NORTH LAKHIMPUR COLLEGE (AUTONOMOUS)

DEPARTMENT OF CHEMISTRY

SYLLABUS OF POST GRADUATE PROGRAMME
(As per NEP 2020 Guidelines)

M.Sc.inChemistry

(As approved by Board of Studies in(Chemistry) held on31st May 2024 and passed by Academic Council held on15.06.2024

M.Sc. programme in Chemistry

1.1 Introduction

A high priority task in the context of future education development agenda in India is fostering quality higher education. Improvement of quality of higher education is considered critical for enabling effective participation of young people in knowledge production, participation in the knowledge economy, improving national competitiveness in a globalized world and for equipping young people with skills relevant for global and national standards and enhancing the opportunities or social mobility. Master of Science (M.Sc.) in Chemistry offered by North Lakhimpur College (Autonomous) is an undergraduate degree that focuses on the study of matter, its properties, composition, structure, and the changes it undergoes during chemical reactions.

1.2 Nature and extent of the M.A. /M.Sc. (Chemistry)

The M.Sc. program is a two-year PG course. Its core subjects include

i. Inorganic Chemistry
ii. Organic Chemistry.
iii. Physical Chemistry –
iv. Research Methodology / Tools and Techniques in Research Methodology
v. Molecular Spectroscopy
vi. Internship / Apprenticeship / Community Engagement
vii. Inorganic Materials of Industrial Importance
viii. Material Chemistry
ix. Quantum Chemistry
x. Research Project
xi. Applied Chemistry
xii. Green and Sustainable Chemistry
xiii. Laboratory Course
xiv. Analytical ChemistrySkills Developed

1.3 Aims of Master's degree Programme in Chemistry

The aims of M.Sc. programme in Chemistry are to provide students with a strong foundation in chemical principles, practical skills, and critical thinking abilities needed for careers in science, research, industry, and education.

To Develop Fundamental Knowledge

i. Provide a solid understanding of the principles of inorganic, organic, physical, and analytical chemistry.
ii. Explain the structure, properties, and reactions of different substances.
iii. To Enhance Practical and Laboratory Skills
iv. Train students in modern laboratory techniques, including synthesis, analysis, and instrumentation.
v. Emphasize safety protocols and good laboratory practices.

To Promote Analytical and Problem-Solving Skills

i. Develop critical thinking and problem-solving abilities through theoretical and experimental learning.
ii. Encourage students to apply chemistry knowledge to real-world problems in medicine, industry, and the environment.

To Foster Research and Innovation

i. Encourage participation in research projects and independent scientific inquiry.
ii. Introduce students to scientific methodologies, data analysis, and report writing.

To Prepare for Professional Careers

i. To equip students with skills required for careers in pharmaceuticals, biotechnology, environmental science, materials science, and education.
ii. Develop communication skills for presenting scientific ideas and collaborating in interdisciplinary teams.

To Support Higher Education and Lifelong Learning

i. Provide a foundation for further studies, such as Ph.D., or professional courses in chemistry, forensic science, and chemical engineering.
ii. Cultivate an appreciation for the evolving nature of chemistry and the importance of lifelong learning.

1.4 Qualification Descriptors

i. Knowledge and Understanding
ii. Cognitive and Intellectual Skills
iii. Practical Skills
iv. Transferable Skills
v. Research and Project Work
vi. Employability and Career Development

1.5 Programme Specific Outcome (PSO)

1. **Advanced and Specialized Knowledge in Chemistry:**

i. Postgraduates will acquire in-depth knowledge in specialized areas of chemistry such as advanced organic synthesis, coordination chemistry, quantum chemistry, spectroscopy, and materials science.

ii. They will be able to critically analyse chemical concepts, design synthetic strategies, and solve advanced theoretical and experimental problems in various branches of chemistry.

2. **Proficiency in Experimental Techniques and Instrumentation:**

i. Postgraduates will master advanced laboratory techniques and instrumentation used in modern chemical research, including NMR, FTIR, GC-MS, TGA, UV-vis, and electrochemical methods.

ii. They will be proficient in planning, executing, and troubleshooting complex experiments and ensuring high standards of precision, accuracy, and reproducibility.

3. **Independent Research and Innovation:**

i. Postgraduates will be capable of designing and executing independent research projects, including literature review, hypothesis formulation, experimentation, data interpretation, and scientific writing.

ii. They will be trained to identify gaps in existing research and propose innovative solutions to address scientific and industrial challenges.

4. **Chemical Safety, Regulatory Awareness, and Ethics:**

i. Postgraduates will adhere to national and international chemical safety standards and demonstrate ethical conduct in research and industrial practices.

ii. They will critically assess the environmental, health, and societal implications of chemical practices and strive for responsible innovation.

5. **Interdisciplinary Integration and Application:**

   i. Postgraduates will integrate chemistry with other scientific disciplines such as nanotechnology, pharmacology, biotechnology, and environmental science for multidisciplinary problem-solving.

   ii. They will effectively contribute to collaborative research and development projects across scientific and engineering domains.

6. **Scientific Communication and Professional Development:**

   i. Postgraduates will demonstrate advanced communication skills in preparing scientific reports, research papers, dissertations, and presentations suitable for academic and industrial contexts.

   ii. They will develop leadership, project management, and collaborative skills essential for professional success in academia, research institutions, and industry.

7. **Environmental Sustainability and Green Chemistry:**

   i. Postgraduates will understand and apply the principles of green chemistry to minimize waste, energy consumption, and hazardous by-products in chemical processes.

   ii. They will actively contribute to sustainable development by innovating environmentally friendly materials, technologies, and practices.

8. **Advanced Computational and Data Analysis Skills**
   i. Postgraduates will acquire proficiency in computational chemistry tools (e.g., Gaussian, ChemDraw, MATLAB) and data analysis software (e.g., Origin, Excel, Python) to support modelling, simulation, and quantitative research.

   ii. They will be able to use statistical, spectroscopic, and computational methods to derive insights from complex datasets and support scientific decision-making.

1.6 Course Learning Outcome (CLO)

The **Course Learning Outcomes (CLOs)** for a **Master of Science (MSc) in Chemistry** focus on developing a strong foundation in chemical principles,

laboratory skills, critical thinking, and research abilities. Specific CLOs of each available course are discussed in the respective papers.

1.7 Teaching Learning Methodologies

The Teaching and Learning Methodologies for a M.Sc. in Chemistry focus on developing theoretical knowledge, practical skills, critical thinking, and research abilities. Here are some common methodologies used:

i. Lecture-Based Learning
ii. Laboratory Based Learning in the form of Experiments
iii. Problem-Based Learning
iv. Group Discussions & Seminars
v. Project-Based Learning & Research
vi. Industrial Visits & Internships
vii. Field Work & Environmental Studies
viii. Assessments & Feedback Analysis

1.8 Assessment and Outcome Measurement Methods

Following methods are adopted to evaluate both theoretical knowledge and practical skills:

1. *Internal Assessment Examinations*: Monitors student progress throughout the course through Sessional Examinations, Home and Class Assignments, Percentage of Class attendance, Sudden Tests, Seminars/Group Discussions.
2. *Summative Assessment*: (final Semester Examinations)
3. *Skill-Based Assessment*: Oral Presentations & Seminars of projects / dissertations, Internship/Industrial Training Reports.

Outcome Measurement Methods:

i. Analysis of Feedback of Students to learn about their learning Experiences
ii. Analysis of Alumni Feedback
iii. Taking and Analysing the Employability & Industry Feedback – For Assessing how well graduates meet industry standards.

2. **Certification Criteria:**

The certification (graduation) criteria for a Master of Science (M.Sc.) in Chemistry typically include the following requirements as per the NEP

guidelines of North Lakhimpur College approved by the **12th Academic Council, North Lakhimpur College (Autonomous) held on 16th May 2023:**

(b) *PG Degree*: Students after completion of the second year and those have secured 80 credits will be awarded the PG degree.

2.1 Other Key Criteria for PG Programme

- *Attendance Requirements*: As per the guidelines of college authority in the concerned academic year.
- Summer Internship/Apprenticeship: Summer internship/apprenticeship is mandatory for all the Education students; PG certificate, 2-year PG Degree. However, for PG certificate it has to be completed during the summer break at the end of 2nd semester.

Summary of the PG Course Structure as per NEP Guidelines
Department of Chemistry
Structure of Syllabus

SEMESTER I: TOTAL CREDITS 20

Course	Course Title	Course Code	Credit	Marks	End Sem Marks	Internal Assessment
Core	(Inorganic Chemistry-I)	**CC-4-MCH-101**	**4**	**80**	**56**	**24**
Core	(Organic Chemistry-I)	**CC-4-MCH-102**	**4**	**80**	**56**	**24**
Core	Physical Chemistry-I	**CC-4-MCH-103**	**4**	**80**	**56**	**24**
Discipline Specific Elective - I	Laboratory Course- I	**DSE-4-MCH-101A**	**4**	**80**	**80**	**0**
Discipline Specific Elective- II	Laboratory Course- I	**DSE-4-MCH-101B**	**4**	**80**	**80**	**0**
Core Option-I	Research Methodology	**CC-4-MCH-104A**	**4**	**80**	**56**	**24**
Core Option-II	Tools and Techniques in Research Methodology	**CC-4-MCH-104B**	**4**	**80**	**56**	**24**

SEMESTER II: TOTAL CREDITS 20

Course	**Course Title**	**Course Code**	**Credit**	**Marks**	**End Sem Marks**	**Internal Assessment**
Core	Inorganic Chemistry-II)	**CC-4-MCH-201**	**4**	**80**	**56**	**24**
Core	Organic Chemistry-II	**CC-4-MCH-202**	**4**	**80**	**56**	**24**
Core	Physical Chemistry II: Molecular Spectroscopy	**CC-4-MCH-203**	**4**	**80**	**56**	**24**
Discipline Specific Elective OPTION I	Laboratory Course-II	**DSE-4-MCH-201A**	**4**	**80**	**80**	**0**
Discipline Specific Elective OPTION II	Laboratory Course-II	**DSE-4-MCH-201B**	**4**	**80**	**80**	**0**
Core	Internship / Apprenticeship / **Community Engagement**	**CC-4-MCH-202**	**4**	**80**	**80**	**0**

SEMESTER III: TOTAL CREDITS 20

Course	Course Title	Course Code	Credit	Marks	End Sem Marks	Internal Assessment
Core	Inorganic Chemistry-III)	**CC-4-MCH-301**	4	80	56	24
Core	Organic Chemistry-III	**CC-4-MCH-202**	4	80	56	24
Core	Physical Chemistry III	**CC-4-MCH-303**	4	80	56	24
Discipline Specific Elective OPTION I	Laboratory Course-III	**DSE-4-MCH-301A**	4	80	80	0
Discipline Specific Elective OPTION II	Laboratory Course-III	**DSE-4-MCH-301B**	4	80	80	0
CORE	**RESEARCH PROJECT**OR CORE COURSE		4	**80**	**80**	**0**
				80	56	24

SEMESTER IV: TOTAL CREDITS 20

Course	Course Title	Course Code	Credit	Marks	End Sem Marks	Internal Assessment
Core	Inorganic Chemistry-IV-Inorganic Materials of Industrial Importance	**CC-4-MCH-401**	4	80	56	24
Core	Organic Chemistry-IV-Green and Sustainable Chemistry	**CC-4-MCH-402**	4	80	56	24
Core	Physical Chemistry IV-Quantum Chemistry	**CC-2-MCH-403**	2	40	28	12
Discipline Specific Elective OPTION I	Analytical Chemistry	**DSE-4-MCH-401A**	4	80	56	24
Discipline Specific Elective OPTION II	Material Chemistry	**DSE-4-MCH-401B**	4	80	56	24
CORE	**RESEARCH PROJECT**OR CORE COURSE	**CC-6-MCH-404**	6	120	120	0

DETAILED SYLLABUS
SEMESTER-I

Course Title: **General Chemistry**
Course Code:**CC-4-MCH-101**
Nature of the course: **Core**
Component of the course: **L=3, T=1, P=0**
Total Credit assigned:**4**
Distribution of Marks: **End Semester=56; In Semester=24 (Total= 80)**

Course Objectives:

CO-1: **To provide** an advanced understanding of atomic structure, bonding, and molecular geometry with a focus on VSEPR, LCAO-MO theory, and electron-deficient compounds.

CO-2: **To impart** detailed knowledge of metal-ligand bonding through crystal field theory and molecular orbital theory in coordination compounds and solids.

CO-3: **To explore** modern acid-base and redox concepts, their applications in electrochemistry, and the use of diagrams and voltammetry in understanding redox processes.

CO-4: **To develop** knowledge of bioinorganic chemistry with an emphasis on metal ions in biological systems, oxygen carriers, electron transport, and enzyme function.

Course Contents

Unit	Content	Marks	L	P	T
I	**Chemical Bonding**: VSEPR Theory: Structure of molecules containing lone pair(s) of electrons, structure and hybridization, Bent's rule, Bent bond, non-bonded repulsion, and structure. LCAO-MO methods in homo and heteronuclear diatomic molecules (O_2, N_2, CO, NO).MO description of tri and tetra atomic molecules (CO_2, NO_2, NO_2^+, CO_3^{2-}, O_3 and NO_3^-). Bonding in electron deficient compounds. Structure and bonding in boranes, carboranes, metallocarboranes, S-N and Se-N and P-N compounds. Metallic and Metal ligand bonding: Spinel and Perovskite structures. Ionic surrounding: Crystal Field Theory; Covalent surrounding: Transition metal MO and ligand field Theory, Transition metal complexes with σ and π bonding ligands. Molecular orbital model, General view of ML6 and ML4 structures: ML6(Oh), ML4(D4h) and ML4(Td). Chemical periodicity, Chemical hardness, Application of	26	15	0	5

	electronegativity.				
II	**Acid Base and Redox Chemistry** (a) Acid-Base concepts, Measure of Acid-Base Strengths, Acid-Base in water. Nonaqueous solvent, aprotic solvent and superacid. Hard and Soft Acids and Bases, application of SHAB principle. Half-cell reaction, reduction potential, application of reduction potential data, electrochemical series; brief idea of corrosion and its prevention; Nernst equation. Latimer and Frost diagram (V, Mn Fe, Cu etc.), disproportionation reaction; cyclic voltammetry.	10	15	0	5
III	**Bioinorganic Chemistry** Fundamentals of inorganic biochemistry, essential, non-essential and role of 3d block elements and non-metals in bio-systems. Natural and synthetic oxygen carriers, Porphyrins, model compounds for oxygen binding and carriers: Haemoglobin, myoglobin, hemerythrin, hemocyanin, Electron transfer protein: Cytochromes, Iron-Sulphur, Nitrogen fixation. Metalloenzymes, corrinoids (vitamin B12 and co-enzyme), carboxy-peptidases, chlorophyll and photosynthesis, Na-K or ATPase or sodium pump, crown ethers, futuristic aspects of organo-transition metal complexes in bioinorganic chemistry	20	15	0	5
Total		56	45	0	15

Mode of Transaction: Lecture Cum Discussion, Self Study and Library Work.

Mode of In-Semester Assessment: (24 Marks)

Sessional Test: Marks: 15
Other Sessional Activities: Marks: 9

In- Semester Assessment Marks: 24

A. Sessional Activity

1. Activities selected from abovementioned list:
   a) Home Assignments
   b) Class Assignments
   c) Seminars
   d) Group Discussions
   e) Sudden Tests
   f) Class Attendance.

Course Learning Outcomes:
After completion of the course, the students will be able to**:**

CLO-1
1.1 **Explain** the principles of VSEPR theory and **predict** molecular geometries involving lone pairs and multiple bonding.

1.2 **Analyse** bonding in diatomic and polyatomic molecules using LCAO-MO theory and **apply** it to explain magnetic and bonding characteristics.

1.3 **Describe** bonding in electron-deficient compounds such as boranes, carboranes, and heteroatom clusters.

CLO-2
2.1 **Compare and contrast** metallic and metal-ligand bonding using CFT, ligand field theory, and MO theory in various ligand environments.

2.2 **Predict** structural and electronic properties of transition metal complexes with σ and π bonding ligands.

CLO-3
3.1 **Apply** acid-base concepts across aqueous and non-aqueous systems including super acids and aprotic solvents.

3.2 **Interpret** redox chemistry through electrochemical series, Latimer and Frost diagrams, and Nernst equation; analyse electron transfer using cyclic voltammetry.

CLO-4
4.1 **Identify** the role of essential and non-essential metal ions in biological systems and their coordination environment.

4.2 **Explain** the function of bioinorganic molecules such as oxygen carriers, electron transfer proteins, and metalloenzymes.

4.3 **Assess** the biological relevance and futuristic applications of organo-transition metal complexes in medicine and bioinorganic chemistry.

Cognitive Map of Course Outcomes Based on Revised Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge	CO-1, CO-2, CO-3	CO-1, CO-2, CO-3	CO-2, CO-3			
Conceptual Knowledge		CO-1, CO-2, CO-3, CO-4	CO-2, CO-3, CO-4	CO-1, CO-2, CO-4	CO-3, CO-4	
Procedural Knowledge			CO-2, CO-3, CO-4	CO-2, CO-3, CO-4	CO-3, CO-4	CO-4
Metacognitive Knowledge					CO-3, CO-4	CO-4

Mapping of Course Learning Outcomes (CLO's) to Programme Specific Outcomes (PSO's)

CLO / PSO	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8
CLO-1	3	1	2	2	2	2	1	2
CLO-2	3	2	3	2	2	2	2	3
CLO-3	2	2	3	3	2	3	3	3
CLO-4	3	3	3	3	3	3	3	2
Average	**2.75**	**2**	**2.75**	**2.5**	**2.25**	**2.5**	**2.25**	**2.5**

Suggested Readings:

Recommended Books:
1. Bioinorganic Chemistry by K. Hussain Reddy, New Age International Publisher.
1. The Inorganic Chemistry of Biological Processes, Hughes, M.N., 2nd edition, Wiley (1981)
2. Bio-coordination Chemistry, D.E. Fenton, Oxford University Monograph Series 1995.
3. Inorganic Chemistry, Gary L.Miessler& Donald A. Tarr 3rd Ed, Pearson
4. Inorganic Chemistry, C.E. Housecraft & A.G. Sharpe, 2nd Ed, Pearson

SEMESTER-I

Course Title: **Organic Chemistry-I**
Course Code:**CC-4-MCH-102**
Nature of the course: **Core**
Component of the course: **L=3, T=1, P=0**
Total Credit assigned:**4**
Distribution of Marks: **End Semester=56; In Semester=24 (Total= 80)**

Course Objectives:

CO-1: **To impart** knowledge of pericyclic reactions and their mechanistic interpretation using molecular orbital methods.

CO-2: **To develop** an understanding of the structure, bonding, and reactivity of aromatic and non-aromatic organic compounds, including concepts in supramolecular chemistry.

CO-3: **To explain** the mechanisms of organic reactions through kinetic, thermodynamic, and isotopic methods, with a focus on reactive intermediates.

CO-4: **To apply** retrosynthetic analysis and protecting group strategies for the synthesis of multifunctional organic molecules.

Course Contents:

Unit	Content	Marks	L	P	T
I	**Pericyclic reactions:** Classification of pericyclic reactions, FMO method, PMO method for the explanation of pericyclic reactions under thermal and photochemical conditions; Cycloaddition reactions: [2+2], [4+2], [6+4] cycloadditions, 1,3-dipolar cycloadditions; the ene reaction, cheletropic reactions, Sigmatropic rearrangement – [m+n] sigmatropic shifts of hydrogen and carbon, Cope and Claisen rearrangement. Electrocyclic reactions, Stereoselectivity and regioselectivity of pericyclic reactions.	13	10	0	3
II	**Structure, bonding and reactivity of organic compounds:** Delocalised Chemical Bonding, Aromaticity, antiaromaticity and homo-aromaticity, metallocene's, tropolones and azulenes. Hyper conjugation, supra molecular chemistry: Bonds weaker than covalent bond (Hydrogen Bond, Addition Compounds), charge transfer complexes, inclusion complexes and crown ethers. Cryptand, rotaxanes, Fullerenes, Graphene's. Phase transfer catalyst. Hammet equation, Taft equation. Influence of reaction medium on rates.	15	10	0	2

III	**Organic reaction mechanism:** Transition state vs. Reaction intermediate, Energy profile of multistep reaction, Significance of rate limiting step in multistep reactions, Catalysed and uncatalyzed reactions, Kinetic vs. Thermodynamic control, Kinetic and non-kinetic methods of studying organic reaction mechanism; Isotope labelling studies and kinetic isotope effects, Cross-over experiment. Reactivity - selectivity principle: Chemo selectivity, regioselectivity, stereoselectivity and stereospecificity in substitution, elimination and addition reactions. Neighbouring group effects. Organic reactive intermediates: Generation, stability and reactivity of carbocations, carbanions, free radicals, carbenes, benzynes and nitrenes.	15	15	0	5
IV	**Disconnection approach in organic synthesis** Disconnection approach in organic synthesis: Acceptor and donor synthons, Use of umpolung, Retrosynthesis of Alcohols (Grignard approaches and hydride transfer approaches) and Carbonyl compounds. One group and two group C-X disconnections. One group and two group C-C disconnections. Retrosynthesis of 1,2-, 1,3-, 1,4-, 1,5- and 1,6-difunctional (O, O and N, O in a difunctional relation) compounds. Use of protecting groups in organic synthesis: protection and deprotection of hydroxyl, dihydroxy, carbonyl, carboxyl and amino groups.	13	10	0	5
Total		56	45	0	15

(L= Lecture, P = Practical, T = Tutorial)

Mode of Transaction: Lecture Cum Discussion, Seminars, Workshops, Group discussion, Seminars, Self Study and Library Work. (Note: This list is suggestive in nature and the modes may be stated as departmental modalities)

Mode of In-Semester Assessment: (24 Marks)

Sessional Test:	Marks: 15
Other Sessional Activities:	Marks: 9
In- Semester Assessment	Marks: 24

Sessional Activity

Activities selected from the above-mentioned list:

- Lecture Cum Discussion,
- Seminars,
- Group discussion,
- Self-Study

- Sudden Test

Course Learning Outcomes:

After completion of the course, the students will be able to**:**

CLO-1
1.1 **Classify** pericyclic reactions and explain their mechanisms using FMO and PMO approaches.
1.2 **Analyse** stereochemistry and regioselectivity in electrocyclic, sigma tropic, cycloaddition, and cheletropic reactions.
1.3 **Predict** outcomes of thermal vs. photochemical pericyclic reactions.

CLO-2
2.1 **Interpret** structural features of delocalized bonding and evaluate aromaticity, antiaromaticity, and homo aromaticity.

2.2 **Explain** molecular recognition in supramolecular systems and describe the chemistry of crown ethers, rotaxanes, cryptands, fullerenes, and graphene.

2.3 **Apply** physical organic chemistry principles (Hammett and Taft equations) to assess reaction behaviour and media effects.

CLO-3
3.1 **Distinguish** between transition states and intermediates using energy profiles and reaction coordinates.

3.2 **Employ** kinetic and non-kinetic methods to elucidate mechanisms, including isotope labelling and crossover experiments.

3.3 **Assess** reactivity and selectivity in substitution, elimination, and addition reactions; and to describe the stability and reactivity of organic intermediates like carbocations, carbanions, free radicals, carbenes, nitrenes, and benzynes.

CLO-4
4.1 **Perform** retrosynthetic analysis using donor and acceptor synthons and disconnection strategies (C–X and C–C).

4.2 **Apply** umpolung techniques and Grignard/hydride-based syntheses of alcohols and carbonyl compounds.

4.3 **Use** protecting and deprotecting group strategies for hydroxyl, carbonyl, carboxyl, and amino functionalities in synthetic planning.

Cognitive Map of Course Outcomes Based on Revised Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge	CO-1, CO-2, CO-3	CO-1, CO-2, CO-3	CO-3			
Conceptual Knowledge		CO-1, CO-2, CO-3, CO-4	CO-2, CO-3, CO-4	CO-1, CO-3, CO-4	CO-2, CO-3	
Procedural Knowledge			CO-3, CO-4	CO-3, CO-4	CO-3, CO-4	CO-4
Metacognitive Knowledge					CO-4	CO-4

Mapping of Course Learning Outcomes (CLO's) to Programme Specific Outcomes (PSO's)

CLO / PSO	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8
CLO-1	3	1	2	2	2	2	1	2
CLO-2	3	2	3	2	2	2	2	2
CLO-3	3	2	3	3	2	2	2	3
CLO-4	3	3	3	3	3	3	3	2
Average	**3**	**2**	**2.75**	**2.5**	**2.25**	**2.25**	**2**	**2.25**

[3 = Strongly aligned, 2 = Moderately aligned, 1 = Weakly aligned]

Suggested Readings:

1. Organic Chemistry, Vols I and II – I. L. Finar, ELBS.
2. Stereochemistry and Mechanism through Solved Problems- P.S. Kalsi, New Age International Publishers
3. Introduction to Spectroscopy – by Donald L. Pavia, Cengage Learning India Private Limited
4. A Guidebook to Mechanism in Organic Chemistry– Peter Sykes, Longman, New York.
5. Organic Chemistry – R. T. Morrison, R. N. Boyd and S. K. Bhattacharjee, Prentice Hall India Limited
6. Organic Chemistry – Paula YurkanisBruice, Pearson
7. Advanced Organic Chemistry: Reaction Mechanism and Structure – Jerry March, Wiley Eastern.
8. Disconnection Approach in Organic Synthesis – S. Warren, Wiley
9. Organic Reaction Mechanism, Christine Willis and martin Willis, Oxford chemistry Primers (No. 74)
10. Disconnection Approach in Organic Synthesis – S. Warren, Wiley

11. Designing Organic Synthesis – S. Warren, Wiley, Chichester
12. The Logic of Organic Synthesis – E.J. Corey and Xue Min Chen, Wiley, New York

SEMESTER-I

Course Title: **Physical Chemistry-I**
Course Code:**CC-4-MCH-103**
Nature of the course: **Core**
Component of the course: **L=3, T=1, P=0**
Total Credit assigned:**4**
Distribution of Marks: **End Semester=56; In Semester=24 (Total= 80)**

Course Objectives:

CO-1: **To provide** a comprehensive understanding of chemical equilibrium, thermodynamics, fugacity, and partial molar properties.

CO-2: **To explain** the principles and mathematical formulations of statistical thermodynamics and its applications to thermodynamic functions.

CO-3: **To explore** photochemical processes, quantum yield, and radiation-matter interactions with emphasis on kinetics and emission mechanisms.

Course Contents

Unit	Content	Marks	L	P	T
I	**Equilibrium and Thermodynamics**: Concept of fugacity and its determination. Ideal solution and non-ideal solutions, Activity and activity coefficient, Determination of activity coefficient, Partial molar quantities: chemical potential, Determination of Partial molar volume, Thermodynamics of mixing. Excess thermodynamic functions, Nernst's Heat Theorem, Third law of thermodynamics, its experimental verification, determination of absolute entropy, Residual entropy.	16	15	0	5
II	**Statistical thermodynamics** Maxwell-Boltzmann distribution law, Bose-Einstein, and Fermi-Dirac distribution law. Boltzmann relation between entropy and probability. Partition functions and thermodynamic functions. Thermodynamic functions of a monatomic gas, Sackur – Tetrode equation. Evaluation of translational Partition function using Particle in a box model for ideal monatomic gas. Rotational and vibrational entropy of gases, Free energy, and Partition functions. General expression for Partition function and equilibrium constant. Energy and heat capacity of gases. Einstein and Debye's theory of heat capacity of solids. Numerical calculations of thermodynamic quantities for monoatomic, diatomic, and polyatomic molecules.	20	15	0	5
III	**Photochemistry** Light absorption: Jablonski Diagram, mechanism of	20	15	0	5

	absorption and emission of photochemical radiation: electric dipole transition, Einstein treatment of absorption and emission phenomena, concept of quantum yield and its determination; Fluorescence emission and structure; Triplet state and phosphorescence emission; delayed fluorescence; Study of kinetics of H2-Cl2 reaction, H2-Br2 reaction, photo dimerization of anthracene, Photosensitisation and quenching, Stern Volmer equation.				
Total		56	45	0	15

(L= Lecture, P = Practical, T = Tutorial)

Mode of Transaction: Lecture Cum Discussion, Seminars, Workshops, Group discussion, Seminars, Self Study and Library Work. (Note: This list is suggestive in nature and the modes may be stated as departmental modalities)

Mode of In-Semester Assessment: (24 Marks)

Sessional Test:	Marks: 15
Other Sessional Activities:	Marks: 9

In- Semester Assessment Marks: 24

Sessional Activity

Activities selected from the above-mentioned list:

- Lecture Cum Discussion,
- Seminars,
- Group discussion,
- Self-Study
- Sudden Test

Course Learning Outcomes:

CLO-1

1.1 **To define and determine** fugacity and activity coefficients in ideal and non-ideal solutions.

1.2 **To interpret** the concepts of partial molar quantities and **apply** them in thermodynamic calculations.

1.3 **To evaluate** entropy using the Third Law and understand residual entropy and Nernst's Heat Theorem.

CLO-2

2.1 **To derive and apply** Maxwell-Boltzmann, Bose-Einstein, and Fermi-Dirac distribution laws.

2.2 **To relate** entropy to probability using Boltzmann's equation and **calculate** thermodynamic functions using partition functions.

2.3 **To compute** entropy, free energy, heat capacity, and equilibrium constants for monoatomic and polyatomic gases and solids using Einstein and Debye theories.

CLO-3

3.1 **To analyze** electronic transitions using the Jablonski Diagram and Einstein's treatment of absorption and emission.

3.2 **To explain and determine** quantum yield, fluorescence, phosphorescence, and photochemical reaction mechanisms.

3.3 **To study and interpret** photochemical kinetics, including H_2-Cl_2, H_2-Br_2 reactions, anthracene photodimerization, and apply the Stern-Volmer equation to quenching phenomena.

Cognitive Map of Course Outcomes Based on Revised Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge	CO-1, CO-2, CO-3	CO-1, CO-2, CO-3	CO-1			
Conceptual Knowledge		CO-1, CO-2, CO-3	CO-2, CO-3	CO-2, CO-3	CO-1, CO-2	
Procedural Knowledge			CO-2, CO-3	CO-3	CO-2, CO-3	
Metacognitive Knowledge					CO-3	CO-3

Mapping of Course Learning Outcomes (CLO's) to Programme Specific Outcomes (PSO's)

CLO / PSO	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8
CLO-1	3	2	2	2	2	2	2	2
CLO-2	3	2	3	2	2	2	2	3
CLO-3	3	3	3	2	2	2	2	3
Average	**3**	**2.33**	**2.67**	**2**	**2**	**2**	**2**	**2.67**

[3 = Strongly aligned, 2 = Moderately aligned, 1 = Weakly aligned]

Suggested Readings:

1. Physical Chemistry by P.W. Atkins
2. Physical Chemistry by I. N. Levine
3. Thermodynamics for Chemist by S. Glasstone

SEMESTER-I

(Option-I)

Course Title: **Laboratory Course-I**
Course Code: **DSE-4-MCH-101A**
Nature of the course: **Discipline Specific Elective**
Component of the course: **L=0, T=0, P=4**
Total Credit assigned:**4**
Distribution of Marks: **End Semester=80; In Semester=0 (Total= 80)**

Course Objectives:

CO-1: **To provide** hands-on training in the synthesis and instrumental characterization of coordination compounds.

CO-2: **To develop** skills in the quantitative estimation of organic compounds and the use of chromatographic methods for separation.

CO-3: **To perform and interpret** physical chemistry experiments related to chemical kinetics and molecular properties.

CO-4: **To reinforce** safety, precision, analytical thinking, and scientific reporting in laboratory work.

Course Contents

Unit	Content	Marks	L	P	T
I	Inorganic Lab I Preparation and characterization (viz. conductivity measurement, IR, UV-Vis) of the following complexes: (any two) 1. Potassium chromioxalate, $K_3[Cr(C_2O_4)_3]$ 2. Reinecke's salt 3.Tris-(thiourea) copper (I) sulphate, $[Cu(tu)_3]2SO_4.2H_2O$ 4. Potassium chromithiocyanate 5. Chloropentaminecobalt (III) chloride [Co $(NH3)_5Cl]$ Cl_2 6. Nitropentaminecobalt (III) chloride [Co (NO_2) $(NH_3)_5]$ Cl2	32	0	30	0
II	Organic Lab I 1. Organic Estimation – (Anyone) i) Estimation of glucose and sucrose in a mixture. ii) Estimation of acetone by iodoform method. iii) Estimation of hydroxyl and amino groups by acetylation method. 2. Separation and identification of three components of organic compounds present in a mixture by TLC.	20	0	30	0
III	Physical Lab I	20	0	30	0

	1. To determine the rate constant of hydrolysis of methyl acetate catalyzed by an acid and also the energy of activation. 2. To determine the velocity constant of hydrolysis of ethyl acetate by NaOH. 3. Determine the rate constant of inversion of cane sugar by analytical method. 4. Study the kinetics of the reaction between iodine and acetone in acidic medium by half life period method and determine the order with respect to iodine and acetone. 5. Determine the molar mass of a polymer by viscometric method.				
IV	Viva Marks	8			
Total		80	0	120	0

(L= Lecture, P = Practical, T = Tutorial)

Mode of Transaction: Lecture Cum Discussion, Seminars, Workshops, Group discussion, Seminars, Self Study and Library Work. (Note: This list is suggestive in nature and the modes may be stated as departmental modalities)

Mode of In-Semester Assessment:

Sessional Test:	Marks: 0
Other Sessional Activities:	Marks: 0

In- Semester Assessment Marks: 0

B. Sessional Activity

Activities selected from the above-mentioned list:

- Laboratory works

Course Learning Outcomes:

CLO-1

1.1 **To synthesize** selected coordination complexes and analyze them using conductivity, IR, and UV-Visible spectroscopy.

1.2 **To interpret** the structure and composition of metal complexes through experimental data.

1.3 **To demonstrate** proficiency in handling inorganic preparations and applying spectroscopic tools for their verification.

CLO-2

2.1 **To estimate** functional groups (hydroxyl, amino, carbonyl) and sugars in organic mixtures using classical methods.

2.2 **To perform and analyze** thin-layer chromatography (TLC) for separation and identification of organic compounds.

2.3 **To demonstrate** accuracy in organic qualitative and quantitative experiments.

CLO-3

3.1 To determine rate constants and activation energy for hydrolysis and kinetic reactions using titration and half-life methods.

3.2 **To calculate** molecular weight of polymers using viscometric analysis.

3.3 **To apply** principles of chemical kinetics and evaluate reaction mechanisms from experimental data.

CLO-4

4.1 **To demonstrate** appropriate use of lab instruments and follow safety protocols.

4.2 **To communicate** experimental findings effectively during viva and through written documentation.

Cognitive Map of Course Outcomes Based on Revised Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge	CO-1, CO-2, CO-3	CO-1, CO-2, CO-3	CO-2			
Conceptual Knowledge		CO-1, CO-2, CO-3	CO-1, CO-2, CO-3	CO-3	CO-3	
Procedural Knowledge			CO-1, CO-2, CO-3	CO-2, CO-3	CO-3	CO-4
Metacognitive Knowledge					CO-4	CO-4

Mapping of Course Learning Outcomes (CLO's) to Programme Specific Outcomes (PSO's)

CLO / PSO	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8
CLO-1	3	3	2	2	2	2	2	2
CLO-2	3	3	2	2	2	2	2	2
CLO-3	3	3	3	2	2	2	2	3
CLO-4	2	3	2	3	2	3	3	2
Average	**2.75**	**3**	**2.25**	**2.25**	**2**	**2.25**	**2.25**	**2.25**

[3 = Strongly aligned, 2 = Moderately aligned, 1 = Weakly aligned]

Suggested Readings:

1. Khosla, B. D.; Garg, V. C. & Gulati, A., Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed.; McGraw-Hill: New York (2003).
3. Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co.: New York (2003).
4. Yadav, J.B., Advanced Practical Physical Chemistry 32nd Ed; Goel Publishing Hour
5. Vogel's Qualitative Inorganic Analysis, Revised by G. Svehla.
6. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
7. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)
8. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry:
9. Preparation and Quantitative Analysis, University Press (2000).

SEMESTER-I
(Option-II)

Course Title: **Laboratory Course-I**
Course Code: **DSE-4-MCH-101B**
Nature of the course: **Discipline Specific Elective**
Component of the course: **L=3, T=1, P=0**
Total Credit assigned:**4**
Distribution of Marks: **End Semester=56; In Semester=24 (Total= 80)**

Course Objectives:

CO-1: **To develop** the ability to synthesize and characterize coordination compounds using modern instrumental techniques.

CO-2: **To introduce** the concept of green chemistry through the preparation and **use** of ionic liquids in organic synthesis.

CO-3: **To perform** experiments related to chemical kinetics, molecular properties, and solution chemistry.

CO-4: **To enhance** analytical, documentation, and oral communication skills through laboratory practice and viva-voce.

Course Contents

Unit	Content	Marks	L	P	T
I	**Inorganic Lab I** Preparation and characterization (viz. conductivity measurement, IR, UV-Vis) of the following complexes: (any two) 1. Sodium ferrioxalate, $Na_3[Fe(C_2O_4)_3]\ 9H_2O$ 2. Tetraamine Cu (II)sulphate, $[Cu\ (NH_3)_4]\ SO_4.H_2O$ 3. Hexa-amine Ni (II) chloride $[Ni\ (NH_3)_6]\ Cl_2$ 2. Sodium CobaltinitriteNa3$[Co\ (NO_2)_6]$ 5. Nitritopentaminecobalt(III) chloride, $[Co(ONO)\ (NH_3)_5]Cl_2$ 6. Hexamine Co (III) sulphatepentahydrate, $[Co\ (NH_3)_6]_2(SO4_3.5H_2O$	32	0	40	0
II	**Organic Lab I** Preparation of Green solvent: Ionic liquid and its use in organic reactions	20	0	40	0
III	**Physical Lab I** 1. To determine the rate constant of hydrolysis of ethyl acetate catalyzed by an acid and the energy of activation. 2. Study the complex formation between Cu2+ ion and ammonia by distribution method and find the	20	0	40	0

	composition of the complex. 3. To determine the radius of a molecule (glycerol) by viscosity measurements. 4. To study the kinetics of reaction between K2S2O8 and KI. a) Determine the rate constant and order of the reaction b) Study the influence of ionic strength on the rate constant. 5. Determine the partial molar volume of ethanol by determining the densities of dilute aqueous solutions.				
IV	Viva Marks	8			
Total		**80**	**0**	**120**	**0**

(L= Lecture, P = Practical, T = Tutorial)

Mode of Transaction: Lecture Cum Discussion, Seminars, Workshops, Group discussion, Seminars, Self Study and Library Work. (Note: This list is suggestive in nature and the modes may be stated as departmental modalities)

Mode of In-Semester Assessment: none

Sessional Test:	Marks: 0
Other Sessional Activities:	Marks: 0

In- Semester Assessment Marks: 0

Sessional Activity

Activities selected from the above-mentioned list:

- Laboratory works

Course Learning Outcomes:

CLO-1

1.1 **To synthesize** transition metal coordination complexes and apply spectroscopic (UV-Vis, IR) and conductivity methods for characterization.

1.2 **To interpret** the bonding and structure of synthesized inorganic complexes through experimental data.

1.3 **To demonstrate** competence in inorganic synthesis, purification, and analytical techniques.

CLO-2

2.1 **To prepare** ionic liquids as green solvents and to apply them in selected organic

reactions.

2.2 **To evaluate** the advantages of green chemistry approaches in laboratory-scale synthesis.

2.3 **To understand** the role of environmentally friendly solvents in promoting sustainable chemistry.

CLO-3

3.1 **To determine** rate constants, order of reaction, and activation energy using kinetic experiments.

3.2 To **study** complex formation reactions and determine molecular composition using distribution methods.

3.3 **To calculate** molecular parameters such as viscosity, partial molar volume, and investigate the influence of ionic strength on reaction rates.

CLO-4

4.1 **To maintain** proper laboratory safety, cleanliness, and handling of reagents and instruments.

4.2 **To communicate** experimental procedures and results effectively during viva and through written laboratory reports.

Cognitive Map of Course Outcomes Based on Revised Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge	CO-1, CO-2, CO-3	CO-1, CO-2, CO-3	CO-2			
Conceptual Knowledge		CO-1, CO-2, CO-3	CO-1, CO-2, CO-3	CO-3	CO-2, CO-3	
Procedural Knowledge			CO-1, CO-2, CO-3	CO-3	CO-3	CO-4
Metacognitive Knowledge					CO-4	CO-4

Mapping of Course Learning Outcomes (CLO's) to Programme Specific Outcomes (PSO's)

CLO / PSO	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8
CLO-1	3	3	2	2	2	2	2	2
CLO-2	3	2	2	2	2	2	3	2
CLO-3	3	3	3	2	2	2	2	3
CLO-4	2	3	2	3	2	3	3	2
Average	**2.75**	**2.75**	**2.25**	**2.25**	**2**	**2.25**	**2.5**	**2.25**

[3 = Strongly aligned, 2 = Moderately aligned, 1 = Weakly aligned]

Suggested Readings:

1. Khosla, B. D.; Garg, V. C. & Gulati, A., Senior Practical Physical Chemistry, R.
   Chand & Co.: New Delhi (2011).
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed.; McGraw-Hill: New York (2003).
3. Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co.: New York (2003).
4. Yadav, J.B., Advanced Practical Physical Chemistry 32nd Ed; Goel Publishing House
5. Vogel's Qualitative Inorganic Analysis, Revised by G. Svehla.
6. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
7. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)
8. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry

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SEMESTER-I

Course Title: **Research Methodology**
Course Code:**CC-4-MCH-104A**
Nature of the course: **Core**
Component of the course: **L=3, T=1, P=0**
Total Credit assigned:**4**
Distribution of Marks: **End Semester=56; In Semester=24 (Total= 80)**

Course Objectives:

CO-1: **To provide** a foundational understanding of the research process including problem identification, hypothesis development, and literature review.

CO-2: **To introduce** methods of data collection, sampling strategies, and statistical tools for data analysis.

CO-3: **To equip** students with the knowledge to test hypotheses, interpret results, and communicate research findings effectively.

CO-4: **To develop** research writing and presentation skills, with an emphasis on academic integrity and the u**se** of digital tools in research.

Course Contents

Unit	Content	Marks	L	P	T
I	**Research Methodology** Meaning of Research (Objectives and motivation of research). Research problems and research design. Research techniques, Sampling, and data analysis. Literature survey (different sources of literature survey including online databases), defining hypothesis, Research design, Sampling Design, Data collection, Data analysis: measures of central tendency, measures of dispersion, measures of asymmetry, measures of relationship. Preparation of research manuscript. Writing a research grant proposal (research funding)	20	15	0	5
II	**Methods of Data Collection and Analysis of Data** Types of Information, Collection of Primary, secondary, and tertiary Data, Observation Method, Interview Method, Collection of Data through Questionnaires, Collection of Data through Schedules, Difference between Questionnaires and Schedules, Some Other Methods of Data Collection, Collection of Secondary Data Selection of Appropriate Method for Data Collection, Case Study Method, Processing Operations, Some Problems in Processing, Elements/Types of Analysis, Statistics in Research.	20	15	0	5
III	**Testing of Hypotheses, Interpretation and Report Writing Lecture:**	16	15	0	5

	What is a Hypothesis? Basic Concepts Concerning Testing of Hypotheses, Procedure for Hypothesis Testing, Flow Diagram for Hypothesis Testing, Measuring the Power of a Hypothesis Test, Tests of Hypotheses. Meaning of Interpretation, Why Interpretation? Technique of Interpretation: Precaution in Interpretation, Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Types of Reports (Research Project and Research article), Oral Presentation, Mechanics of Writing a Research Report, Precautions for Writing Research Reports, Conclusions, writing ethics, avoiding plagiarism, use of computers and Computer Technology in research				
Total		**56**	**45**	**0**	**15**

(L= Lecture, P = Practical, T = Tutorial)

Mode of Transaction: Lecture Cum Discussion, Seminars, Workshops, Group discussion, Seminars, Self Study and Library Work. (Note: This list is suggestive in nature and the modes may be stated as departmental modalities)

Mode of In-Semester Assessment: (24 Marks)

Sessional Test:	Marks: 15
Other Sessional Activities:	Marks: 9

In- Semester Assessment Marks: 24

Sessional Activity

Activities selected from the above-mentioned list:

- Lecture Cum Discussion,
- Seminars,
- Group discussion,
- Self-Study
- Sudden Test

Course Learning Outcomes:

CLO-1

1.1 **To define** research and explain its objectives, motivations, and processes.

1.2 **To identify and formulate** research problems and develop appropriate research and sampling designs.

1.3 **To conduct** literature surveys using diverse sources including online databases.

CLO-2

2.1 **To apply** different data collection methods such as observation, interview, questionnaire, and case study.

2.2 **To classify** primary, secondary, and tertiary data and evaluate appropriate methods for data acquisition.

2.3 **To perform** data analysis using statistical tools including measures of central tendency, dispersion, asymmetry, and correlation.

CLO-3

3.1 **To explain** the process of hypothesis formulation, testing, and the use of statistical tests in validating research.

3.2 **To interpret** research findings accurately and apply best practices in scientific writing and presentation.

3.3 **To prepare** research manuscripts, research grant proposals, and reports while adhering to ethical standards and avoiding plagiarism.

CLO-4

4.1 **To utilize** computer applications and digital tools for data analysis, manuscript preparation, and presentation.

4.2 **To organize** and present research findings through written reports and oral presentations effectively.

Cognitive Map of Course Outcomes Based on Revised Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge	CO-1, CO-2	CO-1, CO-2	CO-2			
Conceptual Knowledge		CO-1, CO-2, CO-3	CO-2, CO-3	CO-2, CO-3	CO-3	
Procedural Knowledge			CO-2, CO-3, CO-4	CO-3	CO-3, CO-4	CO-3, CO-4
Metacognitive Knowledge					CO-4	CO-4

Mapping of Course Learning Outcomes (CLO's) to Programme Specific Outcomes (PSO's)

CLO / PSO	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8
CLO-1	2	1	2	2	2	2	2	3
CLO-2	2	2	2	2	2	2	2	3
CLO-3	2	2	3	3	2	3	3	3
CLO-4	2	2	2	3	2	3	2	3
Average	**2**	**1.75**	**2.25**	**2.5**	**2**	**2.5**	**2.25**	**3**

[3 = Strongly aligned, 2 = Moderately aligned, 1 = Weakly aligned]

Suggested Readings:

1. C. R. Kothari and Gaurav Garg, Research Methodology Methods, and techniques, New Age International
2. Ghosh, B.N., *Scientific Methods and Social Research,* New Delhi: Sterling Publishers Pvt. Ltd.,
3. Gopal, M.H., *Research Reporting in Social Sciences,* Dharwar: Karnatak University
4. Hillway, T., *Introduction to Research,* 2nd ed., Boston: Houghton Mifflin

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SEMESTER-I
(Option2)

Course Title: **Tools and Techniques in Research Methodology**
Course Code:**CC-4-MCH-103**
Nature of the course: **Core**
Component of the course: **L=3, T=1, P=0**
Total Credit assigned:**4**
Distribution of Marks: **End Semester=56; In Semester=24 (Total= 80)**

Course Objectives:

CO-1: **To introduce** the fundamental concepts and processes of research, including its purpose, characteristics, types, and stages.

CO-2: **To equip** students with the skills to design research studies and identify relevant research problems.

CO-3: **To familiarize** students with various sampling techniques and tools for data collection in research.

CO-4: **To enable** learners to process and statistically analyze data using appropriate methods and **interpret** findings accurately.

Course Contents

Unit	Content	Marks	L	P	T
I	**Introduction to Research Methodology:** Meaning of Research, Definitions of Research, Purpose of Research, Characteristics of Research, Types of Research. Research process, (i) Formulating the Research Problem (ii) Extensive Literature Survey (iii) Developing the Research Hypothesis (iv) Preparing the Research Design (v) Determining the Research Design (vi) Collecting the Research Data (vii) Execution of the Project (viii) Analysis of Data (ix) Hypothesis Testing (x) Generalization and Interpretation (xi) Preparing of the Report or Presentation of the Result.	16	10	0	5
II	**Research Design and Problem Identification** Research design, Purpose of Research Design, Characteristics of Good Research Design Research Problem, Definitions of the Problem, Identification of a Research Problem, The Sources of the Problem, Statement of Problem, Objectives of Assumptions about the Problem, Aspects of Delimiting a Problem, Evaluation of the Problem.	16	10	0	5

III	**Sampling Techniques and Tools for Data Collection in Research Methodology:** Sampling, Census Method or Parametric method and Sampling method or Non-parametric method, Assumptions of Sampling, Need of Sampling, Advantages of Sampling, Disadvantages or Limitation of Sampling, Essentials of an Ideal Sample, Characteristics of a Good Sample, Types of Sampling Designs/Methods of Sampling, Difference between Probability and Non-Probability Sampling, Simple Random Sampling, Systematic Sampling, Stratified Sampling, Multiple or Double Repetitive Sampling, Multi Stage Sampling, Cluster Sampling, Non-Probability Sampling Method, incidental or Accidental Sampling, Judgment Sampling, Purposive Sampling, Quota Sampling, Snowball Sampling, Purposive or Expert Choice Sampling, Tools of Data Collection, Questionnaires, Interviews, Schedules, Observation Techniques, Rating Scales.	16	10	0	5
IV	**Data Processing and Statistical Analysis in Research:** Processing and Analysis of Data, Processing Operations, Some Problems in Processing, Elements/Types of Analysis, Statistics in Research, Measures of Central Tendency, Measures of Dispersion, Measures of Asymmetry (Skewness), Measures of Relationship, Simple Regression Analysis, Multiple Correlation and Regression, Partial Correlation, Association in Case of Attributes, Other Measures.	8	15	0	5
Total		56	45	0	15

(L= Lecture, P = Practical, T = Tutorial)

Mode of Transaction: Lecture Cum Discussion, Seminars, Workshops, Group discussion, Seminars, Self Study and Library Work. (Note: This list is suggestive in nature and the modes may be stated as departmental modalities)

Mode of In-Semester Assessment: (24 Marks)

Sessional Test: Marks: 15

Other Sessional Activities: Marks: 09

In- Semester Assessment Marks: 24

Sessional Activity

Activities selected from the above-mentioned list:

- Lecture Cum Discussion,
- Seminars,
- Group discussion,
- Self-Study
- Sudden Test

Course Learning Outcomes:

CLO-1
1.1 **To define** research and **explain** its types, characteristics, and objectives.

1.2 **To describe and apply** the steps involved in the research process from problem formulation to report presentation.

1.3 **To evaluate** the significance of hypothesis development, research design, and literature review in research planning.

CLO-2

2.1 **To define and identify** research problems and explain their significance.
2.2 **To design** structured research plans with clearly defined objectives and delimitations.
2.3 **To assess** the characteristics of a good research design and apply them in various research contexts.

CLO-3
3.1 **To explain** the need, advantages, and limitations of sampling in research.

3.2 **To differentiate** between probability and non-probability sampling methods and apply appropriate techniques.

3.3 **To select and use** suitable tools for data collection such as questionnaires, interviews, schedules, and rating scales.

CLO-4
4.1 **To process** research data accurately and identify potential issues in data handling.

4.2 **To apply** statistical tools including measures of central tendency, dispersion, skewness, and correlation in data analysis.

4.3 **To perform** regression analysis and interpret research findings for drawing valid conclusions.

Cognitive Map of Course Outcomes Based on Revised Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge	CO-1, CO-2, CO-3	CO-1, CO-2, CO-3	CO-3			
Conceptual Knowledge		CO-1, CO-2, CO-3, CO-4	CO-2, CO-3, CO-4	CO-3, CO-4	CO-1, CO-2	
Procedural Knowledge			CO-3, CO-4	CO-3, CO-4	CO-4	CO-4
Metacognitive Knowledge					CO-4	CO-4

Mapping of Course Learning Outcomes (CLO's) to Programme Specific Outcomes (PSO's)

CLO / PSO	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8
CLO-1	2	1	2	2	2	2	2	3
CLO-2	2	1	2	2	2	2	2	3
CLO-3	2	2	2	2	2	2	2	3
CLO-4	2	2	2	2	2	3	2	3
Average	**2**	**1.5**	**2**	**2**	**2**	**2.25**	**2**	**3**

[3 = Strongly aligned, 2 = Moderately aligned, 1 = Weakly aligned]

Suggested Readings:

1. C. R. Kothari and Gaurav Garg, Research Methodology Methods, and techniques, New Age International
2. Ghosh, B.N., *Scientific Methods and Social Research,* New Delhi: Sterling Publishers Pvt. Ltd.,
3. Gopal, M.H., *Research Reporting in Social Sciences,* Dharwar: Karnatak University
4. Hillway, T., *Introduction to Research,* 2nd ed., Boston: Houghton Mifflin

SEMESTER-II

Course Title: **Inorganic Chemistry-II**
Course Code:**CC-4-MCH-201**
Nature of the course: **Core**
Component of the course: **L=3, T=1, P=0**
Total Credit assigned:**4**
Distribution of Marks: **End Semester=56; In Semester=24 (Total= 80)**

Course Objectives:

CO-1: **To understand** the thermodynamic and kinetic stability of coordination compounds, and **to analyze** substitution and electron transfer reaction mechanisms.

CO-2: **To introduce** the fundamental principles of molecular symmetry and group theory, and their applications in classifying molecular structures.

CO-3: **To apply** group theory in the interpretation of spectroscopic data and reaction mechanisms, including orbital symmetry and selection rules.

Course Contents

Unit	Content	Marks	L	P	T
I	**Reaction mechanism II** Lability and inertness, stability constant- formation constant of complexes, chelate effect, Thermodynamic and Kinetic stability; inert and labile complexes; Factor affecting stability, Correlation of stability constant with thermodynamic factors –G, H and S. Determination of stability constant –Jobs and Bjerrum's methods. Mechanism of ligand replacement reactions: Substitution reactions in octahedral [Cr(III), Co(III)] and square planar [Rh(I), Pt(II) and Pd(II)] complexes, Rate of water replacement reaction; Solvolysis and hydrolysis reaction; acid hydrolysis and base hydrolysis reaction; Factors affecting the rate of substitution reaction, trans effect and its importance, theories of trans effect, idea concerning electron transfer reactions, inner and outer sphere reactions.	20	15	0	5
II	**Symmetry operation, elements of symmetry** Matrices and matrix representation of symmetry operations, Definition of Group, finite and infinite group. Examples of groups using geometrical object and symmetry operations. Symmetry elements as elements of group. Point groups. Orthogonality theorem: reducible and irreducible representation, use of vectors and mathematical functions in group representation, Character table for molecular point	20	15	0	5

	group, construction of C2v and C3v Character table. Direct product representation. Projection operator, symmetry adapted linear combination (SALC) for C2v, C3v, D4h and Td point group molecules.				
III	**Chemical Application of Group Theory** Use of group theory in construction of hybrid Orbitals (d2sp and sp3 hybrids). Infrared absorption and Raman scattering spectroscopy, vibrational modes as bases for group representation, Symmetry selection rules for IR and Raman Spectra. Classification of vibrational modes and vibrational analysis. Orbital Symmetry and Chemical reactions – Woodward and Hoffman rules for electrocyclic and cycloaddition reactions.	16	15	0	5
Total		**56**	**45**	**0**	**15**

(L= Lecture, P = Practical, T = Tutorial)

Mode of Transaction: Lecture Cum Discussion, Seminars, Workshops, Group discussion, Seminars, Self Study and Library Work. (Note: This list is suggestive in nature and the modes may be stated as departmental modalities)

Mode of In-Semester Assessment: (24 Marks)

Sessional Test: Marks: 15
Other Sessional Activities: Marks: 9

In- Semester Assessment Marks: 24

Sessional Activity

Activities selected from the above-mentioned list:

- Lecture Cum Discussion,
- Seminars,
- Group discussion,
- Self-Study
- Sudden Test

Course Learning Outcomes:

CLO-1

1.1 **To define and distinguish** between labile and inert complexes based on thermodynamic and kinetic factors.

1.2 **To determine** stability constants using Job's and Bjerrum's methods and relate them to ΔG, ΔH, and ΔS.

1.3 **To analyse** ligand substitution mechanisms in octahedral and square planar complexes.

1.4 **To explain** the trans effect and its role in substitution reactions, and to describe inner- and outer-sphere electron transfer processes.

CLO-2

2.1 **To define** symmetry operations and elements and classify molecules into point groups.

2.2 **To apply** matrix representations and group theory concepts to molecular symmetry.

2.3 **To construct** character tables (C_{2v}, C_{3v}) and use orthogonality and projection operators for generating symmetry-adapted linear combinations (SALCs).

CLO-3

3.1 **To use** group theory to construct hybrid orbitals and predict bonding geometries.

3.2 **To apply** symmetry selection rules in interpreting IR and Raman spectra.

3.3 **To analyse** vibrational modes based on group representation and perform vibrational analysis.

3.4 **To explain** the role of orbital symmetry in pericyclic reactions using Woodward-Hoffmann rules.

Cognitive Map of Course Outcomes Based on Revised Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge	CO-1, CO-2	CO-1, CO-2				
Conceptual Knowledge		CO-1, CO-2, CO-3	CO-2, CO-3	CO-1, CO-2, CO-3	CO-1, CO-3	
Procedural Knowledge			CO-1, CO-2, CO-3	CO-2, CO-3	CO-3	CO-3
Metacognitive Knowledge					CO-3	CO-3

Mapping of Course Learning Outcomes (CLO's) to Programme Specific Outcomes (PSO's)

CLO / PSO	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8
CLO-1	3	2	2	2	2	2	1	2
CLO-2	3	2	3	2	2	2	2	3
CLO-3	3	3	3	2	2	2	2	3
Average	**3**	**2.33**	**2.67**	**2**	**2**	**2**	**1.67**	**2.67**

[3 = Strongly aligned, 2 = Moderately aligned, 1 = Weakly aligned]

Suggested Readings:

1. Inorganic Chemistry: Principles of structure and reactivity, 4thEdition; J.E. Huheey, E.A. Keiter, R.L. Keiter, O.K. Medhi.
2. Advanced Inorganic Chemistry, 6thEdition, F.A. Cotton, G. Wilkinson, C.A. Murillo and M. Bochmann.
3. Inorganic Chemistry, K.F. Purcell, and J.C. Kotz.

SEMESTER-II

Course Title: **Organic Chemistry-II**
Course Code:**CC-4-MCH-202**
Nature of the course: **Core**
Component of the course: **L=3, T=1, P=0**
Total Credit assigned:**4**
Distribution of Marks: **End Semester=56; In Semester=24 (Total= 80)**

Course Objectives:

CO-1: **To provide** comprehensive knowledge of NMR spectroscopy and its applications in molecular structure determination.

CO-2: **To introduce** structural elucidation, synthesis, and biogenesis of alkaloids and terpenoids.

CO-3: **To explain** structural features and synthetic strategies of carbohydrates and peptides.

CO-4: **To explore** principles of heterocyclic chemistry and synthesis of important heterocycles.

CO-5: **To understand** the fundamental concepts of stereochemistry and apply them in stereoselective synthesis.

Course Contents

Unit	Content	Marks	L	P	T
I	**NMR spectroscopy** NMR spectroscopy: Chemical shift, factors affecting chemical shift, spin- spin interaction, coupling constant and Factors affecting, relaxation processes, NOE, Nuclear magnetic double resonance, shift resonance, spin tickling; Proton and 13C NMR spectroscopy of simple organic molecules, living systems – MRI, Two-dimensional NMR, NOESY, DEPT, INEPT terminology, Instrumentation, FT NMR. IR: Application of IR in organic spectroscopy	12	9	0	5
II	**Alkaloids** Alkaloids: Occurrence, classification, general methods of isolation, test for detection. Structure elucidation by physical and chemical methods and synthesis of: Piperine, and Morphine. Terpenoids: Occurrence and classification, isoprene rule, general methods of isolation. Biogenetic pathway of mono- and sesquiterpenes. Structure determination by physical and chemical methods and synthesis of the following: Acyclic monoterpenoid – Linalool.	12	9	0	2

	Monocyclic monoterpenoid -Terpineol, Menthol.				
III	**Carbohydrates** Structure and conformation of disaccharides – sucrose and lactose. Polysaccharides – starch and cellulose. Peptides and Proteins: Structure determination and synthesis of small peptides (di-, and tri-). Solid phase synthesis of peptides. Classification of proteins. Primary, secondary and tertiary structure of proteins.	12	9	0	2
IV	**Heterocyclic Chemistry** Heterocyclic Chemistry: Principles of heterocyclic synthesis involving cyclization and cycloaddition reaction. Synthesis and properties heterocycles containing one and two heteroatoms viz., N, O and S (aziridine, oxirane, pyrazole, isoxazole, imidazole, oxazole and thiazole).	8	9	0	2
V	**Stereochemistry** Concept of pro stereoisomerism and prochirality – Homotopic and heterotopic ligands and faces; Optical purity and enantiomeric excess; Chirality in molecules devoid of chiral centers - allenes, spirans and biphenyls. Classification of stereoselective synthesis: diastereoselective and enantioselective reactions; Nucleophilic addition to aldehydes and acyclic ketones: Cram and Felkin – Ahn model. Enantioselective synthesis.	12	9	0	4
Total		56	45	0	15

(L= Lecture, P = Practical, T = Tutorial)

Mode of Transaction: Lecture Cum Discussion, Seminars, Workshops, Group discussion, Seminars, Self Study and Library Work. (Note: This list is suggestive in nature and the modes may be stated as departmental modalities)

Mode of In-Semester Assessment: (24 Marks)

Sessional Test:	Marks: 15
Other Sessional Activities:	Marks: 9
In- Semester Assessment	Marks: 24

Sessional Activity

Activities selected from the above-mentioned list:

- Lecture Cum Discussion,
- Seminars,
- Group discussion,
- Self-Study
- Sudden Test

Course Learning Outcomes:

CLO-1

1.1 **To explain** the principles of NMR spectroscopy, including chemical shift, spin-spin coupling, relaxation, and instrumentation.

1.2 **To interpret** proton and carbon NMR spectra of organic molecules and biomolecules, including applications like MRI and 2D NMR techniques (NOESY, DEPT, INEPT).

1.3 **To apply** IR spectroscopy in identifying organic functional groups and molecular structure.

CLO-2

2.1 **To classify and describe** the occurrence and extraction methods of alkaloids and terpenoids.

2.2 **To elucidate** structures of natural products like piperine and morphine using physical and chemical techniques.

2.3 **To explain** the biogenetic pathways of mono- and sesquiterpenes and synthesize key terpenoids like linalool, terpineol, and menthol.

CLO-3

3.1 **To describe** the structure and conformation of important disaccharides and polysaccharides.

3.2 **To determine and synthesize** small peptides using conventional and solid-phase techniques.

3.3 **To classify** proteins and describe their primary, secondary, and tertiary structures.

CLO-4

4.1 **To explain** the principles of heterocyclic synthesis, including cyclization and cycloaddition.

4.2 **To synthesize and analyze** the chemical properties of heterocycles containing one or more heteroatoms (N, O, S), including aziridine, oxirane, pyrazole, imidazole, and thiazole.

CLO-5

5.1 **To define and apply** concepts of prochirality, optical purity, and chirality in systems without chiral centres.

5.2 **To classify** stereoselective reactions and apply models (Cram, Felkin–Ahn) for predicting stereochemical outcomes.
5.3 **To perform** retrosynthetic analysis for enantioselective and diastereoselective syntheses.

Cognitive Map of Course Outcomes Based on Revised Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge	CO-1, CO-2	CO-1, CO-2	CO-1, CO-2			
Conceptual Knowledge		CO-2, CO-3, CO-4	CO-2, CO-3, CO-4	CO-3, CO-5	CO-4, CO-5	
Procedural Knowledge			CO-3, CO-4, CO-5	CO-4, CO-5	CO-5	CO-5
Metacognitive Knowledge						CO-5

Mapping of Course Learning Outcomes (CLO's) to Programme Specific Outcomes (PSO's)

CLO / PSO	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8
CLO-1	3	3	2	2	2	2	2	3
CLO-2	3	3	3	2	2	2	2	2
CLO-3	3	3	3	2	2	2	2	3
CLO-4	3	2	3	3	2	2	2	2
CLO-5	3	2	3	3	3	2	3	3
Average	**3.0**	**2.6**	**2.8**	**2.4**	**2.2**	**2.0**	**2.2**	**2.6**

[3 = Strongly aligned, 2 = Moderately aligned, 1 = Weakly aligned]

Suggested Readings:

1. Organic Chemistry of Natural Products, Vol I and II, Gurdeep Chatwal, Himalaya Publishing House, Bombay.
2. Heterocyclic Chemistry: Synthesis, Reactions and Mechanisms – Raj K. Bansal, Wiley Eastern.
3. Chemistry of Organic Natural Products, Vol I and II, O.P. Agarwal, Goel Publishing House, Meerut.
4. The Alkaloids: K. W. Bentley.
5. Organic Chemistry, Vol- II, I.L. Finar
6. Heterocyclic Chemistry – T.L. Gilchrist, Longman Scientific and Technical/Pitman Publ. Ltd.

SEMESTER-II

Course Title: **Physical Chemistry-II**
Course Code:**CC-4-MCH-203**
Nature of the course: **Core**
Component of the course: **L=3, T=1, P=0**
Total Credit assigned:**4**
Distribution of Marks: **End Semester=56; In Semester=24 (Total= 80)**

Course Objectives:

CO-1: **To understand** the theoretical principles, selection rules, and instrumentation of various spectroscopic techniques.

CO-2: **To interpret** spectroscopic data for structural elucidation of organic and inorganic compounds.

CO-3: **To develop** problem-solving skills through the application of spectroscopy in modern chemical analysis.

CO-4: **To integrate** advanced spectroscopic techniques in research and practical applications.

Course Contents:

Unit	Content	Marks	L	P	T
I	**Raman Spectroscopy** Quantum theory of Raman Effect, Selection rules, mutual exclusion principle, vibration rotation Raman spectra. Intensity of Raman lines.	10	8	0	2
II	**UV-Visible spectroscopy** Electronic transitions and selection rules, Frank Condon principle and electronic spectra of polyatomic molecules, Fluorescence and phosphorescence, solvent effects, absorption and intensity shifts, Calculation of absorption maxima by Woodward-Fieser Rules.	10	8	0	3
III	**Mass spectrometry** Ion fragmentation mechanism, Base peak and molecular ion peak, metastable peak, instrumentation and techniques, ionization methods, isotopic distribution, Application in determining the structure of organic and inorganic compounds.	10	8	0	3
IV	**Photoelectron Spectroscopy** Introduction to Photoelectron Spectroscopy, Auger electron spectroscopy. Chemical information from ESCA	8	8	0	2

V	**Mossbauer spectroscopy** Principle of Mossbauer spectroscopy, Instrumentation, Application of Mossbauer spectroscopy: the isomer shift, magnetic interaction, quadruple splitting, line with. Application to iron to iron and tin compounds.	8	8	0	3
VI	**ESR spectroscopy** Principle, resonance condition, Origin of g-value, spin orbit coupling, Kramer degeneracy, zero-field splitting, hyperfine & super hyper interaction, line width and application of ESR in organic radicals.	10	5	0	2
Total		**56**	**45**	**0**	**15**

(L= Lecture, P = Practical, T = Tutorial)

Mode of Transaction: Lecture Cum Discussion, Seminars, Workshops, Group discussion, Seminars, Self Study and Library Work. (Note: This list is suggestive in nature and the modes may be stated as departmental modalities)

Mode of In-Semester Assessment:(24 Marks)

Sessional Test:	Marks: 15
Other Sessional Activities:	Marks: 9

In- Semester Assessment Marks: 24

Sessional Activity

Activities selected from the above-mentioned list:

- Lecture Cum Discussion,
- Seminars,
- Group discussion,
- Self-Study
- Sudden Test

Course Learning Outcomes:

CLO-1

1.1 **To explain** the quantum mechanical basis of Raman Effect and apply selection rules.

1.2 **To interpret** vibrational-rotational Raman spectra and apply the mutual exclusion principle.

1.3 **To assess** the intensity of Raman lines in molecular systems.

CLO-2

2.1 **To describe** electronic transitions and selection rules in UV-Visible spectroscopy.

2.2 **To apply** the Franck-Condon principle and analyze solvent effects and spectral

shifts.
2.3 **To calculate** λmax using Woodward–Fieser rules for conjugated systems.

CLO-3
3.1 **To explain** ion fragmentation mechanisms and identify peaks (molecular ion, base, metastable) in mass spectra.
3.2 **To describe** instrumentation and ionization techniques in mass spectrometry.
3.3 **To apply** mass spectrometry in structural elucidation of organic and inorganic compounds.

CLO-4
4.1 **To explain** the principle and chemical applications of photoelectron spectroscopy (UPS and XPS).
4.2 **To interpret** chemical shifts and Auger electron spectra to derive electronic structure information.

CLO-5
5.1 **To describe** the principle and instrumentation of Mössbauer spectroscopy.
5.2 **To interpret** spectral parameters such as isomer shift, quadrupole splitting, and magnetic interactions.
5.3 **To apply** Mössbauer spectroscopy to iron and tin compounds in coordination and organometallic chemistry.

CLO-6
6.1 **To describe** the principles and resonance condition of ESR spectroscopy.
6.2 **To explain** the significance of g-values, hyperfine interactions, and zero-field splitting.
6.3 **To apply** ESR spectroscopy to organic radicals and transition metal complexes.

Cognitive Map of Course Outcomes Based on Revised Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge	CO-1, CO-2	CO-1, CO-2	CO-2			
Conceptual Knowledge		CO-1, CO-2, CO-3	CO-2, CO-3	CO-3, CO-4	CO-3, CO-4	
Procedural Knowledge			CO-3, CO-4	CO-3, CO-4	CO-4	CO-4
Metacognitive Knowledge						CO-4

Mapping of Course Learning Outcomes (CLO's) to Programme Specific Outcomes (PSO's)

CLO / PSO	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8
CLO-1	3	2	2	2	2	2	2	2
CLO-2	3	2	2	2	2	2	2	2
CLO-3	3	3	3	2	2	2	2	3
CLO-4	3	3	3	2	2	2	2	3
CLO-5	3	3	3	3	2	2	2	3
CLO-6	3	3	3	2	2	2	2	3
Average	**3.0**	**2.7**	**2.7**	**2.2**	**2.0**	**2.0**	**2.0**	**2.5**

[3 = Strongly aligned, 2 = Moderately aligned, 1 = Weakly aligned]

Suggested Readings:

1. Fundamentals of Molecular Spectroscopy by C.N. Banwell and E.M. McCash, Tata McGraw Hill.
2. Introduction to Molecular Spectroscopy by G.M. Barrow, McGraw Hill.
3. Physical Chemistry by P.W. Atkins
4. Quantum Chemistry, by Ira N. Levine, Pentice Hall
5. Organic Spectroscopy – by William Kemp, Palgrave Macmillan.

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SEMESTER-II
(Option 1)

Course Title: **Laboratory Course-II**
Course Code: **DSE-4-MCH-201A**
Nature of the course: **Discipline Specific Elective**
Component of the course: **L=0, T=0, P=4**
Total Credit assigned:**4**
Distribution of Marks: **End Semester=80; In Semester=0 (Total= 80)**

Course Objectives:

CO-1: **To provide** hands-on training in inorganic analysis of ores, alloys, and the synthesis of nanoparticles using established techniques.

CO-2: **To introduce** qualitative separation, identification, and simple organic synthesis methods using classical and chromatographic techniques.

CO-3: **To perform** analytical and kinetic measurements using physical chemistry experiments and instrumentation such as conductometry and polarimetry.

CO-4: **To enhance** scientific reporting, critical thinking, and oral communication skills through laboratory-based assessments.

Course Contents

Unit	Content	Marks	L	P	T
I	**Inorganic Lab 2** 1. Estimation of $Mg2^+$ and $Ca2^+$ by complexometric method in different ores and from given solution with one / two components. 2. Estimation of alloys – Brass, Cu-Ni, etc. 3. Synthesis and characterization of nanoparticles by sol-gel and co-precipitation methods.	24	0	40	0
II	**Organic Lab 2** 1. Separation and identification of amino acids present in a mixture by paper chromatography. 2. Organic Preparation - Cannizaro reaction of benzaldehyde (separation of benzyl alcohol and benzoic acid by solvent extraction) Oxidation of p-nitrotoluene to p-nitrobenzoic acid Reduction of benzophenone to benzhydrol Phthalic anhydride to phthalimide One –step preparation	24	0	40	0
III	**Physical Lab 2** To study hydrolysis of methyl acetate in presence of HCl and H_2SO_4 and hence analytically	24	0	40	0

	To determine Polarimetrically the relative strength of the acids (use Guggenheim method) 1. Determine the equivalent conductivity of acetic acid at infinite dilution by Kohlrausch's method. 2. Determine the relative strength of acetic acid and mono chloro acetic acid by conductance measurement. 3. Determine the specific rotation of sucrose and hence determine the unknown concentration of supplied solution by polarimetric measurements. 1. Determination of pH of a mixture of CH_3COOH and CH_3COONa and hence determine the dissociation constant of the acid. 2. Preparation of conducting polymers and study of their electrical conductivity.				
IV	Viva	8			
Total		80	0	120	0

(L= Lecture, P = Practical, T = Tutorial)

Mode of Transaction: Lecture Cum Discussion, Seminars, Workshops, Group discussion, Seminars, Self Study and Library Work. (Note: This list is suggestive in nature and the modes may be stated as departmental modalities)

Mode of In-Semester Assessment: None

Sessional Test:	Marks: 0
Other Sessional Activities:	Marks: 0

In- Semester Assessment Marks: 0

Sessional Activity

Activities selected from the above-mentioned list:

- Laboratory works
- Group discussion,
- Self-Study

Course Learning Outcomes:

CLO-1

1.1 **To estimate** divalent metal ions (Mg^{2+}, Ca^{2+}) using complexometric titration methods.

1.2 **To analyze** the composition of alloys such as brass and Cu-Ni through quantitative inorganic analysis.

1.3 **To synthesize** metal oxide or mixed-metal nanoparticles via sol-gel and co-precipitation methods and to characterize their physical properties.

CLO-2

2.1 **To separate and identify** amino acids in mixtures using paper chromatography.

2.2 **To perform** classical organic preparations such as Cannizzaro reactions, oxidations, and reductions.

2.3 **To purify and identify** organic products using solvent extraction and melting point techniques.

CLO-3

3.1 **To compare** the catalytic efficiency of strong acids (HCl vs. H_2SO_4) in ester hydrolysis using the Guggenheim method.

3.2 **To determine** equivalent and specific conductance values of weak and substituted acids using conductometric methods.

3.3 **To analyze** the optical activity of compounds using polarimetry and determine concentrations of optically active substances.

3.4 **To calculate** dissociation constants using pH measurements of buffer solutions
.

3.5 **To prepare** conducting polymers and measure their electrical conductivity experimentally.

CLO-4

4.1 **To demonstrate** competence in handling laboratory instruments and reagents with safety and accuracy.

4.2 **To effectively communicate** experimental procedures and interpretations through viva and laboratory records.

Cognitive Map of Course Outcomes Based on Revised Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge	CO-1, CO-2	CO-1, CO-2, CO-3	CO-1, CO-2			
Conceptual Knowledge		CO-1, CO-2, CO-3	CO-1, CO-2, CO-3	CO-3, CO-4	CO-4	
Procedural Knowledge			CO-1, CO-2, CO-3	CO-3, CO-4	CO-4	CO-3, CO-4
Metacognitive Knowledge						CO-4

Mapping of Course Learning Outcomes (CLO's) to Programme Specific Outcomes (PSO's)

CLO / PSO	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8
CLO-1	3	3	2	2	2	2	2	2
CLO-2	3	3	2	2	2	2	2	2
CLO-3	3	3	3	2	2	2	3	3
CLO-4	2	3	3	3	2	3	2	2
Average	**2.75**	**3.0**	**2.5**	**2.25**	**2.0**	**2.25**	**2.25**	**2.25**

[3 = Strongly aligned, 2 = Moderately aligned, 1 = Weakly aligned]

Suggested Readings:

1. Vogel, Arthur I: A Test book of Quantitative Inorganic Analysis (Rev. by G.H. Jeffery and others) 5th Ed., The English Language Book Society of Longman.
2. Christian, Gary D; Analytical Chemistry, 6th Ed., John Wiley & Sons, New York, 2004.
3. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000).
4. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009).
5. Khosla, B. D.; Garg, V. C. & Gulati, A., Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
6. Yadav, J.B., Advanced Practical Physical Chemistry 32nd Ed; Goel Publishing Hour

SEMESTER-II
(Option 1)

Course Title: **Laboratory Course-II**
Course Code: **DSE-4-MCH-201B**
Nature of the course: **Discipline Specific Elective**
Component of the course: **L=0, T=0, P=4**
Total Credit assigned:**4**
Distribution of Marks: **End Semester=80; In Semester=0 (Total= 80)**

Course Objectives:

CO-1: **To develop** practical skills in quantitative analysis of metal ions and alloys using complexometric methods and biogenic nanoparticle synthesis.

CO-2: **To introduce** synthetic organic transformations, including the preparation of dyes, intermediates, and green reagents.

CO-3: **To carry out** physical chemistry experiments related to solution chemistry, micelle formation, reaction kinetics, and coordination equilibria.

CO-4: **To enhance** scientific interpretation, reporting, and oral communication through viva and laboratory practices.

Course Contents

Unit	Content	Marks	L	P	T
I	**Inorganic Lab 2** 1. Estimation of $Zn2^{+}$ and Cu^{2+} by complexometric method in different ores and from given solution with one / two components. 2. Estimation of alloys – Bronze, Cu-Ni, etc. 3. Synthesis and characterization of nanoparticles by biogenic methods.	24	0	40	0
II	**Organic Lab 2** 1. Twopreparations for p-nitrobenzene azo 2-naphthol (Para Red) from p-nitroaniline. 2. Benzanilide from benzophenone. 3. Dibenzyl from benzoin 4. Preparation of Green reagent: TetrabutylammoniumTribromide (TBATB) and its use.	24	0	40	0
III	Physical Lab 2 1. Determine the specific rotation of sucrose and hence determine the unknown concentration of supplied solution by polarimetric measurements.	24	0	40	0

	2. Determine the amount of each component of the following ternary mixture by Conductometric titration. HCl, CH_3COOH, $CuSO_4$ HCl, NaCl, NH_4Cl 3. Determine the ionization constant of acetic acid by conductivity method. 4. Determination of Critical Micelle Concentration (CMC) of Sodium dodecyl sulphate (SDS) by surface tension measurement. To find the stability constant of the co-ordination compound formed between Cu2+ and 5-Sulphosalicylic acid. 1. Establish the order reaction for $K_2C_2O_4 + 2HgCl_2 \rightarrow Hg_2Cl_2 + 2KCl + 2CO_2$ by the method of ratio variation.				
	Viva	8			
	Total	80	0	120	0

(L= Lecture, P = Practical, T = Tutorial)

Mode of Transaction: Lecture Cum Discussion, Seminars, Workshops, Group discussion, Seminars, Self Study and Library Work. (Note: This list is suggestive in nature and the modes may be stated as departmental modalities)

Mode of In-Semester Assessment: **None**

Sessional Test:	Marks: 0
Other Sessional Activities:	Marks: 0

In- Semester Assessment Marks: 0

Sessional Activity

Activities selected from the above-mentioned list:

- Laboratory works
- Group discussion,
- Self-Study

Course Learning Outcomes:

CLO-1

1.1 **To estimate** Zn^{2+} and Cu^{2+} ions from ores and solutions using complexometric titration.

1.2 To **analyse** the composition of alloys such as bronze and Cu-Ni.

1.3 **To synthesize and characterize** nanoparticles using biogenic methods and understand their chemical relevance.

CLO-2

2.1 **To synthesize** organic compounds such as Para Red dye, benzanilide, and dibenzyl through classical organic reactions.

2.2 **To prepare and apply** green reagents such as tetrabutylammonium tribromide (TBATB) in organic transformations.

2.3 **To demonstrate** the ability to carry out multi-step synthesis and isolate/purify organic products effectively.

CLO-3

3.1 **To determine** the specific rotation of sucrose and calculate unknown concentrations using polarimetry.

3.2 **To perform** conductometric titrations for analysing ternary mixtures and ionization constants.

3.3 **To determine** critical micelle concentration (CMC) using surface tension measurements.

3.4 **To evaluate** stability constants for metal-ligand complexes and interpret coordination equilibria.

3.5 **To establish** reaction order through kinetic analysis using the method of variation of ratios.

CLO-4

4.1 **To follow** good laboratory practices and safety protocols while conducting experiments.

4.2 **To articulate** scientific findings effectively in viva examinations and laboratory records.

Cognitive Map of Course Outcomes Based on Revised Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge	CO-1, CO-2	CO-1, CO-2	CO-1, CO-2			
Conceptual Knowledge		CO-1, CO-2, CO-3	CO-2, CO-3	CO-3, CO-4	CO-3, CO-4	
Procedural Knowledge			CO-1, CO-2, CO-3	CO-3, CO-4	CO-4	CO-2, CO-3
Metacognitive Knowledge						CO-4

Mapping of Course Learning Outcomes (CLO's) to Programme Specific Outcomes (PSO's)

CLO / PSO	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8
CLO-1	3	3	2	2	2	2	2	2
CLO-2	3	3	3	2	2	2	3	2
CLO-3	3	3	3	2	2	2	3	3
CLO-4	2	3	2	3	2	3	2	2
Average	**2.75**	**3.0**	**2.5**	**2.25**	**2.0**	**2.25**	**2.5**	**2.25**

[3 = Strongly aligned, 2 = Moderately aligned, 1 = Weakly aligned]

Suggested Readings:

1. Vogel, Arthur I: A Test book of Quantitative Inorganic Analysis (Rev. by G.H. Jeffery and others) 5th Ed., The English Language Book Society of Longman.
2. Christian, Gary D; Analytical Chemistry, 6th Ed., John Wiley & Sons, New York, 2004.
3. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000).
4. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009).
5. Khosla, B. D.; Garg, V. C. & Gulati, A., Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
6. Yadav, J.B., Advanced Practical Physical Chemistry 32nd Ed; Goel Publishing Hour

SEMESTER-II

Course Title: Internship/Apprenticeship/**Community Engagement)**
Course Code:**CC-4-MCHE-204**
Nature of the course: **Core**
Component of the course: **L=0, T=0, P=4**
Total Credit assigned:**4**
Distribution of Marks: **End Semester=80; In Semester=0 (Total= 80)**

Course Objectives:

CO-1: To develop technical Skills of the students through internship programmes

CO-2: To develop skills in planning, executing, and managing projects within a specified timeframe and budget.

CO-3: To cultivate the ability to identify issues, analyze data, and implement effective solutions in a professional context.

Course Contents

Unit	Content	Marks	L	P	T
			0	120	0

(L= Lecture, P = Practical, T = Tutorial)

Mode of In-Semester Assessment: **NONE**

Preparation and Submission of Report of Internship/Apprenticeship/Community Engagement **Activity: Marks 80**
Marks' Distribution:
Objective/Importance of the present work Marks 10
Field/experimental work Marks 35
Discussion of the Present work/Results/Observations Marks 25
Presentation/Viva Marks 10

Students will go for internship/Apprenticeship in the concerned subject or an allied field and will submit a report of the same after the completion of the internship/Apprenticeship.

Students may undertake community engagement activities during which they can leverage their specialized knowledge to benefit local communities. Some possible programmes are:

a. Science Workshops for Schools: Hands-on experiments, science fairs, chemistry magic shows, and career talks.
b. Public Health and Safety Campaigns: Partner with local health organizations to educate the community on issues related to chemical safety, environmental hazards, and health.
c. Environmental Conservation Projects: Water and soil testing for pollutants, community clean-up drives, and developing sustainable waste management practices.

d. Mentorship Programs: Develop mentorship programs where chemistry graduates can guide high school or undergraduate students interested in chemistry.
e. Chemistry in the Community Workshops: Conduct workshops that demonstrate the role of chemistry in everyday life and practical applications.
f. Collaborations with Local Businesses: Conducting audits of chemical use, suggesting greener alternatives, and implementing recycling programs.
g. Chemical Disaster Preparedness: Work with local emergency services to develop and disseminate chemical disaster preparedness plans.
h. Public Lectures and Seminars: Organize public lectures and seminars on various chemistry-related topics.

Mode of Transaction: Lecture Cum Discussion, Seminars, Workshops, Group discussion, Seminars, Self Study and Library Work. (Note: This list is suggestive in nature and the modes may be stated as departmental modalities)

Sessional Activity

Activities selected from the above-mentioned list:

- Lecture Cum Discussion,
- Seminars,
- Group discussion,
- Self-Study
- Sudden Test

Course Learning Outcomes:

1. **To improve** written and oral communication skills through report writing, presentations, and collaborative projects.
2. **To achieve proficiency in specific technical skills** and laboratory techniques that are critical for professional practice.
3. **To enhance skills in explaining** complex scientific concepts to non-specialist audiences, improving public understanding of chemistry during community engagement programmes.
4. **To develop** a sense of social responsibility by using chemical knowledge to address community issues and promote public health and safety.
5. **To cultivate** leadership skills through organizing and leading community projects and activities.
6. **To learn** to interact respectfully and effectively with individuals from diverse backgrounds, enhancing cultural awareness.

Cognitive Map of Course Outcomes Based on Revised Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge	CO-1	CO-1	CO-1			
Conceptual Knowledge		CO-1, CO-2	CO-2, CO-3	CO-2, CO-3	CO-3	
Procedural Knowledge			CO-2, CO-3	CO-2, CO-3	CO-3	CO-2, CO-3
Metacognitive Knowledge						CO-3

Mapping of Course Learning Outcomes (CLO's) to Programme Specific Outcomes (PSO's)

CLO / PSO	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8
CLO-1	2	2	2	2	2	3	2	2
CLO-2	3	3	3	2	2	2	2	2
CLO-3	2	2	3	2	2	3	3	2
CLO-4	2	2	2	3	2	2	3	2
CLO-5	2	2	2	2	3	3	3	2
CLO-6	2	2	2	2	3	3	2	2
Average	**2.17**	**2.17**	**2.33**	**2.17**	**2.33**	**2.67**	**2.5**	**2.0**

[3 = Strongly aligned, 2 = Moderately aligned, 1 = Weakly aligned]

SEMESTER-III

Course Title: **Inorganic Chemistry-III**
Course Code:**CC-4-MCH-301**
Nature of the course: **Core**
Component of the course: **L=3, T=1, P=0**
Total Credit assigned:**4**
Distribution of Marks: **End Semester=56; In Semester=24 (Total= 80)**

Course Objectives:

CO-1: **To understand** the chemistry, magnetic, and spectral properties of lanthanides and actinides and their complexation behaviour.

CO-2: **To explore** the properties, bonding, and reactivity of transition metal and organo-transition metal complexes, including their spectroscopic and magnetic characterization.

CO-3: **To apply** multinuclear NMR spectroscopy (^{1}H, ^{31}P, ^{19}F) in analysing structural features and dynamics of coordination compounds.

CO-4: **To interpret** magnetic properties of coordination complexes using crystal field theory and temperature-dependent behaviour.

Course Contents

Unit	Content	Marks	L	P	T
I	**Chemistry of Lanthanides and Actinides** Electronic configuration, lanthanide contraction, separation of lanthanides, Magnetic and spectral properties of lanthanides and actinides, lanthanide shift reagents. Stability of lanthanide and actinide complexes.	10	10	0	2
II	**Properties of transition metal complexes** *Transition metals and periodic properties*: Transition metal donor-acceptor compounds, Coordination number and geometries, 18-electron rule, Stability of metal complexes, common ligands and complexes, Stereo chemically non-rigid systems. Introduction to transition metal organometallic chemistry: Metal carbon bond formation, 18 and 16 electron organometallic complexes. Isolobel analogy in organometallic compounds. Bonding in organo-transition metal compounds: Metal carbonyls, metal olefins, metal carbene, Role of co-ligands like phosphine, arsine, stibine, N2, O2 and NO. Oxidative addition, reductive elimination andβ-	25	10	0	5

	elimination reaction. Electronic spectrum and magnetic properties of transition metals complexes: Electronic states and terms for transition metals. Selection rules, Orgel diagram and Tanabe Sugano diagrams: Application in transition metal electronic spectroscopy. Electronic spectra and structure, d-d and charge transfer transitions.				
III	Application of NMR spectroscopy (1H, 31P and 19F) Chemical shift, factors contributing to chemical shift, spin-spin coupling and its implication to structure determination; simplification of complex spectra; Use of 31P and 19F NMR incoordination chemistry: metal-ligand interaction; isomer determination; evaluation of stereo chemical non-rigidity in molecules; NMR spectra of paramagnetic compounds.	10	10		3
IV	**Magnetochemistry** Types of magnetic bodies (e.g. Diamagnetic, Paramagnetic, ferromagnetic, and antiferromagnetic), antiferromagnetic coupling, Magnetic properties based on crystal field theory: spin only magnetic moments, spin-state equilibrium in octahedral stereochemistry: cross-over region, quenching of orbital magnetic moment by CF, orbital contribution, effect of temperature on magnetic behaviour, magnetic properties of octahedral, tetrahedral, tetragonally distorted octahedral and sequence planer complexes.	11	15		5
Total		**56**	**45**	**0**	**15**

(L= Lecture, P = Practical, T = Tutorial)

Mode of Transaction: Lecture Cum Discussion, Seminars, Workshops, Group discussion, Seminars, Self Study and Library Work. (Note: This list is suggestive in nature and the modes may be stated as departmental modalities)

Mode of In-Semester Assessment: (24 Marks)

Sessional Test:	Marks: 15
Other Sessional Activities:	Marks: 9

In- Semester Assessment Marks: 24

Sessional Activity

1. Activities selected from the above-mentioned list:
   - Lecture Cum Discussion,
   - Seminars,

- Group discussion,
- Self-Study
- Sudden Test

Course Learning Outcomes:

CLO-1

1.1 **To describe** the electronic configuration, lanthanide contraction, and methods for separation of lanthanides.

1.2 **To explain** magnetic and spectral behaviour of lanthanide and actinide elements and interpret their complex stability.

1.3 **To apply** lanthanide shift reagents in analytical and structural chemistry.

CLO-2

2.1 **To explain** periodic trends and coordination numbers of transition metals, and to apply the 18-electron rule in predicting complex stability.

2.2 To **classify and describe** the structure and bonding in organo-transition metal compounds including metal carbonyls, olefins, and carbenes.

2.3 **To analyse** the role of ligands like phosphine, arsine, stibine, N_2, O_2, and NO in metal-ligand bonding and reactivity.

2.4 **To interpret** reaction mechanisms such as oxidative addition, reductive elimination, and β-elimination in organometallic chemistry.

2.5 **To use** Orgel and Tanabe–Sugano diagrams for assigning electronic transitions in transition metal complexes and relate spectral features to structure.

CLO-3

3.1 **To interpret** NMR chemical shifts and coupling patterns in ^{1}H, ^{31}P, and ^{19}F NMR spectra.

3.2 **To evaluate** metal-ligand interactions, isomerism, and non-rigid stereochemistry in coordination compounds using multinuclear NMR.

3.3 **To identify and analyse** paramagnetic effects in NMR spectra of metal complexes.

CLO-4

4.1 **To classify** magnetic substances and explain their behaviour using crystal field

theory.

4.2 **To calculate** spin-only and orbital contributions to magnetic moments and interpret the effect of temperature and geometry.

4.3 **To describe** antiferromagnetic coupling and spin-state equilibria in octahedral and other coordination geometries.

Cognitive Map of Course Outcomes Based on Revised Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge	CO-1, CO-2	CO-1, CO-2	CO-1, CO-2			
Conceptual Knowledge		CO-1, CO-2, CO-3, CO-4	CO-2, CO-3, CO-4	CO-2, CO-3, CO-4	CO-2, CO-3, CO-4	
Procedural Knowledge			CO-2, CO-3, CO-4	CO-3, CO-4	CO-3, CO-4	CO-3, CO-4
Metacognitive Knowledge						CO-4

Mapping of Course Learning Outcomes (CLO's) to Programme Specific Outcomes (PSO's)

CLO / PSO	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8
CLO-1	3	2	2	2	2	2	2	2
CLO-2	3	2	3	2	2	2	2	2
CLO-3	3	3	3	2	2	2	2	3
CLO-4	3	2	3	2	2	2	2	2
Average	**3.0**	**2.25**	**2.75**	**2.0**	**2.0**	**2.0**	**2.0**	**2.25**

[3 = Strongly aligned, 2 = Moderately aligned, 1 = Weakly aligned]

Suggested Readings:

Textbooks:

1. Inorganic Chemistry, Shriver & Atkins, 5th Edition Oxford
2. Fundamentals of Molecular Spectroscopy: C.N. Banwell and E.M. McCash, Tata McGraw Hills

Recommended Books:

1. Inorganic Chemistry, W.W. Porterfield, 2nd Edition, Academic Press
2. Physical Methods for Chemist, Russell S. Drago
3. Elements of Magnetochemistry, R. L. Dutta and A Syamal

SEMESTER-III

Course Title: **Organic Chemistry-III**
Course Code:**CC-4-MCH-302**
Nature of the course: **Core**
Component of the course: **L=3, T=1, P=0**
Total Credit assigned:**4**
Distribution of Marks: **End Semester=56; In Semester=24 (Total= 80)**

Course Objectives:

CO-1: **To understand** modern strategies for carbon–carbon and carbon–carbon double bond formation using organometallic and olefination methods.

CO-2: **To study** various oxidation and reduction methods used in modern organic synthesis and their mechanistic pathways.

CO-3: **To introduce** emerging tools and methodologies such as solid-phase, combinatorial, microwave-assisted, and nanoparticle-based synthesis.

CO-4: **To explore** the principles and synthetic applications of organic photochemistry and rearrangement reactions under photoexcitation.

Course Contents

Unit	Content	Marks	L	P	T
I	**Organic synthesis I** Organometallic reagents information of carbon-carbon bonds: Organopalladium in C-C Formation (Heck reaction, Suzuki, and Negishi Coupling). Formation of C=C bonds by elimination reactions, syn elimination; Wittig and related reactions, Peterson olefination, and Julia reaction. Olefin metathesis, Grubbs catalyst, Shrock catalyst etc.	15	10	0	5
II	**Organic synthesis II** Definition and Classification. Oxidation by Mn (VII) and Cr (IV)reagents. Oxidation(i)of carbon-carbon double bond: dihydroxylation by KMnO4, OsO4 (including Sharpless asymmetric dihydroxylation), iodine and silver carboxylate (Woodward and Prevost condition) and peroxyacid. Use of SeO2 and DDQ. Swern-Pftzner-Moffatf and Albright-Goldman, TPAP. (ii)of alcohols and of 1,2-diols: Use of Cr (VI) based reagents (PCC, PDC), DMSO base reagent. Reduction(i) by catalytic hydrogenation: both heterogeneous (H2/Pd-C, H2/Pt2O, Lindler's and Rosendmund's reduction) and homogeneous (Wilkinson catalyst), (ii) by hydride transfer (LiAlH4,	16	15	0	5

	NaBH4, 9-BBN (iii)by dissolving metal (alkali metals in liquid ammonia) and (iv)by diimide, DIBAL, NaCNBH4, SMEAH (Red Al), Superhydride and Selectride, 9BBN.				
III	**Organic Synthesis III** Elementary idea of PASE synthesis with types and examples, combinatorial chemistry, parallel synthesis, use of nano particles in organic synthesis, microwave synthesis, DOMINO type reactions (Cascade)	10	10		2
IV	**Photochemistry** Photochemistry carbonyl compounds-representation of the excited states of ketones, photolysis of saturated and β, γ-unsaturated ketones. Photoreduction of saturated arylalkyl and α, β– unsaturated ketones and ρ–benzoquinone. Patterno-Buchi reaction, |2+2|-cycloaddition, Olefinic photochemistry- photo stereo mutation of cis-trans isomers, optical pumping, 2+2|-cycloaddition, Photochemistry of conjugated polyenes- cycloaddition and dimerization of 1, 2-butadiene. Photo arrangements-photo-Fries rearrangement and photorearrangement of cyclohexadienones, Barton rearrangement. Optical Pumping.	15	10		3
Total		**56**	**45**	**0**	**15**

(L= Lecture, P = Practical, T = Tutorial)

Mode of Transaction: Lecture Cum Discussion, Seminars, Workshops, Group discussion, Seminars, Self Study and Library Work. (Note: This list is suggestive in nature and the modes may be stated as departmental modalities)

Mode of In-Semester Assessment: (24 Marks)

Sessional Test:	Marks: 15
Other Sessional Activities:	Marks: 9

In- Semester Assessment Marks: 24

Sessional Activity

Activities selected from the above-mentioned list:

- Lecture Cum Discussion,
- Seminars,
- Group discussion,
- Self-Study
- Sudden Test

Course Learning Outcomes:

CLO-1

1.1 **To apply** organopalladium-mediated C–C bond-forming reactions such as Heck, Suzuki, and Negishi coupling.

1.2 **To explain** the mechanisms of C=C bond formation using elimination, Wittig, Peterson, and Julia olefination reactions.

1.3 **To describe** olefin metathesis reactions and the use of Grubbs and Schrock catalysts in modern synthetic applications.

CLO-2

2.1 **To classify** organic oxidation reactions and apply methods such as dihydroxylation, peroxyacid oxidation, and DDQ-mediated dehydrogenation.

2.2 **To analyze** oxidation of alcohols and diols using Cr(VI), PCC, PDC, and DMSO-based reagents.

2.3 **To compare and select** appropriate reduction methods, including catalytic hydrogenation (homogeneous and heterogeneous), hydride transfer reagents (e.g., $LiAlH_4$, $NaBH_4$), and specialized reducing agents (e.g., DIBAL, Superhydride, Selectride).

CLO-3

3.1 **To explain** the concepts and strategies of solid-phase organic synthesis (SPOS) and combinatorial chemistry.

3.2 **To apply** parallel synthesis, microwave-assisted synthesis, and nanoparticle-mediated reactions in synthetic organic chemistry.

3.3 **To describe and utilize** cascade (DOMINO-type) reactions for multi-step transformations.

CLO-4

4.1 **To describe** photochemical behavior of carbonyl compounds and analyze their excited-state reactivity.

4.2 **To interpret** mechanisms and synthetic utility of photochemical transformations including Paternò–Büchi, [2+2] cycloadditions, photoreductions, and rearrangements.

4.3**To discuss** the concept and application of optical pumping in organic photochemistry.

Cognitive Map of Course Outcomes Based on Revised Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge	CO-1, CO-2	CO-1, CO-2	CO-1, CO-2			
Conceptual Knowledge		CO-1, CO-2, CO-3, CO-4	CO-1, CO-2, CO-3	CO-2, CO-3, CO-4	CO-2, CO-3, CO-4	
Procedural Knowledge			CO-1, CO-2, CO-3, CO-4	CO-3, CO-4	CO-3, CO-4	CO-3, CO-4
Metacognitive Knowledge						CO-4

Mapping of Course Learning Outcomes (CLO's) to Programme Specific Outcomes (PSO's)

CLO / PSO	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8
CLO-1	3	2	2	2	2	2	2	2
CLO-2	3	2	3	2	2	2	2	2
CLO-3	3	3	3	2	3	2	3	3
CLO-4	3	2	3	2	2	2	2	2
Average	**3.0**	**2.25**	**2.75**	**2.0**	**2.25**	**2.0**	**2.25**	**2.25**

[3 = Strongly aligned, 2 = Moderately aligned, 1 = Weakly aligned]

Suggested Readings:

1. Modern Methods of Organic Synthesis – Carruthers and Coldham, Cambridge University Press
2. Organic Synthesis – M.B. Smith, McGraw Hill. (Reference book)
3. Principles of Organic Synthesis – R.O.C. Norman and J M Coxon
4. Advanced Organic Chemistry Part A and B: Carey and Sundberg
5. Synthetic Approaches in Organic Chemistry – R.K. Bansal- Narosa Publishing House, New Delhi

SEMESTER-III

Course Title: **Physical Chemistry-III**
Course Code:**CC-4-MCH-303**
Nature of the course: **Core**
Component of the course: **L=3, T=1, P=0**
Total Credit assigned:**4**
Distribution of Marks: **End Semester=56; In Semester=24 (Total= 80)**

Course Objectives:

CO-1: **To develop** a detailed understanding of chemical kinetics including theories of reaction rates, mechanisms, fast reactions, and enzyme catalysis.

CO-2: **To introduce** the theoretical and practical aspects of electrochemical systems, including ion-solvent interactions, electrode kinetics, and corrosion.

Course Contents

Unit	Content	Marks	L	P	T
I	**Chemical Kinetics and Reaction Dynamics:** i Transition state theory, postulates, mathematical treatment of transition state theory, Eyring equation. ii Kinetics of Chain reactions, determination of chain length, kinetics of H_2-Br_2 reaction, thermal decomposition of acetaldehyde. Kinetics of non-stationary chain reactions, hydrogen- oxygen reaction, and explosion limits iii Unimolecular reactions - Lindemann theory, Hinshelwood, Kassel-Rice-Ramsperger theory iv Study of fast reactions, derivation of rate constant, relaxation time for fast reactions, Methods for the study of fast reactions: Stoppard flow method, continuous flow method, flash photolysis, and pulse radiolysis. v Kinetics of reactions in solution-Factors affecting the kinetic study of reactions in solution, Diffused controlled reactions in solution, Debye Smoluchowski equation. Influence of ionic strength on the rates of ionic reactions, salt effects. vi Rate of enzyme catalyst reaction, Michaelis-Menten equation; temperature, pH and concentration dependence of enzyme catalysed reactions; acid-base catalysis and acidity	35	20	0	8

	function.				
II	**Electrochemistry** i **Ion-solvent interactions**: The Born model-thermodynamic parameters of ion-solvent interactions-structural treatment; the ion-dipole model –its modifications, ion-quadrupole, and ion-induced dipole interactions. Debye-Húckel theory of ion-ion interactions– derivation, validity, and limitations; extended Debye-Húckel-Onsager equation. Ion-Association: Bjerrums hypothesis. ii **Kinetics of electrode reactions**: Butler Volmer equation, Tafel equations and Tafel plots, Calculations of exchange current density and transfer co-efficient for electrode processes. Overvoltage: Definition and applications in the study of electro deposition of metals in aqueous solution, corrosion of metals. Inhibition of corrosion.	21	25	0	7
Total		56	45	0	15

(L= Lecture, P = Practical, T = Tutorial)

Mode of Transaction: Lecture Cum Discussion, Seminars, Workshops, Group discussion, Seminars, Self Study and Library Work. (Note: This list is suggestive in nature and the modes may be stated as departmental modalities)

Mode of In-Semester Assessment: (24 Marks)

Sessional Test:	Marks: 15
Other Sessional Activities:	Marks: 9

In- Semester Assessment Marks: 24

Sessional Activity

1. Activities selected from the above-mentioned list:
   - Lecture Cum Discussion,
   - Seminars,
   - Group discussion,
   - Self-Study
   - Sudden Test

Course Learning Outcomes:

CLO-1

1.1 **To explain** the postulates and mathematical derivation of transition state theory using the Eyring equation.

1.2 **To analyze** the kinetics of chain reactions and calculate chain lengths for reactions such as H_2–Br_2 and thermal decomposition processes.

1.3 **To describe** the mechanisms and kinetic treatment of unimolecular reactions using Lindemann, Hinshelwood, and RRK (Rice-Ramsperger-Kassel) theories.

1.4 **To derive** rate constants and relaxation times for fast reactions and to apply experimental techniques such as stopped-flow, flash photolysis, and pulse radiolysis.

1.5 **To evaluate** reaction rates in solution with a focus on diffusion-controlled processes using the Debye–Smoluchowski equation and ionic strength effects.

1.6 **To apply** Michaelis–Menten kinetics to enzyme-catalysed reactions and interpret the influence of pH, temperature, and concentration.

1.7 **To explain** the concepts of acid-base catalysis and the use of acidity functions.

CLO-2

2.1 **To describe** ion-solvent interactions using the Born model and ion-dipole, ion-quadrupole, and induced dipole theories.

2.2 **To derive and evaluate** the Debye–Hückel equation and its limitations and apply the extended Debye–Hückel–Onsager model to electrolyte solutions.

2.3 **To explain** ion-association behaviour using Bjerrum's hypothesis.

2.4 **To analyze** the kinetics of electrode reactions using the Butler–Volmer equation and to derive and interpret Tafel plots.

2.5 **To calculate** electrochemical parameters such as exchange current density and transfer coefficients.

2.6 **To discuss** the role of overvoltage in metal electrodeposition, corrosion, and methods of corrosion inhibition.

Cognitive Map of Course Outcomes Based on Revised Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge	CO-1, CO-2	CO-1, CO-2	CO-1, CO-2			
Conceptual Knowledge		CO-1, CO-2	CO-1, CO-2	CO-1, CO-2	CO-1, CO-2	

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Procedural Knowledge			CO-1, CO-2	CO-1, CO-2	CO-1, CO-2	CO-2
Metacognitive Knowledge						CO-2

Mapping of Course Learning Outcomes (CLO's) to Programme Specific Outcomes (PSO's)

CLO / PSO	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8
CLO-1	3	2	3	2	2	2	2	3
CLO-2	3	3	3	2	2	2	2	3
Average	**3.0**	**2.5**	**3.0**	**2.0**	**2.0**	**2.0**	**2.0**	**3.0**

[3 = Strongly aligned, 2 = Moderately aligned, 1 = Weakly aligned]

Suggested Readings:

1. Chemical Kinetics – K. J. Laidler, Pearson Education India.
2. Modern Electrochemistry – Vol I, II by J. O. M. Bockris& A. K. N. Reddy
3. Chemical Kinetics and Reaction Dynamics – P. L. Houston, Dover Publications
4. Kinetics and Mechanism – A. A. Pearson, R. G. Frost, John Wiley and Sons
5. Electrochemical Methods: Fundamentals and Applications, A. J. Bard, L. R. Faulkner, John Wiley and Sons.
6. An Introduction to Electrochemistry – S. Glasstone, East West Press.
7. Physical Chemistry – P.W. Atkins, Oxford University Press.

SEMESTER-III
(OPTION I)

Course Title:**(Laboratory Course-III)**
Course Code: **DSE-4-MCH-301A**
Nature of the course: **Discipline Specific Elective**
Component of the course: **L=0, T=0, P=4**
Total Credit assigned:**4**
Distribution of Marks: **End Semester=80; IA=0 (Total= 80)**

Course Objectives:

CO-1: **To synthesize and characterize** inorganic complexes and nanoparticles using modern analytical tools.

CO-2: **To perform** multi-step organic synthesis involving rearrangement and substitution reactions, with product identification using chromatography and spectroscopy.

CO-3: **To apply** physicochemical principles and instrumental methods to determine reaction constants, verify laws, and quantify chemical species.

Course Contents

Unit	Content	Marks	L	P	T
I	**Inorganic Lab** 1.Synthesis and characterization (melting point, conductivity, IR, UV-vis etc.) of Ni-DMG complex and estimate the percentage of nickel in the synthesized compound. 2. Synthesis and characterization of Schiff-base ligands and their metal complexes. 3.Synthesis and characterization of metal and metal oxide nanoparticles by surfactant assisted methods.	25		40	
II	**Organic Lab** 1. Benzilic acid from benzoin via benzyl (Benzilic acid rearrangement) 2. Benzanilide from benzophenone via oxime (Beckman rearrangement) 3. Indigo from anthranilic acid via phenylglycine-o-carboxylic acid and indoxyl 4. Sandmeyer reaction: *ortho*-Chlorotoluene from *ortho*-toluidine (steam distillation of the product) 5. Acridone from anthranilic acid via o-chlorobenzoic acid and phenylanthranilic acid 6. Sulphanilamide from acetanilide via p-acetamido	25		40	

	benzene sulphonyl chloride and p-acetamido benzenesulphonamide 7. Pinacolone from benzophenone via pinacol (Pinacol pinacolone rearrangement) 8.Preparation, purification (by TLC) and spectroscopic identification (UV and IR) of the prepared organic compounds and (B) Estimation Preparation:				
III	**Physical Lab** 1. Determination of hydrolysis constant of aniline hydrochloride by pH measurements. 2. Determine the strengths of the components of the following mixtures by conductometric titration: Hydrochloric acid and acetic acid Sulphuric acid and copper sulphate 3. Determine the strengths of HCl and CH3COOH in each mixture by pH-metric titration. 4. Verify Beer's law and determine the unknown concentration of supplied solutions like KMnO4 / $K_2Cr_2O_7$ 5.Determine the composition of iron-salicylic acid complex spectrophotometrically by Job's method. 6. Least squares fitting and plotting linear and exponential graphs performing theoretical calculations using a computer.	22		40	
	Viva	8			
Total		**80**	**0**	**120**	**0**

(L= Lecture, P = Practical, T = Tutorial)

Mode of Transaction: Lecture Cum Discussion, Seminars, Workshops, Group discussion, Seminars, Self Study and Library Work. (Note: This list is suggestive in nature and the modes may be stated as departmental modalities)

Mode of In-Semester Assessment: **None**

Sessional Test:	Marks: 0
Other Sessional Activities:	Marks: 0

In- Semester Assessment Marks: 0

Sessional Activity

Activities selected from the above-mentioned list:

- Lecture Cum Discussion,
- Laboratory works
- Self-Study

- Sudden Test

Course Learning Outcomes:

CLO-1

1.1 **To synthesize and characterize** Ni-DMG and Schiff-base metal complexes using melting point, conductivity, UV-Vis, and IR techniques.

1.2 **To estimate** the percentage of nickel in a coordination compound through gravimetric or instrumental methods.

1.3 **To prepare and analyse** metal/metal oxide nanoparticles using surfactant-assisted methods and evaluate their physicochemical properties.

CLO-2

2.1 **To carry out** organic preparations including benzilic acid, benzanilide, indigo, ortho-chlorotoluene, acridone, sulphanilamide, and pinacolone using classical synthetic routes.

2.2 **To purify** synthesized organic compounds using thin-layer chromatography (TLC) and identify them using UV and IR spectroscopy.

2.3 **To demonstrate** the principles and techniques involved in rearrangement and substitution reactions commonly used in medicinal and industrial chemistry.

CLO-3

3.1 **To determine** hydrolysis constants and acid strengths using pH measurements and titration methods (conductometric and pH-metric).

3.2 **To verify** Beer's Law and determine unknown concentrations using spectrophotometry.

3.3 **To determine** complex stoichiometry (e.g., Fe-salicylate) using Job's method.

3.4 **To apply** statistical and computational tools such as least squares fitting to experimental data and generate linear/exponential plots using software.

Cognitive Map of Course Outcomes Based on Revised Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge	CO-1, CO-2	CO-1, CO-2	CO-1, CO-2			
Conceptual Knowledge		CO-1, CO-2	CO-1, CO-2	CO-1, CO-2	CO-1, CO-2	
Procedural Knowledge			CO-1, CO-2	CO-1, CO-2	CO-1, CO-2	CO-2
Metacognitive Knowledge						CO-2

Mapping of Course Learning Outcomes (CLO's) to Programme Specific Outcomes (PSO's)

CLO / PSO	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8
CLO-1	3	2	3	2	2	2	2	3
CLO-2	3	3	3	2	2	2	2	3
Average	**3.0**	**2.5**	**3.0**	**2.0**	**2.0**	**2.0**	**2.0**	**3.0**

[3 = Strongly aligned, 2 = Moderately aligned, 1 = Weakly aligned]

Suggested Readings:

1. Vogel, Arthur I: A Test book of Quantitative Inorganic Analysis (Rev. by G.H. Jeffery and others) 5th Ed., The English Language Book Society of Longman.
2. Willard, Hobert H. et al.: Instrumental Methods of Analysis, 7th Ed., Wardsworth Publishing Company, Belmont, California, USA, 1988.
3. Christian, Gary D; Analytical Chemistry, 6th Ed., John Wiley & Sons, New York, 2004.
4. Harris, Daniel C: Exploring Chemical Analysis, Ed. New York, W. H. Freeman, 2001.
5. Khopkar, S. M. Basic Concepts of Analytical Chemistry. New Age, International Publisher, 2009.
6. Skoog, D. A. Holler F.J. and Nieman, T.A. Principles of Instrumental Analysis, Thomson Asia Pvt. Ltd. Singapore.
7. Mikes, O. &Chalmes, R.A. Laboratory Handbook of Chromatographic & Allied Methods, Elles Harwood Ltd. London.
8. Vogel's Qualitative Inorganic Analysis, A. I. Vogel, Prentice Hall, 7th Ed
9. Textbook of Practical Organic Chemistry, A. I. Vogel, Prentice Hall, 5th Ed.
10. Practical Organic Chemistry, F. G. Mann. & B. C. Saunders, Orient Longman, 1960

SEMESTER-III
(OPTION II)

Course Title:**(Laboratory Course-III)**
Course Code: **DSE-4-MCH-301B**

Nature of the course: **Discipline Specific Elective**
Component of the course: **L=0, T=0, P=4**
Total Credit assigned:**4**
Distribution of Marks: **End Semester=80; In Semester=0 (Total= 80)**

Course Objectives:

CO-1: To perform the synthesis and characterization of coordination compounds, Schiff-base ligands, and nanoparticles using instrumental and spectroscopic methods.

CO-2: To carry out green and classical organic syntheses, along with estimations of functional groups using eco-friendly methods.

CO-3: To apply spectroscopic, kinetic, and thermodynamic techniques to investigate chemical properties, reactions, and molecular behaviour using experimental and computational methods.

Course Contents

Unit	Content	Marks	L	P	T
I	**Inorganic Lab** 1. Synthesis and characterization (melting point, conductivity, IR, UV-vis etc.) of Ni- DMG complex and estimate the percentage of nickel in the synthesized compound. 2. Synthesis and characterization of Schiff-base ligands and their metal complexes. 3. Synthesis and characterization of metal and metal oxide nanoparticles by surfactant Assisted methods.	22	0	40	0
II	Organic Lab 1. Estimation: Estimation of glycine by formalin method. 2. Estimation of halogen by fusion method. 3. Estimation of hydroxyl and amino groups by acetylation method. 4. Synthesis of Deep Eutectic Solvents (DES) and their use. 5. Green synthesis of Coumarin derivative (clay catalyzed). 6. Benzoin condensation using green catalysts (co-enzymes).	25	0	40	0
III	**Physical Lab** 1. Determine the composition of the binary mixture ($K_2Cr_2O_7$ and $KMnO_4$) by spectroscopic method (MLRA).	25	0	40	0

	1. Determine the indicator constant of methyl red. 2. Investigate the reaction between H2O2 and HI (clock reaction). Determine the energy of activation. 3. Determination of molecular surface energy and the association factor for ethanol. 4. Study and compare the spectroscopic properties of acetone in different solvents. 5. Perform theoretical calculations using a computer. Charge density distribution and shapes of s and p orbitals. 6. Potential energy diagram of hydrogen molecule ion				
	Viva	8			
Total		**80**	**0**	**120**	**0**

(L= Lecture, P = Practical, T = Tutorial)

Mode of Transaction: Lecture Cum Discussion, Seminars, Workshops, Group discussion, Seminars, Self Study and Library Work. (Note: This list is suggestive in nature and the modes may be stated as departmental modalities)

Mode of In-Semester Assessment: **None**

Sessional Test:	Marks: 0
Other Sessional Activities:	Marks: 0

In- Semester Assessment Marks: 0

Sessional Activity

Activities selected from the above-mentioned list:

- Lecture Cum Discussion,
- Laboratory works
- Self-Study
- Sudden Test

Course Learning Outcomes:

CLO-1

1.1 **To synthesize and characterize** the Ni-DMG complex and determine the nickel content using quantitative analysis.

1.2 **To prepare** Schiff-base ligands and their metal complexes and characterize them using melting point, IR, UV-Vis, and conductivity methods.

1.3 **To synthesize** metal and metal oxide nanoparticles via surfactant-assisted methods and analyze their physical and chemical properties.

CLO-2

2.1 **To estimate** glycine, halogens, hydroxyl, and amino groups using formalin, fusion, and acetylation methods, respectively.

2.2. **To synthesize and apply** Deep Eutectic Solvents (DES) and perform green synthesis of coumarin derivatives and benzoin condensation using clay and biocatalysts.

2.3 **To demonstrate** awareness of green chemistry principles in organic laboratory practices.

CLO-3

3.1 **To determine** the composition of a binary mixture ($K_2Cr_2O_7$ and $KMnO_4$) by spectrophotometric MLRA technique.

3.2 **To determine** the indicator constant of methyl red and study reaction kinetics using clock reactions.

3.3 **To measure** molecular surface energy and the association factor of ethanol through physical chemistry techniques.

3.4 **To analyse** solvent effects on spectroscopic properties and perform computational modelling (e.g., orbital visualization, potential energy diagrams) for molecular systems.

Cognitive Map of Course Outcomes Based on Revised Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge	CO-1, CO-2	CO-1, CO-2	CO-1, CO-2			
Conceptual Knowledge		CO-1, CO-2, CO-3	CO-1, CO-2, CO-3	CO-1, CO-2, CO-3		
Procedural Knowledge			CO-1, CO-2, CO-3	CO-1, CO-2, CO-3	CO-2, CO-3	CO-3
Metacognitive Knowledge						CO-3

Mapping of Course Learning Outcomes (CLO's) to Programme Specific Outcomes (PSO's)

CLO / PSO	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8
CLO-1	3	3	2	2	2	2	2	2
CLO-2	3	3	2	3	3	2	3	2
CLO-3	3	3	3	2	3	3	3	3
Average	**3.0**	**3.0**	**2.3**	**2.3**	**2.7**	**2.3**	**2.7**	**2.3**

[3 = Strongly aligned, 2 = Moderately aligned, 1 = Weakly aligned]

Suggested Readings:

1. Vogel, Arthur I: A Test book of Quantitative Inorganic Analysis (Rev. by G.H. Jeffery and others) 5th Ed., The English Language Book Society of Longman.
2. Willard, Hobert H. et al.: Instrumental Methods of Analysis, 7th Ed., Wardsworth Publishing Company, Belmont, California, USA, 1988.
3. Christian, Gary D; Analytical Chemistry, 6th Ed., John Wiley & Sons, New York, 2004.
4. Harris, Daniel C: Exploring Chemical Analysis, Ed. New York, W. H. Freeman, 2001.
5. Khopkar, S. M. Basic Concepts of Analytical Chemistry. New Age, International Publisher, 2009.
6. Skoog, D. A. Holler F.J. and Nieman, T.A. Principles of Instrumental Analysis, Thomson Asia Pvt. Ltd. Singapore.
7. Mikes, O. &Chalmes, R.A. Laboratory Handbook of Chromatographic & Allied Methods, Elles Harwood Ltd. London.
8. Vogel's Qualitative Inorganic Analysis, A. I. Vogel, Prentice Hall, 7th Ed
9. Textbook of Practical Organic Chemistry, A. I. Vogel, Prentice Hall, 5th Ed.
10. Practical Organic Chemistry, F. G. Mann. & B. C. Saunders, Orient Longman, 1960

SEMESTER-III

Course Title: **RESEARCH PROJECT** OR CORE COURSE
Course Code:**CC-4-MCH-304A**
Nature of the course: **Core (Optional)**
Component of the course: **L=0, T=0, P=4**
Total Credit assigned:**4**
Distribution of Marks: **End Semester=80; In Semester=0 (Total= 80)**

Course Objectives:

CO-1: To develop the ability to conduct independent research or literature review in a specialized area of chemistry by identifying relevant scientific questions and formulating clear objectives.
CO-2: To enhance proficiency in scientific investigation, including literature analysis, experimental or theoretical methodology, data interpretation, and critical evaluation of findings.
CO-3: To cultivate scientific communication skills through the preparation of structured reports and effective oral presentations, while adhering to academic and ethical standards.

Course Contents

Unit	Content	Marks	L	P	T
I					
Total		**80**	**0**	**120**	**0**

(L= Lecture, P = Practical, T = Tutorial)

Case 1: Project work: Student will submit the progress of the work at the end of the semester examination.
Case 2: Comprehensive Review work on a specified topic: Student will submit a report of the comprehensive review of literature at the end of the semester examination.

Mark distribution in either case will be as follows:
A. **Project work**
1. Literature Review 10 Marks
2. Objectives 10 Marks
3. Progress of the work 30 Marks
5. Presentation/Viva 30 Marks

B. **Comprehensive Review**
1. Objective 5 Marks
2. Review 30 Marks
3.References 5 Marks
4. Prospects 15 Marks
5. Presentation/Viva 25 Marks

Mode of Transaction: Lecture Cum Discussion, Seminars, Workshops, Group discussion, Seminars, Self Study and Library Work. (Note: This list is suggestive in nature and the modes may be stated as departmental modalities)

Mode of In-Semester Assessment: **None**

Course Learning Outcomes:

CLO-1: (Research Knowledge and Problem Identification)

1.1: **To understand and critically review** scientific literature in a specialized area of chemistry.

1.2: **To identify** research gaps and formulate relevant objectives or hypotheses for project or review work.

1.3: **To demonstrate an understanding** of the fundamental principles and current developments in the selected area.

CLO-2: (Research Methodology and Experimental/Analytical Skills)

2.1: **To plan and execute** a research strategy involving experimental or literature-based work, including data collection and analysis.

2.2: **To apply** appropriate scientific techniques, software tools, or theoretical approaches for solving a defined research problem (for experimental projects).

2.3: **To synthesize and organize** findings from scientific literature (for review-based projects).

CLO-3: (Scientific Writing and Communication)

3.1: **To write** a well-structured scientific report or dissertation following academic conventions.

3.2: **To prepare** and deliver an oral presentation summarizing the objectives, methods, findings, and implications of the work.

3.3: **To effectively** use visual aids (e.g., graphs, tables, diagrams) to communicate data and concepts.

CLO-4: (Critical Thinking and Ethical Understanding)

4.1: **To evaluate** the significance, limitations, and prospects of the research topic.

4.2: **To demonstrate** academic integrity, proper referencing, and ethical conduct in all stages of the research process.

In this paper students will have to carry out project work (Laboratory experiments or Comprehensive Review work on a specified topic) either at their respective colleges or any other R&D laboratory and UGC recognized University under guidance of a faculty member. The students will start their project work during the semester break in between the semester examinations. The area of work is to be decided by the advisor. On completion of the project work students will have to submit the work in the form of a dissertation followed by an oral presentation in the presence of faculty members and an external expert.

Cognitive Map of Course Outcomes Based on Revised Bloom's Taxonomy

Knowledge Dimension	**Remember**	**Understand**	**Apply**	**Analyze**	**Evaluate**	**Create**
Factual Knowledge	CLO-1	CLO-1	CLO-2			
Conceptual Knowledge		CLO-1, CLO-2	CLO-2	CLO-1, CLO-2	CLO-4	CLO-4
Procedural Knowledge			CLO-2	CLO-2, CLO-3	CLO-4	CLO-3, CLO-4
Metacognitive Knowledge				CLO-4	CLO-4	CLO-3, CLO-4

Mapping of Course Learning Outcomes (CLO's) to Programme Specific Outcomes (PSO's)

CLO / PSO	**PSO-1**	**PSO-2**	**PSO-3**	**PSO-4**	**PSO-5**	**PSO-6**	**PSO-7**	**PSO-8**
CLO-1	3	2	3	2	2	2	2	2
CLO-2	3	3	3	2	3	2	3	3
CLO-3	2	3	2	2	2	3	2	2
CLO-4	2	2	3	3	2	3	3	3
Average	**2.5**	**2.5**	**2.8**	**2.3**	**2.3**	**2.5**	**2.5**	**2.5**

[3 = Strongly aligned, 2 = Moderately aligned, 1 = Weakly aligned]

SEMESTER-III

Course Title: RESEARCH PROJECT OR **CORE COURSE (Applied Chemistry)**
Course Code:**CC-4-MCH-304B**
Nature of the course: **Core (Optional)**
Component of the course: **L=3, T=1, P=0**
Total Credit assigned:**4**
Distribution of Marks: **End Semester=56; In Semester=24 (Total= 80)**

Course Objectives:

CO-1: **To explore** the historical and traditional applications of chemistry in ancient India, including metallurgy, textiles, dyes, and medicinal preparations.

CO-2: **To understand** the chemistry and manufacturing processes involved in soaps, textiles, and cosmetics used in modern daily life.

CO-3: **To examine** the chemical basis of food, metabolism, nutrition, and preservation, including food safety and environmental concerns.

CO-4: **To analyse** the role and chemistry of agrochemicals such as pesticides, plant growth regulators, and household formulations.

Course Contents

Unit	Content	Marks	L	P	T
I	**Applied Chemistry in ancient India:** Textile Technology in ancient India, dyeing, washing spinning and weaving technology. Paper and ink making, Paints and Dyes, Perfumes and Cosmetics, Alcoholic Liquors. Metallurgy in ancient India, Metals and their making: Suvarna(gold) and its different types, prosperities, Rajata(silver), Tamra(copper), Loha(iron), Vanga(tin), Naga / sisa (lead), Pittala(brass), gold-silver alloy, metallurgical processes and minerals. Glass Making. Preparation of different types of Bhasmas (Gold Bhasma, Silver Bhasma, Copper Bhasma and Lead Bhasma) and their medicinal values.	11	15	0	3
II	**Soap, Textiles and Cosmetics:** *Soaps and Detergents*: Introduction, Raw Materials required for soap manufacturing, methods of manufacturing soap, chemistry of cleaning, Dry Cleaning, Removal of Spots and Stains, Detergents, Manufacturing of detergents. *Textiles*: Classification of textiles, natural textiles, synthetic textiles: Cotton, Linen or Flax, Silk and wool, viscose rayon, Nylons, Polyesters, polyacrylic fibers and background chemistry. *Cosmetics:* Introduction, Shampoos, Hair curling and	15	10	0	3

	Straightening products, Hair setting and styling products, hair colouring products, hair tonic and restorers, Facial make up materials, Cold creams and vanishing creams. Bleach cream. Nail lacquers removers, antiperspirants, deodorants, Shaving and aftershave preparations.				
III	**Chemical approaches to Food** Introduction, types of nutrients, Energy from food, Energy values and energy needs of body. Perfect food. Metabolism of Carbohydrate, oxidation of glucose, energetics of metabolic processes. Diabetes mellitus and insulin. Foods and protein quality. Metabolism of proteins, proteins as source of energy. Nitrogen equilibrium, mineral elements, vitamins-types, structure, and uses. Preservation of food and food poisoning. Toxic materials in foods, Sweetening agents, Cholesterol, Role of Vitamins and co-enzymes. Kitchen Pollution.	15	10	0	4
IV	**Agrochemicals in common use** Introduction, pesticides and their classification, synthetic organic insecticides, chlorinated hydrocarbons, cyclodiene insecticides, organophosphates, and their mode of action. Nerve poisons, carbamates, organic thiocyanates, Rotenoids, Rodenticides. Chemicals for the control of plant diseases, control of weeds, plant growth regulators, inhibitors or retardants, Fumigants, Formulation and toxicity of pesticides, Lethal dose, Hormones and growth inhibitors. Household agrochemicals. Background chemistry.	15	10	0	5
Total		56	45	0	15

(L= Lecture, P = Practical, T = Tutorial)

Mode of In-Semester Assessment: (24 Marks)

Sessional Test:	Marks: 15
Other Sessional Activities:	Marks: 9

In- Semester Assessment Marks: 24

Sessional Activity

Activities selected from the above-mentioned list:

- Lecture Cum Discussion,
- Seminars,
- Group discussion,

- Self-Study
- Sudden Test

Course Learning Outcomes:

CLO-1
1.1 **To describe** ancient Indian contributions to chemistry in areas such as textile technology, metallurgy, glassmaking, and cosmetics.

1.2 **To explain** the preparation and chemical basis of Bhasmas (e.g., gold, silver, copper, lead) and their traditional medicinal uses.

1.3 **To evaluate** the materials and processes used in ancient dyeing, weaving, metal processing, and perfumery.

CLO-2

2.1 **To identify** raw materials and chemical processes involved in soap and detergent manufacturing.

2.2 **To classify** natural and synthetic textile fibres and describe their chemical properties.

2.3 **To describe** the formulation and chemistry of cosmetic products including hair care, skin care, deodorants, and makeup.

CLO-3
3.1 **To define** major food components and explain their metabolic pathways including carbohydrate and protein metabolism.

3.2 **To interpret** the roles of vitamins, minerals, coenzymes, and hormones in human nutrition.

3.3 **To evaluate** food preservation methods, food poisoning causes, and the chemistry of food additives such as sweeteners and cholesterol regulators.

3.4 **To assess** the impact of kitchen pollution and chemical exposure from daily cooking practices.

CLO-4
4.1 **To classify** agrochemicals based on their structure, function, and mode of action.

4.2 **To explain** the mechanisms of insecticides, herbicides, rodenticides, and plant growth regulators.

4.3 **To assess** the toxicity, formulation, and safe usage of pesticides including LD_{50} values and household applications.

4.4 **To describe** the environmental and physiological effects of synthetic agrochemicals and their background chemistry.

Cognitive Map of Course Outcomes Based on Revised Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge	CO-1, CO-2, CO-3, CO-4	CO-1, CO-2, CO-3, CO-4	CO-2, CO-3, CO-4			
Conceptual Knowledge		CO-1, CO-2, CO-3, CO-4	CO-2, CO-3, CO-4	CO-3, CO-4	CO-3, CO-4	
Procedural Knowledge			CO-2, CO-3, CO-4	CO-3, CO-4	CO-3, CO-4	CO-4
Metacognitive Knowledge					CO-4	CO-4

Mapping of Course Learning Outcomes (CLO's) to Programme Specific Outcomes (PSO's)

CLO / PSO	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8
CLO-I	3	2	2	2	2	2	2	2
CLO-II	3	3	2	2	2	2	2	2
CLO-III	3	2	3	2	2	3	3	3
CLO-IV	3	3	3	3	3	2	3	2
Average	**3**	**2.5**	**2.5**	**2.25**	**2.25**	**2.25**	**2.5**	**2.25**

[3 = Strongly aligned, 2 = Moderately aligned, 1 = Weakly aligned]

Suggested Readings:

1. A textbook of Applied Chemistry, P S Kalsi, M R Manrao, Kalyani Publishres
2. Principles of Biochemistry – A.L. Lehninger, D.L. Nelson and M.N. Cox, CBS Publishers, and Distributors.
3. Srilakshmi B (2017): Nutrition Science,6th Multicolour Ed. New Age International (P) Ltd.
4. Roday S (2012): Food Science and Nutrition, 2nd Ed. Oxford University Press.
5. Mann J and Truswell (2017): Essentials of Human Nutrition, 5th Ed. Oxford University Press.
6. P.C. Ray, History of Chemistry in ancient and medieval India, Chowkhambha Krishnadas Academy, Reprint Edition, 1 January 2004.
7. Textbook on IKS by Prof. B Mahadevan, IIM Bengaluru
8. Kapur K and Singh A.K (Eds) 2005). Indian Knowledge Systems, Vol. 1. Indian Institute of Advanced Study, Shimla. Tatvabodh of Sankaracharya, Central Chinmay Mission Trust, Bombay, 1995.

SEMESTER IV

Course Title: **Inorganic Chemistry**
Course Code: **CC-4-MCH-401**
Nature of the course: **Core**
Component of the course: **L=3, T=1, P=0**
Total Credit assigned: **4**
Contact Hours: **60**
Distribution of Marks: **End Semester=56; In Semester =24 (Total= 80)**

Course Objectives:

CO-1: **To understand** the chemical principles, raw materials, and manufacturing processes involved in silicate-based industries such as glass, ceramics, and cement.

CO-2: **To explore** the composition, production, and classification of fertilizers used in agriculture.

CO-3: **To learn** the fundamentals of surface coatings, including paints, pigments, and metallic finishes used in industrial applications.

CO-4: **To study** the types, working principles, and chemistry behind different batteries and energy storage devices.

Course Contents

Unit	Content	Marks	L	P	T
I	**Silicate Industries** *Glass*: Glassy state and its properties, classification (silicate and non-silicate glasses). Manufacture and processing glass. Composition and properties of the following types of glasses: Soda lime glass, lead glass, armored glass, safety glass, borosilicate glass, fluorosilicate, colored glass, photosensitive glass. *Ceramics*: Important clays and feldspar, ceramic, their types, and manufacture. High technology ceramics and their applications, superconducting and semiconducting oxides, fullerenes carbon nanotubes and carbon fiber. *Cement*: Classification of cement, ingredients and their role, Manufacture of cement and the setting process, quick setting cements.	16	15	0	3
II	**Fertilizers** Different types of fertilizers. Manufacture of the following fertilizers: Urea, ammonium nitrate, calcium ammonium nitrate, ammonium phosphates; polyphosphate, superphosphate, compound and mixed fertilizers, potassium chloride, potassium sulphate.	15	10	0	2

III	**Surface Coatings** Objectives of coatings surfaces, preliminary treatment of surface, classification of surface coatings. Paints and pigments-formulation, composition, and related properties. Oil paint, Vehicle, modified oils, Pigments, toners and lakes pigments, Fillers, Thinners, Enamels, emulsifying agents. Special paints (Heat retardant, Fire retardant, Eco-friendly paint, Plastic paint), Dyes, Wax polishing, Water and Oil paints, additives, Metallic coatings, metal spraying and anodizing.	15	10	0	5
IV	**Batteries** Primary and secondary batteries, battery components and their role, Characteristics of Battery. Working of following batteries: Pb acid, Li-Battery, Solid state electrolyte battery. Fuel cells, Solar cell and polymer cell.	10	10	0	5
Total		**56**	**45**	**0**	**15**

(L= Lecture, P = Practical, T = Tutorial)

Mode of In-Semester Assessment: (24 Marks)

Sessional Test:	Marks: 15
Other Sessional Activities:	Marks: 9
In- Semester Assessment	Marks: 24

Sessional Activity

1. Activities selected from the above-mentioned list:
   - Lecture Cum Discussion,
   - Seminars,
   - Group discussion,
   - Self-Study
   - Sudden Test

Course Learning Outcomes:

CLO-I

1.1 **To describe** the properties and classification of glass and explain the manufacturing and processing of various industrial glasses.

1.2 **To identify** types of ceramics, clays, and feldspars and to explain ceramic manufacturing processes and applications of advanced ceramics.

1.3 **To explain** the classification, ingredients, and setting process of different types of cement including quick-setting cement.

1.4 **To evaluate** the uses of superconducting and semiconducting oxides, carbon nanotubes, and fullerenes in high-tech applications.

CLO-II
2.1 **To classify** different types of fertilizers and explain their role in agriculture.

2.2 **To describe** the manufacturing processes of nitrogenous, phosphatic, and potassic fertilizers including urea, ammonium nitrate, and superphosphate.

2.3 **To evaluate** the composition and applications of compound and mixed fertilizers.

CLO-III
3.1 **To explain** the objectives and types of surface coatings and the preparation of surfaces for coating.

3.2 **To describe** the formulation and components of paints, pigments, fillers, thinners, and special coatings like eco-friendly or heat-resistant paints.

3.3 **To differentiate** among types of coatings such as enamels, emulsions, metallic coatings, and anodized finishes.

3.4 **To explain** the role of dyes, waxes, and polishing agents in industrial surface treatment.

CLO-IV
4.1 **To differentiate** between primary and secondary batteries and explain the roles of battery components.

4.2 **To describe** the working and characteristics of Pb-acid, lithium, solid-state, and polymer batteries.

4.3 **To explain** the principles and applications of fuel cells and solar cells as alternative energy sources.

Table 1: Cognitive Map of Course Outcomes Based on Revised Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge	CO-1, CO-2, CO-3, CO-4	CO-1, CO-2, CO-3, CO-4	CO-2, CO-3, CO-4			
Conceptual Knowledge		CO-1, CO-2, CO-3, CO-4	CO-2, CO-3, CO-4	CO-1, CO-3, CO-4	CO-1, CO-3, CO-4	
Procedural Knowledge			CO-2, CO-3, CO-4	CO-3, CO-4	CO-3, CO-4	CO-4
Metacognitive Knowledge					CO-4	CO-4

Table 2: Mapping of Course Learning Outcomes (CLO's) to Programme Specific Outcomes (PSO's)

CLO / PSO	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8
CLO-I	3	2	2	2	3	2	3	2
CLO-II	3	3	2	2	2	2	2	2
CLO-III	3	3	3	2	3	3	3	3
CLO-IV	3	2	3	3	2	2	3	3
Average	**3**	**2.5**	**2.5**	**2.25**	**2.5**	**2.25**	**2.75**	**2.5**

[3 = Strongly aligned, 2 = Moderately aligned, 1 = Weakly aligned]

Suggested Readings:

1. E. Stocchi: Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.
2. R. M. Felder, R. W. Rousseau: Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi.
3. W. D. Kingery, H. K. Bowen, D. R. Uhlmann: Introduction to Ceramics, Wiley Publishers, New Delhi.
4. J. A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
5. P. C. Jain, M. Jain: Engineering Chemistry, Dhanpat Rai & Sons, Delhi.
6. R. Gopalan, D. Venkappayya, S. Nagarajan: Engineering Chemistry, Vikas Publications, New Delhi.
9. 7. B. K. Sharma: Engineering Chemistry, Goel Publishing House, Meerut..

SEMESTER IV

Course Title: **Organic Chemistry-IV:Green and Sustainable Chemistry**
Course Code: **CC-4-MCH-402**
Nature of the course: **Core**
Component of the course: **L=3, T=1, P=0**
Total Credit assigned: **4**
Contact Hours: **60**
Distribution of Marks: **End Semester=56; In Semester =24 (Total= 80)**

Course Objectives:

CO-1: **To introduce** the fundamental principles, need, and goals of green chemistry and highlight its importance in reducing environmental impact.

CO-2: **To explore** the twelve principles of green chemistry and their application in designing safer, more efficient, and environmentally friendly chemical syntheses.

CO-3: **To examine** examples of green reactions, reagents, and energy-efficient techniques such as microwave and ultrasound-assisted syntheses.

CO-4: **To understand** the role of green chemistry in sustainable development and its potential in promoting safer and solvent-free chemical practices.

Course Contents

Unit	Content	Marks	L	P	T
I	**Introduction to Green Chemistry** What is Green Chemistry? Need for Green Chemistry. Goals of Green Chemistry. Limitations? Obstacles in the pursuit of the goals of Green Chemistry; E-factor.	10	5	0	2
II	**Principles of Green Chemistry and Designing a Chemical synthesis:** Twelve principles of Green Chemistry with their explanations and examples and special emphasis on the following: 1. Designing a green synthesis using these principles; Prevention of waste/ byproducts. 2. Atom Economy, calculation of atom economy for chemical transformations. **Prevention/ minimization of hazardous/ toxic products**: 1. Green solvents- supercritical fluids, water, ionic liquid and PEGs as green solvents for organic reactions. 2. Energy requirements for reactions- alternative sources of energy: use of microwaves and ultrasonic energy.	20	20	0	5

	3. Selection of starting materials; carbohydrate avoidance of unnecessary derivatization (protection, blocking group) 4. Use of catalytic reagents in preference to stoichiometric reagents. catalysis- use of zeolite, PTC catalyzed green reactions, co-enzymes as catalysts. 5. Prevention of chemical accidents by designing greener processes, inherent safer design.				
III	**Examples of Green Reagents/ Synthesis/ Reactions** Green synthesis of the following compounds: adipic acid, catechol, disodium iminodiacetate, paracetamol, ibuprofen. Microwave assisted reactions: *Microwave assisted reactions in water* (oxidation of toluene to benzoic acid, oxidation of alcohols); *microwave assisted reactions in organic solvents* (Diels-Alder reaction and Decarboxylation); *Microwave assisted solvent-free reactions* (solid state reaction) (Deprotection and Saponification) Ultrasound assisted reactions: Reformatsky reaction, Ullmann's coupling and Cannizaro reaction under sonication.	16	15	0	5
IV	**Green chemistry in sustainable development** Oxidation reagents and catalysts; multifunctional reagents; Combinatorial green chemistry; Proliferation of solventless reactions.	10	5	0	3
Total		56	45	0	15

(L= Lecture, P = Practical, T = Tutorial)

Mode of In-Semester Assessment: (24 Marks)

A. Sessional Test: Marks: 15
B. Other Sessional Activities: Marks: 9

In- Semester Assessment Marks: 24

C. Sessional Activity

1. Activities selected from the above-mentioned list:
   - Lecture Cum Discussion,
   - Seminars,
   - Group discussion,
   - Self-Study
   - Sudden Test

Course Learning Outcomes:

CLO-I
1.1 **To define** green chemistry and explain its goals, significance, and challenges.

1.2 **To evaluate** the need for green chemistry in the context of environmental safety and industrial sustainability.

1.3 **To calculate** E-factor and assess the environmental efficiency of chemical processes.

CLO-II
2.1 **To describe** and apply the twelve principles of green chemistry in real-world chemical design.

2.2 **To calculate** atom economy and analyze synthetic routes based on efficiency and waste minimization.

2.3 **To select** green solvents (e.g., water, PEGs, supercritical fluids, ionic liquids) and alternative energy sources (microwaves, ultrasound) for chemical reactions.

2.4 **To design** greener chemical processes through catalyst selection (zeolites, co-enzymes, PTC) and safer reagents.

2.5 **To prevent** chemical hazards through safer design strategies and inherent safety principles.

CLO-III
3.1 **To synthesize** industrially relevant compounds (e.g., paracetamol, adipic acid, ibuprofen) using green methods.

3.2 **To perform and explain** microwave-assisted reactions in aqueous, organic, and solvent-free conditions.

3.3 **To demonstrate** ultrasound-assisted reactions such as Cannizzaro and Ullmann coupling using sonication.

3.4 **To compare** traditional vs. green synthetic methods in terms of safety, efficiency, and sustainability.

CLO-IV
4.1 **To analyse** the role of green chemistry in sustainable development and pollution prevention.

4.2 **To identify and apply** oxidation reagents, multifunctional reagents, and combinatorial methods in green synthesis.

4.3 **To promote** solventless reactions and evaluate their impact on green manufacturing.

Table 1: Cognitive Map of Course Outcomes Based on Revised Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge	CO-1, CO-2, CO-3, CO-4	CO-1, CO-2, CO-3, CO-4	CO-2, CO-3			
Conceptual Knowledge		CO-1, CO-2, CO-3, CO-4	CO-2, CO-3, CO-4	CO-2, CO-3, CO-4	CO-1, CO-2, CO-3, CO-4	
Procedural Knowledge			CO-2, CO-3	CO-3, CO-4	CO-3, CO-4	CO-2, CO-4
Metacognitive Knowledge					CO-4	CO-4

Table 2: Mapping of Course Learning Outcomes (CLO's) to Programme Specific Outcomes (PSO's)

CLO / PSO	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8
CLO-I	3	2	2	3	2	2	3	2
CLO-II	3	3	3	3	3	3	3	3
CLO-III	3	3	3	3	3	2	3	3
CLO-IV	3	2	3	3	3	2	3	3
Average	**3**	**2.5**	**2.75**	**3**	**2.75**	**2.25**	**3**	**2.75**

[3 = Strongly aligned, 2 = Moderately aligned, 1 = Weakly aligned]

Suggested Readings:

Textbooks:

1. V. Kumar, An introduction to Green Chemistry, Vishal Publications (2020).

Reference Books:

1. P. T. Anastas & J. K. Warner: Oxford Green Theory and Practical, University Press (1998).
2. A. S. Matlack: Introduction to Green Chemistry, Marcel Dekker (2001).
3. M. C. Cann& M. E. Connely: Real-World cases in Green Chemistry, American Chemical Society, Washington (2000).

SEMESTER IV

Course Title: **Physical Chemistry-IV: Quantum Chemistry**
Course Code: **CC-4-MCH-403**
Nature of the course: **Core**
Component of the course: **L=1, T=1, P=0**
Total Credit assigned: **2**
Contact Hours:**30**
Distribution of Marks: **End Semester=28; In Semester =12 (Total= 40)**

Course Objectives:

CO-1: **To introduce** quantum mechanical models and their application to simple physical systems such as harmonic oscillators, rotors, and tunnelling.
CO-2: **To apply** approximate methods such as the variation theorem and perturbation theory for solving problems in quantum chemistry.
CO-3: **To explain** molecular orbital and valence bond approaches to chemical bonding, including the Born–Oppenheimer approximation and hybridization.

Course Contents

Unit	Content	Marks	L	P	T
I	Quantum mechanical models Simple Harmonic Oscillator-Schrodinger equation and its solution, Hermite polynomials, two-particle rigid rotor- rotational energy levels of diatomic molecules, particle in a ring, quantum mechanical tunnelling.	10	5	0	5
II	Approximate methods Variation theorem, linear variation functions. Time independent Perturbation theory for non-degenerate systems (up to second order in energy).	8	5	0	5
III	Born-Oppenheimer approximation LCAO-MO and VB treatment of the Hydrogen molecule and Hydrogen molecule ion, Extension of the LCAO-MO method to homo-and heteronuclear diatomic molecules and ions -: CO, NO, NO+, NO−, HF, CN, CN−. Construction of wave functions of SP, SP2, and SP3 hybrid orbitals.	10	5	0	5
Total		**28**	**15**	**0**	**15**

(L= Lecture, P = Practical, T = Tutorial)

Mode of In-Semester Assessment: (12 Marks)

Sessional Test:	Marks: 7
Other Sessional Activities:	Marks: 5

In- Semester Assessment Marks: 12

Sessional Activity

Activities selected from the above-mentioned list:

- Lecture Cum Discussion,
- Seminars,
- Group discussion,
- Self-Study
- Sudden Test

Course Learning Outcomes:

CLO-I

1.1 **To solve** the Schrödinger equation for a one-dimensional harmonic oscillator and interpret Hermite polynomial solutions.

1.2 **To determine** rotational energy levels using the rigid rotor model and apply it to diatomic molecules.

1.3 **To describe** quantum mechanical tunnelling and analyse its applications in molecular systems.

1.4 **To model** a particle in a ring and relate the quantized energy levels to cyclic systems.

CLO-II

2.1 **To explain** the variational principle and apply it to estimate ground state energies of quantum systems.

2.2 **To construct** and apply linear variation functions in quantum calculations.

2.3 **To apply** time-independent perturbation theory to non-degenerate systems and determine first- and second-order energy corrections.

CLO-III

3.1 **To describe** the Born–Oppenheimer approximation and apply it to molecular systems.

3.2 **To construct** molecular orbitals using LCAO-MO and valence bond methods for H_2^+ and H_2.

3.3 **To use** LCAO-MO theory to diatomic molecules such as CO, NO, HF, CN, and their ions.

3.4 **To construct** wave functions for SP, SP^2, and SP^3 hybrid orbitals and **explain** molecular geometries using hybridization concepts.

Table 1: Cognitive Map of Course Outcomes Based on Revised Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge	CO-1, CO-2, CO-3	CO-1, CO-2, CO-3	CO-1, CO-2, CO-3			
Conceptual Knowledge		CO-1, CO-2, CO-3	CO-1, CO-2, CO-3	CO-1, CO-2, CO-3	CO-2, CO-3	
Procedural Knowledge			CO-1, CO-2, CO-3	CO-2, CO-3	CO-2, CO-3	CO-3
Metacognitive Knowledge					CO-3	CO-3

Table 2: Mapping of Course Learning Outcomes (CLO's) to Programme Specific Outcomes (PSO's)

CLO / PSO	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8
CLO-I	3	2	2	2	2	2	2	3
CLO-II	3	3	3	2	2	2	2	3
CLO-III	3	2	3	2	3	2	2	3
Average	**3**	**2.33**	**2.67**	**2**	**2.33**	**2**	**2**	**3**

[3 = Strongly aligned, 2 = Moderately aligned, 1 = Weakly aligned]

Suggested Readings:

Textbooks:

1. Physical Chemistry by P.W. Atkins
2. Quantum Chemistry, by Ira N. Levine, Pentice Hall

Recommended Books:

1. Physical Chemistry by I. N. Levine
2. Introduction to Quantum Chemistry by A.K. Chandra, Tata McGraw Hill.
3. Molecular Quantum Mechanics by P.W. Atkins & R.S. Friedman, Oxford University Press.
4. Solid State Chemistry and its Applications- A. R. West, Wiley India
5. Introduction to Thermal Analysis: Techniques and Applications- M.E. Brown, Springer

6. Introduction to Instrumental analysis – R.D. Braun, McGraw Hill

SEMESTER IV

Course Title: **Analytical Chemistry**
Course Code: **DSE-4-MCH-401A**
Nature of the course: **Discipline Specific Elective**
Component of the course: **L=3, T=1, P=0**
Total Credit assigned: **4**
Contact Hours:**60**
Distribution of Marks: **End Semester=56; In Semester =24 (Total= 80)**

Course Objectives:

CO-1: **To introduce** the principles and applications of UV-Visible, IR, and X-ray diffraction methods used in chemical analysis.

CO-2: **To explain** the theory and instrumentation of electrochemical and thermal analysis techniques including cyclic voltammetry and DSC.

CO-3: **To understand** various chromatographic separation methods and their application in chemical and biochemical analysis.

CO-4: **To explore** the fundamentals of microscopic techniques such as SEM, TEM, and AFM.

CO-5: **To familiarize** students with advanced surface and structural characterization tools used for industrial catalyst analysis.

Course Contents

Unit	Content	Marks	L	P	T
I	Instrumentation and application of UV-Visible, IR, Principles and applications of powder and single Crystal XRD.	10	9	0	3
II	Polarography Basic principles, instrumentation, and applications of cyclic voltammetry. Thermal methods: Principles and applications of Thermogravimetry (TG), Derivative thermogravimetry (DTG), Differential thermal analysis (DTA) and Differential scanning calorimetry (DSC).	11	9	0	3
III	Chromatographic methods Chromatographic methods: Adsorption, liquid-liquid Partition, ion–exchange, HPLC, gel permeation chromatography and gas chromatography, HPTLC,	10	9	0	3

	Flash chromatography.				
IV	Electron Microscopy Transmission Electron Microscopy (TEM), Scanning Electron Microscopy (SEM), Atomic Force Microscopy (AFM)	10	9	0	3
V	Characterization techniques of industrial catalysts Low energy electron diffraction (LEED), Field emission and ionization microscopy (FEM, FIM), Surface extended X-ray absorption fine structure spectroscopy (SEXAFS), Scanning-tunnelling microscopy (STM) temperature programmed desorption (TDP) and molecular beam techniques, EPR, PES, AES techniques.	15	9	0	3
Total		56	45	0	15

(L= Lecture, P = Practical, T = Tutorial)

Mode of In-Semester Assessment: (24 Marks)

Sessional Test: Marks: **15**

Other Sessional Activities: Marks: **9**

In- Semester Assessment Marks: **24**

Sessional Activity

Activities selected from the above-mentioned list:

- Lecture Cum Discussion,
- Seminars,
- Group discussion,
- Self-Study
- Sudden Test

Course Learning Outcomes:

CLO-I

1.1 **To explain** the instrumentation and working principles of UV-Visible and IR spectroscopy.

1.2 **To describe** the theory and application of powder and single crystal X-ray diffraction in material characterization.

CLO-II

2.1 **To understand** the basic principles and instrumentation of polarography and cyclic voltammetry.

2.2 **To apply** electrochemical methods to study redox systems and surface reactions.

2.3 **To explain** the principles and applications of thermal techniques including TG, DTG, DTA, and DSC in material analysis.

CLO-III

3.1 **To classify** different chromatographic techniques based on separation mechanisms.

3.2 **To describe** the working principles and applications of gas chromatography, HPLC, HPTLC, and flash chromatography.

3.3 **To apply** chromatographic methods in the qualitative and quantitative analysis of chemical mixtures.

CLO-IV

4.1 **To explain** the principles, instrumentation, and resolution capabilities of TEM and SEM.

4.2 **To describe** the application of atomic force microscopy (AFM) in topographical and material surface analysis.

CLO-V

5.1 **To identify and describe** surface-sensitive techniques such as LEED, FEM, FIM, STM, SEXAFS, TPD, PES, AES, and EPR.

5.2 **To interpret** surface structural data obtained from advanced spectroscopic and microscopic techniques.

5.3 **To evaluate** the properties and catalytic behaviour of industrial catalysts using characterization tools.

Table 1: Cognitive Map of Course Outcomes Based on Revised Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual Knowledge	CO-1, CO-2, CO-3, CO-4, CO-5	CO-1, CO-2, CO-3, CO-4, CO-5	CO-2, CO-3, CO-4, CO-5			
Conceptual Knowledge		CO-1, CO-2, CO-3, CO-4, CO-5	CO-2, CO-3, CO-4, CO-5	CO-3, CO-4, CO-5	CO-2, CO-5	CO-5
Procedural Knowledge			CO-2, CO-3, CO-4, CO-5	CO-3, CO-4, CO-5	CO-4, CO-5	CO-5
Metacognitive Knowledge					CO-5	CO-5

Table 2: Mapping of Course Learning Outcomes (CLO's) to Programme Specific Outcomes (PSO's)

CLO / PSO	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8
CLO-I	3	2	2	2	2	2	2	3
CLO-II	3	3	3	2	2	2	2	3
CLO-III	3	3	3	2	3	2	2	3
CLO-IV	3	3	3	2	3	2	2	3
CLO-V	3	3	3	3	3	2	2	3
Average	**3**	**2.8**	**2.8**	**2.2**	**2.6**	**2**	**2**	**3**

[3 = Strongly aligned, 2 = Moderately aligned, 1 = Weakly aligned]

Suggested Readings:

Textbooks:

1. 1.Instrumental Methods of Chemical Analysis - H Kaur, Pragati Prakashan Applications- A. R. West, Wiley India

2. Introduction to Thermal Analysis: Techniques and Applications- M.E. Brown, Springer

3. Introduction to Instrumental analysis – R.D. Braun, McGraw Hill.

SEMESTER IV

Course Title: **Material Chemistry**
Course Code: **DSE-4-MCH-401A**
Nature of the course: **Discipline Specific Elective**
Component of the course: **L=3, T=1, P=0**
Total Credit assigned: **4**
Contact Hours:**60**
Distribution of Marks: **End Semester=56; In Semester =24 (Total= 80)**

Course Objectives:

CO-1: **To provide** foundational understanding of materials of technological importance, particularly in the field of nanobiotechnology, nanotoxicity, and catalysis, including their characterization methods.

CO-2: **To explain** the classification, structure-property relationships, and technological applications of polymers, conducting polymers, and ceramic materials.

CO-3: **To introduce** fundamental concepts in nanoscience and nanotechnology, focusing on nanostructured materials, synthesis methods, and catalytic applications.

Course Contents

Unit	Content	Marks	L	P	T
I	**Materials of technological importance** Introduction to nano biotechnology (bio-imaging, bio-labelling, and drug delivery), nanotoxicity and nano catalysis. Application of powder XRD, TEM, FT-IR, UV-Vis and Fluorescence spectroscopy in determining/characterization of nano particles.	16	15	0	5
II	**Polymer materials** Classification of polymers, Molecular forces and chemical bonding in polymers, Texture of Polymers. Determination of crystalline melting point and degree of crystallinity, Morphology of crystalline polymers, Factors affecting crystalline melting point. Physical, thermal, Flow&MechanicalPropertiesofpolymers.Conductingpolymers-Introduction, conduction mechanism, polyaniline (PANI), polyacetylene, polyparaphenylene and polypyrrole, applications of conducting polymers, Ion-exchange resins and their applications. Polymer matrix composites. Ceramic & Refractory: Introduction, classification, properties, raw materials, manufacturing and applications.	20	15	0	5
III	**Nanostructured materials** Introduction to Nanoscience and Nanotechnology, influence of nano over micro / macro.1D, 2D and 3D nanostructured materials, Quantum Dots shell	20	15	0	5

	structures, mechanical-physical chemical properties, Quantum confinement effect and Surface plasmon resonance. Synthesis and modification of nanoparticles: Top-Down and Bottom-Up approach, experimental procedure (coprecipitation, Sol-gel, Hydrothermal, colloidal etc.), HSAB rule for precipitation, nucleation (homogeneous and heterogeneous), crystal growth, morphology dependence properties. Introduction to surface active agents, types of surfactants. Basic characterizations for structural purity and morphology study. Applications of metal oxide and semiconductor nanoparticles in catalysis (photocatalysis, electrocatalysis etc.) and energy.				
Total		56	45	0	15

(L= Lecture, P = Practical, T = Tutorial)

Mode of In-Semester Assessment: (24 Marks)

Sessional Test:	Marks: 15
Other Sessional Activities:	Marks: 9

In- Semester Assessment Marks: 24

Sessional Activity

Activities selected from the above-mentioned list:

- Lecture Cum Discussion,
- Seminars,
- Group discussion,
- Self-Study
- Sudden Test

Course Learning Outcomes:

CLO-I

1.1 **To explain** the principles of nanobiotechnology and its applications in bio-imaging, drug delivery, and labeling.

1.2 **To describe** the effects and importance of nanotoxicity and nanocatalysis in real-world systems.

1.3 **To apply** powder XRD, TEM, FT-IR, UV-Vis, and fluorescence spectroscopy for nanoparticle characterization.

CLO-II

2.1 **To classify** polymers and explain the influence of bonding and molecular forces on polymer properties.

2.2 **To determine** polymer crystallinity and describe factors affecting crystalline melting point and morphology.

2.3 **To describe** the structure, conduction mechanism, and applications of conducting polymers and ion-exchange resins.

CLO-III

3.1 **To distinguish** between 1D, 2D, and 3D nanostructures and explain quantum confinement and surface plasmon resonance.

3.2 **To compare** synthesis methods such as sol-gel, coprecipitation, and hydrothermal approaches for nanoparticles.

3.3 **To evaluate** the catalytic and energy applications of metal oxide and semiconductor nanoparticles.

Table 1: Cognitive Map of Course Outcomes Based on Revised Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge	CO-1, CO-2, CO-3	CO-1, CO-2	CO-1			
Conceptual Knowledge		CO-1, CO-2, CO-3	CO-2, CO-3	CO-3	CO-1, CO-3	
Procedural Knowledge			CO-1, CO-3	CO-3	CO-3	CO-3
Metacognitive Knowledge					CO-3	CO-3

Table 2: Mapping of Course Learning Outcomes (CLO's) to Programme Specific Outcomes (PSO's)

CLO / PSO	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8
CLO-1	3	2	2	2	2	2	2	3
CLO-2	3	2	2	2	2	2	2	2
CLO-3	3	2	3	2	2	2	3	3
Average	**3**	**2**	**2.33**	**2**	**2**	**2**	**2.33**	**2.67**

[3 = Strongly aligned, 2 = Moderately aligned, 1 = Weakly aligned]

Suggested Readings:

Textbooks:

1. Solid State Chemistry and its applications A.R. West, John Wiley & Sons
2. Polymer Science by V.R. Gowarikar, N. V. Viswanathan and Jayadev Sreedhar

Recommended Books:

1. Inorganic Chemistry, Shriver & Atkins, 5th Edition Oxford
2. Introduction to Polymer by R. J. Young and P. A. Lovell

SEMESTER IV

Course Title: **RESEARCH PROJECT OR CORE COURSE**
Course Code: **CC-6-MCH-404**
Nature of the course: **Core**
Component of the course: **L=0, T=0, P=6**
Total Credit assigned: **6**
Contact Hours:**180**
Distribution of Marks: **End Semester=120; In Semester =0 (Total= 120)**

Course Objectives:

CO-I:To provide the students with brief exposure to materials of technological importance.

CO-II:To provide knowledge about synthesis and structural properties of nano materials.

Course Contents

Unit	Content	Marks	L	P	T
I		**120**	**0**	**180**	**0**

(L= Lecture, P = Practical, T = Tutorial)

In this paper students will have to carry out project work (Laboratory experiments) either at their respective colleges or any other R&D laboratory and UGC recognized University under guidance of a faculty member. Students will do the project work during the semester break after 5th semester and may take at the maximum of 45days for the project work. The area of work is to be decided by the advisor. On completion of the project work students will have to submit the work in the form of a dissertation followed by oral presentation in the presence of faculty members and an external expert.
[Mark Distribution for evaluation of the Project Work

Laboratory Experiment
1. Literature Review 20 Marks
2. Objectives 20 Marks
3. Experimental work 30 Marks
4. Results & Discussions 30 Marks
5. Presentation and Viva 20 Marks

Mode of In-Semester Assessment: **NONE**

Course Learning Outcomes:

CLO-I:To l**earnhow** to correctly conduct scientific research.

CLO-II:To assess and use sources of information.

CLO-III:To understand scientific methods of data collection and analysis.

CLO-IV:Todevelop specific laboratory skills, research methodology, and critical thinking abilities.

Table 1: Cognitive Map of Course Outcomes Based on Revised Bloom's Taxonomy

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge	CO-1	CO-1				
Conceptual Knowledge		CO-1, CO-2	CO-2	CO-2		
Procedural Knowledge			CO-1, CO-2	CO-1, CO-2	CO-2	CO-2
Metacognitive Knowledge				CO-1, CO-2	CO-2	CO-2

Table 2: Mapping of Course Learning Outcomes (CLO's) to Programme Specific Outcomes (PSO's)

CLO / PSO	PSO-1	PSO-2	PSO-3	PSO-4	PSO-5	PSO-6	PSO-7	PSO-8
CLO-1	2	3	3	2	2	3	2	2
CLO-2	2	2	3	2	2	3	2	3
CLO-3	2	3	3	2	2	3	2	3
CLO-4	3	3	3	3	2	3	3	3
Average	**2.25**	**2.75**	**3**	**2.25**	**2**	**3**	**2.25**	**2.75**

[3 = Strongly aligned, 2 = Moderately aligned, 1 = Weakly aligned]

Suggested Readings:

Textbooks:

1. Solid State Chemistry and its applications A.R. West, John Wiley & Sons
2. Polymer Science by V.R. Gowarikar, N. V. Viswanathan and Jayadev Sreedhar

Recommended Books:

1. Inorganic Chemistry, Shriver & Atkins, 5th Edition Oxford
2. Introduction to Polymer by R. J. Young and P. A. Lovell