CO5	3	3	3	3	2	3	3	3	3	3
CO6	3	3	3	3	3	3	3	3	2	3
Legend: 1 = Low correlation 2 = Medium correlation 3 = High correlation – = No significant correlation										

Summary of Attainment

This course contributes strongly to the following Program Outcomes:
- PO1: Knowledge of Chemistry
- PO2: Problem Analysis
- PO3: Design/Development of Solutions
- PO4: Investigation of Complex Problems
- PO5: Modern Tool Usage
- PO8: Ethics
- PO9: Communication Skills
- PO10: Lifelong Learning

Course code	CEMC455X8 CEMC455X9	Practical (Organic, Computer and Food Processing)	Credit 2+1+1 (0-0-4) Full Marks: 50
Core/Elective/Other		Core	Compulsory

Course Objectives:

1. To develop experimental competence in organic qualitative analysis and compound synthesis.
2. To impart basic programming skills using C language for chemical and scientific data handling.
3. To provide an understanding of the chemistry behind food constituents, processing, and preservation.
4. To correlate chemical principles with real-world applications in food technology and sustainability.

Course Outcomes (COs):

CO1: Perform qualitative analysis and identify organic compounds using chromatographic and spectroscopic methods.
CO2: Extract renewable chemicals from natural resources and analyze their properties.
CO3: Synthesize, purify, and evaluate organic compounds through laboratory experiments.
CO4: Write and execute basic programs in C for problem-solving in scientific contexts.
CO5: Explain the principles and chemistry of food constituents, processing, and preservation techniques.
CO6: Apply preservation techniques in preparing, packaging, and storing processed foods.

Course content

Unit 1 (Organic Practical) 25 Marks 2 credits

Laboratory work: **15 marks**

1. **Liquid Sample**

Qualitative analysis (color, odour, solubility etc.); Thin Layer Chromatography (TLC), boiling point determination, Assign 1H-NMR, 13C-NMR spectra, Identify the liquid substance.

2. Extraction of Renewable chemicals

Take a particular part of a plant such as fruit, leaf, bark, heavy wood, etc. Weight it. Extract with a particular solvent. Remove the volatiles. Purify. Weigh the product. Calculate % yield, Analyze the product by Thin Layer Chromatography, calculate Rf value. UV-VIS spectral characterizations: Measure λmax, εmax and explain. Submit the product with proper label.

3. **Preparation**

Preparation of pure organic compound single-step or two step procedure and submission of crystallized product: Table Preparation; Weigh the compound, calculate theoretical yield, prepare the compound, weigh the product, calculate % yield, crystallize, check M.P., submit crystallized product.

4. **Sessional Work**

To be awarded by the class teacher on the basis performance of the students during the course work. [5]

5. **Viva Voce**

To be jointly conducted by the external and internal examiners during the examination. [5]

Unit 2 Computer, Food Processing and Preservation **25 Marks, 2 credits**

Computer (1 credit, 12.5 marks)

Problem solving using C language Lab:

- Introduction to C Language
- C Language Input (scanf()) and Output (printf()) Statements
- Assignment, Arithmetic, Relational, and Logical Operators
- Conditional Statements: If, If-Else
- Looping Constructs: For, While, Do-While
- Switch Statement, break and continue Statements
- Function Definition and Declaration (Prototype), including Recursion and Return Statement
- One-Dimensional and Two-Dimensional Arrays.

Chemistry in Food Processing and Preservation (1 credit, 12.5 marks)

- **Constituents of Food**: **Food Pigments & Flavouring Agents**: Importance, types and sources of pigments, their changes during processing and storages

- **Food preservation:** Principles and methods: **Canning;** Preservation principle of canning of food items; **Dehydration and drying of food items;** Water activity of food and its significance in food preservation, **Low temperature preservation; Use of preservative in foods**; **Hurdle technology.**

EXPERIMENTS

I: Preparation of jams, jellies, syrups, squashes
II: Preparation of mixed fruit juices
III: Preservation of processed food
IV: Packaging of processed and preserved food
V: Value addition in food products

CO–PO Mapping												
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	2	2	1	2	1	1	1	2	1	1
CO2	3	2	3	2	1	2	1	1	1	2	1	1
CO3	3	3	3	2	1	2	1	1	1	2	1	1
CO4	2	3	3	3	2	1	1	1	1	2	1	1
CO5	2	2	2	2	1	2	1	1	1	2	1	1
CO6	2	2	3	2	1	3	1	1	1	2	1	1
(3 = Strong Correlation, 2 = Moderate Correlation, 1 = Slight Correlation, 0 = No Correlation)												

Summary of Attainment

This course contributes strongly to the following Program Outcomes:

- PO1: Knowledge of Chemistry
- PO2: Problem Analysis
- PO3: Design/Development of Solutions
- PO4: Investigation of Complex Problems
- PO5: Modern Tool Usage
- PO8: Ethics
- PO9: Communication Skills
- PO10: Lifelong Learning

Course code	CEMC456X9	Field visit / Industry visit / Case Study / Hands on Practical / Skill Enhanced Course	Credit (0-1-1) Full Marks: 25
Core/Elective/Other		Core	Compulsory

Course Objectives (COs):

1. To expose students to real industrial, field, or laboratory environments related to chemistry.
2. To bridge the gap between theoretical knowledge and practical/industrial applications.
3. To develop skills in observation, data collection, documentation, and technical reporting.
4. To enhance professional ethics, teamwork, and communication skills.

Course Outcomes (COs):

CO1 Understand industrial, field, or instrumental practices relevant to chemistry.
CO2 Apply theoretical chemical knowledge to real-life industrial or field problems.
CO3 Collect, analyze, and interpret experimental or field data systematically.
CO4 Prepare a comprehensive technical report following scientific standards.
CO5 Demonstrate professional ethics, teamwork, and safety awareness.

Course content

Industry Visit and submission of report (approximately 10 pages).

OR

Field Work, Sample Collection and submission of Report on Field Work (approximately 10 pages).

OR

Hands on training on scientific instruments and submission of a report.

CO–PO Mapping (Numerical)

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	1	1	1	1	1	1	1	1	1	1
CO2	3	3	2	2	1	2	1	1	1	2	1	1
CO3	3	3	3	2	1	2	1	1	1	2	1	1
CO4	2	2	2	2	1	1	1	1	1	3	1	1
CO5	1	1	1	1	1	3	2	2	2	2	1	1

(3 = Strong, 2 = Moderate, 1 = Low correlation)

Summary of Attainment

This course contributes strongly to the following Program Outcomes:

- PO1: Knowledge of Chemistry
- PO2: Problem Analysis
- PO3: Design/Development of Solutions
- PO4: Investigation of Complex Problems
- PO5: Modern Tool Usage
- PO8: Ethics
- PO9: Communication Skills
- PO10: Lifelong Learning

SEMESTER-III

Course code : CEMC501X0(MOOC)

Marks: 40 + 10; Lecture hours: 40; Credit (L+T+P): 4 (3-1-0)

DSE 1: Advanced Organic / Inorganic/ Physical - I

Marks: 40 + 10; Lecture hours: 40; Credit (L+T+P): 4 (3-1-0)

Course code	**CEME502A0**	**Advance Organic Chemistry –I**	**Credit 4 (3-1-0)** **Full Marks: 50**
Core/Elective/Other		**Elective**	**Compulsory**

Course Objectives:

The course **Advanced Organic Chemistry** aims to equip students with a deep understanding of modern organic reaction mechanisms, structure–reactivity relationships, and synthetic applications. Students will learn to:

1. Analyze and predict the outcomes of **pericyclic and sigmatropic reactions** using molecular orbital theories and symmetry principles.
2. Quantitatively correlate molecular structure with **reactivity and equilibrium** using linear free energy relationships (LFERs).
3. Understand the preparation, bonding, and reactivity of **organometallic compounds** and apply them in organic synthesis.
4. Appreciate the chemical basis of **biologically active molecules**, such as antibiotics, and their structure–activity relationships.
5. Develop problem-solving, analytical, and critical-thinking skills applicable to research, industrial, and medicinal chemistry contexts.

Course Outcomes (COs):

After successful completion of this course, the student will be able to:

CO1: Explain the **classification, mechanisms, and stereochemical aspects of sigmatropic rearrangements**, including Cope, Claisen, chelotropic, ene and group transfer reactions using FMO, PMO and Woodward–Hoffmann rules.

CO2: Apply **Woodward–Hoffmann symmetry rules and molecular orbital theories** to predict feasibility, regio- and stereochemistry of pericyclic and sigmatropic reactions and solve related numerical and conceptual problems.

CO3: Analyze **Linear Free Energy Relationships (LFERs)** and apply Hammett, Taft, Yukawa–Tsuno and

Grunwald–Winstein equations to correlate structure with reactivity and equilibrium behavior.

CO4: Describe the **preparation, bonding, structure and reactivity of organometallic π-complexes**, including hapticity and nucleophilic addition rules, and apply them in organic synthesis.

CO5: Understand the **role of transition-metal organometallics in modern organic synthesis** and evaluate their synthetic applications.

CO6: Explain the **structure, synthesis, and biological activity of antibiotics**, with special emphasis on **Penicillin** and its action against bacteria.

Course content:

Unit-01: Pericyclic reaction III:

Classification and mechanism of different Sigmatropic rearrangements with examples, Frontier Molecular Orbital theory of Sigmatropic rearrangement, Cope rearrangement and related reactions, Claisen rearrangement and all the related reactions, Perturbation molecular orbital theory (PMO) and Woodward Hofmann symmetry rules for sigmatropic reactions, problems related to different sigmatropic rearrangements, modified and degenerate Cope rearrangement, fluxional molecules, chelotropic reactions, group transfer reactions, ene reactions and problems.

Unit 02: Linear Free Energy Relationships

Linear Free Energy Relationship: Quantitative correlations of rate and equilibria. Linear free energy relationships with special reference to Hammett, Taft equation, Yukawa-Tauno and Grunwald-Weinstein equations.

Unit-03: Organometallic Chemistry

Preparation and reactions of pi-complexes, haptonumbers, rules for nucleophilic addition to complexes, applications to typical synthesis, use of transition metals: organometallics in organic synthesis.

Unit-04: Biological Active Molecules

Antibiotics, Penicillin: Structure, Synthesis and biological activity to bacteria.

CO–PO Mapping Matrix							
CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	3	3	2	2	1
CO2	3	3	3	3	2	2	1
CO3	3	2	3	2	3	2	1
CO4	3	2	2	2	1	2	3
CO5	3	2	2	2	1	2	3
CO6	3	3	3	3	2	2	1
Correlation Scale: 3 – High, 2 – Medium, 1 – Low							

Summary of Attainment

This course contributes strongly to the following Program Outcomes:

- PO1: Apply fundamental principles of chemistry to understand molecular structure and reactivity.
- PO2: Analyze chemical problems using logical and scientific reasoning.
- PO3: Apply theoretical knowledge to solve complex chemical reactions.
- PO4: Demonstrate critical thinking and interpretation of data.
- PO5: Use modern chemical tools and techniques.
- PO6: Develop research aptitude and lifelong learning skills.
- PO7: Demonstrate ethical and professional responsibility.

Course code	CEME502B0	Advance Inorganic Chemistry –I	Credit 4 (3-1-0) Full Marks: 50
Core/Elective/Other		Elective	Compulsory

Course Objectives:

1. **Develop a comprehensive understanding** of the structure, bonding, and reactivity of transition metal complexes, including sandwich, multidecker, bioorganometallic, and f-block organometallic systems.
2. **Introduce fundamental principles of catalysis**, including catalytic cycles and reaction sequences, and explain their applications in important industrial and environmental processes.
3. **Explain major homogeneous and heterogeneous catalytic processes** such as hydrogenation, hydroformylation, Fischer–Tropsch synthesis, methanol carbonylation, olefin oxidation, and polymerization using organometallic catalysts.
4. **Apply group theory concepts** to analyze molecular symmetry, normal modes of vibration, IR and Raman activity, and electronic transitions in coordination compounds.
5. **Correlate crystal field theory and ligand field theory** with spectroscopic properties using Orgel and Tanabe–Sugano diagrams and symmetry considerations.
6. **Utilize symmetry principles and orbital symmetry rules** to interpret vibronic coupling, selection rules, and conservation of orbital symmetry in chemical reactions.
7. **Enhance problem-solving, analytical, and critical-thinking skills** through quantitative and qualitative treatment of catalytic mechanisms and group theoretical applications.
8. **Prepare students for advanced research and interdisciplinary applications** in catalysis, materials chemistry, bioorganometallic chemistry, and molecular spectroscopy.

Course Outcomes (COs):

After successful completion of this course, the student will be able to:

CO1: Explain structure, bonding, and reactivity of transition metal complexes including sandwich, bioorganometallic, and f-block organometallic systems.

CO2: Describe and analyze homogeneous and heterogeneous catalytic processes relevant to industrial chemistry.

CO3: Apply group theory to interpret molecular symmetry, vibrational spectroscopy, and electronic structure of transition metal complexes.

CO4: Utilize symmetry principles and orbital symmetry rules to explain spectroscopic behavior and pericyclic reactions.

Course content:

Unit 1: Organometallic Chemistry II: Chemistry of transition metal complexes with diolefin and cyclic polyenes: 3-8 membered ring systems; Sandwich and non-sandwich complexes; Organometallic chemistry of heterocyclic ligands (N, B, O); Multidecker sandwich complexes; Bioorganometallic chemistry; Organometallic polymers; Main group organometallic chemistry; Organometallic chemistry of Lanthanoids and Actinoids.

Unit 2: **Catalysis:** Chemical engineering fundamentals in catalysis; Catalytic cycle; Sequences in catalysed reactions; Catalytic converters; Alkene hydrogenation; Water gas shift reaction; Fischer Tropsch process; Hydroformylation (Oxo process); Methanol carbonylation and Oxidation of Olefins: Monsanto's acetic acid synthesis; Celanese process with LiI modified Rhodium catalyst; Tennessee Eastman acetic anhydride process, Cativa process, Wacker process; Polymerization of olefins; Ziegler-Natta catalyst.

Unit 3: Chemical applications of group theory-I:
(1) Symmetry of normal modes, normal modes analysis, selection rules for IR and Raman transitions. IR and Raman transitions for nonlinear molecules (C_{2v}, C_{3v}, C_{4v}, D_{2h}, D_{3h}, D_{4h}, T_d and O_h symmetries)
(2) Crystal Field splitting of orbital degeneracy of free ions under D_{4h}, T_d and O_h symmetries. Splitting free ion terms in weak crystal fields, symmetries and multiplicities of energy levels in strong crystal fields, Strong field – weak field correlation diagram for d^2 system (O_h and T_d symmetry), Orgel diagram, Tanabe-Sugano diagrams, Effect of lowering of symmetry on the orbitals and energy levels, vanishing of quantum mechanical integral, transition probability, selection rules. Justification of Laporte selection rule.

Unit 4: Chemical applications of group theory-II:
(**1**) Group theoretical considerations of vibronic coupling and vibronic polarization, polarization of electronically allowed transitions, spectroscopic properties of transition metal complexes.
(**2**) Utilization of group theory in hybridization and molecular orbital description, applications of symmetry principles in Woodward-Hoffman type reactions like dimerization of ethylene and Diels-Alder reaction, Conservation of orbital symmetry.

CO–PO Mapping Matrix

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7

CO1	3	2	3	2	3	2	1
CO2	3	3	3	2	2	2	2
CO3	3	3	2	3	3	2	1
CO4	3	3	3	3	2	2	1
Correlation Scale: 3 – High, 2 – Medium, 1 – Low							

Summary of Attainment

This course contributes strongly to the following Program Outcomes:

- PO1: Apply fundamental principles of chemistry to understand structure, bonding, and reactivity.
- PO2: Analyze chemical systems using mathematical and scientific reasoning.
- PO3: Apply theoretical concepts to real-world chemical processes and reactions.
- PO4: Demonstrate critical thinking in interpretation of spectroscopic and theoretical data.
- PO5: Use modern tools, models, and computational concepts in chemistry.
- PO6: Develop research aptitude, problem-solving ability, and lifelong learning skills.
- PO7: Demonstrate ethical, environmental, and professional responsibility.

Course code	CEME502C0	Advance Physical Chemistry –I	Credit 4 (3-1-0) Full Marks: 50
Core/Elective/Other		Elective	Compulsory

Course Objectives:

1. **Provide a strong foundation in matrix mechanics**, including representations, eigenvalue problems, angular momentum operators, and variational methods used in quantum mechanics.
2. **Develop conceptual understanding of perturbation theory**, both time-independent and time-dependent, and apply it to important physical systems such as the Stark effect, Zeeman effect, helium atom, and particle-in-a-box problems.
3. **Explain the interaction of radiation with matter** using semi-classical time-dependent perturbation theory, and introduce fundamental principles of spectroscopy, lasers, and masers through Einstein's coefficients and transition probabilities.
4. **Introduce semiempirical quantum chemical methods**, with special emphasis on Hückel Molecular Orbital theory for conjugated systems and its applications to molecular structure and reactivity.
5. **Enable quantitative interpretation of molecular properties** such as delocalization energy, excitation energy, ionization energy, charge density, bond order, and free valence index using molecular orbital concepts.
6. **Apply group theoretical methods to quantum mechanics**, including symmetry operations, representations, direct products, and projection operators.
7. **Analyze molecular vibrations and electronic transitions** using group theory to interpret IR and Raman spectra and derive selection rules.
8. **Correlate symmetry principles with chemical bonding and reactivity**, including ligand field theory, crystal field theory, and pericyclic reactions governed by Woodward–Hoffmann rules.
9. **Enhance analytical, mathematical, and problem-solving skills** required for advanced studies and research in theoretical chemistry, spectroscopy, and molecular science.

Course Outcomes (COs):

After successful completion of the course, the learner will be able to:

1. **CO1:** Apply matrix mechanics, eigenvalue problems, angular momentum operators, and variational principles in quantum mechanical systems.
2. **CO2:** Analyze atomic and molecular systems using time-independent and time-dependent perturbation theory and radiation–matter interaction concepts.
3. **CO3:** Apply semiempirical quantum chemical methods, particularly Hückel Molecular Orbital theory, to conjugated molecular systems.
4. **CO4:** Use group theoretical methods to analyze molecular symmetry, vibrations, spectroscopy, electronic

transitions, and chemical reactions.

Course content:

Unit-1: Matrix mechanics:

Basis and representations, Elementary matrix properties, Unitary and similarity transformation in quantum mechanics, Energy representations, angular momentum matrices, the pauli spin matrices. Matrix eigen value problem. Linear variational principle and matrix.

Unit-2: Perturbation theory & : Semi-classical treatment of radiation-matter interaction

Time independent degenerate perturbation theory and its applications (particle in a box problem, He atom, Stark effect, Zeeman effect etc.

Theoretical basis of interaction of radiation with matter: time dependent perturbation theory, Harmonic perturbation and transition probabilities, Einstein‟s A& B co-efficient, LASER and MASER

Unit-3: Semiempirical methods in Quantum Chemistry:

The Hϋckel Molecular orbital Theory: Mathematical formalism of Hϋckel theory, Hϋckel MO's and orbital of 1,3-Butadine, Nodal properties of the π-MO of butadiene, Alternate and nonalternate conjugated hydrocarbons, Analytical expression for Hϋckel MO's and orbital energies in linear and cyclic polyenes. Delocalization energy, excitation energy and Ionization energy of conjugated hydrocarbons, charge density, Bond order and free valence index derived from Hϋckel MO's.

Unit-4: Group Theory and Quantum Mechanics:

Quantum mechanics and group representation theory, Direct product representation, Vanishing of quantum mechanical integral, Transition probability, Selection Rules, Projection operator, symmetry adapted linear combination of atomic orbitals. Application of group theory to molecular vibrations, Normal modes, Vibrational transitions, IR and Raman Spectra and Selection rule, Application of group theory to Ligand and crystal field theory, Symmetry and chemical reactions; Woodward –Hoffmann Rule.

CO–PO Mapping Matrix							
COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	3	3	2	2	2	1
CO2	3	3	3	3	2	2	1
CO3	3	2	3	2	2	2	1
CO4	3	3	3	3	3	2	1
3 – High correlation, 2 – Moderate correlation, 1 – Low correlation							

Summary of Attainment

This course contributes strongly to the following Program Outcomes:

1. **PO1:** Fundamental knowledge of chemistry and quantum mechanics
2. **PO2:** Mathematical and logical problem-solving ability
3. **PO3:** Application of theoretical concepts to chemical systems
4. **PO4:** Critical thinking and data interpretation
5. **PO5:** Use of modern tools and techniques
6. **PO6:** Research aptitude and lifelong learning
7. **PO7:** Ethical, professional, and safety awareness

DSE 2: Advanced Organic / Inorganic/ Physical - II

Marks: 40 + 10; Lecture hours: 40; Credit (L+T+P): 4 (3-1-0)

(Organic Chemistry Special)

Course code	CEME503A0	Advanced Organic –II	Credit 4 (3-1-0) Full Marks: 50
Core/Elective/Other		Elective	Compulsory

Course Objectives:

1. **Introduce the fundamental concepts of supramolecular chemistry**, including host–guest interactions, molecular recognition, hydrogen bonding, and non-covalent interactions.
2. **Explain the structure, properties, synthesis, and applications** of supramolecular hosts such as crown ethers, cryptands, and cyclodextrins.
3. **Develop an understanding of bioorganic chemistry**, focusing on enzymes, enzyme kinetics, mechanisms, and their applications in organic synthesis and biomimetic systems.
4. **Describe self-assembly processes and soft materials**, including micelles, vesicles, gels, liquid crystals, and photo-responsive supramolecular systems.
5. **Introduce functional supramolecular materials** used in chemical sensors, molecular electronics, organic conductors, and dye-sensitized solar cells.
6. **Explain the structural organization and biological functions** of peptides, proteins, and nucleic acids, emphasizing secondary structures and molecular recognition.
7. **Promote awareness of green chemistry principles**, sustainable chemical processes, renewable resources, and environmentally benign synthesis.
8. **Encourage analytical thinking and interdisciplinary learning** by integrating concepts from chemistry, biology, materials science, and environmental science.
9. **Prepare students for advanced research and industrial applications** in bioorganic chemistry, supramolecular science, and sustainable chemistry.

Course Outcomes (COs):

After successful completion of the course, the learner will be able to:

1. **CO1:** Explain the principles of supramolecular chemistry, molecular recognition, and host–guest interactions involving crown ethers, cryptands, and cyclodextrins.
2. **CO2:** Understand enzyme structure, kinetics, and mechanisms, and apply enzymatic and biomimetic concepts in organic synthesis.

3. **CO3:** Describe self-assembling systems, soft materials, and functional supramolecular systems used in sensing, energy, and molecular electronics.
4. **CO4:** Explain the structure, organization, and biological functions of peptides, proteins, and nucleic acids.
5. **CO5:** Apply the principles of green chemistry to develop sustainable, environmentally benign chemical processes.

Course content:

Unit-01: Bioorganic and Supramolecular Chemistry-I

Crown ethers: discovery, nomenclature, synthesis, properties and applications. Cryptands: structures and applications. molecular recognition: definition, examples of molecular recognition utilizing H-bonding, electrostatic, solvophobic, pi-pi interaction, etc., application of molecular recognition. H-bonding in molecular organization, chiral recognition, Introduction to molecular mechanics calculation and its use in the design of molecular receptors.

Unit-02: Bioorganic and Supramolecular Chemistry-II

Cyclodextrins: Structure, property, applications. Enzymes: enzyme kinetics, mechanism; application of enzymes in organic synthesis, model enzymes based on cyclodextrins.

Unit 03: Bioorganic and Supramolecular Chemistry-III

Self-assembling systems: micelles, reverse micelles; vesicles, fibers and tubules; amphiphiles, bola-amphiphiles, Self-replication. Gels: definition, classification, examples, study of the morphology and rheology of gels, applications Chemical sensors. Photo-responsive systems, Dye sensitized solar cell, Liquid Crystals, Molecular Electronic devices, organic conductors.

Unit-04: Peptides and Nucleic acids

Peptides and Proteins: Structure and Functions; α-helix, β-pleated sheet, β-turn, 3.10 helix, Ramachandran plot. Nucleic acids: Structure and functions; replication of nucleic acids.

Unit-05: Green Chemistry

The current status of chemistry and the environment. What is green chemistry? How Green and Renewables are related to sustainability. Principles, methodologies and techniques in Green Chemistry. Synthesis in aqueous media, Catalytic methods in synthesis, Examples of green chemistry. Future trends in green chemistry. Unconventional energy sources in synthesis: solar energy.

CO–PO Mapping Matrix

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	3	2	3	2	1
CO2	3	3	3	2	2	2	1
CO3	3	2	3	3	3	2	1
CO4	3	2	2	2	1	2	1
CO5	3	3	3	2	2	2	3

Programme Outcomes (POs)

- **PO1:** Apply fundamental knowledge of chemistry to understand molecular structure and function
- **PO2:** Analyze chemical systems using scientific reasoning and problem-solving skills
- **PO3:** Apply theoretical concepts to practical and interdisciplinary chemical problems
- **PO4:** Demonstrate critical thinking and interpretation of chemical data
- **PO5:** Use modern tools, techniques, and interdisciplinary approaches
- **PO6:** Develop research aptitude and lifelong learning skills
- **PO7:** Demonstrate environmental awareness, sustainability, and ethical responsibility

(Inorganic Chemistry Special)

<table>
<tr><td>Course code</td><td>CEME503B0</td><td>Advance Inorganic Chemistry –II</td><td>Credit 4 (3-1-0)
Full Marks: 50</td></tr>
<tr><td colspan="2">Core/Elective/Other</td><td>Elective</td><td>Compulsory</td></tr>
<tr><td colspan="4">Course Objectives:</td></tr>
<tr><td colspan="4">
1. Provide in-depth knowledge of bioinorganic chemistry, emphasizing the role of metal ions in biological systems and their importance in enzymatic catalysis and metabolic processes.
2. Explain the structure, function, and catalytic mechanisms of metal-containing enzymes involving Cu, Zn, Fe, Mo, and V, with special reference to their active sites and biological significance.
3. Develop an understanding of metalloenzymes and metalloproteins involved in redox reactions, oxygen transport, electron transfer, and photosynthesis.
4. Describe the role of metal ions in genetic information transfer, including DNA replication, transcription, translation, and metal–nucleic acid interactions.
5. Introduce the principles of inorganic photochemistry, including photophysical and photochemical processes, excited states, and radiation–matter interactions.
6. Explain electronic excited states of coordination compounds, including ligand field, charge transfer, Franck–Condon states, and related photochemical pathways.
7. Analyze photophysical phenomena such as fluorescence, phosphorescence, quantum yield, delayed fluorescence, and fluorescence quenching using kinetic and spectroscopic principles.
8. Apply selection rules, transition probabilities, and Jablonski diagrams to understand photochemical reactions of coordination and organometallic compounds.
9. Highlight applications of inorganic photochemistry in solar energy conversion, photochemical water splitting, photosensitization, and storage of solar energy.
10. Enhance analytical, interpretative, and research skills relevant to bioinorganic chemistry, photochemistry, and advanced chemical sciences.
</td></tr>
<tr><td colspan="4">Course Outcomes (COs):</td></tr>
<tr><td colspan="4">After successful completion of the course, the learner will be able to:

1. O1: Explain the structure, function, and catalytic mechanisms of metal-containing enzymes and metalloproteins involved in biological processes.
2. CO2: Analyze the role of metal ions in genetic information transfer and their interactions with nucleic acids and biomolecules.
3. CO3: Understand fundamental principles of inorganic photochemistry, including excited states,
</td></tr>
</table>

photophysical and photochemical processes.
4. **CO4:** Apply selection rules, transition probabilities, and kinetic concepts to interpret fluorescence, phosphorescence, and photochemical reactions.
5. **CO5:** Evaluate applications of inorganic and organometallic photochemistry in solar energy conversion, water splitting, and related technologies.

Course content:

Unit: 1: Bioinorganic chemistry-II

Cu, Zn and Fe containing enzyme (active site structure and enzymatic activity and mechanism): Catalase, Peroxidase, Cytochrome P450, Cu-Zn Super oxide dismutase, Ascorbate oxidase, Galactose oxidase, Alcohol dehydrogenase, carboxy peptidase, Amino peptidase, Molybdenum containing enzymes(active site structure and enzymatic activity and mechanism): Nitrogenase, Nitrate reductase, Xanthine oxidase, DMSO reductase, Formate dehydrogenase, Sulphite oxidase. Vanadium containing protein: Amavadin, Vanadium bromo peroxidase. Vitamin B12(cyano cobalamine/coenzyme) active site structure and enzymatic activity and mechanism, Chlorophil (active site structure and activity and mechanism),Photosystem-I and Photo System II. Metal ions in genetic information transfer: Replication, transcription and translation process. Interaction of metal ions with nucleic acids and their monomeric constituents-metal complexes of nucleosides and nucleotide.

Unit: 2: Inorganic photochemistry

Introduction to inorganic photochemistry, photophysical and photochemical process, characteristics of the electronically excited states of inorganic compounds, ligand field states, charge transfer states, Frank Condon (FC) states, THEXI and DOSENCO states, kinetics of photochemical process, photosensitization. Transition probabilities, Transition moment integral and its applications. Selections rules. Jablonski diagram, Fluorescence and phosphorescence, delayed fluorescence, quantum yield, mechanism and decay kinetics of photophysical processes. Fluorescence quenching (dynamic and static), Stern-Volmer equation. Photochromism; chemical actinometry, photochemical reaction of coordination compounds. Photochemical splitting of water, photochemical conversion and storage of solar energy, organometallic photochemistry.

CO–PO Mapping Matrix

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	3	2	2	2	1
CO2	3	3	2	2	2	2	1
CO3	3	2	3	2	3	2	1
CO4	3	3	3	3	3	2	1
CO5	3	2	3	2	3	2	3

Programme Outcomes (POs)

- **PO1:** Apply fundamental knowledge of chemistry to understand structure, bonding, and reactivity
- **PO2:** Analyze chemical systems using scientific reasoning and problem-solving skills
- **PO3:** Apply theoretical concepts to interdisciplinary and applied chemical problems
- **PO4:** Demonstrate critical thinking and interpretation of experimental and theoretical data
- **PO5:** Use modern tools, techniques, and spectroscopic methods
- **PO6:** Develop research aptitude and lifelong learning skills
- **PO7:** Demonstrate ethical, environmental, and professional responsibility

(Physical Chemistry Special)

Course code	**CEME503C0**	**Advance Physical Chemistry –II**	**Credit 4 (3-1-0)** **Full Marks: 50**
Core/Elective/Other		**Elective**	**Compulsory**

Course Objectives:

1. **Introduce the fundamental concepts of solid state chemistry**, including crystal structures, electrical conductivity, lattice vibrations, superconductivity, and X-ray diffraction.
2. **Explain the theory and effects of defects in solids**, including point, line, and plane defects, and their influence on material properties.
3. **Apply band theory** to understand the electronic properties of metals, semiconductors (intrinsic and extrinsic), insulators, and hopping semiconductors.
4. **Develop an understanding of statistical mechanics**, including ensembles, phase space, partition functions, and the derivation of thermodynamic properties of classical and quantum systems.
5. **Explain quantum statistical phenomena**, including Bose–Einstein and Fermi–Dirac statistics, black body radiation, electron gas behavior, and Bose–Einstein condensation.
6. **Introduce non-equilibrium thermodynamics**, including entropy production, Onsager reciprocal relations, microscopic reversibility, cyclic and oscillatory reactions, and irreversible processes.
7. **Develop analytical and problem-solving skills** for interpreting experimental and theoretical data in solid state, statistical, and non-equilibrium systems.
8. **Prepare students for research and interdisciplinary applications**, emphasizing the connection between theoretical principles and practical materials science, energy, and chemical systems.

Course Outcomes (COs):

After successful completion of the course, the learner will be able to:

1. **CO1:** Explain the fundamental concepts of solid state chemistry including crystal structures, electrical conductivity, lattice vibrations, superconductivity, and X-ray diffraction.
2. **CO2:** Analyze defects in solids and apply band theory to understand the electrical properties of metals, semiconductors, and insulators.
3. **CO3:** Apply principles of statistical mechanics to derive thermodynamic properties of systems using classical and quantum ensembles.
4. **CO4:** Interpret quantum statistical distributions (Bose–Einstein and Fermi–Dirac) and explain phenomena such as black body radiation, electron gas behavior, and Bose–Einstein condensation.
5. **CO5:** Explain the principles of non-equilibrium thermodynamics, entropy production, Onsager relations, and

irreversible processes in physical and chemical systems.

Course content:

Unit 1: Solid state chemistry- I

Electrical conductivity of metals; free electron theory of metals (classical and quantum theory), X-ray diffraction, Laue's diffraction, atomic scattering factor and geometrical structure factor, Hall effect, Lattice vibration: phonon and exciton, superconductors.

Unit 2: Solid state chemistry- II

Defects in solids: Point, line and plane defects. Determination of equilibrium concentration of Schottky defect and Frenkel defects, stoichiometric imbalance in crystals. Band theory: band gap, metal, insulators, semiconductors (intrinsic and extrinsic), hopping semiconductors; rectifiers and transistors.

Unit 3: Statistical mechanics-II

Concept of ensemble and phase space, ergodic hypothesis, Liouville's theorem, Concept of different ensembles, microcanonical ensembles: partition function, temperature, Cannonical ensemble, distribution, probability and partition function. Black body radiation in details, relation between Lagrangian undetermined multipliers, Principle of equipartition of energy, chemically equilibrium system of interacting particles, imperfect gas. Grand canonical ensemble: nature of quantum particle, Bose- Einstein and Fermi-Dirac statistics, specific heat of electron gas, Bose-Einstein condensation.

Unit 4: Non-equilibrium thermodynamics

Characterization of non-equilibrium states: entropy production rate; Onsager reciprocal relations, principle of microscopic reversibility and detailed balancing, Progogine's principle of minimum entropy production, affinity, thermonuclear pressure difference and thermoelectric effect, cyclic and oscillatory reactions, non-linear region, higher order symmetries.

CO–PO Mapping Matrix

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7
CO1	3	2	3	2	3	2	1
CO2	3	3	3	2	2	2	1
CO3	3	3	3	3	2	2	1
CO4	3	3	3	3	2	2	1
CO5	3	2	3	3	2	2	2

Programme Outcomes (POs)

- **PO1:** Apply fundamental knowledge of chemistry and physics to understand material properties
- **PO2:** Analyze chemical and physical systems using mathematical and scientific reasoning
- **PO3:** Apply theoretical concepts to explain real-world physical and chemical phenomena
- **PO4:** Demonstrate critical thinking and interpretation of experimental and theoretical data
- **PO5:** Use modern tools, techniques, and models in physical chemistry
- **PO6:** Develop research aptitude, analytical ability, and lifelong learning skills
- **PO7:** Demonstrate ethical, professional, and scientific responsibility

DSE 3: Research Project 1, Dissertation

(Organic/Inorganic/Physical Special)

Marks: 100; Lecture hours: 200; Credit : 8

Review work / Industry Visit / Field work:

Course code	CEME504A9/ CEME504B9/ CEME504C9	Research Project, Dissertation –I	Credit 8 (0-0-8) Full Marks: 100
Core/Elective/Other		Elective	Compulsory

Course Objectives:

1. To enable students to identify and formulate a **research problem** through literature survey and consultation with a supervisor.
2. To develop skills in **critical analysis, research methodology, and scientific report writing**.
3. To provide practical exposure through **industry visits, field work, or internships**, linking theory with real-world applications.
4. To enhance **independent thinking, problem-solving ability, and ethical research practices**.
5. To improve **communication and presentation skills** through seminar lectures and structured presentations.

Course Outcomes (COs):

1. CO1: Identify and formulate a suitable research problem or contemporary topic through systematic literature review and consultation with the course instructor.
2. CO2: Apply appropriate research methodologies and analytical techniques to conduct review work, industry-based studies, field work, or independent research.
3. CO3: Prepare structured technical and research reports in accordance with standard scientific writing and ethical guidelines.
4. CO4: Demonstrate professional competence and experiential learning through industry visits, field work, or internships, integrating theoretical knowledge with practical exposure.
5. CO5: Communicate research outcomes effectively through seminar presentations and PowerPoint-based oral communication.

Course content:

Review in an area of contemporary interest: Topic to be finalized in consultation with the Incharge and a Review-Report (approximately 10 pages) has to be submitted.

OR

Industry Visit:

It will involve visit to an Industry and submission of a Work-Report (approximately 10 pages) on the Industry Visit

OR

Field Work, Sample Collection and submission of a Work-Report (approximately 10 pages) on the Field Work.

OR

Internship (With the consent of the project supervisor and HOD)

[30]

Research Work:

Unit 01:

Research problem has to be finalized in consultation with the Incharge. The work has to be carried out under the supervision of the Incharge and Research Report of approximately 25 pages has to be submitted. [50]

Unit 02

Seminar Lecture has to be delivered on the total work carried out. It will involve Power Point Presentation (Industry visit: 2 slides, Review: 2 slides, Research work: 5 slides; total presentation time = 10 minutes (max.) [20]

CO–PO Mapping Matrix

COs / POs	PO1	PO2	PO3	PO4	PO5
CO1	2	3	-	-	2
CO2	3	3	1	-	2
CO3	2	2	1	3	1
CO4	2	2	3	1	2
CO5	1	1	1	3	2
3 – High correlation, 2 – Moderate correlation, 1 – Low correlation					

Program Outcomes (POs)

PO1: Apply disciplinary knowledge to analyze and solve academic, research, and real-world problems.

PO2: Demonstrate critical thinking, research aptitude, and problem-analysis skills using appropriate methodologies.

PO3: Exhibit professional ethics, social responsibility, and teamwork in academic, research, and industrial environments.

PO4: Communicate effectively through scientific writing, documentation, and oral presentations.

PO5: Engage in self-directed learning and lifelong learning, adapting to emerging technologies and contemporary research trends.

CEMO505X9

Social Service / Community Engagement

Marks: 25; Credit: 2

SEMESTER-IV

DSE 5: Advanced Organic / Inorganic/ Physical - III

Marks: 40 + 10; Lecture hours: 40; Credit (L+T+P): 4 (3-1-0)

(Organic Chemistry Special)

Course code	**CEME551A0**	**Advance Organic Chemistry –III**	**Credit 4 (3-1-0)** **Full Marks: 50**
Core/Elective/Other		**Elective**	**Compulsory**

Course Objectives:

1. Provide fundamental knowledge of organic photochemical principles and reaction mechanisms.
2. Develop understanding of photochemical transformations of organic molecules and their synthetic applications.
3. Introduce the structural, functional, and biochemical significance of vitamins and co-enzymes.
4. Explain systematic approaches to the synthesis and reactivity of heterocyclic compounds.
5. Enhance analytical and problem-solving skills related to organic reaction mechanisms.

Course Outcomes (COs):

On successful completion of the course, the students will be able to:

1. **CO1:** Explain fundamental concepts and mechanisms involved in organic photochemical reactions.
2. **CO2:** Analyze photochemical reactions of carbonyl compounds, alkenes, and conjugated systems with appropriate mechanisms.
3. **CO3:** Understand the structure, synthesis, and biological functions of vitamins and co-enzymes such as NAD.
4. **CO4:** Apply generalized strategies for the synthesis of five-, six-, and seven-membered heterocyclic compounds.
5. **CO5:** Evaluate the reactivity of heterocyclic systems towards electrophiles, nucleophiles, and reactive intermediates.
6. **CO6:** Solve mechanism-based and application-oriented problems in photochemistry and heterocyclic chemistry.

Course content:

Unit-01: Organic Photochemistry-I

Organic Photochemistry: Fundamental concepts, Photochemistry of carbonyl compounds, Norrish type- I and type II processes, Patterno Buchi reaction, Barton reaction, Hofmann-Löffler-Freytag reaction, photolysis of hypohalites, addition reaction, oxidation reaction, problems related to these reactions.

Unit-02: Organic Photochemistry-II

Photochemical reduction, photorearrangments, substitution reaction, cis-trans isomerism, photochemistry of butadiene, di-pi methane rearrangement and related processes, dimerization of alkenes, photochromism, photochemistry of santonin.

Unit-03: Vitamins and co-enzymes

Vitamins: structure, synthesis and function, coenzymes, NAD: structure and function.

Unit-04: Heterocycles

Heterocycles: Synthesis and Reactions: Generalized approach to the synthesis of heterocycles possessing 5-,6-, and 7- membered rings with one or two or three heteroatoms per ring. Reactions of heterocycles: oxidation and reduction reactions with electrophiles, nucleophiles and other reactive intermediates with typical monocyclic and fused ring systems as examples.

CO–PO Mapping Matrix

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	–	–	–	–	–	1
CO2	3	3	2	–	–	–	–	1
CO3	2	1	–	–	3	–	–	1
CO4	3	2	2	–	–	–	–	1
CO5	3	3	2	–	–	–	–	1
CO6	2	3	2	–	–	1	–	
Correlation Levels: 3 = High, 2 = Moderate, 1 = Low								

Program Outcomes (POs)

(Standard B.Sc./M.Sc. Chemistry POs as per UGC/NAAC norms)

PO Code **Program Outcome Description**

PO Code	**Program Outcome Description**
PO1	Apply knowledge of basic concepts and principles of chemistry
PO2	Analyze chemical problems using scientific reasoning
PO3	Design and interpret experiments and chemical reactions
PO4	Use modern tools and techniques in chemical sciences
PO5	Understand interdisciplinary applications of chemistry
PO6	Communicate scientific concepts effectively
PO7	Demonstrate professional ethics and academic integrity
PO8	Engage in lifelong learning and self-development

(Inorganic Chemistry Special)

Course code	**CEME551B0**	**Advance Inorganic Chemistry –III**	**Credit 4 (3-1-0)** **Full Marks: 50**
Core/Elective/Other		**Elective**	**Compulsory**

Course Objectives:

1. Introduce fundamental principles governing magnetic properties of inorganic compounds.
2. Explain the theoretical basis of paramagnetism, diamagnetism, and collective magnetic phenomena.
3. Develop understanding of metal carbonyls and organometallic clusters with respect to bonding and electron counting.
4. Provide insight into metal–metal bonding, including multiple metal–metal bonds.
5. Strengthen analytical ability in correlating structure, bonding, and magnetic behavior of inorganic systems.

Course Outcomes (COs):

On successful completion of the course, the students will be able to:

1. **CO1:** Explain the basic magnetic properties of substances using orbital and spin angular momentum concepts.
2. **CO2:** Analyze paramagnetic, diamagnetic, ferro-, ferri-, and antiferromagnetic behavior using classical and quantum models.
3. **CO3:** Interpret temperature-dependent magnetic properties using Curie and Curie–Weiss laws and multiplet theory.
4. **CO4:** Evaluate magnetic interactions in transition metal, lanthanide, and actinide compounds, including exchange mechanisms.
5. **CO5:** Describe the synthesis, structure, bonding, and reactivity of metal carbonyls and metal carbonyl clusters.
6. **CO6:** Apply total valence electron (TVE) counting rules to low- and high-nuclearity organometallic clusters.
7. **CO7:** Understand the nature of metal–metal bonds, including multiple bonds, through structural and electronic analysis.

Course content:

Unit 1: Magnetochemistry-I

Magnetic properties of substances, orbital and spin angular momentum of electrons, paramagnetic moment and magnetic susceptibility. Paramagnetic and diamagnetic materials, ferromagnetism, ferrimagnetism, antiferromagnetism, magnetic permeability, magnetic susceptibility, magnetization, classical theory of diamagnetism (Langevin's theory), classical theory of paramagnetism (Langevin's theory), spin-orbit coupling.

Unit 2: Magnetochemistry-II

Magnetic properties and temperature – The Curie and Curie-Weiss law, derivation of Curie law. Microstates, hole formalism, multiplet, multiplet width, Lande interval rule, magnetic moments for different multiplet widths, quenching of orbital contribution, high spin/low spin equilibrium.

Antiferromagnetic interactions in inorganic compounds: Mechanism like – direct interaction, super exchange interactions. Magnetic behavior of lanthanides and actinides.

Unit 3: Metal Carbonyls and Clusters:

Carbonyl ligand; Binding in carbonyl ligands; Synthesis, structure and reactivity of metal carbonyls; Metal carbonyl anions; Metal carbonyl halides; Low nuclearity (M3-M4) and high nuclearity (M5-M10) carbonyl clusters (LNCC and HNCC); Capping rule; Total valence electron counts in d-block organometallic clusters; Condensed cages; TVE count in condensed clusters, Halide clusters of Nb, Ta, Mo, W, Re. Synthesis, structure and bonding; Interstitial Clusters-hydrides; Carbides and nitrides;

Unit 4: Metal-Metal Bonding:

Metal-metal bonds, Metal-metal multiple bonds: Examples, synthesis, structures, bonding; Electronic transition; Metal-metal quadruple bond; Metal-metal quintuple bond

CO–PO Mapping Matrix

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	2	2	2	–	–	–	1
CO2	3	3	2	3	–	–	–	1
CO3	3	3	2	3	–	–	–	1
CO4	2	3	3	2	2	–	–	1
CO5	3	2	3	2	2	–	–	1
CO6	3	3	3	2	–	–	–	2
CO7	3	3	3	2	–	–	–	2
(Correlation Level: 3 = High, 2 = Moderate, 1 = Low)								

rogram Outcomes (POs)

(Standard Chemistry Program Outcomes as per UGC/NAAC)

PO Code	Program Outcome Description
PO1	Apply fundamental principles of chemistry
PO2	Analyze and solve complex chemical problems
PO3	Understand structure–bonding–property relationships
PO4	Use theoretical models and modern concepts in chemistry
PO5	Apply chemistry knowledge to interdisciplinary areas
PO6	Communicate scientific concepts effectively
PO7	Demonstrate professional ethics and scientific integrity

(Physical Chemistry Special)

Course code	**CEME551C0**	**Advance Physical Chemistry –III**	**Credit 4 (3-1-0)** **Full Marks: 50**
Core/Elective/Other		**Elective**	**Compulsory**

Course Objectives:

The objectives of this course are to:

1. Develop a rigorous understanding of quantum mechanics applied to many-electron systems.
2. Explain electronic structure, spin states, and term symbols of atoms using quantum mechanical models.
3. Apply perturbation theory to interpret magnetic resonance spectroscopic techniques.
4. Introduce semi-empirical, ab initio, and density functional methods used in computational chemistry.
5. Enable students to correlate theoretical concepts with spectroscopic and computational results.

Course Outcomes (COs):

On successful completion of the course, the students will be able to:

1. **CO1:** Apply Pauli's antisymmetry principle and Slater determinants to describe many-electron wavefunctions.
2. **CO2:** Analyze electronic structure of atoms using Hartree–Fock theory, Roothaan equations, and related theorems.
3. **CO3:** Interpret atomic spectra using LS and jj coupling schemes, term symbols, and Zeeman splitting.
4. **CO4:** Apply perturbation theory to explain NMR and ESR spectral features of simple and complex spin systems.
5. **CO5:** Evaluate electron correlation effects using configuration interaction methods.
6. **CO6:** Compare semi-empirical, ab initio, and density functional approaches in computational chemistry.
7. **CO7:** Assess the applicability, advantages, and limitations of DFT in comparison with MO theory.

Course content:

Unit-1: Quantum mechanics of many electron systems:

Identical particle and Pauli's Antisymmetry principle, Slater determinant for system with more than two electrons, Eigen functions of many electron spin operator: Pure spin states, Energy expectation value of pure spin states; Orbitals in many electron atoms: The Hartree-Fock Theory, Koopman's theorem, The Hatree-Fock-Roothaan method for closed cell systems, Roothaan equation, Brillouin's theorem.

Unit-2: Atomic Spectroscopy:
Ground state electronic configuration of elements, Spectroscopic term symbol: LS coupling scheme, j-j coupling scheme, Electronic spectrum of many electron atoms, Zeeman Effect in many electron atoms, Electron correlation and method of configuration interaction.

Unit-3: Applications of perturbation theory:
The Hellmann-Feynman theorem, Electrical responsive properties, perturbation treatment to, NMR spectroscopy: A-X, A2 Spin system, more than two spin system; ESR spectroscopy: total magnetic Hamiltonian of an electron, magnetic interaction in atoms, application of perturbation theory on the splitting of ESR lines on some model system.

Unit-4: Computational Chemistry
CNDO formalism, INDO formalism, Basic NDDO formalism:
MNDO, AM1, PM3. Ab Initio HF theory: Basis set: Gaussian functions, single Zeta, multiple Zita and split valence functions, polarization and diffuse functions. Electron correlation in MO theory: Configuration interaction: single determinant reference, multi reference.

Density Functional Theory (DFT): Philosophy, early approximations, Hohenberg-Kohn existence theorem, Hohenberg-Kohn variational theorem, Kohn-Sham SCF methodology, Exchange correlation functionals: Local density approximation, density gradient and kinetic energy corrections. Advantages and dis-advantages of DFT compare to MO theory, General performance of DFT.

CO–PO Mapping Matrix

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CO1	3	2	2	2	–	–	–	1
CO2	3	3	2	3	–	–	–	1
CO3	3	3	3	2	–	–	–	1
CO4	2	3	3	3	2	–	–	1
CO5	3	3	2	3	–	–	–	1
CO6	3	2	2	3	2	–	–	2
CO7	2	3	2	3	2	–	–	2
(Correlation Levels: 3 = High, 2 = Moderate, 1 = Low)								

Program Outcomes (POs)

(Standard Chemistry Program Outcomes – UGC/NAAC)

PO Code **Program Outcome Description**

PO Code	Program Outcome Description
PO1	Apply fundamental principles of chemistry and quantum mechanics
PO2	Analyze and solve theoretical and computational chemistry problems
PO3	Understand structure–property relationships in atomic and molecular systems
PO4	Use mathematical and computational tools in chemical sciences
PO5	Apply chemistry concepts to interdisciplinary scientific problems
PO6	Communicate scientific ideas clearly and effectively
PO7	Demonstrate professional ethics and academic integrity
PO8	Engage in independent and lifelong learning

DSE 6: Advanced Organic / Inorganic/ Physical - IV

Marks: 40 + 10; Lecture hours: 40; Credit (L+T+P): 4 (3-1-0)

(Organic Chemistry Special)

Course code	CEME552A0	Advance Organic Chemistry –IV	Credit 4 (3-1-0) Full Marks: 50
Core/Elective/Other		Elective	Compulsory

Course Objectives:

The objectives of this course are to:

1. Develop advanced understanding of conformational analysis and its influence on chemical reactivity.
2. Explain stereochemical behavior of fused, medium, and polycyclic ring systems.
3. Introduce modern models explaining stereoselective and enantioselective reactions.
4. Provide theoretical foundations of chiroptical properties and optical activity.
5. Enable interpretation of ORD and CD spectra for configurational and conformational analysis

Course Outcomes (COs):

On successful completion of the course, the students will be able to:

1. **CO1:** Apply Curtin–Hammett principle and quantitative models to analyze conformational equilibria and reactivity.
2. **CO2:** Interpret conformations, stability, and stereochemical features of fused and bridged ring systems.
3. **CO3:** Analyze stereochemistry, energy, symmetry, and optical activity of medium and polycyclic ring systems.
4. **CO4:** Explain modern stereochemical models governing nucleophilic additions and stereoselective reactions.
5. **CO5:** Evaluate stereoselective and enantioselective reactions using mechanistic and conformational arguments.
6. **CO6:** Understand the origin of optical activity and apply ORD and CD techniques for stereochemical assignments.
7. **CO7:** Interpret chiroptical rules (Cotton effect, helicity, exciton chirality) in complex organic molecules.

Course content:

Unit-01: Stereochemistry-III

Conformation and Chemical Reactivity : Curtin-Hammett principle, its derivation under different conditions and applications; quantitative treatment of mobile systems, Winstein Holness equation and Eliel equation - their applications ; allylic 1,2 - and 1, 3-strain (in pseudoallylic systems also), their applications.

Unit-02: Stereochemistry-IV

Fused ring systems, *trans* and *cis* declaims, conformation, steroid and nonsteroid conformation, symmetry, torsion angle enthalphy, entropy, free energy, substituted declains q-methyldecalins and 9,10 dimethyldecalins, decalones; conformation of cis-octalins and trans-octalins, conformation of hydrindanes.

Unit 03: Stereochemistry-V

Stereochemistry of 4-10 membered rings, perhydrophenanthrenes and perhydroanthracenes, conformation, energy, symmetry and optical activity, relative stability.

Unit- 04: Stereochemistry-VI

Modern concepts of nucleophilic addition to carbonyl compounds: Cieplak model, examples. Stereoselective reactions of acyclic ketones, Stereoselective ester aldol, Stereoselective epoxidation reactions. Enantioselective reactions.

Unit- 05: Stereochemistry-VII

Optical rotation, specific and molecular rotations-their units, origin of optical rotation, circular birefringence, optical rotatory dispersion (ORD), circular dichroism (CD), differential dichroic absorption, specific ellipticity and molar ellipticity, mean residue ellipticity, plane curves and their applications, Cotton effect, applications of CD and ORD curves, helicity rule, Brewster's rule, Lowe's rule, exciton chirality (dibenzoate chirality rule) Davydov splitting-applications with different steroidal glycols.

CO–PO Mapping Matrix

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	2	–	–	–	1
CO2	3	2	3	2	–	–	–	1
CO3	3	3	3	2	–	–	–	1
CO4	3	3	3	2	2	–	–	1
CO5	3	3	3	2	2	–	–	2
CO6	2	2	3	3	–	–	–	1
CO7	2	3	3	3	–	–	–	2
(Correlation Levels: 3 = High, 2 = Moderate, 1 = Low)								

Program Outcomes (POs)

PO Code	Program Outcome Description
PO1	Apply advanced concepts of organic chemistry
PO2	Analyze stereochemical and mechanistic problems
PO3	Correlate structure, conformation, and reactivity
PO4	Use theoretical and spectroscopic tools
PO5	Apply chemistry concepts to interdisciplinary areas
PO6	Communicate chemical concepts effectively
PO7	Demonstrate academic integrity and ethical practices
PO8	Engage in lifelong learning and professional development

(Inorganic Chemistry Special)

Course code	CEME552B0	Advance Inorganic Chemistry –IV	Credit 4 (3-1-0) Full Marks: 50
Core/Elective/Other		Elective	Compulsory

Course Objectives:

The objectives of this course are to:

1. Provide a comprehensive understanding of reaction mechanisms in coordination and inorganic systems.
2. Explain kinetic and mechanistic aspects of ligand substitution, redox, and electron transfer reactions.
3. Introduce experimental techniques for measuring reaction rates, including fast reaction methods.
4. Develop knowledge of electroanalytical and thermal analytical techniques used in coordination chemistry.
5. Enable interpretation of electrochemical and instrumental data for characterization of metal complexes.

Course Outcomes (COs):

On successful completion of the course, the students will be able to:

1. CO1: Explain energy profiles, reactivity patterns, and mechanistic pathways of inorganic reactions in metal complexes.
2. CO2: Distinguish between inert and labile complexes and analyze substitution mechanisms in octahedral and square planar complexes.
3. CO3: Interpret redox and electron transfer mechanisms including outer-sphere, inner-sphere, and atom transfer processes.
4. CO4: Apply electroanalytical techniques such as polarography, cyclic voltammetry, and coulometry to inorganic systems.
5. CO5: Analyze thermal methods (DTA, TGA, DSC) and their applications in coordination chemistry.
6. CO6: Use advanced instrumental techniques such as ITC and DLS for characterization of metal complexes and interactions.
7. CO7: Correlate mechanistic, electrochemical, and analytical data to explain structure–reactivity relationships in inorganic chemistry.

Course content:

Unit: 1: Inorganic reaction mechanism

Energy profile of reactions, discussion on general reactivity of metal complexes, inert and labile complexes, different types of mechanisms („D", „A", „I_a" and „I_d"). Techniques for experimental measurements of reaction rates, techniques for fast reaction. Substitution reactions: Application of CFT, mechanism of ligand substitution in octahedral complexes, mechanism of isomerisation and racemisation, substitution reactions in square planar complexes. *Cis-* and *trans-* effects.

Mechanism of redox reactions with reference to metal complexes. Electron transfer reactions – outer sphere and inner sphere, atom transfer, induced electron transfer reactions, two electron transfer reactions, complementary and non-complementary reactions, synthetic implications of electron transfer reactions, solid state electron transfer reactions. Electroprotic reactions. Twist mechanism of racemisation, inversion of configuration and associated process.

Unit: 2: Analytical chemistry

Electro analytical methods: Basic principles-polarised and depolarized electrodes; diffusion current, *dropping mercury electrode* (*DME), polarographic wave;* Ilkovic equation (simplified derivation) and its significance; half-wave potential and its applications in identification of elements. Ilkovic-Heyrovsky equation, Cottrell equation.

Cyclic voltametry and Coulometry: Basic principle, three electrode configuration. Solvents and supporting electrolytes. Representation of cyclic voltammogram, half wave potential, irreversible, reversible and quasi-reversible redox processes. Electron transfer at a constant potential, no. of electron transfer. Application in coordination chemistry (characterization, determination of redox potential), e.g. ferrocene, Co(II)/Co(III); Ni(II)/Ni(III); Cu(I)/Cu(II); $Ru(II)(bpy)_3$

Thermal methods of analysis: Basic principles of Differential Thermal Analysis, Thermo Gravimetric Analysis, Differential scanning calorimetry (DSC), Application in coordination chemistry

Instrumental analysis: Isothermal Titration Calorimetry(ITC) basic principle and application , dynamic light scattering(DLS) basic principle and application.

CO–PO Mapping

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	3	2	-	-	-	1
CO2	3	3	3	2	-	-	-	1
CO3	3	3	3	2	2	-	-	1
CO4	3	2	2	3	2	-	-	1
CO5	2	2	2	3	2	-	-	1
CO6	2	2	2	3	3	-	-	2
CO7	3	3	3	2	2	-	-	2
(3 = High, 2 = Moderate, 1 = Low)								

Program Outcomes (POs)

PO Code	Program Outcome Description
PO1	Apply fundamental principles of inorganic and analytical chemistry
PO2	Analyze and solve complex chemical and mechanistic problems
PO3	Correlate structure, bonding, and reactivity in chemical systems
PO4	Use analytical, electrochemical, and instrumental techniques
PO5	Apply chemistry knowledge to interdisciplinary and applied fields
PO6	Communicate scientific concepts effectively
PO7	Demonstrate ethical practices and scientific integrity
PO8	Engage in lifelong learning and professional development

(Physical Chemistry Special)

Course code	CEME552C0	Advance Physical Chemistry –IV	Credit 4 (3-1-0) Full Marks: 50
Core/Elective/Other		Elective	Compulsory

Course Objectives:

The objectives of this course are to:

1. Provide advanced understanding of chemical kinetics using thermodynamic and statistical approaches.
2. Explain structure, properties, and characterization techniques of macromolecules and biopolymers.
3. Develop knowledge of electrochemical theories and processes in electrolyte solutions and interfaces.
4. Introduce fundamental principles of pharmaceutical chemistry and drug action mechanisms.
5. Correlate physical chemistry concepts with biological and pharmaceutical applications.

Course Outcomes (COs):

On successful completion of the course, the students will be able to:

CO1: Apply thermodynamic and statistical theories to analyze chemical reaction rates and surface reactions.

CO2: Interpret polymer molecular weight, conformation, and thermodynamics using experimental techniques.

CO3: Explain structure and spectroscopic characterization of biomolecules such as proteins and nucleic acids.

CO4: Analyze electrochemical behavior of electrolyte solutions, interfaces, and energy devices.

CO5: Understand principles of drug action, structure–activity relationships, and classification of drugs.

CO6: Correlate kinetic, electrochemical, and biochemical principles with pharmaceutical applications.

Course content:

Unit-I: Chemicals Kinetics-II

Thermodynamics formulation of reaction rates, Potential energy surface, reaction co-ordinates and reaction path, BEBO method. Absolute rate theory by using partition function; statistical formulation of chemical kinetics, equilibrium formulation, derivation of expression for specific rate, entropy of activation, volume of activation. Rates of chemisorptions, rates of desorption, Rate processes and some physical phenomena. Statistical approach to rate theory: Hinshelwood, RRK and RRKM theories. Reaction in molecular beams and shockwaves. Application of absolute reaction rate theory in viscosity. Diffusion controlled reaction (full and partial microscopic diffusion controlled). Bimolecular surface reaction: reaction between two adsorbed molecules, reaction between a gas molecule and an adsorbed molecule, inhibition, exchange reactions. TST of surface reaction.

Unit-II: Macromolecules and Biopolymers

Molecular weight of polymers, molecular weight determination by viscosity, osmometry, light scattering, diffusion and ultracentrifugation methods. Thermodynamics of polymer solutions. Polymer conformation, Structure of biomolecules i) Protein-building, peptide bonds, primary, secondary, tertiary, quaternary structure. Phi-Psi map 2) Nucleic acids- A,B,Z conformations, t-RNA conformation, carbohydrates and lipids biomembranes. a) SDS-PAGE (for proteins) b) agarose gel method (for nucleic acids). Techniques to study biomolecules: CD, ORD, Fluorescence, IR and Raman spectroscopy.

Unit –III: Electrochemistry

Debye Huckel theory, its modifications and extensions, mean ionic activity co-efficients, ion association, and precise determination of dissociation constants of weak electrolytes by method of emf and conductance measurements, ion-solvent interaction and solvation number. Non stationary processes in electrolytic solutions, Onsager conductance equation, Surface tension of electrolyte solution, thermodynamics of ideally polarized electrodes, structures of metal and semiconductor-electrolyte junctions, fuel cell.

Unit- IV: Pharmaceutical Chemistry

Important aspects of pharmaceutical chemistry, importance of chemistry in pharmaceuticals, some important terms used in chemistry of drugs, pharmacopeia, Classification of drugs and their nomenclature, Theory of drug action and structure activity relation, drug receptors: isolation, modification and localization, theories related to drug action, Hyponotics and sedative drugs, antiparkinson, antifungal, Vitamins, antimalarial drugs.

CO–PO Mapping

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1	3	3	2	2	-	-	-	1
CO2	3	2	3	2	2	-	-	1
CO3	3	2	3	3	2	-	-	1
CO4	3	3	2	3	2	-	-	1
CO5	3	2	3	2	3	-	-	1
CO6	3	3	3	2	2	-	-	2
(3 = High, 2 = Moderate, 1 = Low)								

Program Outcomes (POs)

PO1: Apply fundamental principles of chemistry, physics, and mathematics to understand and solve chemical problems.
PO2: Analyze chemical systems using theoretical concepts, experimental methods, and quantitative reasoning.

PO3: Correlate structure, bonding, and properties of chemical compounds and materials.
PO4: Use modern analytical, spectroscopic, and computational tools for qualitative and quantitative chemical analysis.
PO5: Apply chemical knowledge to interdisciplinary fields such as biology, materials science, environmental science, and pharmaceutical sciences.
PO6: Communicate scientific ideas, experimental results, and technical information effectively through written, oral, and graphical formats.
PO7: Demonstrate professional ethics, laboratory safety, environmental awareness, and academic integrity.
PO8: Engage in lifelong learning, self-development, and adaptation to emerging trends in chemical sciences.

DSE 7: Research Project 2, Dissertation
(Organic/Inorganic/Physical Special)
Marks: 100; Lecture hours: 200; Credit : 8

Course code	CEME553A9/ CEME-553B9/ CEME-553C9	Research Project 2, Dissertation	Credit 8 (0-0-8) Full Marks: 100
Core/Elective/Other		Elective	Compulsory
Course Objectives:			
The objectives of this course are to: 1. Expose students to contemporary developments in chemistry and allied industries. 2. Develop skills in literature survey, data collection, analysis, and scientific reporting. 3. Provide experiential learning through industry exposure or field-based investigation. 4. Enhance understanding of real-world applications of chemical principles. 5. Train students in formulating research problems and objectives. 6. Develop experimental design, methodology, and data analysis skills. 7. Promote independent research aptitude under faculty supervision. 8. Enhance scientific writing and documentation skills. 9. Improve professional communication and documentation skills.			
Course Outcomes (COs):			
On successful completion of the course, the students will be able to: **CO1:** Identify and critically review a contemporary topic in chemistry or related areas. **CO2:** Analyze industrial or field-based processes using chemical principles. **CO3:** Collect, organize, and interpret experimental or observational data. **CO4:** Prepare a structured technical report following scientific writing standards. **CO5:** Demonstrate professional ethics, teamwork, and safety awareness during visits or fieldwork. **CO6:** Formulate a research problem and objectives in consultation with the supervisor. **CO7:** Apply appropriate experimental or theoretical methods to solve research problems. **CO8:** Analyze results critically and draw scientifically valid conclusions. **CO9:** Prepare a comprehensive research dissertation (~25 pages). **CO10:** Present research and academic work effectively using scientific presentation tools.			

CO11: Defend research findings through oral communication and discussion.
Course content:

Review work / Industry Visit / Field work:

Review in an area of contemporary interest: Topic to be finalized in consultation with the Incharge and a Review-Report (approximately 10 pages) has to be submitted.

OR

Industry Visit:

It will involve visit to an **Industry** and submission of a Work-Report (approximately 10 pages) on the Industry Visit

OR

Field Work, Sample Collection and submission of a Work-Report (approximately 10 pages) on the Field Work.

OR

Internship (With the consent of the project supervisor and HOD) [30]

Research Work:

Research Work (extension from Semester III):

Unit 01:

Research problem has to be finalized in consultation with the Incharge. The work has to be carried out under the supervision of the Incharge and Research Report of approximately 25 pages has to be submitted.

[50]

Unit 02

Seminar Lecture has to be delivered on the total work carried out. It will involve Power Point Presentation (Industry visit: 2 slides, Review: 2 slides, Research work: 5 slides; total presentation time = 10 minutes (max.)).

[20]

CO–PO Mapping Table

(Review Work / Industry Visit / Field Work / Research Work)

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO1 Identify & review contemporary topic	2	3	2	2	2	–	–	2
CO2 Analyze industry / field processes	3	3	3	2	3	–	–	2
CO3 Data / sample collection & analysis	2	3	2	3	2	–	–	1

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8
CO4 Technical report writing	2	2	2	2	–	3	–	1
CO5 Ethics, safety & teamwork	–	–	–	–	–	2	3	1
CO6 Research problem formulation	3	3	2	2	–	–	–	2
CO7 Experimental / theoretical execution	3	3	3	3	2	–	–	2
CO8 Data interpretation & conclusions	3	3	3	2	2	–	–	2
CO9 Dissertation preparation	2	2	2	2	–	3	–	2
CO10 Scientific presentation	–	–	–	2	–	3	–	1
CO11 Oral defense & discussion	–	2	–	–	–	3	–	2

PO Alignment (Indicative)

- **PO1:** Fundamental chemistry knowledge
- **PO2:** Analysis and problem solving
- **PO3:** Structure–property–application correlation
- **PO4:** Use of modern tools and techniques
- **PO5:** Interdisciplinary and industrial relevance
- **PO6:** Communication skills
- **PO7:** Ethics and safety
- **PO8:** Lifelong learning and research aptitude

CEMC554X0

Marks: 50; Credit : 4

Internship / Capstone Project / Applied Field or Industry Project / Innovation / Incubation / Entrepreneurship /Start up Proposal or Practice

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CEMO555X0

Marks: 25; Credit : 2

Intellectual Property Right / Skill Enhanced Course

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Suggested Reading (Organic Chemistry):

1. Photochemistry and Pericyclic Reactions, Jagdamba Singh and Jaya Singh
2. Advanced Organic Chemistry, Part-A, F.A. Carey and R.J. Sundburg
3. Advanced Organic Chemistry, Part-B, F.A. Carey and R.J. Sundburg
4. March‟s Advanced Organic Chemistry, Michael B. Smith and Jerry March
5. Organic Chemistry, T.W. Graham, Solomons and Craig B. Fryhle
6. Organic Chemmistry, Paula Yurkanis Bruice
7. Green Chemistry, Paul T. Anantas and Tracy C. Williamson
8. Green Chemistry: Theory and Practice, Paul T. Anastas and John C. Warner
9. Molecular Gels: Materials with Self-Assembled Fibrillar Networks, Richard G. Weiss and P. Terech.
10. Spectroscopic Identification of Organic Compounds, Robert M. Silverstein and Francis X. Webster
11. Organic Synthesis: The Disconnection Approach, Stuart Warren
12. Modern Methods of Organic Synthesis: William Carruthers and Iain Coldham

Suggested Reading (Inorganic Chemistry):

1. Chemical Application of Group Theory – F.A. Cotton
2. Group Theory – Robert L. Carter
3. Symmetry in Chemistry – Jeffe & Archin
4. Symmetry in Molecules – J. M. Hollar
5. Symmetry Orbitals & Spectra – Jeffe & Archin
6. Physical Methods in Inorganic Chemistry – R. S. Drago
7. Electron Spin Resonance – Assculieien
8. Fundamentals of Molecular Spectroscopy – C. W. Banwell
9. Introduction to Molecular Spectroscopy – G. M. Barrow
10. Advanced Inorganic Chemistry – F. A. Cotton & G. Wilkinson
11. Inorganic Chemistry – J. E. HUheey, E. A. Keiter & R. L. Keiter
12. Chemistry of The Elements – N. N. Greenwood & A. Earnshaw
13. An Introduction to Inorganic Chemistry – K. F. Puecell & J. C. Kotz
14. Concept and Model in Inorganic Chemistry – Douglass, McDanniel & Alexander
15. Coordination Chemistry – S. F. A. Kettle
16. Valence Theoru – S. F. A. Kettle, J. N. Murral & S. Teddler

17. Valence – C. A. Coulson
18. Theoretical Approach to Inorganic Chemistry – A. F. Williams
19. Theoretical Inorganic Chemistry M. C. Dey and I. Selbin
20. Introduction to Ligand Field Theory – C. J. Ballhausen
21. Introduction to Ligand Field – B. N. Figgis
22. Inorganic Electronic Spectroscopy – A. B. P. Lever
23. Elements in Magnetochemistry – R. L. Dutta and A. Shyamal
24. Organo Transition Metal Chemistry – S. G. Davies
25. Principles and Application of Organotransition Metal Chemistry – J. P. Collman, L. S. Hegedus, Borton & R. G. Finke
26. Organometallic Chemistry – An Introduction – R. C. Mahrotra & A. Singh
27. Principles of Organometallic Chemistry _ G. E. Coats, H. L. H. Green, P.Powell & K. Wade
28. Basic Organomtallic Chemistry – J. J. Zuckerman and I. Haiduc
29. The Organometallic Chemistry of Transition Metals – R. H. Carbtree
30. Bioinorganic Chemistry – R. W. Hay
31. Introduction to Bioinorganic Chemistry - D.R. Williams
32. Elements of Bioinorganic Chemistry – G. N. Mukherjee & A. Das
33. Inorganic Chemistry – D. F. Shriver, P. W. Atkins & C. H. Langford
34. Instrumental Methods Analysis – Williiard, merit, Dean & Sett
35. Electroanalytical Techniques for Inorganic Chemistry – J. B. Headri
36. Comprehensive Coordination Chemistry – G. Wilkinson, R. A. Gillard & J. A. McCleverty (eds)
37. Inorganic Chemistry – A. G. Sharpe
38. Inorganic Chemistry – Modern Introduction
39. Fundamentals of Analytical Chemistry – D. A. Skoog, D. M. West and F. J. Holler
40. Analytical Chemistry – G. D. Christian
41. Analytical Chemistry, Principles – J. H. Kennedy

Practical (Inorganic):

1. Spot Tests of Inorganic Analysis – F. Feigel & V. Anger (translated by R. Oesper)
2. Macro and Semi Macro Qualitative Inorganic Analysis - A. J. Vogel
3. Quantitative Inorganic Analysis - G. Charlot & D. Bezier (translated by R. C. Murray)
4. Quantitative Chemical Analysis - I. M. Kolthoff, E. B. Sandel, J. Meehan and S. Bruckenstei
5. Advanced Experiments in Inorganic Chemistry – G. N. Mukkherjee.

Suggested Reading (Physical Chemistry):

1. Elementary Quantum Chemistry – F. I. Pilar
2. Quantum Chemistry – I. N. Levine
3. Molecular Quantum Mechanics – P. W. Atkins
4. Quantum Mechanics – J. I. Powel, B. Crasemann
5. Introduction to Quantum Mechanics – D. J. Griffiths
6. The Feynman Lectures in Physics, Vol. 3 – R. P. Feynman, R. B. Leighton, M. Sands
7. Chemical Applications of Group Theory – F. A. Cotton
8. Group Theory and Chemistry – D. M. Bishop
9. Coulson's Valance - R. McWeeny
10. Thermodynamics and an Introduction to Thermodynamics – H. B. Callen
11. Theories of chemical reaction rates – K. J. Laider
12. Theory of Rate Processes – S. Glaasstone, K. J. Laidler, H. Eyring
13. Principles of Physical Biochemistry – K. E. van Holde, C. Johnson, P. S. Ho
14. Modern Electrochmistry – J. O‟M. Bockris, A. K. N. Reddy
15. Physical Chemistry of Macromolecules – C. Tanford
16. Polymer Chemistry – P. J. Flory
17. Molecular Spectroscopy – I. N. Levine
18. Molecular Spectroscopy – J. D. Graybeal
19. Principles of Fluorescence Spectroscopy – J. R. Lakowicz
20. Introduction to Magnetic Resonance – A. Carrington, A. D. McLachlan
21. Statistical and Thermal Physics – F. Reif
22. Statistical Mechanics – D. A. McQuarrie
23. Statistical Mechanics – S. K. Ma
24. Statistical Mechanics – K. Huang
25. Statistical Mechanics – R. K. Patharia
26. Statistical Mechanics – B. B. Laud
27. Chemical Kinetics and Dynamics – J. I. Steinfeld, J. S. Francisco, W. L. Hase
28. Molecular Reaction Dynamics – R. D. Levine
29. Molecular Reaction Dynamics and Chemical Reactivity – R. D. Levine, R. B. Bernstein
30. Introduction to Solid State Physics – C. Kittel
31. Introduction to Solid State Theory – O. Madelung
32. Solid State Physics – A. J. Dekker
33. Molecular Modelling Principles and Application – A. R. Leach
34. Genetic Algorithm in Search Optimization and Machine Learning-D.E. Goldberg
35. Computational Intelligence-A. Konar
36. Photodissociation Dynamics-R. Schinke

37. Modern Spectroscopy-J. M. Hollas
38. Symmetry and Spectroscopy-D. C. Harris, M. D. Bertolucci
39. Molecular Vibrations-E. B. Wilson Jr., J. C. Decius, P. C. Cross
40. Microwave Spectroscopy- C. H. Townes and A. L. Schawlow
41. Laser Spectroscopy- W. Demtroder
42. Practical Physical Chemistry- A. M. James, F. F. Prichard
43. Findlay's Practical Physical Chemistry- B. P. Levitt
44. Experimental Physical Chemistry- Shoemaker and Garland

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1. Rahman, M.S. "Handbook of Food Preservation", Marcel Dekker, 1999.
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1. Food Science, 5th Ed, 1997, B. Srilakshmi, New Age International (P) Ltd, New Delhi.
2. N.N. Potter CBS Publishers and Distributors, Delhi, 5th Ed, 1996 Food Science.
3. Food Processing and Preservation by B. Sivasankar

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31/10/2025