Vidyasagar University

Dept. of Chemistry and Chemical Technology

The Syllabus
For

M.Sc. in Chemistry

[w.e. f. 2025 - 2026]

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 77 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 group theory, magnetochemistry, organometallic, 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, 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 group theory, magnetochemistry, organometallic, 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	CEM-101	Organic Chemistry - I	40 + 10	40	4 (3-1-0)
	CEM-102	Inorganic Chemistry- I	40 + 10	40	4 (3-1-0)
	CEM-103	Physical Chemistry - I	40 + 10	40	4 (3-1-0)
	CEM-104	Research Methodology and Ethics	40 + 10	40	4 (3-1-0)
	CEM-105	Practical (Inorganic Chemistry and Physical Chemistry)	25 + 25	50 + 50	2 + 2 (0-0-2, 0-0-2))
	CEM-IKS-106	Indian Knowledge System (IKS)	25	20	2 (2-0-0)
	CEM-LPV-107	Life and Philosophy of Vidyasagar	Compulsory non-credit course		
	TOTAL		275	280	22
II	CEM-201	Organic Chemistry - II	40 + 10	40	4 (3-1-0)
	CEM-202	Inorganic Chemistry- II	40 + 10	40	4 (3-1-0)
	CEM-203	Physical Chemistry - II	40 + 10	40	4 (3-1-0)
	CEM-204	Advanced Spectroscopic Technics for Structure and Property	40 + 10	40	4 (3-1-0)
	CEM-205	Practical (Organic, Computer and Food Processing)	25 + 25	50 + 50	2 + 2 (0-0-2, 0-0-2)
	CEM-206	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*				
	CEM-301	ADVANCED ORGANIC / INORGANIC / PHYSICAL CHEMISTRY-I	40 + 10	40	4 (3-1-0)
	CEM-302	ADVANCED ORGANIC / INORGANIC / PHYSICAL CHEMISTRY-II	40 + 10	40	4 (3-1-0)
	CEM-303	Research Project 1, Dissertation	100	200	8 (0-0-8)
	CEM-304 (MOOC)	MOOC	40 + 10	40	4 (3-1-0)
	CEM-305	Social Service / Community Engagement	25	50	2 (0-0-2)
	TOTAL		275	370	22
IV	*SPECIALISATION: ORGANIC / INORGANIC / PHYSICAL CHEMISTRY*				
	CEM-401	ADVANCED ORGANIC / INORGANIC / PHYSICAL CHEMISTRY-III	40 + 10	40	4 (3-1-0)
	CEM-402	ADVANCED ORGANIC / INORGANIC / PHYSICAL CHEMISTRY-IV	40 + 10	40	4 (3-1-0)
	CEM-403	Research Project 2, Dissertation	100	200	8 (0-0-8)
	CEM-404	Internship / Capstone Project / Applied Field or Industry Project / Innovation / Incubation / Entrepreneurship /Start up Proposal or Practice	50	100	4 (0-0-4)

	CEM-405	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	CEM-101	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.

Course content:

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	CEM-102	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.

Course content:

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	CEM-103	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).

Course content:

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
- PO2: Problem Analysis
- PO4: Investigation of Complex Problems
- PO5: Modern Tool Usage
- PO7: Environment and Sustainability
- PO9: Communication Skills
- PO10: Lifelong Learning

Course code	CEM-104	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.

Course content:

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	CEM-105	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.

Course content:

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

A. Laboratory work **Marks:15**

1. Quantitative estimation of metal ions /alloys / 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	CEM- IKS-106	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	CEM-LPV- 107	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.			

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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31/10/2025