CURRICULUM FRAMEWORK FOR THREE YEAR UG DEGREE/FOUR YEAR UG DEGREE (HONOURS WITHOUT RESEARCH)/ FOUR YEAR UG DEGREE (HONOURS WITH RESEARCH) IN (Name of Department: CHEMISTRY) (As per NEP 2020 Guidelines)

(As approved by Board of Studies in (Chemistry) held **on31st May 2024** and passed by Academic Council held on ----------)

1.0. About the B.Sc. programme in Chemistry:

1.1. **Introduction: Bachelor of Science (B.Sc.) in Chemistry** 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 B.A. /B.Sc. (Department)**: The B.Sc. program is a four-year undergraduate course. Its core subjects include

a. **Inorganic Chemistry** – Study of metals, minerals, and non-carbon-based compounds.
b. **Organic Chemistry** – Study of carbon-containing compounds and their reactions.
c. **Physical Chemistry** – Understanding chemical thermodynamics, kinetics, quantum chemistry, and spectroscopy.
d. **Analytical Chemistry** – Techniques like chromatography, titration, and spectroscopy to analyse substances.
e. **Biochemistry** – Study of chemical processes in living organisms.
f. **Environmental Chemistry** – Study of pollutants, green chemistry, and environmental impact.
g. **Industrial Chemistry** – Applications of chemistry in industries like pharmaceuticals, petrochemicals, and materials science.

Skills Developed

a. Laboratory techniques and instrumentation
b. Problem-solving and critical thinking
c. Data analysis and scientific research
d. Chemical safety and handling

1.3. **Aims of bachelor's degree Programme in Chemistry:** The aims of a B.Sc. 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.

To Enhance Practical and Laboratory Skills

i. Train students in **modern laboratory techniques**, including synthesis, analysis, and instrumentation.

ii. 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 **M.Sc., 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. Practical and Experimental Skills

iii. Cognitive and Analytical Skills

iv. Communication and IT Skills

v. Professional and Ethical Responsibility

vi. Employability and Lifelong Learning

1.5. Programme Specific Outcome (PSO's):

1. **Fundamental Knowledge in Chemistry:**
    i. Graduates will demonstrate a strong foundation in the core areas of chemistry, including organic, inorganic, physical, and analytical chemistry.
    ii. They will be able to apply principles and concepts from these areas to solve complex chemical problems.
2. **Laboratory Skills and Techniques:**
    i. Graduates will be proficient in conducting experiments, using modern instruments, and employing appropriate techniques in a chemistry laboratory.
    ii. They will be able to analyse and interpret experimental data accurately and safely.
3. **Research, Critical Thinking and Problem-Solving Abilities:**
    i. Graduates will develop the ability to design, conduct, and evaluate research in chemistry.
    ii. They will be skilled in applying critical thinking and problem-solving approaches to address scientific questions and real-world issues.
4. **Chemical Safety and Ethics:**
    i. Graduates will be aware of and adhere to chemical safety regulations and ethical guidelines in both academic and professional settings.
    ii. They will understand the environmental and societal impacts of chemical processes and products.
5. **Interdisciplinary Knowledge and Skills:**
    i. Graduates will integrate knowledge from chemistry with other disciplines such as physics, biology, and environmental science to address interdisciplinary problems.
    ii. They will be able to collaborate effectively in multidisciplinary teams.
6. **Communication and Professional Skills:**

i. Graduates will be able to communicate chemical information clearly and effectively in both written and oral forms to scientific and non-scientific audiences.

ii. They will develop professional skills such as teamwork, leadership, and time management.

7. **Ensuring Environmental Awareness and Sustainable Development through Chemistry:**

i. Graduates will be able to demonstrate an understanding of the chemical principles underlying environmental processes and issues and apply sustainable practices in chemical usage and waste management to promote environmental protection and sustainability.

ii. Graduates will understand the global impact of chemical research and practices, including their roles in addressing worldwide challenges such as climate change, health, energy, and sustainable development, and engage responsibly as global citizens in scientific and environmental initiatives.

8. **Enhancing Computer Skills for Scientific Data Analysis and Research**

Graduates will develop basic to intermediate computer skills, including the use of software tools for data analysis, chemical modelling, and scientific report writing, to support research, documentation, and effective communication in chemistry.

1.6. Course Learning Outcome (CLO):

The **Course Learning Outcomes (CLOs)** for a **Bachelor of Science (BSc) 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 **B.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:

a. *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.
b. *Summative Assessment*: (final Semester Examinations)
c. *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 Bachelor of Science (B.Sc.) in Chemistry typically include the following requirements as per the Clause of 3.2 of NEP guidelines of North Lakhimpur College approved by the 12th Academic Council, North Lakhimpur College (Autonomous) held on 16th May 2023:

(a) *UG Certificate*: Students who opt to exit after completion of the first year and have secured 40 credits will be awarded a UG certificate if, in addition, they complete one vocational course of 4 credits during the summer vacation of the first year. These students are allowed to re-enter the degree programme within three years and complete the degree programme within the stipulated maximum period of seven years.

(b) *UG Diploma*: Students who opt to exit after completion of the second year and have secured 80 credits will be awarded the UG diploma if, in addition, they

complete one vocational course of 4 credits during the summer vacation of the second year. These students are allowed to re-enter within a period of three years and complete the degree programme within the maximum period of seven years.

(c) *3-year UG Degree*: Students who wish to undergo a 3-year UG programme will be awarded UG Degree in the Major discipline after successful completion of three years, securing 120 credits and satisfying the minimum credit requirement as given in table 2 (Section 5).

(d) *4-year UG Degree (Honours)*: A four-year UG Honours degree in the major discipline will be awarded to those who complete a four-year degree programme with 160 credits and have satisfied the credit requirements as given in table 2 in Section 5.

(e) *4-year UG Degree (Honours with Research):* Students who secure 75% marks and above in the first six semesters and wish to undertake research at the undergraduate level can choose a research stream in the fourth year. They should do a research project or dissertation under the guidance of a faculty member of the University/College. The research project/dissertation will be in the major discipline. The students who secure 160 credits, including 12 credits from a research project/dissertation, are awarded UG Degree (Honours with Research).

(f) *UG Degree Programmes with Single Major:* A student must secure a minimum of 50% credits from the major discipline for the 3-year/4-year UG degree to be awarded a single major. For example, in a 3-year UG programme, if the total number of credits to be earned is 120, a student of Chemistry with a minimum of 60 credits will be awarded a B.Sc. in Chemistry with a single major. Similarly, in a 4-year UG programme, if the total number of credits to be earned is 160, a student of Chemistry with a minimum of 80 credits will be awarded a B.Sc. (Hons. /Hon. With Research) in Chemistry in a 4-year UG programme with single major.

2.1 **Other Key Criteria for UG Programme**:

Attendance Requirements: As per the guidelines of college authority in the concerned academic year.

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

SEMESTER I

Course	Course Title	Course Code	Credit	Marks	End Sem Marks	Internal Assessment
Major	General Chemistry	MAJ-4-CHE-101	4	80	56	24
Major	Chemistry Practical	MAJ-1-CHE-101	1	20	20	0
Minor	General Chemistry	MIN-4-CHE-101	4	80	56	24
Minor	Chemistry Practical	MIN-1-CHE-101	1	20	20	0
MDC	Energy and Environment	MDC-3-CHE-101	3	60	42	18
SEC	Environmental Monitoring and Assessment-I	SEC-3-CHE-101	1	40	28	12
SEC	SEC Practical	SEC-2-CHE-101	2	40	40	0

SEMESTER II

Course	Course Title	Course Code	Credit	Marks	End Sem Marks	Internal Assessment
Major	General Chemistry	MAJ-4-CHE-201	4	80	56	24
Major	Chemistry Practical	MAJ-1-CHE-201	1	20	20	0
Minor	General Chemistry	MIN-4-CHE-201	4	80	56	24
Minor	Chemistry Practical	MIN-1-CHE-201	1	20	20	0
MDC	Food nutrition and preservation	MDC-3-CHE-201	3	60	42	18
SEC	Environmental Monitoring and Assessment-II	SEC-3-CHE-201	1	40	28	12
SEC	SEC Practical	SEC-2-CHE-201	2	40	40	0

SEMESTER III

Course	Course Title	Course Code	Credit	Marks	End Sem Marks	Internal Assessment
Major	Inorganic Chemistry	MAJ-3-CHE-301	3	60	42	18
Major	Chemistry Practical	MAJ-1-CHE-301	1	20	20	0
Major	Organic Chemistry	MAJ-3-CHE-302	3	60	42	18
Major	Chemistry Practical	MAJ-1-CHE-302	1	20	20	0
Minor	General Chemistry	MIN-1-CHE-301	1	40	28	12
Minor	Chemistry Practical	MIN-1-CHE-301	1	20	20	0
DSE (Option 1)	Physical Chemistry: Chemical Thermodynamics	DSE-2-CHE-301A	2	40	28	12
DSE (Option 2)	Physical Chemistry: Basic Computational Chemistry	DSE-2-CHE-301A	2	40	28	12
MDC	Water Remediation and Conservation Studies	MDC-3-CHE-301	3	60	42	18
SEC	Environmental Monitoring and Assessment-III	SEC-3-CHE-301	1	40	28	12
SEC	SEC Practical	SEC-2-CHE-301	2	40	40	0

SEMESTER IV

Course	Course Title	Course Code	Credit	Marks	End Sem Marks	Internal Assessment
Major	Inorganic Chemistry	MAJ-4-CHE-401	4	80	56	24
Major	Organic Chemistry	MAJ-4-CHE-402	4	80	56	24
Major	Physical Chemistry	MAJ-4-CHE-403	4	80	56	24
Major	Chemistry Practical (**Option A**) (General Chemistry)	MAJ-4-CHE-401A	4	80	80	0
Major	Chemistry Practical (**Option B**) (Computational Chemistry Practical I)	MAJ-4-CHE-401B	4	80	80	0

SEMESTER V

Course	Course Title	Course Code	Credit	Marks	End Sem Marks	Internal Assessment
Major	Inorganic Chemistry	MAJ-5-CHE-501	5	100	70	30
Major	Organic Chemistry	MAJ-4-CHE-502	4	80	56	24
Major	Physical Chemistry	MAJ-4-CHE-503	4	80	56	24
DSE	Chemistry Practical I (General Chemistry) OPTION1	DSE-3-CHE-501A	3	60	60	0
DSE	Computational Chemistry Practical II OPTION2	DSE-3-CHE-501B	3	60	60	0
Major	INTERNSHIP	MAJ-4-CHE-501	4	80	80	0

SEMESTER VI

Course	Course Title	Course Code	Credit	Marks	End Sem Marks	Internal Assessment
Major	Inorganic Chemistry	MAJ-5-CHE-601	5	100	70	30
Major	Organic Chemistry	MAJ-4-CHE-602	4	80	56	24
Major	Physical Chemistry	MAJ-4-CHE-603	4	80	56	24
Major	Chemistry Practical (General Chemistry)	MAJ-4-CHE-601	4	80	80	0
DSE	Chemistry and Environment (Option 1)	DSE-3-CHE-601A	3	60	60	0
DSE	Chemistry in Ancient India (Option 2)	DSE-3-CHE-601B	3	60	42	18

SEMESTER VII

Course	Course Title	Course Code	Credit	Marks	End Sem Marks	Internal Assessment
Major	Inorganic Chemistry	MAJ-4-CHE-701	4	80	56	24
Major	Organic Chemistry	MAJ-4-CHE-702	4	80	56	24
Major	Physical Chemistry	MAJ-4-CHE-703	4	80	56	24
DSE	Laboratory Course-I (Option 1)	DSE-4-CHE-701A	4	80	80	0
	Laboratory Course-I (Option 2)	DSE-4-CHE-701B	4	80	80	0
Minor	Analytical Methods in Chemistry	MIN-4-CHE-701	4 (3+1)	80 (60+20)	Theory 42 Practical 20	Theory 18 Practical 0

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SEMESTER VIII

Course	Course Title	Course Code	Credit	Marks	End Sem Marks	Internal Assessment

Compulsory Papers						
Major	Spectroscopy II	MAJ-4-CHE-801	4	80	56	24
Major	Research Methodology	MAJ-4-CHE-802	4	80	56	24
Option 1: For B.Sc. (Honours) degree in Chemistry						
Major	Inorganic Chemistry	MAJ-4-CHE-801	4	80	56	24
Major	Organic Chemistry	MAJ-4-CHE-801	4	80	56	24
Major	Laboratory Course II	MAJ-4-CHE-801	4	80	80	0
Option 2: For B.Sc. (Honours with Research) degree in Chemistry						
Major	Research project	RP-12-CHE-801	12	240	As directed by Academic Council	

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SEMESTER-I

Course Title: **General Chemistry**
Course Code: **MAJ-4-CHE-101**
Nature of the course: **Major**
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 Explain the principles of wave mechanics, quantum numbers, and atomic orbitals, and their significance in understanding atomic structure.

CO-2: To Describe periodic trends in atomic and ionic properties, including effective nuclear charge, atomic radii, ionization enthalpy, and electronegativity

CO-3: To Explain the electronic effects (inductive, resonance, hyperconjugation), stability of reactive intermediates, and the energy profile of organic reactions.

CO-4: **To Illustrate** the preparation and reaction mechanisms of alkanes, alkenes, and alkynes, including elimination and addition reactions.

CO-5: **To Describe** the deviations of real gases from ideal behaviour using the van der Waals equation and the concept of critical constants.

CO-6: **To Explain** the physical properties of liquids such as vapour pressure, surface tension, and viscosity, and their dependence on solutes and temperature.

Course Contents

Unit	Content	Marks	L	P	T
I	**Atomic Structure:** Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Wave mechanics: de Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, significance of ψ and ψ^2. Quantum numbers and their significance. Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shapes of *s*, *p*, *d* and *f* orbitals. Contour boundary and probability diagrams. Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, Variation of orbital energy with atomic number.	10	8	0	2
II	**Periodicity of Elements:** *s*, *p*, *d*, *f* block elements, the long form of periodic table. Detailed discussion of the following properties of the elements, with reference to *s* and *p*-block. (a) Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table. (b) Atomic radii (van der Waals) (c) Ionic and crystal radii. (d) Covalent radii (octahedral and tetrahedral) (e) Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy. (f) Electron gain enthalpy, trends of electron gain enthalpy. (g) Electronegativity, Pauling's/ Mulliken's/ Allred Rachow's/ and Mulliken-Jaffé's electronegativity scales. Variation of electronegativity with bond order, partial charge, hybridization, group electronegativity. Sanderson's electron density ratio.	9	7	0	3
III	**Basic Organic Chemistry:** ***Organic Compounds****:* Influence of hybridization on bond properties. ***Electronic effects****:* Inductive, electrometric, resonance and mesomeric effects, hyperconjugation and their applications; Electrophiles and Nucleophiles; Nucleophilicity and basicity; Types, shape and their	9	8	0	2

	relative stability of Carbocations, Carbanions, Free radicals and Carbenes, Nitrenes. Organic acids and bases; their relative strength, Energy profile diagrams of one step, two steps & three steps reactions, Activation energy				
IV	**Chemistry of Aliphatic Hydrocarbons:** **A. Carbon-Carbon sigma bond** Chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Wurtz-Fittig Reactions, Corey House Reaction, Free radical substitutions: Halogenation -relative reactivity and selectivity. **B. Carbon-Carbon pi bonds:** Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations. Special emphasis on preparation of alkenes by Syn elimination – Pyrolysis of esters, Chugaev, Wittig and Heck Reaction. ***Reactions of alkenes:*** Electrophilic additions and their mechanisms. Regioselective (directional selectivity) and Stereoselective addition reactions. Mechanism of hydroboration-oxidation, reduction (catalytic and chemical), Syn and anti-hydroxylation (oxidation), Simple effect of Stereoselectivity & Stereospecificity; Kinetically Controlled & Thermodynamically Controlled reactions. 1,2-and 1,4-addition reactions in conjugated dienes and, Diels-Alder reaction. ***Reactions of alkynes:*** Acidity, Electrophilic and Nucleophilic additions. Hydration to form carbonyl compounds, Alkylation of terminal alkynes.	10	7	0	3
V	**Gaseous state**: **Behaviour of real gases**: Deviations from ideal gas behaviour, compressibility factor, *Z*, and its variation with pressure for different gases. Causes of deviation from ideal behaviour: van der Waals equation of state, its derivation and application in explaining real gas behaviour, mention of other equations of state (Berthelot, Dietrici); virial equation of state; van der Waals equation expressed in virial form and calculation of Boyle temperature. Isotherms of real gases and their comparison with van der Waals isotherms, continuity of states, critical state, relation between critical constants and van der Waals constants, law of corresponding states.	10	10	0	4

VI	**Liquid state:** Qualitative treatment of the structure of the liquid state; Radial distribution function; physical properties of liquids; vapour pressure, surface tension and coefficient of viscosity, and their determination. Effect of addition of various solutes on surface tension and viscosity. Explanation of cleansing action of detergents. Temperature variation of viscosity of liquids and comparison with that of gases. Qualitative discussion of structure of water.	8	5	0	1
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: 14**
Other Sessional Activities:	**Marks: 10**

In- Semester Assessment **Marks: 24**

A. Sessional Activity

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

Course Learning Outcomes (CLOs)

By the end of this unit, students will be able to:

CLO-1

1.1 **Recall** the fundamental concepts of atomic structure, including Bohr's theory, quantum numbers, and wave functions.

1.2 **Explain** the significance of Schrödinger's wave equation and the shapes of atomic orbitals.

1.3 **Interpret** the principles of Pauli's Exclusion Principle, Hund's Rule, and Aufbau's Principle in electron configuration.

CLO-2

2.1 **Describe** the periodic trends in atomic and ionic radii, ionization enthalpy, and electron gain enthalpy.

2.2 **Apply** Slater's rules to calculate the effective nuclear charge and understand its variation across the periodic table.
2.3 **Explain** the different electronegativity scales and their dependence on bond order, hybridization, and group electronegativity.

CLO-3

3.1 **Recall** the various electronic effects (inductive, electromeric, resonance, and hyperconjugation) and their applications.
3.2 **Describe** the types, structures, and relative stabilities of carbocations, carbanions, free radicals, carbenes, and nitrenes.
3.3 **Interpret** energy profile diagrams of one-step and multi-step reactions, activation energy, and reaction mechanisms.

CLO-4

4.1 **Explain** the mechanisms of the Wurtz, Wurtz-Fittig, Corey-House, Chugaev, Wittig, and Heck reactions.
4.2 **Illustrate** the formation of alkenes and alkynes through elimination reactions, including Saytzeff and Hofmann eliminations.
4.3 **Interpret** the stereoselective and regioselective addition reactions of alkenes and the acidity of alkynes.

CLO-5

5.1 **Describe** the causes of deviation from ideal gas behaviour and the significance of the compressibility factor (Z).
5.2 **Explain** the van der Waals equation and its application in understanding real gases.

CLO-6

6.1 **Describe** the radial distribution function and its significance in understanding liquid structure.
6.2 **Explain** the determination of surface tension and viscosity and their variation with solutes and temperature.
6.3 **Interpret** the molecular structure of water and its unique physical properties.

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

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluation	Create
Factual Knowledge	CO1, CO3					
Conceptual Knowledge		CO1, CO2, CO3, CO4, CO5, CO6	CO1, CO2, CO3, CO4, CO5			
Procedural Knowledge			CO5, CO6			

Metacognitive Knowledge						

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	-	-
CLO_2	3	-	3	-	-	2	-	-
CLO_3	3	-	3	2	2	2	2	-
CLO_4	3	3	3	2	2	2	2	-
CLO_5	3	-	3	-	3	2	2	-
CLO_6	3	3	3	2	3	2	2	-
Average	**3**	**1**	**3**	**1**	**1.67**	**2**	**1.33**	**0**

(3=High, 2=Moderate, 1=Low)

Suggested Readings:

1. Lee, J.D. *Concise Inorganic Chemistry* ELBS, 1991.
2. Douglas, B.E. and McDaniel, D.H. *Concepts & Models of Inorganic Chemistry* Oxford, 1970
3. Atkins, P.W. & Paula, J. *Physical Chemistry*, 10th Ed., Oxford University Press, 2014.
4. Day, M.C. and Selbin, J. *Theoretical Inorganic Chemistry*, ACS Publications, 1962.
5. Rodger, G.E. *Inorganic and Solid-State Chemistry*, Cengage Learning India Edition, 2002.
6. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
7. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
8. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
9. Eliel, E. L. & Wilen, S. H. Stereochemistry of Organic Compounds; Wiley London, 1994.
10. Kalsi, P. S. Stereochemistry Conformation and Mechanism; New Age International, 2005.
11. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry Ed., Oxford University Press (2006).
12. Ball, D. W. Physical Chemistry Thomson Press, India (2007).
13. Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
14. Mortimer, R. G. Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP (2009).
15. Negi, A. S; Anand, S. C. *A Textbook of Physical Chemistry* New Age International Publishers
16. Pahari, S *Physical Chemistry Vol I &II* New Central Book Agency (P) Ltd.
17. Puri, Sharma, Pathania, Principles *of Physical Chemistry* Vishal Publishing Co.

SEMESTER-I

Course Title: **Chemistry Practical**
Course Code: **MAJ-1-CHE-101**
Nature of the course: **Major**
Component of the course: **L=0, T=0, P=1**
Total Credit assigned: **1**
Contact Hours: **30**
Distribution of Marks: **End Semester=20; IN SEMESTER =0 (Total= 20)**

Course Objectives:

CO-1: To Analyse acid-base titration data to estimate the composition of carbonate, bicarbonate, and hydroxide mixtures in each sample.

CO-2: To Perform the crystallization of organic compounds using different solvents and evaluate the effect of impurities on melting points.

CO-3: To Investigate the relationship between surface tension/viscosity and solute concentration using experimental techniques.

Course Contents

Unit	Content	Marks	L	P	T
I	Acid-Base Titrations (i) Estimation of carbonate and hydroxide present together in mixture. (ii) Estimation of carbonate and bicarbonate present together in a mixture.	7	0	10	0
II	1. Purification of organic compounds by crystallization using the following solvents: a. Water b. Alcohol c. Alcohol-Water 2. (Experiment) Determination of the melting points of above compounds and unknown organic compounds (Kjeldahl method and electrically heated melting point apparatus) (a) Effect of impurities on the melting point – mixed melting point of two unknown organic compounds	5	0	10	0
III	**Surface tension measurements.** a. Determine the surface tension of various liquids by drop number method. b. Study the variation of surface tension of detergent solutions with concentration.	6	0	10	0

	Viscosity measurement using Ostwald's viscometer. a. Determination of viscosity of aqueous solutions of (i) polymer (ii) ethanol and (iii) sugar at room temperature. b. Study the variation of viscosity of sucrose solution with the concentration of solute.				
	Viva	2			
Total		20	0	30	0

Mode of Transaction: Laboratory Works, Experiments.

Mode of In-Semester Assessment: NONE

Course Learning Outcomes (CLOs)

By the end of this course, students will be able to:

CLO-1

1.1 **Perform** acid-base titrations to estimate the composition of carbonate, bicarbonate, and hydroxide in a mixture.
1.2 **Analyse** titration curves and endpoint detection methods for accurate estimation of acid-base components.
1.3 **Interpret** the role of indicators and pH changes in determining the composition of complex acid-base systems.

CLO-2

2.1 **Apply** crystallization techniques using different solvents to purify organic compounds.
2.2 **Determine** the melting points of pure and impure compounds using Kjeldahl and electrically heated apparatus.
2.3 **Determine** the effect of impurities on the melting point by conducting mixed melting point experiments.

CLO-3

3.1 **Determine** the surface tension of liquids using the drop number method and analyse its variation with detergent concentration.
3.2 **Determine** the viscosity of aqueous solutions (polymers, ethanol, sugar) using Ostwald's viscometer.

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

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluation	Create
Factual Knowledge	CO1	CO1				
Conceptual Knowledge	CO1, CO2	CO2, CO3	CO1, CO2, CO3			
Procedural Knowledge				CO1, CO2, CO3		
Metacognitive Knowledge						

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	3	3	3	1	2	2
CLO_2	3	3	3	3	3	1	2	2
CLO_3	3	3	3	3	3	1	2	2
Average	**3**	**3**	**3**	**3**	**3**	**1**	**2**	**2**

(3=High, 2=Moderate, 1=Low)

Suggested Readings:

1. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education (2009)
2. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.,* Pearson (2012)
3. Mendham, J., A. I. Vogel's *Quantitative Chemical Analysis 6th Ed.,* Pearson, 2009.
4. Nad, A.K., Mahapatra, B., Ghoshal, A., An Advanced Course in Practical Chemistry, New Central Book Agency (P) Ltd., Kolkata, India.
5. Das, Subhas C, Advanced Practical Chemistry for 3-Year Honours Course. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi (2011).
6. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry 8th Ed*.; McGraw-Hill: New York (2003).
7. Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry 3rd Ed.;* W.H. Freeman & Co.: New York (2003).
8. Yadav, J.B., *Advanced Practical Physical Chemistry 32nd Ed*; Goel Publishing House

SEMESTER-I

Course Code: **MIN-4-CHE-101**
Course Title: **General Chemistry**
Nature of the Course: **Minor**
Total Credit assigned: **4**
Distribution of Credits: **L=3, T=1, P=0**
Contact Hours: **60**
Distribution of Marks: **End Semester=56; In Semester =24 (Total= 80)**

Course Objectives:

CO-1: To Explain the principles of wave mechanics, quantum numbers, and atomic orbital, and their significance in understanding atomic structure.

CO-2: To Describe periodic trends in atomic and ionic properties, including effective nuclear charge, atomic radii, ionization enthalpy, and electronegativity

CO-3: To Explain the electronic effects (inductive, resonance, hyperconjugation), stability of reactive intermediates, and the energy profile of organic reactions.

CO-4: **To Illustrate** the preparation and reaction mechanisms of alkanes, alkenes, and alkynes, including elimination and addition reactions.

CO-5: **To Describe** the deviations of real gases from ideal behaviour using the vander Waal's equation and the concept of critical constants.

CO-6: **To Explain** the physical properties of liquids such as vapour pressure, surface tension, and viscosity, and their dependence on solutes and temperature.

Course Contents

Unit	Content	Marks	L	P	T
	Inorganic Part (For all NEP Students)				
I	**Atomic Structure:** Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Wave mechanics: de Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, significance of ψ and ψ^2. Quantum numbers and their significance. Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shapes of *s*, *p*, *d* and *f* orbitals. Contour boundary and probability diagrams.	10	8	0	2

	Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, Variation of orbital energy with atomic number.				
II	**Periodicity of Elements:** *s*, *p*, *d*, *f* block elements, the long form of periodic table. Detailed discussion of the following properties of the elements, with reference to *s* and *p*-block. Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table. a. Atomic radii (vander Waals) b. Ionic and crystal radii. c. Covalent radii (octahedral and tetrahedral) d. Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy. e. Electron gain enthalpy, trends of electron gain enthalpy. f. Electronegativity, Pauling's/ Mulliken's/ Allred Rachow's/ and Mulliken-Jaffé's electronegativity scales. Variation of electronegativity with bond order, partial charge, hybridization, group electronegativity. Sanderson's electron density ratio.	9	7	0	3
Organic Part (For NEP Students admitted in 2025 and onwards)					
III	**Basic Organic Chemistry:** ***Organic Compounds****:* Influence of hybridization on bond properties. ***Electronic effects****:* Inductive, electrometric, resonance and mesomeric effects, hyperconjugation and their applications; Electrophiles and Nucleophiles; Nucleophilicity and basicity; Types, shape and their relative stability of Carbocations, Carbanions, Free radicals and Carbenes, Nitrenes. Organic acids and bases; their relative strength,	9	8	0	2

	Energy profile diagrams of one step, two steps & three steps reactions, Activation energy.				
IV	**Chemistry of Aliphatic Hydrocarbons:** **A. Carbon-Carbon sigma bond** Chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Wurtz-Fittig Reactions, Corey House Reaction, Free radical substitutions: Halogenation -relative reactivity and selectivity. **B. Carbon-Carbon pi bonds:** Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations. Special emphasis on preparation of alkenes by Syn elimination – Pyrolysis of esters, Chugaev, Wittig and Heck Reaction. ***Reactions of alkenes:*** Electrophilic additions and their mechanisms. Regioselective (directional selectivity) and Stereoselective addition reactions. Mechanism of hydroboration-oxidation, reduction (catalytic and chemical), Syn and anti-hydroxylation (oxidation), Simple effect of Stereoselectivity & Stereospecificity; Kinetically Controlled & Thermodynamically Controlled reactions. 1,2-and 1,4-addition reactions in conjugated dienes and, Diels-Alder reaction. ***Reactions of alkynes:*** Acidity, Electrophilic and Nucleophilic additions. Hydration to form carbonyl compounds, Alkylation of terminal alkynes.	10	7	0	3
Organic Part (For NEP Students admitted upto 2024)					
III	**Fundamentals of Organic Chemistry:** Physical Effects, Electronic Displacements: Inductive Effect, Electromeric Effect, Resonance and Hyperconjugation. Cleavage of Bonds: Homolysis and Heterolysis. Structure, shape and reactivity of organic molecules: Nucleophiles and electrophiles. Reactive Intermediates: Carbocations, Carbanions and free radicals. Strength of organic acids and bases: Comparative study with	10	7	0	3

	emphasis on factors affecting *p*K values. Aromaticity: Benzenoids and Hückel's rule				
IV	**Stereochemistry:** Conformation with respect to ethane, butane and cyclohexane. Configuration: Geometrical and Optical isomerism; Enantiomerism, Diastereomerism and Meso Compounds.	9	8	0	2
Physical Part (For all NEP Students)					
V	**Gaseous state**: **Behaviour of real gases**: Deviations from ideal gas behaviour, compressibility factor, *Z*, and its variation with pressure for different gases. Causes of deviation from ideal behaviour: Vander Waal's equation of state, its derivation and application in explaining real gas behaviour, mention of other equations of state (Berthelot, Dietrici); virial equation of state; Vander Waal's equation expressed in virial form and calculation of Boyle temperature. Isotherms of real gases and their comparison with Vander Waal's isotherms, continuity of states, critical state, relation between critical constants and Vander Waal's constants, law of corresponding states.	10	10	0	4
VI	**Liquid state:** Qualitative treatment of the structure of the liquid state; Radial distribution function; physical properties of liquids; vapour pressure, surface tension and coefficient of viscosity, and their determination. Effect of addition of various solutes on surface tension and viscosity. Explanation of cleansing action of detergents. Temperature variation of viscosity of liquids and comparison with that of gases. Qualitative discussion of structure of water.	8	5	0	1
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: 14**

Other Sessional Activities: **Marks: 10**

In- Semester Assessment **Marks:24**

B. Sessional Activity

1. Activities selected from abovementioned list:
   g) Home Assignments
   h) Class Assignments
   i) Seminars
   j) Group Discussions
   k) Sudden Tests
   l) Class Attendance.

Course Learning Outcomes (CLOs)

By the end of this course, students will be able to:

CLO-1

1.1 **Recall** the fundamental concepts of atomic structure, including Bohr's theory, quantum numbers, and wave functions.

1.2 **Explain** the significance of Schrödinger's wave equation and the shapes of atomic orbitals.

1.3 **Interpret** the principles of Pauli's Exclusion Principle, Hund's Rule, and Aufbau's Principle in electron configuration.

CLO-2

2.1 **Describe** the periodic trends in atomic and ionic radii, ionization enthalpy, and electron gain enthalpy.

2.2 **Apply** Slater's rules to calculate the effective nuclear charge and understand its variation across the periodic table.

2.3 **Explain** the different electronegativity scales and their dependence on bond order, hybridization, and group electronegativity.

CLO-3

3.1 **Recall** the various electronic effects (inductive, electromeric, resonance, and hyperconjugation) and their applications.

3.2 **Describe** the types, structures, and relative stabilities of carbocations, carbanions, free radicals, carbenes, and nitrenes.

3.3 **Interpret** energy profile diagrams of one-step and multi-step reactions, activation energy, and reaction mechanisms.

CLO-4

4.1 **Explain** the mechanisms of the Wurtz, Wurtz-Fittig, Corey-House, Chugaev, Wittig, and Heck reactions.

4.2 **Illustrate** the formation of alkenes and alkynes through elimination reactions, including Saytzeff and Hofmann eliminations.

4.3 **Interpret** the stereoselective and regioselective addition reactions of alkenes and the acidity of alkynes.

CLO-5

5.1 **Describe** the causes of deviation from ideal gas behaviour and the significance of the compressibility factor (Z).

5.2 **Explain** the Vander Waal's equation and its application in understanding real gases.

CLO-6

6.1 **Describe** the radial distribution function and its significance in understanding liquid structure.

6.2 **Explain** the determination of surface tension and viscosity and their variation with solutes and temperature.

6.3 **Interpret** the molecular structure of water and its unique physical properties.

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

Knowledge Dimension	**Remember**	**Understand**	**Apply**	**Analyse**	**Evaluation**	**Create**
Factual Knowledge	CO1, CO3					
Conceptual Knowledge		CO1, CO2, CO3, CO4, CO5, CO6	CO1, CO2, CO3, CO4, CO5			
Procedural Knowledge			CO5, CO6			
Metacognitive Knowledge						

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	-	-
CLO_2	3	-	3	-	-	2	-	-
CLO_3	3	-	3	2	2	2	2	-
CLO_4	3	3	3	2	2	2	2	-
CLO_5	3	-	3	-	3	2	2	-
CLO_6	3	3	3	2	3	2	2	-
Average	**3**	**1**	**3**	**1**	**1.67**	**2**	**1.33**	**0**

(3=High, 2=Moderate, 1=Low)

Suggested Readings:

18. Lee, J.D. *Concise Inorganic Chemistry* ELBS, 1991.
19. Douglas, B.E. and McDaniel, D.H. *Concepts & Models of Inorganic Chemistry* Oxford, 1970
20. Atkins, P.W. & Paula, J. *Physical Chemistry*, 10th Ed., Oxford University Press, 2014.
21. Day, M.C. and Selbin, J. *Theoretical Inorganic Chemistry*, ACS Publications, 1962.
22. Rodger, G.E. *Inorganic and Solid-State Chemistry*, Cengage Learning India Edition, 2002.
23. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
24. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
25. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
26. Eliel, E. L. & Wilen, S. H. Stereochemistry of Organic Compounds; Wiley London, 1994.
27. Kalsi, P. S. Stereochemistry Conformation and Mechanism; New Age International, 2005.

28. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry Ed., Oxford University Press (2006).
29. Ball, D. W. Physical Chemistry Thomson Press, India (2007).
30. Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
31. Mortimer, R. G. Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP (2009).
32. Negi, A. S; Anand, S. C. *A Textbook of Physical Chemistry* New Age International Publishers
33. Pahari, S *Physical Chemistry Vol I &II* New Central Book Agency (P) Ltd.
34. Puri, Sharma, Pathania, Principles *of Physical Chemistry* Vishal Publishing Co.

SEMESTER-I

Course Title: **Chemistry Practical**
Course Code: **MIN-1-CHE-101**
Nature of the course: **Major**
Component of the course: **L=0, T=0, P=1**
Total Credit assigned: **1**
Contact Hours: **30**
Distribution of Marks: **End Semester=20; IN SEMESTER =0 (Total= 20)**

Course Objectives:

CO-1: To Analyse acid-base titration data to estimate the composition of carbonate, bicarbonate, and hydroxide mixtures in each sample.

CO-2: To Perform the crystallization of organic compounds using different solvents and evaluate the effect of impurities on melting points.

CO-3: To Investigate the relationship between surface tension/viscosity and solute concentration using experimental techniques.

Course Contents

Unit	Content	Marks	L	P	T
I	Acid-Base Titrations (i) Estimation of carbonate and hydroxide present together in mixture. (ii) Estimation of carbonate and bicarbonate present together in a mixture.	7	0	10	0
II	1. Purification of organic compounds by crystallization using the following solvents: a. Water b. Alcohol c. Alcohol-Water 2. (Experiment) Determination of the melting points of above compounds and unknown organic compounds (Kjeldahl method and electrically heated melting point apparatus) (b) Effect of impurities on the melting point – mixed melting point of two unknown organic compounds	5	0	10	0
III	**Surface tension measurements.** a. Determine the surface tension of various liquids by drop number method. b. Study the variation of surface tension of detergent solutions with concentration.	6	0	10	0

	Viscosity measurement using Ostwald's viscometer. a. Determination of viscosity of aqueous solutions of (i) polymer (ii) ethanol and (iii) sugar at room temperature. b. Study the variation of viscosity of sucrose solution with the concentration of solute.				
	Viva	2			
Total		20	0	30	0

Mode of Transaction: Laboratory Works, Experiments.

Mode of In-Semester Assessment: NONE

Course Learning Outcomes (CLOs)

By the end of this course, students will be able to:

CLO-1

1.1 **Perform** acid-base titrations to estimate the composition of carbonate, bicarbonate, and hydroxide in a mixture.
1.2 **Analyse** titration curves and endpoint detection methods for accurate estimation of acid-base components.
1.3 **Interpret** the role of indicators and pH changes in determining the composition of complex acid-base systems.

CLO-2

2.1 **Apply** crystallization techniques using different solvents to purify organic compounds.
2.2 **Determine** the melting points of pure and impure compounds using Kjeldahl and electrically heated apparatus.
2.3 **Determine** the effect of impurities on the melting point by conducting mixed melting point experiments.

CLO-3

3.1 **Determine** the surface tension of liquids using the drop number method and analyse its variation with detergent concentration.
3.2 **Determine** the viscosity of aqueous solutions (polymers, ethanol, sugar) using Ostwald's viscometer.

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

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluation	Create
Factual Knowledge	CO1	CO1				
Conceptual Knowledge	CO1, CO2	CO2, CO3	CO1, CO2, CO3			
Procedural Knowledge				CO1, CO2, CO3		
Metacognitive Knowledge						

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	3	3	3	1	2	2
CLO_2	3	3	3	3	3	1	2	2
CLO_3	3	3	3	3	3	1	2	2
Average	**3**	**3**	**3**	**3**	**3**	**1**	**2**	**2**

(3=High, 2=Moderate, 1=Low)

Suggested Readings:

9. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education (2009)
10. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.,* Pearson (2012)
11. Mendham, J., A. I. Vogel's *Quantitative Chemical Analysis 6th Ed.,* Pearson, 2009.
12. Nad, A.K., Mahapatra, B., Ghoshal, A., An Advanced Course in Practical Chemistry, New Central Book Agency (P) Ltd., Kolkata, India.
13. Das, Subhas C, Advanced Practical Chemistry for 3-Year Honours Course. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi (2011).
14. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry 8th Ed*.; McGraw-Hill: New York (2003).
15. Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry 3rd Ed.;* W.H. Freeman & Co.: New York (2003).
16. Yadav, J.B., *Advanced Practical Physical Chemistry 32nd Ed*; Goel Publishing House

SEMESTER-I

Course Title: **Energy and Environment**
Course Code: **MDC-3-CHE-101**
Nature of the course: **Minor**
Component of the course: **L=2, T=1, P=0**
Total Credit assigned: **3**
Contact Hours: **45**
Distribution of Marks: End **Semester=42; In Semester =18 (Total= 60)**

Course Objectives:

CO-1: **To Define** key components of an ecosystem and describe their functions

CO-2: **To Explain** the causes and effects of air pollution, including global warming and ozone depletion.

CO-3: **To Explain** methods for assessing water quality and propose strategies for water purification.

CO-4: **To Compare and evaluate** different energy sources based on their environmental impact and sustainability.

Course Contents

Unit	Content	Marks	L	P	T
I	**Environment and its Segments:** Ecosystem, components of ecosystem, structure of ecosystem, function of an ecosystem, major regions of atmosphere.	7	6	0	2
II	**Air Pollution:** Air pollutants, types of air pollutants, atmospheric pollutants, greenhouse effect, CFCs, smog, effects of air pollution, air pollution control, global warming, effects on forests, crops, Ozone layer depletion, ozone holes.	10	8	0	4
III	**Water Pollution:** Water, sources water, water pollution, Fresh water, surface water, groundwater pollution, marine pollution, thermal pollution, eutrophication, marine eutrophication, wastewater treatment, purification of water, characteristics of potable water.	10	8	0	4
IV	**Energy:** Energy resources, types of energy, conventional (non-renewable) energy sources, coal, advantages and disadvantages of solid coal, petroleum, longevity of petroleum, disadvantages of petroleum, natural gas,	15	8	0	5

	nuclear energy, wind energy, hydroelectric power, wave power, ocean thermal energy conservation, nuclear pollution, effects of radiation on human health, effects of radioactive pollution, prevention and control of radioactive waste, disposal of radioactive wave.				
Total		42	30	0	15

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

Mode of In-Semester Assessment: (18 Marks)

A. Sessional Test: Marks: 11

B. Other Sessional Activities: Marks: 7

In- Semester Assessment Marks: 18

C. Sessional Activity

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

Course Learning Outcomes (CLOs)

By the end of this course, students will be able to

CLO-1

1.1 **Define** key terms related to ecosystems, such as components, structure, and function.
1.2 **Identify** the major regions of the atmosphere and their characteristics.
1.3 **Explain** how ecosystems function and the interactions between their components.

CLO-2

2.1 **List** the major air pollutants and classify them based on their sources.
2.2 **Recall** the effects of air pollution on forests, crops, and human health.
2.3 **Describe** the greenhouse effect, global warming, and ozone depletion with examples.

CLO-3

3.1 **Identify** different sources of water pollution, including surface water and groundwater contamination.
3.2 **Recall** the characteristics of potable water and its significance.
3.3 **Explain** the process of wastewater treatment and how it helps in pollution control.

CLO-4

4.1 **List** various conventional and non-conventional energy sources.

4.2 **Identify** the effects of nuclear pollution and radioactive waste on human health.

4.3 **Discuss** different energy sources based on their advantages and disadvantages.

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

Knowledge Dimension	**Remember**	**Understand**	**Apply**	**Analyse**	**Evaluation**	**Create**
Factual Knowledge	CO1	CO1, CO2, CO3, CO4				
Conceptual Knowledge	CO1, CO2	CO1, CO2, CO3, CO4				
Procedural Knowledge						
Metacognitive Knowledge						

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	3	1	3	1	3	-
CLO_2	3	3	3	1	3	1	3	-
CLO_3	3	3	3	1	3	1	3	-
CLO_4	3	3	3	1	3	1	3	-
Average	**3**	**3**	**3**	**1**	**3**	**1**	**3**	**0**

(3=High, 2=Moderate, 1=Low)

Suggested Readings:

1. E. Stocchi: Industrial Chemistry, Vol -I, Ellis Horwood Ltd. UK.

2. B. K. Sharma: Industrial Chemistry, Goel Publishing House, Meerut.

3. B. C. Das: Industrial Chemicals and environment, Kalyani Publishers.

Course Title: **Environmental Monitoring and Assessment-I**
Course Code: **SEC-3-CHE-101**
Nature of the course: **Skill Enhancement Course (SEC)**
Component of the course: **L=1, T=0, P=2**
Total Credit assigned: **3 (Theory1+Practical 2)**
Contact Hours: **15(Theory) + 60 (Practical)**

Distribution of Marks:

Theory	**Credit=1**	**End Semester=28**	**In Semester =12**	**Total =40**
Practical	**Credit=2**	**End Semester=40**	**In Semester =0**	**Total =40**

Course Objectives:

CO-1: To develop an understanding of the structure and components of the environment, biogeochemical cycles, atmospheric chemistry, air pollution, photochemical smog, ozone depletion, and their impacts on living organisms and ecosystems.

CO-2: To analyze the sources, effects, and control measures of major environmental pollutants, including greenhouse gases, and to evaluate environmental issues such as global warming, ozone layer depletion, and air quality management.

CO-3: To provide knowledge of conventional and non-conventional energy resources, nuclear energy and waste management, and the role of biocatalysis in promoting sustainable and green chemical processes.

Unit 1: Environment and its segments, Marks 20, 10 Lectures

Ecosystems, Biogeochemical cycles of carbon, nitrogen and Sulphur. Air Pollution: major regions of atmosphere. Chemical and photochemical reactions in atmosphere. Air pollutants: types, sources, particle size and chemical nature; Photochemical smog: its constituents and photochemistry. Environmental effects of ozone layers. Major sources of air pollution. Pollution by SO_2, CO_2, CO, NO_2 and H_2S and control procedures. Effects of air pollution on living organisms and vegetation. Greenhouse effect and global warming, Ozone depletion by oxides of nitrogen, chlorofluorocarbons and halogens, removal of Sulphur from coal

Unit 2: Energy and Environment, Marks 08, 5 Lectures

Sources of energy: coal, petrol and natural gas. Nuclear fusion/fission, solar energy, hydrogen, geothermal, tidal and hydel. Nuclear Pollution: Disposal of nuclear waste, nuclear disaster and its management.

Biocatalysis: Introduction to biocatalysts: Importance in green chemistry and chemical industry

Suggested Readings

1. Saikia, B.; 2021, Fuel Chemistry.
2. Raven, P.H, Hassenzahl, D.M., Hager, M.C, Gift, N.Y., and Berg, L.R. (2015). *Environment,* 8thEdition. Wiley Publishing, USA.
3. Singh, J.S., Singh, S.P., and Gupta, S.R. (2017). *Ecology, Environmental Science and Conservation.* S. Chand Publishing, New Delhi.
4. Odum, E.P., Odum, H.T., and Andrews, J. (1971). *Fundamentals of Ecology.* Saunders,Philadelphia, USA.
5. Raven, P.H, Hassenzahl, D.M., Hager, M.C, Gift, N.Y., and Berg,L.R. (2015). *Environment,* 9thEdition. Wiley Publishing, USA.
6. Gadgil, M. and Guha, R. (1993). *This Fissured Land: An Ecological History of India.* University of California Press, Berkeley, USA.
7. McCully, P. (1996). *Rivers no more: the environmental effects of dams,* In: *Silenced Rivers: The Ecology and Politics of Large Dams,* Zed Books, New York, USA.
8. B C Das, (2022) Industrial Chemicals and Environment, Kalyani Publishers, Ludhiana

Practical/Exercises/Experiential activities/Outreach activities

1. Schematic collection of data for depicting ecological pyramids in the College campus
2. Field visit to nearby terrestrial and aquatic ecosystems like Dulung Reserve Forest, Satajaan Bird Sanctuary (Wetland), Dirgha Reserve Forest etc.
3. Develop and understand working models of renewable/non-renewable sources of energy Comparison of energy demand and consumption of a particular state over the years using graphical tools
4. Determination of water percentage in crude oil by Dean and Stark method
5. Determination of oil and grease content in effluent water
6. Monitoring of ambient air quality; determination of particulate matter in air samples.
7. Determination of Sulphur dioxide and Nitrogen dioxide in air samples.

SEMESTER II

Course Title: **General Chemistry**
Course Code: **MAJ-4-CHE-201**
Nature of the course: **MAJOR COURSE**
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 =18 (Total= 80)**

Course Objectives:

CO1- To Understand the principles of chemical bonding, including ionic, covalent, and metallic bonds, and apply molecular orbital theory to explain bonding in simple molecules.

CO-2: **To Explain** oxidation-reduction reactions and **apply** standard electrode potentials to predict the feasibility of redox reactions.

CO-3: **To Understand** the concept of aromaticity and **apply** electrophilic substitution mechanisms to predict reaction outcomes in aromatic compounds.

CO-4: **To Classify** different types of stereoisomerism and apply CIP rules to assign absolute configurations to chiral molecules.

CO-5: **To Explain** the stability of cycloalkanes using Baeyer strain theory and analyse the conformational preferences of cyclohexane.

CO-6: To Understand the structure of crystalline solids, **analys**e X-ray diffraction patterns using Bragg's law, and explain defects in solids.

CO-7: **To Explain** the principles of ionic equilibrium, **appl**y the Henderson equation to buffer solutions, and **analyse** acid-base titration curves.

Course Contents

Unit	Content	Marks	L	P	T
I	**Chemical Bonding:** (i) *Ionic bond:* General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Born-Landé equation with derivation and importance of Kapustinskii expression for lattice energy. Madelung constant, Born-Haber cycle and its application, Solvation energy. (ii) *Covalent bond:* Lewis's structure, Valence Bond theory (Heitler-London approach). Energetics of	13	12	0	3

	hybridization, equivalent and non-equivalent hybrid orbitals. Bent's rule, Resonance and resonance energy, Molecular orbital theory. Molecular orbital diagrams of diatomic and simple polyatomic molecules N_2, O_2, C_2, B_2, F_2, CO, NO, and their ions; HCl, BeF_2, CO_2, (idea of s-p mixing and orbital interaction to be given). Formal charge, Valence shell electron pair repulsion theory (VSEPR), shapes of simple molecules and ions containing lone pairs and bond pairs of electrons, multiple bonding (σ and π bond approach) and bond lengths. Covalent character in ionic compounds, polarizing power and polarizability. Fajan's rules and consequences of polarization. Ionic character in covalent compounds: Bond moment and dipole moment. Percentage ionic character from dipole moment and electronegativity difference. *Metallic Bond:* Qualitative idea of valence bond and band theories. Semiconductors and insulators, defects in solids. (iii) *Weak Chemical Forces:* van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interactions, Instantaneous dipole-induced dipole interactions. Repulsive forces, Hydrogen bonding (theories of hydrogen bonding, valence bond treatment) Effects of chemical force, melting and boiling points, solubility energetics of dissolution process.				
II	**Oxidation-Reduction:** Redox equations, Standard Electrode Potential and its application to inorganic reactions.	5	3	0	2
III	**Aromatic Hydrocarbons:** ***Aromaticity****:* Hückel's rule, aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples. Electrophilic aromatic substitution: halogenation, nitration, sulphonation and Friedel-Craftt' alkylation/acylation with their mechanism.	7	5	0	1
IV	**Stereochemistry:** Definition and classification of stereoisomerism **Geometrical isomerism:** Restricted rotation about C=C bonds, Physical & Chemical properties of Geometrical isomers, Cis–trans and, syn-anti isomerism, E/Z notations with C.I.P rules. ***Optical Isomerism****:* Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two or more chiral-centres,	7	7	0	3

	Distereoisomers, meso structures & Epimers, Racemic mixture and resolution, Threo & Erythro forms, Relative and absolute configuration: D/L and R/S designations.				
V	**Cycloalkanes and Conformational analysis:** **Cycloalkanes**: Preparation and their relative stability, Baeyer strain theory, Conformation analysis of alkanes (Ethane and Butane): Relative stability: Energy diagrams of cyclohexane: Chair, Boat and Twist boat forms; Relative stability with energy diagrams.	5	4	0	1
VI	**Solid state:** Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, elementary ideas of symmetry, symmetry elements and symmetry operations, qualitative idea of point and space groups, seven crystal systems and fourteen Bravais lattices; X-ray diffraction, Bragg's law, a simple account of rotating crystal method and powder pattern method. Analysis of powder diffraction patterns of NaCl, CsCl and KCl. Defects in crystals. Glasses and liquid crystals.	10	8	0	3
VII	**Ionic equilibrium:** Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect; dissociation constants of mono-, di- and tri-protic acids. Salt hydrolysis, hydrolysis constants, degree of hydrolysis and pH for different salts. Buffer solutions; Henderson equation, buffer capacity, buffer range, buffer action, applications of buffers in analytical chemistry, Solubility and solubility product. Qualitative treatment of acid – base titration curves (calculation of pH at various stages). Theory of indicators; selection of indicators and their limitations. Multistage equilibria in polyelectrolytes.	9	7	0	2
Total		56	45	0	15

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

Mode of In-Semester Assessment: (24 Marks)

C. Sessional Test:	**Marks: 14**
D. Other Sessional Activities:	**Marks: 10**
In- Semester Assessment	**Marks: 24**

D. Sessional Activity

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

Course Learning Outcomes:
By the end of this course, students will be able to

CLO-1

1.1 **Explain** the fundamental concepts of ionic, covalent, and metallic bonding, including their properties and formation.
1.2 **Apply** molecular orbital theory (MOT) and valence bond theory (VBT) to determine bonding in simple molecules.
1.3 **Analyse** weak chemical forces such as van der Waals interactions and hydrogen bonding and their impact on physical properties.

CLO-2

2.1 **Define** oxidation-reduction reactions and balance redox equations using appropriate methods.
2.2 **Explain** the concept of standard electrode potential and its applications in predicting inorganic reactions.
2.3 **Apply** redox concepts to determine the feasibility of chemical reactions in electrochemical systems.

CLO-3

3.1 **Apply** Hückel's rule to determine the aromaticity of compounds, including arenes and heterocycles.
3.2 **Explain** the mechanism of electrophilic aromatic substitution reactions such as halogenation, nitration, and Friedel-Crafts reactions.
3.3 **Analyse** the reactivity and orientation effects in substituted benzene derivatives.

CLO-4

4.1 **Differentiate** between various types of stereoisomerism, including geometrical and optical isomerism.
4.2 **Assign** E/Z and R/S configurations based on Cahn-Ingold-Prelog (CIP) priority rules.
4.3 **Explain** the significance of chirality, enantiomers, and diastereomers in stereochemical properties and reactions.

CLO-5

5.1 **Explain** the concept of ring strain and the relative stability of cycloalkanes using Baeyer strain theory.
5.2 **Perform c**onformational analysis of ethane and butane, including energy diagrams.
5.3 **Compare** the stability of chair, boat, and twist-boat conformations of cyclohexane with energy diagrams.

CLO-6

6.1 **Describe** the fundamental properties of crystalline solids, including symmetry elements and Bravais lattices.
6.2 **Apply** Bragg's law to analyse X-ray diffraction patterns of crystalline solids.
6.3 **Explain** crystal defects, liquid crystals, and glasses, and their applications in material science.

CLO-7

7.1 **Explain** the concepts of strong, moderate, and weak electrolytes and their degree of ionization.
7.2 **Apply** the Henderson equation to calculate pH and buffer capacity in buffer solutions.
7.3 **Analyse** acid-base titration curves and select appropriate indicators based on pH changes.

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

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge	CO1, CO2, CO3, CO6	CO1, CO3, CO4, CO6	CO2, CO5, CO7	CO3, CO5, CO7		
Conceptual Knowledge	CO1, CO3, CO4	CO1, CO2, CO3, CO4, CO5, CO6, CO7	CO1, CO2, CO3, CO4, CO5, CO6, CO7	CO2, CO4, CO5, CO6, CO7		
Procedural Knowledge			CO2, CO5, CO6, CO7	CO3, CO5, CO6, CO7		
Metacognitive Knowledge						

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

CLO's	PSO_1	PSO_2	PSO_3	PSO_4	PSO_5	PSO_6	PSO_7	PSO_8
CLO1	3	1	3	1	2	2	1	1
CLO2	3	2	3	2	2	2	2	1
CLO3	3	2	3	2	1	2	1	1
CLO4	3	2	3	2	1	2	1	1
CLO5	3	2	2	2	1	2	1	1
CLO6	3	2	3	2	2	2	1	2
CLO7	3	2	3	2	2	2	2	2
Average	**3.0**	**1.86**	**2.86**	**1.86**	**1.57**	**2.0**	**1.29**	**1.29**

Suggested Readings:

1. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry Ed., Oxford University Press (2006).
2. Ball, D. W. Physical Chemistry Thomson Press, India (2007).
3. Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
4. Mortimer, R. G. Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP (2009).
5. Negi,A.S; Anand,S.C. *A Textbook of Physical Chemistry* New Age International Publishers
6. Pahari,S, *Physical Chemistry Vol I &II* New Central Book Agency (P) Ltd.
7. Puri, Sharma, Pathiana; *Principles of Physical Chemistry* Vishal Publishing Co.
8. Lee, J.D. *Concise Inorganic Chemistry* ELBS, 1991.

9. Douglas, B.E. and McDaniel, D.H. *Concepts & Models of Inorganic Chemistry* Oxford, 1970
10. Atkins, P.W. & Paula, J. *Physical Chemistry*, 10th Ed., Oxford University Press, 2014.
11. Day, M.C. and Selbin, J. *Theoretical Inorganic Chemistry*, ACS Publications, 1962.
12. Rodger, G.E. *Inorganic and Solid-State Chemistry*, Cengage Learning India Edition, 2002.

SEMESTER II

Course Title: **Chemistry Practical**
Course Code: **MAJ-1-CHE-201**
Nature of the course: **Major**
Component of the course: **L=0, T=0, P=1**
Total Credit assigned: **1**
Contact Hours: **30**
Distribution of Marks: **End Semester=20; In Semester =0 (Total= 20)**

Course Objectives:

CO-1: To apply volumetric analysis techniques to estimate Fe (II) and oxalic acid using standardized $KMnO_4$ and $K_2Cr_2O_7$ solutions with appropriate indicators.

CO-2: To perform paper and thin-layer chromatography (TLC) to separate and identify mixtures of amino acids, sugars, and organic compounds.

CO-3: To conduct pH-metric titrations and buffer preparation to analyse the pH behaviour of acid-base systems and evaluate their buffering capacity.

Course Contents

Unit	Content	Marks	L	P	T
I	**Quantitative Analysis** i. Estimation of Fe (II) or oxalic acid using standardized $KMnO_4$ solution. ii. Estimation of Fe (II) with $K_2Cr_2O_7$ using diphenylamine as internal indicator.	8	0	10	0
II	**Chromatography (experiment):** i. Separation of a mixture of two amino acids by paper chromatography ii. Separation of a mixture of two sugars by paper chromatography iii. Separation of a mixture of o-and p-nitrophenol or o-and p-aminophenol by thin layer chromatography (TLC).	5	0	10	0
III	**pH-metry** 1. Study the effect on pH of addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their mixtures. 2. Preparation of buffer solutions of different pH a. Sodium acetate-acetic acid b. Ammonium chloride - ammonium hydroxide 3. pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.	5	0	10	0

	Viva	2			
Total		**20**	**0**	**30**	**0**

Mode of Transaction: Laboratory Works, Experiments.

Mode of In-Semester Assessment: NONE

Course Learning Outcomes:

By the end of this course, students will be able to

CLO-1

1.1 **Perform** volumetric analysis to estimate Fe (II) and oxalic acid using standardized $KMnO_4$ solution.
1.2 **Conduct** titration of Fe (II) using $K_2Cr_2O_7$ with diphenylamine as an internal indicator.
1.3 **Analyse** and interpret titration results to determine the concentration of unknown solutions accurately.

CLO-2

2.1 **Apply** paper chromatography to separate a mixture of amino acids and sugars.
2.2 **Perform** thin-layer chromatography (TLC) for the separation of o- and p-nitrophenol or o- and p-aminophenol.
2.**3 Interpret** chromatographic results by analyzing Rf values and identifying the separated components.

CLO-3

3.1 **Conduct** pH-metric titrations to determine the neutralization points of strong acid-strong base and weak acid-strong base systems.
3.2 **Prepare** buffer solutions of different pH values and evaluate their buffering capacity.
3.3 **Analyse** the effect of adding HCl or NaOH to acetic acid-sodium acetate and ammonium chloride-ammonium hydroxide mixtures.

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

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge	CO1	CO1, CO2				
Conceptual Knowledge		CO1, CO2, CO3	CO1, CO2, CO3	CO1, CO2, CO3		
Procedural Knowledge			CO1, CO2, CO3	CO1, CO2, CO3	CO3	
Metacognitive Knowledge						

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

Course Outcomes (CO)	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CLO1	3	3	3	2	2	2	1	1
CLO2	3	3	3	2	2	2	2	1
CLO3	3	3	3	2	2	2	3	2
Average Score	**3.0**	**3.0**	**3.0**	**2.0**	**2.0**	**2.0**	**2.0**	**1.33**

Suggested Reading:

1. Mendham, J., A. I. Vogel's *Quantitative Chemical Analysis 6th Ed.,* Pearson, 2009.
2. Das, Subhas C, Advanced Practical Chemistry for 3-Year Honours Course.
3. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education (2009)
4. Yadav, J.B., *Advanced Practical Physical Chemistry 32nd Ed*; Goel Publishing House

SEMESTER II

Course Code: **MIN-4-CHE-201**
Course Title: **General Chemistry**
Nature of the Course: **Minor**
Total Credit assigned: **4**
Distribution of Credits: **L=3, T=1, P=0**
Contact Hours: **60**
Distribution of Marks: **End Semester=56; In Semester =18 (Total= 80)**

Course Objectives:

CO1-To Understand the principles of chemical bonding, including ionic, covalent, and metallic bonds, and apply molecular orbital theory to explain bonding in simple molecules.

CO-2: **To Explain** oxidation-reduction reactions and **apply** standard electrode potentials to predict the feasibility of redox reactions.

CO-3: **To Understand** the concept of aromaticity and **apply** electrophilic substitution mechanisms to predict reaction outcomes in aromatic compounds.

CO-4: **To classify** different types of stereoisomerism and apply CIP rules to assign absolute configurations to chiral molecules.

CO-5: **To Explain** the stability of cycloalkanes using Baeyer strain theory and analyse the conformational preferences of cyclohexane.

CO-6: To Understand the structure of crystalline solids, **analys**e X-ray diffraction patterns using Bragg's law, and explain defects in solids.

CO-7: **To Explain** the principles of ionic equilibrium, **appl**y the Henderson equation to buffer solutions, and **analyse** acid-base titration curves.

Course Contents

Unit	Content	Marks	L	P	T
	Inorganic Part (For all NEP Students)				
I	**Chemical Bonding:** (iii) *Ionic bond:* General characteristics, types of ions, size effects, radius ratio rule and itslimitations. Packing of ions in crystals. Born-Landé equation with derivation and importance of Kapustinskii expression for lattice energy. Madelung constant, Born-Haber cycle and its application, Solvation energy. (iv) *Covalent bond:* Lewis's structure, Valence Bond theory (Heitler-London approach).Energetics of hybridization, equivalent and non-equivalent hybrid orbitals. Bent's rule, Resonance and resonance energy, Molecular orbital theory. Molecular orbital diagrams of diatomic and simple polyatomic molecules N_2, O_2, C_2, B_2, F_2, CO, NO, and their ions; HCl, BeF_2, CO_2, (idea of s-p mixing and orbital interaction to be given). Formal charge, Valence shell electron pair repulsion theory (VSEPR), shapes of simple molecules and ions containing lone pairs and bond pairs of electrons, multiple bonding (σ and π bond approach) and bond lengths. Covalent character in ionic compounds, polarizing power and polarizability. Fajan's rules and consequences of polarization. Ionic character in covalent compounds: Bond moment and dipole moment. Percentage ionic character from dipole moment and electronegativity difference. *Metallic Bond:* Qualitative idea of valence bond and band theories. Semiconductors andinsulators, defects in solids. (iv) *Weak Chemical Forces:* Vander Waal's forces, ion-dipole forces, dipole-dipoleinteractions, induced dipole interactions, Instantaneous dipole-induced dipole interactions. Repulsive forces, Hydrogen bonding (theories of hydrogen bonding, valence bond treatment) Effects of chemical force, melting and boiling points, solubility energetics of dissolution process.	13	12	0	3

II	**Oxidation-Reduction:** Redox equations, Standard Electrode Potential and its application to inorganic reactions.	5	3	0	2
Organic Part (For NEP Students admitted in 2025 and onwards)					
III	**Aromatic Hydrocarbons:** ***Aromaticity****:* Hückel's rule, aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples. Electrophilic aromatic substitution: halogenation, nitration, sulphonation and Friedel-Craftt' alkylation/acylation with their mechanism.	7	5	0	1
IV	**Stereochemistry I:** Definition and classification of stereoisomerism **Geometrical isomerism:** Restricted rotation about C=C bonds, Physical & Chemical properties of Geometrical isomers, Cis–trans and, syn-anti isomerism, E/Z notations with C.I.P rules. ***Optical Isomerism****:* Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two or more chiral-centres, Distereoisomers, meso structures & Epimers, Racemic mixture and resolution, Threo &Erythro forms, Relative and absolute configuration: D/L and R/S designations.	7	7	0	3
V	**Cycloalkanes and Conformational analysis:** **Cycloalkanes**: Preparation and their relative stability, Baeyer strain theory, Conformation analysis of alkanes (Ethane and Butane): Relative stability: Energy diagrams of cyclohexane: Chair, Boat and Twist boat forms; Relative stability with energy diagrams.	5	4	0	1
Organic Part (For NEP Students admitted upto 2024)					
III	**Aliphatic Hydrocarbons**	19	16	0	5

	Alkanes: *Preparation*: Catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from Grignard reagent. *Reactions*: Free radical Substitution: Halogenation. **Alkenes:** (Up to 5 Carbons): *Preparation*: Elimination reactions: Dehydration of alkenes and dehydrohalogenation of alkyl halides (Saytzeff's rule). *Reactions*: cis-addition (*alk*. $KMnO_4$) and trans-addition (bromine), Addition of HX (Markownikoff's and anti Markownikoff's addition), Hydration, Ozonolysis. **Alkynes:** (Up to 5 Carbons): *Preparation*: Acetylene from CaC_2 and conversion into higher alkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinal dihalides. *Reactions*: formation of metal acetylides, addition of bromine and alkaline KMnO4, ozonolysis and oxidation with hot alk. $KMnO_4$.				
Physical Part (For all NEP Students)					
VII	**Ionic equilibrium:** Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect; dissociation constants of mono-, di- and tri-protic acids. Salt hydrolysis, hydrolysis constants, degree of hydrolysis and pH for different salts. Buffer solutions; Henderson equation, buffer capacity, buffer range, buffer action, applications of buffers in analytical chemistry, Solubility and solubility product. Qualitative treatment of acid – base titration curves (calculation of pH at various stages). Theory of indicators; selection of indicators and their limitations. Multistage equilibria in polyelectrolytes.	9	7	0	2
Total		56	45	0	15

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

Mode of In-Semester Assessment: (24 Marks)

E. Sessional Test:	**Marks: 14**
F. Other Sessional Activities:	**Marks: 10**
In- Semester Assessment	**Marks: 24**

E. Sessional Activity

2. Activities selected from above mentioned list:
    g) Home Assignments
    h) Class Assignments
    i) Seminars
    j) Group Discussions
    k) Sudden Tests
    l) Class Attendance.

Course Learning Outcomes:

By the end of this course, students will be able to

CLO-1

1.1 **Explain** the fundamental concepts of ionic, covalent, and metallic bonding, including their properties and formation.

1.2 **Apply** molecular orbital theory (MOT) and valence bond theory (VBT) to determine bonding in simple molecules.

1.3 **Analyse** weak chemical forces such as Vander Waal's interactions and hydrogen bonding and their impact on physical properties.

CLO-2

2.1 **Define** oxidation-reduction reactions and balance redox equations using appropriate methods.

2.2 **Explain** the concept of standard electrode potential and its applications in predicting inorganic reactions.

2.3 **Apply** redox concepts to determine the feasibility of chemical reactions in electrochemical systems.

CLO-3

3.1 **Apply** Hückel's rule to determine the aromaticity of compounds, including arenes and heterocycles.

3.2 **Explain** the mechanism of electrophilic aromatic substitution reactions such as halogenation, nitration, and Friedel-Crafts reactions.

3.3 **Analyse** the reactivity and orientation effects in substituted benzene derivatives.

CLO-4

4.1 **Differentiate** between various types of stereoisomerism, including geometrical and optical isomerism.

4.2 **Assign** E/Z and R/S configurations based on Cahn-Ingold-Prelog (CIP) priority rules.

4.3 **Explain** the significance of chirality, enantiomers, and diastereomers in stereochemical properties and reactions.

CLO-5

5.1 **Explain** the concept of ring strain and the relative stability of cycloalkanes using Baeyer strain theory.

5.2 **Perform c**onformational analysis of ethane and butane, including energy diagrams.

5.3 **Compare** the stability of chair, boat, and twist-boat conformations of cyclohexane with energy diagrams.

CLO-6

6.1 **Describe** the fundamental properties of crystalline solids, including symmetry elements and Bravais lattices.

6.2 **Apply** Bragg's law to analyse X-ray diffraction patterns of crystalline solids.

6.3 **Explain** crystal defects, liquid crystals, and glasses, and their applications in material science.

CLO-7

7.1 **Explain** the concepts of strong, moderate, and weak electrolytes and their degree of ionization.

7.2 **Apply** the Henderson equation to calculate pH and buffer capacity in buffer solutions.

7.3 **Analyse** acid-base titration curves and select appropriate indicators based on pH changes.

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

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge	CO1, CO2, CO3, CO6	CO1, CO3, CO4, CO6	CO2, CO5, CO7	CO3, CO5, CO7		
Conceptual Knowledge	CO1, CO3, CO4	CO1, CO2, CO3, CO4, CO5, CO6, CO7	CO1, CO2, CO3, CO4, CO5, CO6, CO7	CO2, CO4, CO5, CO6, CO7		
Procedural Knowledge			CO2, CO5, CO6, CO7	CO3, CO5, CO6, CO7		
Metacognitive Knowledge						

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

CLO's	PSO_1	PSO_2	PSO_3	PSO_4	PSO_5	PSO_6	PSO_7	PSO_8
CLO1	3	1	3	1	2	2	1	1
CLO2	3	2	3	2	2	2	2	1
CLO3	3	2	3	2	1	2	1	1
CLO4	3	2	3	2	1	2	1	1
CLO5	3	2	2	2	1	2	1	1
CLO6	3	2	3	2	2	2	1	2
CLO7	3	2	3	2	2	2	2	2
Average	**3.0**	**1.86**	**2.86**	**1.86**	**1.57**	**2.0**	**1.29**	**1.29**

Suggested Readings:

13. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry Ed., Oxford University Press (2006).
14. Ball, D. W. Physical Chemistry Thomson Press, India (2007).
15. Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
16. Mortimer, R. G. Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP (2009).
17. Negi,A.S; Anand,S.C.*A Textbook of Physical Chemistry* New Age International Publishers
18. Pahari,S, *Physical Chemistry Vol I &II* New Central Book Agency (P) Ltd.
19. Puri, Sharma, Pathiana; *Principles of Physical Chemistry* Vishal Publishing Co.
20. Lee, J.D. *Concise Inorganic Chemistry* ELBS, 1991.
21. Douglas, B.E. and McDaniel, D.H. *Concepts & Models of Inorganic Chemistry* Oxford, 1970
22. Atkins, P.W. & Paula, J. *Physical Chemistry*, 10^{th} Ed., Oxford University Press, 2014.
23. Day, M.C. and Selbin, J. *Theoretical Inorganic Chemistry*, ACS Publications, 1962.
24. Rodger, G.E. *Inorganic and Solid-State Chemistry*, Cengage Learning India Edition, 2002.

SEMESTER II

Course Title: **Chemistry Practical**
Course Code: **MIN-1-CHE-201**
Nature of the course: **Major**
Component of the course: **L=0, T=0, P=1**
Total Credit assigned: **1**
Contact Hours: **30**
Distribution of Marks: **End Semester=20; In Semester =0 (Total= 20)**

Course Objectives:

CO-1: To apply volumetric analysis techniques to estimate Fe (II) and oxalic acid using standardized $KMnO_4$ and $K_2Cr_2O_7$ solutions with appropriate indicators.

CO-2: To perform paper and thin-layer chromatography (TLC) to separate and identify mixtures of amino acids, sugars, and organic compounds.

CO-3: To conduct pH-metric titrations and buffer preparation to analyse the pH behaviour of acid-base systems and evaluate their buffering capacity.

Course Contents

Unit	Content	Marks	L	P	T
I	**Quantitative Analysis** iii. Estimation of Fe (II) or oxalic acid using standardized $KMnO_4$ solution. iv. Estimation of Fe (II) with $K_2Cr_2O_7$ using diphenylamine as internal indicator.	8	0	10	0
II	**Chromatography (experiment):** iv. Separation of a mixture of two amino acids by paper chromatography v. Separation of a mixture of two sugars by paper chromatography vi. Separation of a mixture of o-and p-nitrophenol or o-and p-aminophenol by thin layer chromatography (TLC).	5	0	10	0
III	**pH-metry** 4. Study the effect on pH of addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their mixtures. 5. Preparation of buffer solutions of different pH c. Sodium acetate-acetic acid d. Ammonium chloride - ammonium hydroxide 6. pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.	5	0	10	0

	Viva	2			
Total		**20**	**0**	**30**	**0**

Mode of Transaction: Laboratory Works, Experiments.

Mode of In-Semester Assessment: NONE

Course Learning Outcomes:

By the end of this course, students will be able to

CLO-1

1.1 **Perform** volumetric analysis to estimate Fe (II) and oxalic acid using standardized $KMnO_4$ solution.
1.2 **Conduct** titration of Fe (II) using $K_2Cr_2O_7$ with diphenylamine as an internal indicator.
1.3 **Analyse** and interpret titration results to determine the concentration of unknown solutions accurately.

CLO-2

2.1 **Apply** paper chromatography to separate a mixture of amino acids and sugars.
2.2 **Perform** thin-layer chromatography (TLC) for the separation of o- and p-nitrophenol or o- and p-aminophenol.
2.**3 Interpret** chromatographic results by analyzing Rf values and identifying the separated components.

CLO-3

3.1 **Conduct** pH-metric titrations to determine the neutralization points of strong acid-strong base and weak acid-strong base systems.
3.2 **Prepare** buffer solutions of different pH values and evaluate their buffering capacity.
3.3 **Analyse** the effect of adding HCl or NaOH to acetic acid-sodium acetate and ammonium chloride-ammonium hydroxide mixtures.

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

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge	CO1	CO1, CO2				
Conceptual Knowledge		CO1, CO2, CO3	CO1, CO2, CO3	CO1, CO2, CO3		
Procedural Knowledge			CO1, CO2, CO3	CO1, CO2, CO3	CO3	
Metacognitive Knowledge						

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

Course Outcomes (CO)	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CLO1	3	3	3	2	2	2	1	1
CLO2	3	3	3	2	2	2	2	1
CLO3	3	3	3	2	2	2	3	2
Average Score	**3.0**	**3.0**	**3.0**	**2.0**	**2.0**	**2.0**	**2.0**	**1.33**

Suggested Reading:

1. Mendham, J., A. I. Vogel's *Quantitative Chemical Analysis 6th Ed.,* Pearson, 2009.
2. Das, Subhas C, Advanced Practical Chemistry for 3-Year Honours Course.
3. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education (2009)
4. Yadav, J.B., *Advanced Practical Physical Chemistry 32nd Ed*; Goel Publishing House

SEMESTER II

Course Title: **Food nutrition and preservation**
Course Code: **MDC-3-CHE-201**
Nature of the course: **Multidisciplinary Course (MDC)**
Component of the course: **L=2, T=1, P=0**
Total Credit assigned: **3**
Contact Hours: **45**
Distribution of Marks: **End Semester=42; In Semester =18 (Total= 60)**

Course Objectives:
CO-1: **To explain** the fundamental concepts of nutrition, including undernutrition, overnutrition, and optimal nutrition, and their impact on human health.

CO-2: **To describe** the role of basal metabolism, energy expenditure, and dietary allowances in maintaining proper nutrition for individuals.

CO-3: **To classify** the essential nutrients, their functions, and their significance in a balanced diet for maintaining overall health.

CO-4: **To illustrate** various food preservation techniques, their principles, and the importance of food safety standards in ensuring nutritional value.

Course Contents

Unit	Content	Marks	L	P	T
I	**Introduction:** Nutrition (Under nutrition, over nutrition, optimal nutrition) and Nutrients (Nutrition, Malnutrition, and mental development).	10	5	0	2
II	**Energy considerations in nutrition:** Food, preliminary idea of basal metabolism, energy expenditure "off work", energy expenditure for work, respiratory quotients of foodstuffs, measurements of energy requirements, recommended dietary allowances for an Indians.	10	10	0	3
III	**Elements of nutrition:** Components of an adequate diet, preliminary idea of carbohydrates, lipids and proteins, vitamins and their importance in human bodies, dietary fibres, balanced diet, nutrition for health in India.	10	8	0	5
IV	**Food preservation:** Food preservation: definition, objectives and principles of food preservation. Different methods of food preservation. Preserved Products: Jam, Jelly,	12	7	0	5

	Marmalade, Sauces, Pickles, Squashes, Syrups-types, composition and manufacture, selection, cost, storage, uses and nutritional aspects, Food Standards: ISI, Agmark, FPO, MPO, PFA, FSSAI				
Total		42	30	0	15

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

Mode of In-Semester Assessment: (18 Marks)

G. Sessional Test: **Marks: 11**

H. Other Sessional Activities: **Marks: 7**

In- Semester Assessment **Marks: 18**

F. Sessional Activity

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

Expected Course learning outcome:

CLO-1

1.1 **To define** nutrition, undernutrition, overnutrition, and optimal nutrition.
1.2 **To explain** the role of nutrients in human health and mental development.
1.3 **To classify** different types of malnutrition and their impact on overall well-being.

CLO-2

2.1 **To recall** the concept of basal metabolism and its significance in energy balance.
2.2 **To describe** the process of energy expenditure for work and rest.
2.3 **To explain** the measurement of energy requirements and the recommended dietary allowances for Indians.

CLO-3

3.1 **To list** the essential components of an adequate diet, including carbohydrates, lipids, and proteins.
3.2 **To explain** the importance of vitamins and dietary fibers in maintaining human health.
3.3 **To discuss** the concept of a balanced diet and its significance in preventing nutritional deficiencies.

CLO-4

4.1 **To define** food preservation and its objectives and principles.

4.2 **To describe** different methods of food preservation and their applications.

4.3 **To explain** the importance of food standards such as ISI, Agmark, FPO, MPO, PFA, and FSSAI in ensuring food quality and safety.

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

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluate	Create
Factual Knowledge	CO1	CO1, CO2				
Conceptual Knowledge	CO1, CO2	CO2, CO3	CO2, CO3			
Procedural Knowledge		CO3	CO2, CO3, CO4	CO4		
Metacognitive Knowledge					CO4	CO4

Mapping of Course Outcomes (CO) to Programme Specific Outcomes (PSO)

CO / PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CLO1	3	1	2	2	2	2	1	1
CLO2	3	2	3	2	2	2	2	1
CLO3	3	2	3	2	3	2	2	1
CLO4	2	3	2	3	3	3	3	2
Average	2.75	2	2.5	2.25	2.5	2.25	2	1.25

Suggested Readings:

1. Srilakshmi B (2017): Nutrition Science,6th Multicolour Ed. New Age International (P) Ltd.
2. Roday S (2012): Food Science and Nutrition, 2nd Ed. Oxford University Press.
3. Mann J and Truswell (2017): Essentials of Human Nutrition, 5th Ed. Oxford University Press.
4. Jain JL e*tal.* (2021) Fundamentals of Biochemistry, 7th Ed, S. Chand and company Ltd.

Course Title: **Environmental Monitoring and Assessment-II**
Course Code: **SEC-3-CHE-201**
Nature of the course: **Skill Enhancement Course (SEC)**
Component of the course: **L=1, T=0, P=2**
Total Credit assigned: **3 (Theory1+Practical 2)**
Contact Hours: **15(Theory) + 60 (Practical)**

Distribution of Marks:

Theory	**Credit=1**	**End Semester=28**	**In Semester =12**	**Total =40**
Practical	**Credit=2**	**End Semester=40**	**In Semester =0**	**Total =40**

Course Objectives:

CO-1: To develop an understanding of global and Indian freshwater resources, their distribution, utilization, conservation, and the challenges associated with freshwater availability and sustainability.

CO-2: To examine the hydrological cycle, aquatic ecosystems, sources and impacts of water pollution, and the effects of pollutants on water resources and ecosystem health.

CO-3: To provide knowledge of water quality assessment, wastewater treatment and purification methods, industrial effluent management, sludge disposal, and advanced water treatment technologies for environmental protection and sustainable water resource management.

Unit 1: Fresh water, Marks 10, 5 Lectures

Global distribution of fresh water, the sources of freshwater for terrestrial life, limits of global freshwater resources, man's water requirements, the future scenario, causes of wastage and degeneration of freshwater resources, conservation of freshwater resources, freshwater resources of India: (1) The resource base (2) Requirement of fresh water in India (3) Freshwater conservation in India

Unit 2: Water Pollution, Marks 18, 10 Lectures

Water pollution: Hydrological cycle, water resources, aquatic ecosystems, Sources and nature of water pollutants, Techniques for measuring water pollution, Impacts of water pollution on hydrological and ecosystems. Water purification methods. Effluent treatment plants (primary, secondary and tertiary treatment). Industrial effluents from the following industries and their treatment: electroplating, textile. Tannery, diary, petroleum and petrochemicals, agro, fertilizers etc. Sludge disposal. Industrial waste management, incineration of waste. Water treatment and purification (Reverse osmosis,

electro dialysis, ion-exchange). Water quality parameters for waste watter, industrial water and domestic water.

Suggested Readings

1. Brusseau, M.L., Pepper, I.L. and Gerba, C.P. (2019). *Environmental and Pollution Science,* 3rdEdition. Academic Press, USA.
2. Carson, R. (2002). Silent Spring. Houghton Mifflin Harcourt, USA. Pp. 1-264.
3. Raven, P.H, Hassenzahl, D.M., Hager, M.C, Gift, N.Y. and Berg, L.R. (2015). Environment, 9thEdition. Wiley Publishing, USA.
4. Singh, J.S., Singh, S.P. and Gupta, S.R. (2017). Ecology, Environmental Science andConservation. S. Chand Publishing, New Delhi.
5. Divan, S. and Rosencranz, A. (2002). *Environmental Law and Policy in India: Cases, Material &Statutes,* 2nd Edition. Oxford University Press, India.
6. B C Das, (2022) Industrial Chemicals and Environment, Kalyani Publishers, Ludhiana
7. D K Asthana, Meera Ashthana (2016) Environment: Problems and solutions, S Chand Company and Ltd., New Delhi

Practical/Exercises/Experiential activities/Outreach activities

1. Estimation of total hardness, calcium and magnesium hardness in given water samples.
2. Determination of total alkalinity of given water sample.
3. Determination of chloride content of water samples.
4. Determine water quality of a given location using rapid pollution monitoring kits
5. Prepare water audit report of the college/house/locality/colony.
8. Depict temperature/precipitation trend of a given study area using online data

SEMESTER III

Course Title: **Inorganic Chemistry**
Course Code: **MAJ-3-CHE-301**
Nature of the course: **Major Course**
Component of the course: **L=2, T=1, P=0**
Total Credit assigned: **3**
Contact Hours: **45**
Distribution of Marks: **End Semester=42; In Semester =18 (Total= 60)**

Course Objectives:

CO-1: To explain the principles and applications of metallurgical processes including reduction and purification techniques in the extraction of metals.

CO-2: To understand and apply the different theories of acids and bases, including Arrhenius, Brönsted-Lowry, and Lewis concepts, and the HSAB principle in acid-base chemistry.

CO-3: To analyse the chemical properties, structural features, and compound formation tendencies of s- and p-block elements, with emphasis on selected compounds of boron, silicon, nitrogen, phosphorus, sulfur, and halogens.

Course Contents

Unit	Content	Marks	L	P	T
I	**General Principles of Metallurgy:** Chief modes of occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon and carbon monoxide as reducing agent. Electrolytic Reduction, Hydrometallurgy. Methods of purification of metals: Electrolytic Kroll process, Parting process, van Arkel-de Boer process and Mond's process, Zone refining.	10	10	0	2
II	**Acids and Bases:** Arrhenius Theory, Brönsted-Lowry concept of acid-base reactions, solvated proton, relative strength of acids, types of acid-base reactions, levelling solvents, Lewis's acid-base concept, Classification of Lewis acids, Hard and Soft Acids and Bases (HSAB) Application of HSAB principle.	12	10	0	1
III	**Chemistry of *s* and *p* Block Elements:** Inert pair effect, Relative stability of different oxidation states, diagonal relationship and anomalous behaviour of first member of each group. Allotropy and catenation. Complex formation tendency of *s* and *p* block elements. Study of the following compounds	20	10	0	2

	with emphasis on structure, bonding, preparation, properties and uses. Boric acid and borates, boron nitrides, borohydrides (diborane) carboranes and graphitic compounds, silanes, Oxides and oxoacids of nitrogen, Phosphorus, and chlorine. Peroxo acids of sulphur, interhalogen compounds, polyhalide ions, pseudo halogens and basic properties of halogens.				
Total		42	30	0	15

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

Mode of In-Semester Assessment: (18 Marks)

A. Sessional Test:	**Marks: 11**
B. Other Sessional Activities:	**Marks: 7**

In- Semester Assessment **Marks: 18**

Sessional Activity

Activities selected from above mentioned list:

a) Home Assignments
b) Class Assignments
c) Seminars
d) Group Discussions
e) Sudden Tests
f) Class Attendance.

Course Learning Outcomes:

CLO-1

2.1 **To describe** the occurrence of metals in nature based on standard electrode potentials and classify extraction methods accordingly.
2.2 **To explain** the principles of Ellingham diagrams and apply them to predict the feasibility of reduction processes using carbon and carbon monoxide.
2.3 **To outline** various metal purification techniques such as the Kroll process, van Arkel–de Boer process, Mond's process, and zone refining, and evaluate their industrial significance.

CLO-2

2.1. **To differentiate** between various acid-base theories including Arrhenius, Brönsted-Lowry, and Lewis concepts.
2.2. **To explain** the concepts of acid strength, levelling solvents, and the classification of Lewis acids.

2.3. **To apply** the Hard and Soft Acids and Bases (HSAB) principle in predicting the stability and reactivity of acid-base interactions.

CLO-3

1.1 **To explain** periodic trends such as inert pair effect, oxidation states, and diagonal relationships among s and p block elements.
1.2 **To discuss** unique properties such as allotropy, catenation, and the formation of complex compounds among s and p block elements.
1.3 **To analyse** the structure, bonding, preparation, and applications of selected compounds like boric acid, diborane, silanes, oxides and oxoacids of N, P, Cl, peroxo acids of sulfur, interhalogens, and pseudo halogens.

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-1, CO-2	CO-2			
Conceptual Knowledge		CO-2, CO-3	CO-1, CO-3	CO-3		
Procedural Knowledge			CO-1	CO-3	CO-3	
Metacognitive Knowledge					CO-3	

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

CO / PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CLO-1	3	2	3	2	2	2	3	2
CLO-2	3	2	3	2	2	3	3	2
CLO-3	3	2	3	2	2	3	3	3
Average	**3**	**2**	**3**	**2**	**2**	**2.67**	**3**	**2.33**

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

Suggested Readings:

1. Lee, J.D. *Concise Inorganic Chemistry*, ELBS, 1991.
2. Douglas, B.E; Mc Daniel, D.H. & Alexander, J.J. *Concepts & Models of Inorganic Chemistry 3rd Ed.*, John Wiley Sons, N.Y. 1994.
3. Cotton, F.A. & Wilkinson, G. *Advanced Inorganic Chemistry*, 5th edition., Wiley, VCH, 1999.
4. Rodger, G.E. *Inorganic and Solid-State Chemistry*, Cengage Learning India Edition, 2002.
5. Miessler, G. L. & Donald, A. Tarr. *Inorganic Chemistry* 4th Ed., Pearson, 2010
6. Atkin, P. *Shriver & Atkins' Inorganic Chemistry* 5th Ed. Oxford University Press (2010).

SEMESTER III

Course Title: **Chemistry Practical**
Course Code: **MAJ-1-CHE-301**
Nature of the course: **Major**
Component of the course: **L=0, T=0, P=1**
Total Credit assigned: **1**
Contact Hours: **30**
Distribution of Marks: **End Semester=20; In Semester =0 (Total= 20)**

Course Objectives:
CO-1: To apply iodometric and iodimetric titration techniques for the quantitative estimation of metal ions and available chlorine in bleaching agents.
CO-2: To perform inorganic preparations of coordination and double salts, understanding their chemical principles, reaction conditions, and crystallization techniques.

Course Contents

Unit	Content	Marks	L	P	T
I	**Iodo / Iodimetric Titrations:** (i) Estimation of Cu (II) and $K_2Cr_2O_7$ using sodium thiosulphate solution (Iodimetrically). (ii) Estimation of available chlorine in bleaching powder iodometrically.	12	0	15	0
II	**Inorganic preparations:** (i) Cuprous Chloride, Cu_2Cl_2 (ii) Preparation of Manganese (III) phosphate, $MnPO_4.H_2O$ (iii) Preparation of Aluminium potassium sulphate $KAl(SO_4)_2.12H_2O$ (Potash alum) or Chrome alum.	6	0	15	0
III	Viva Voce	2			
Total		20	0	30	0

Mode of Transaction: Laboratory Works, Experiments.

Mode of In-Semester Assessment: NONE

Course Learning Outcomes:

CLO-1

1.1 **To understand** the principles of iodometric and iodimetric titrations and their significance in redox chemistry.
1.2 **To accurately estimate** Cu (II) and $K_2Cr_2O_7$ using sodium thiosulphate by applying iodimetric techniques.

1.3 **To determine** the available chlorine content in bleaching powder using iodometric titration.

CLO-2

2.1 **To synthesize** inorganic compounds such as cuprous chloride, manganese (III) phosphate, and potash alum or chrome alum through controlled precipitation or crystallization.
2.2 **To understand** the underlying reaction mechanisms and conditions required for successful inorganic synthesis.
2.3 **To develop** practical skills in filtration, crystallization, and purification techniques used in inorganic compound preparation.

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-2	CO-1			
Conceptual Knowledge		CO-1, CO-2	CO-1, CO-2	CO-2		
Procedural Knowledge			CO-1, CO-2	CO-2	CO-2	
Metacognitive Knowledge					CO-2	

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

CLO / PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CLO-1	3	3	3	2	2	2	2	2
CLO-2	3	3	3	2	2	3	3	2
Average	**3**	**3**	**3**	**2**	**2**	**2.5**	**2.5**	**2**

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

Suggested Reading:

1. Mendham, J., A. I. Vogel's *Quantitative Chemical Analysis 6th Ed.,* Pearson, 2009.
2. Das, Subhas C, Advanced Practical Chemistry for 3-Year Honours Course.
3. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education (2009).

SEMESTER III

Course Title: **Organic Chemistry**
Course Code: **MAJ-3-CHE-302**
Nature of the course: **Major**
Component of the course: **L=2, T=1, P=0**
Total Credit assigned: **3**
Contact Hours: **45**
Distribution of Marks: **End Semester=42; In Semester =18 (Total= 60)**

Course Objectives:

CO-1: To understand the structure, reactivity, and mechanisms of halogenated hydrocarbons and organometallic compounds, and apply them in organic synthesis.

CO-2: To analyse the synthesis, reactivity, and mechanism of reactions involving alcohols, phenols, ethers, and epoxides, including rearrangement and oxidation reactions.

CO-3: To explore the structure and reactivity of carbonyl compounds and active methylene compounds and apply key reactions in synthetic organic chemistry.

Course Contents

Unit	Content	Marks	L	P	T
I	**Chemistry of Halogenated Hydrocarbons:** **Part A** **Alkyl halides**: Methods of preparation including Hunsdiecker Reaction, nucleophilic substitution reactions – S_N1, S_N2 and S_N^i mechanisms with stereochemical aspects and effect of solvent etc.; nucleophilic substitution vs. elimination. **Aryl halides**: Preparation, including preparation from diazonium salts. nucleophilic aromatic substitution; SNAr, Benzyne mechanism. Relative reactivity of alkyl, allyl/benzyl, vinyl and aryl halides towards nucleophilic substitution reactions. **Part B** Organometallic compounds of Mg and Li – Use in synthesis of organic compounds.	12	10	0	5
II	**Alcohols, Phenols, Ethers and Epoxides:** ***Alcohol****:* preparation, properties and relative reactivity of 1°, 2°, 3° alcohols, PDC, PCC, Bouvaelt-Blanc Reduction.	12	10	0	5

	Preparation and properties of glycols: Oxidation by OsO_4, alkaline $KMnO_4$, Pb $(OAc)_4$ & HIO_4, Pinacol-Pinacolone rearrangement. Trihydric alcohols*:* Glycerol /Preparation & Properties. ***Phenols****:* Acidity of phenol and factors effecting it, Ring substitution reactions, Reimer–Tiemann and Kolbe's–Schmidt Reactions, Fries and Claisen rearrangements with mechanism. ***Ethers and Epoxides:*** Reactions of ethers with acids. Reactions of epoxides with alcohols, ammonia derivatives and LiAlH4				
III	**Carbonyl Compounds:** **Part A** Structure, reactivity and preparation: Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanism; Mechanisms of Aldol and Benzoin condensation, Claisen-Schmidt, Perkin, Cannizzaro and Wittig reaction, Beckmann and Benzil-Benzilic acid rearrangements, and Baeyer Villiger oxidation, Clemmensen, Wolff-Kishner, MPV, LiAlH4, NaBH4, SeO2, (Synthetic applications only). Addition reactions of unsaturated carbonyl compounds: Michael addition. Unsaturated Aldehydes (Acrolein, Crotonaldehyde, Cinnamaldehyde) Unsaturated Ketone (MVK). **Part B** Active methylene compounds: Keto-enol tautomerism. Preparation and synthetic applications of diethyl malonate and ethyl acetoacetate, Knoevenagel condensation.	14	10	0	5
Total		42	30	0	15

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

Mode of In-Semester Assessment: (18 Marks)

C. Sessional Test: **Marks: 11**

D. Other Sessional Activities: **Marks: 7**

In- Semester Assessment **Marks: 18**

Sessional Activity

Activities selected from above mentioned list:

g) Home Assignments
h) Class Assignments
i) Seminars
j) Group Discussions
k) Sudden Tests
l) Class Attendance.

Course Learning Outcomes (CLO's):

CLO-1

1.1 **To describe** the preparation and reactivity of alkyl and aryl halides, including mechanisms like SN1, SN2, SNi, SNAr, and benzyne.
1.2 **To compare** the reactivity of different classes of halides (alkyl, allyl, benzyl, vinyl, aryl) in nucleophilic substitution reactions.
1.3 **To apply** the use of Grignard reagents and organolithium compounds in organic synthesis.

CLO-2

2.1 **To differentiate** between the reactivity of primary, secondary, and tertiary alcohols, and explain key oxidation and reduction reactions.

2.2 **To describe** the synthesis and reactions of phenols, including mechanisms of Reimer–Tiemann, Kolbe's–Schmidt, Fries, and Claisen rearrangements.

2.3 **To analyse** the reactions of ethers with acids and epoxides with nucleophiles such as alcohols, amines, and hydride donors.

CLO-3

3.1. **To explain** the reactivity of aldehydes and ketones through nucleophilic addition and condensation reactions and apply them to multi-step syntheses.
3.2. **To learn** the mechanism and synthetic application of rearrangement and oxidation reactions including Cannizzaro, Wittig, Beckmann, and Baeyer–Villiger.
3.3. **To apply** the chemistry of active methylene compounds such as diethyl malonate and ethyl acetoacetate in synthetic transformations like Knoevenagel condensation.

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-1, CO-2	CO-1			
Conceptual Knowledge		CO-1, CO-2, CO-3	CO-1, CO-2	CO-2, CO-3		
Procedural Knowledge			CO-1, CO-2, CO-3	CO-3	CO-3	
Metacognitive Knowledge					CO-3	

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

CLO / PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CLO-1	3	2	3	2	2	2	2	2
CLO-2	3	2	3	2	2	3	3	2
CLO-3	3	2	3	2	2	3	3	3
Average	**3**	**2**	**3**	**2**	**2**	**2.67**	**2.67**	**2.33**

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

Suggested Readings:

1. Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India)Pvt. Ltd. (Pearson Education).
2. Finar, I. L. *Organic Chemistry* (*Volume 1*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Graham Solomons, T.W. *Organic Chemistry,* John Wiley & Sons, Inc.
4. Kalsi, P. S. *Textbook of Organic Chemistry 1st Ed.*, New Age International (P)Ltd. Pub.
5. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; *Organic Chemistry,* Oxford University Press.

SEMESTER III

Course Title: **Chemistry Practical**
Course Code: **MAJ-1-CHE-302**
Nature of the course: **Major**
Component of the course: **L=0, T=0, P=1**
Total Credit assigned: **1**
Contact Hours: **30**
Distribution of Marks: **End Semester=20; In Semester =0 (Total= 20)**

Course Objectives:

CO-1: To develop practical skills in applying chromatographic techniques for the separation and identification of organic compounds such as amino acids, sugars, and isomeric phenols.

CO-2: To apply thermochemical principles to determine various enthalpies and heat capacities through calorimetric experiments and analyse thermal changes in chemical processes.

Course Contents

Unit	Content	Marks	L	P	T
I	**Organic Chemistry:** Topic: Chromatography a. Separation of a mixture of two amino acids by paper chromatography b. Separation of a mixture of two sugars by paper chromatography c. Separation of a mixture of o-and p-nitrophenol or o-and p-aminophenol by thin layer chromatography (TLC)	10	0	15	0
II	**Physical Chemistry:** (a) Determination of heat capacity of a calorimeter for different volumes using change of enthalpy data of a known system (method of back calculation of heat capacity of calorimeter from known enthalpy of solution or enthalpy of neutralization). (b) Determination of heat capacity of the calorimeter and enthalpy of neutralization of hydrochloric acid with sodium hydroxide. (c) Calculation of the enthalpy of ionization of ethanoic acid. (d) Determination of heat capacity of the calorimeter and integral enthalpy (endothermic and exothermic) solution of salts.	8	0	15	0

	(e) Determination of basicity/proticity of a polyprotic acid by the thermochemical method in terms of the changes of temperatures observed in the graph of temperature versus time for different additions of a base. Also calculate the enthalpy of neutralization of the first step. (f) Determination of enthalpy of hydration of copper sulphate. (g) Study of the solubility of benzoic acid in water and determination of ΔH.				
III	Viva Voce	2			
Total		20	0	30	0

Mode of Transaction: Laboratory Works, Experiments.

Mode of In-Semester Assessment: NONE

Course Learning Outcomes:

CLO-1

1.1 **To perform** paper chromatography for the separation and identification of amino acids and sugars in mixtures.
1.2 **To apply** thin layer chromatography (TLC) for the resolution of structurally similar organic compounds (e.g., o- and p-isomers).
1.3 **To interpret** chromatographic results, calculate Rf values, and evaluate separation efficiency.

CLO-2

2.1 **To determine** the heat capacity of a calorimeter using enthalpy changes from known neutralization and solution reactions.
2.2 **To calculate** various enthalpy changes such as neutralization, ionization, hydration, and dissolution using temperature-time data.
2.3 **To experimentally determine** the basicity of polyprotic acids and apply thermochemical methods to understand reaction energetics.

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-1, CO-2	CO-1, CO-2			
Conceptual Knowledge		CO-1, CO-2	CO-1, CO-2	CO-2		
Procedural Knowledge			CO-1, CO-2	CO-2	CO-2	
Metacognitive Knowledge					CO-2	

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

CLO / PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CLO-1	3	3	3	2	2	2	2	2
CLO-2	3	3	3	2	2	3	3	2
Average	**3**	**3**	**3**	**2**	**2**	**2.5**	**2.5**	**2**

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

Suggested Reading:

1. Mendham, J., A. I. Vogel's *Quantitative Chemical Analysis 6th Ed.,* Pearson, 2009.
2. Das, Subhas C, Advanced Practical Chemistry for 3-Year Honours Course.
3. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education (2009)
4. Yadav, J.B., *Advanced Practical Physical Chemistry 32nd Ed*; Goel Publishing House

SEMSETER III

Course Title: **General Chemistry (Inorganic, Organic and Physical Chemistry)**
Course Code: **MIN-1-CHE-301**
Nature of the course: **Minor**
Component of the course: **L=1, T=0, P=0**
Total Credit assigned: **1**
Contact Hours: **15**
Distribution of Marks: **End Semester=28; In Semester =12 (Total= 40)**

Course Objectives:

CO-1: To understand the bonding, structure, and nomenclature of coordination compounds using Valence Bond Theory and identify isomerism in complexes.

CO-2: To explain the reactivity and mechanisms of nucleophilic substitution reactions of alkyl and aryl halides, and their synthetic applications.

CO-3: To apply principles of electrolytic conductance to study properties of electrolytes, ionic mobility, and perform conductometric titrations.

Course Contents

Unit	Content	Marks	L	P	T
I	**Coordination Chemistry:** Valence Bond Theory (VBT): IUPAC (2005) system of nomenclature. Inner and outer orbital complexes of Cr, Fe, Co, Ni and Cu (coordination numbers 4 and 6). Structural and stereoisomerism in complexes with coordination numbers 4 and 6. Drawbacks of VBT.	10	5	0	0
II	**Alkyl and Aryl Halides:** *Alkyl Halides*: (Up to 5 Carbons): Types of Nucleophilic Substitution (SN1, SN2 and SNi) reactions. Preparation: from alkenes and alcohols. Reactions: hydrolysis, nitrite & nitro formation, nitrile & isonitrile formation. Williamson's ether synthesis *Aryl Halides*: *Preparation*: (Chloro, bromo and iodo-benzene case): from phenol, Sandmeyer & Gattermann reactions. *Reactions* (Chlorobenzene): Aromatic nucleophilic substitution (replacement by –OH group) and effect of nitro substituent. Benzyne Mechanism: KNH2/NH3 (or NaNH2/NH3).	10	5	0	0
III	**Conductance:** Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Kohlrausch's law of independent migration of ions. Transference number and its experimental determination using Moving boundary	8	5	0	0

	methods. Ionic mobility. Applications of conductance measurements: determination of degree of ionization of weak electrolyte, solubility and solubility products of sparingly soluble salts, ionic product of water, hydrolysis constant of a salt. Conductometric titrations (only acid base).				
Total		28	15	0	0

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

Mode of In-Semester Assessment: (12 Marks)

A. Sessional Test:	**Marks: 7**
B. Other Sessional Activities:	**Marks: 5**
In- Semester Assessment	**Marks: 12**

Sessional Activity

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

Course Learning Outcomes:

CLO-1

1.1 **To describe** the basic concepts of Valence Bond Theory (VBT) and apply it to inner and outer orbital complexes of transition metals.

1.2 **To use** IUPAC rules for the systematic nomenclature of coordination compounds.

1.3 **To identify** and differentiate between structural and stereoisomerism in coordination complexes with coordination numbers 4 and 6.

CLO-2

2.1 **To compare** SN1, SN2, and SNi mechanisms of nucleophilic substitution in alkyl halides and correlate them with stereochemical outcomes.

2.2 **To outline** preparation methods and chemical reactions of alkyl and aryl halides, including the Sandmeyer, Gattermann, and Williamson ether synthesis.

2.3 **To explain** the benzyne mechanism and the effect of substituents on nucleophilic aromatic substitution reactions.

CLO-3

3.1 **To define and distinguish** between specific, molar, and equivalent conductivity and explain their dependence on concentration.

3.2 **To apply** Kohlrausch's law and determine ionic mobility and transference numbers using the moving boundary method.

3.3 **To use conductance measurements to determine** properties such as solubility products, degree of ionization, ionic product of water, and perform acid-base conductometric titrations.

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-2, CO-3			
Conceptual Knowledge		CO-1, CO-2, CO-3	CO-2, CO-3	CO-1, CO-3		
Procedural Knowledge			CO-3	CO-3	CO-3	
Metacognitive Knowledge					CO-3	

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

CLO / PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CLO-1	3	2	2	2	1	2	2	2
CLO-2	3	2	2	2	1	2	2	2
CLO-3	3	3	3	2	2	3	3	3
Average	**3**	**2.33**	**2.33**	**2**	**1.33**	**2.33**	**2.33**	**2.33**

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

Reference Books:

1. J. D. Lee: A new Concise Inorganic Chemistry, E L. B. S.

2. F. A. Cotton & G. Wilkinson: Basic Inorganic Chemistry, John Wiley.

3. Douglas, McDaniel and Alexader: Concepts and Models in Inorganic Chemistry, John Wiley.

4. James E. Huheey, Ellen Keiter and Richard Keiter: Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Publication.

5. T. W. Graham Solomon: Organic Chemistry, John Wiley and Sons.

6. Peter Sykes: A Guidebook to Mechanism in Organic Chemistry, Orient Longman.

7. E. L. Eliel: Stereochemistry of Carbon Compounds, Tata McGraw Hill.

8. I. L. Finar: Organic Chemistry (Vol. I & II), E. L. B. S.

9. R. T. Morrison & R. N. Boyd: Organic Chemistry, Prentice Hall.

10. Arun Bahl and B. S. Bahl: Advanced Organic Chemistry, S. Chand

SEMESTER III

Course Title: **Chemistry Practical**
Course Code: **MIN-1-CHE-301**
Nature of the course: **Minor**
Component of the course: **L=0, T=0, P=1**
Total Credit assigned: **1**
Contact Hours: **30**
Distribution of Marks: **End Semester=20; In Semester =0 (Total= 20)**

Course Objectives:

CO-1: To perform systematic qualitative analysis of organic compounds with mono-functional groups and prepare suitable derivatives for identification.

CO-2: To conduct conductometric titrations for **analysing** acid-base reactions and interpret conductivity changes to determine equivalence points.

Course Contents

Unit	Content	Marks	L	P	T
I	***Organic Chemistry*:** Systematic Qualitative Organic Analysis of Organic Compounds possessing mono-functional groups (-COOH, phenolic, aldehydic, ketonic, amide, nitro, amines) and preparation of one derivative.	9	0	15	0
II	***Physical Chemistry*:** Perform the following conductometric titrations: ***a.*** Strong acid vs. strong base or, ***b.*** Weak acid vs. strong base	9	0	15	0
III	Viva Voce	2			
Total		**20**	**0**	**30**	**0**

Mode of Transaction: Laboratory Works, Experiments.

Mode of In-Semester Assessment: NONE

Course Learning Outcomes:

CLO-1

1.1 **To identify** organic compounds with mono-functional groups such as carboxylic acids, phenols, aldehydes, ketones, amides, nitro compounds, and amines through systematic analysis.
1.2 **To perform** confirmatory tests for functional groups and distinguish between similar classes of compounds.
1.3 **To prepare** solid derivatives of organic compounds for further characterization and confirmation of functional groups.

CLO-2

2.1 **To understand** the principle of conductometric titration and distinguish between strong and weak acids or bases using conductivity data.

2.2 **To carry out** titrations such as strong acid vs. strong base or weak acid vs. strong base using conductometric methods.

2.3 **To plot and interpret** conductometric titration curves to accurately determine the equivalence point.

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-1, CO-2	CO-1, CO-2			
Conceptual Knowledge		CO-1, CO-2	CO-1, CO-2	CO-2		
Procedural Knowledge			CO-1, CO-2	CO-2	CO-2	
Metacognitive Knowledge					CO-2	

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

CO / PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CLO-1	3	3	2	2	2	2	2	2
CLO-2	3	3	3	2	2	2	2	2
Average	**3**	**3**	**2.5**	**2**	**2**	**2**	**2**	**2**

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

Suggested Reading:

1. Mendham, J., A. I. Vogel's *Quantitative Chemical Analysis 6th Ed.,* Pearson, 2009.
2. Das, Subhas C, Advanced Practical Chemistry for 3-Year Honours Course.
3. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education (2009)
4. Yadav, J.B., *Advanced Practical Physical Chemistry 32nd Ed*; Goel Publishing House

SEMESTER III

Course Title: **Physical Chemistry: Chemical Thermodynamics**
Course Code: **DSE-2-CHE-301A**
Nature of the course: **Discipline Specific Elective Course**
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 explain the laws of thermodynamics, thermochemical principles, and free energy functions, and apply them to physical and chemical processes.

CO-2: To understand and analyse systems of variable composition, including partial molar properties, chemical potential, and the thermodynamics of ideal mixtures.

Course Contents

Unit	Content	Marks	L	P	T
I	**Chemical Thermodynamics:** Zeroth law of thermodynamics. *First law of thermodynamics:* Concept of heat, q, work, w, internal energy, U, and statement of first law; enthalpy, H, relation between heat capacities, calculations of q, w, U and H for reversible, irreversible and free expansion of gases under isothermal and adiabatic conditions. *Thermochemistry:* Heats of reactions: standard states; enthalpy of formation of molecules and ions and enthalpy of combustion and its applications; calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data, effect of temperature (Kirchhoff's equations) and pressure on enthalpy of reactions. *Second Law:* Concept of entropy; Statement of the second law of thermodynamics; molecular and statistical interpretation of entropy. Calculation of entropy change for reversible and irreversible processes. *Third Law:* Statement of third law, concept of residual entropy, calculation of absolute entropy of molecules.	20	10	0	5

	Free Energy Functions: Gibbs and Helmholtz energy; variation of S, G, A with T, V, P; Free energy change and spontaneity. Relation between Joule-Thomson coefficient and other thermodynamic parameters; inversion temperature; Gibbs-Helmholtz equation; Maxwell relations.				
II	**Systems of Variable Composition:** Partial molar quantities, dependence of thermodynamic parameters on composition; Gibbs- Duhem equation, chemical potential of ideal mixtures, change in thermodynamic functions in mixing of ideal gases.	8	10	0	5
Total		28	20	0	10

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

Mode of In-Semester Assessment: (12 Marks)

A. Sessional Test:	**Marks: 7**
B. Other Sessional Activities:	**Marks: 5**
In- Semester Assessment	**Marks: 12**

Sessional Activity

1. Activities selected from above mentioned list:
   g) Home Assignments
   h) Class Assignments
   i) Seminars
   j) Group Discussions
   k) Sudden Tests
   l) Class Attendance.

Course Learning Outcomes:

CLO-1

1.1 **To explain** the concepts of heat, work, internal energy, enthalpy, and their interrelation under various thermodynamic conditions (isothermal, adiabatic, reversible, and irreversible processes).

1.2 **To apply** thermochemical data to calculate bond energies, heats of reaction, and evaluate the effect of temperature and pressure using Kirchhoff's equations.

1.3 **To interpret** entropy and free energy changes in chemical systems and apply second and third laws of thermodynamics to predict spontaneity and equilibrium.

CLO-2

2.1 **To define** and calculate partial molar quantities and their significance in thermodynamic systems.

2.2 **To apply** the Gibbs-Duhem equation and understand the concept of chemical potential in mixtures.

2.3 **To evaluate** thermodynamic changes associated with the mixing of ideal gases and relate them to system behaviour.

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-1, CO-2	CO-1			
Conceptual Knowledge		CO-1, CO-2	CO-1, CO-2	CO-2		
Procedural Knowledge			CO-1, CO-2	CO-2	CO-2	
Metacognitive Knowledge					CO-2	

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

CLO / PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CLO-1	3	2	3	2	2	2	2	2
CLO-2	3	2	3	2	2	2	2	2
Average	**3**	**2**	**3**	**2**	**2**	**2**	**2**	**2**

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

Reference Books:

1. G. M. Barrow: Physical Chemistry Tata McGraw-Hill (2007).
2. G. W. Castellan: Physical Chemistry 4th Edn. Narosa (2004
3. Negi, A. S; Anand, S. C. A Textbook of Physical Chemistry New Age International Publishers
4. Pahari, S, Physical Chemistry Vol I &II New Central Book Agency (P) Ltd.
5. Puri, Sharma, Pathania, Principles of Physical Chemistry Vishal Publishing Co.

SEMESTER III

Course Title: **Physical Chemistry: Basic Computational Chemistry**
Course Code: **DSE-2-CHE-301B**
Nature of the course: **Discipline Specific Elective Course**
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 the fundamental concepts, historical development, and significance of computational chemistry in modern scientific research.

CO-2: To understand molecular modelling methods, coordinate systems, potential energy surfaces, force fields, and quantum chemical approaches like ab initio, post-Hartree-Fock, and DFT.

CO-3: To familiarize students with computer hardware, software, programming concepts, and their applications in solving basic chemical problems.

Course Contents

Unit	Content	Marks	L	P	T
I	**Introduction to Computational Chemistry:** Overview of computational chemistry, Historical development and significance, Information provided by computational chemistry.	8	3	0	3
II	**Introduction to molecular modelling:** Concepts of coordinate systems (Cartesian and Z-matrix), potential energy surface, global and local minima. Force Field (Bond stretching, Angle bending, non-bonded interactions), Ab initio methods, Hartree-Fock theory, post-Hartree-Fock methods (MP2, CI, CC), Density Functional Theory (DFT), Basic idea about Monte Carlo and Molecular dynamics simulations.	10	6	0	7
III	**Introduction to computer hardware and software:** Model of a computer, Basic idea of algorithm, Input devices, output devices, storage devices, Memory, Central processing Unit, I/O unit, Elementary ideas about operating system (Windows and Linux), Programming languages: BASIC and FORTRAN. Introductory Ideas to write simple programs applicable to Chemistry: Calculate the volume of an ideal gas and van der Waals gas for given Temperature and Pressure, pH of a solution for a given H^+ ion concentration,	10	6	0	5

	thermodynamic quantities of a monoatomic gas (Internal energy, heat capacity, entropy and free energy), Matrix algebra (addition and multiplication), Value of determinant.				
Total		28	15	0	15

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

Mode of In-Semester Assessment: (12 Marks)

A. Sessional Test:	**Marks: 7**
B. Other Sessional Activities:	**Marks: 5**
In- Semester Assessment	**Marks: 12**

Sessional Activity

1. Activities selected from above mentioned list:
   m) Home Assignments
   n) Class Assignments
   o) Seminars
   p) Group Discussions
   q) Sudden Tests
   r) Class Attendance.

Course Learning Outcomes

CLO-1

1.1 **To describe** the origin, scope, and evolution of computational chemistry.

1.2 **To identify** the types of information that computational chemistry provides in chemical research and applications.

1.3 **To recognize** the interdisciplinary role and utility of computational methods in theoretical and applied chemistry.

CLO-2

2.1 **To explain** coordinate systems (Cartesian and Z-matrix), potential energy surfaces, and concepts of global and local minima.

2.2 **To describe** classical force fields and the components involved in molecular mechanics such as bond stretching and non-bonded interactions.

2.3 **To differentiate** between ab initio, post-Hartree-Fock, and DFT methods, and understand basic concepts of Monte Carlo and molecular dynamics simulations.

CLO-3

3.1 **To outline** the components of a computer system including CPU, memory, storage, and I/O devices.

3.2 **To distinguish** between Windows and Linux operating systems and identify programming languages relevant to computational chemistry.

3.3 **To write and interpret** simple programs in BASIC or FORTRAN for solving elementary chemical problems such as gas laws, thermodynamic properties, and matrix operations.

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-3			
Conceptual Knowledge		CO-1, CO-2, CO-3	CO-2, CO-3	CO-2		
Procedural Knowledge			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	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CLO-1	3	2	2	2	3	2	2	2
CLO-2	3	2	3	2	3	2	2	2
CLO-3	3	3	3	2	3	3	2	3
Average	**3**	**2.33**	**2.67**	**2**	**3**	**2.33**	**2**	**2.33**

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

Reference Books:

1. Computational Chemistry, Errol Lewars, Kluwer Academic Publisher
2. Fundamentals of Computers, V. Rajaraman and Neeharika Adabala, Prentice-Hall of India.
3. Understanding Molecular Simulation, Daan Frenkel, Academic Press.
4. Introduction to Computational Chemistry, Frank Jensen, John-Wiley and Sons.

SEMESTER III

Course Title: **Water remediation and conservation studies**
Course Code: **MDC-3-CHE-301**
Nature of the course: **Multidisciplinary Course (MDC)**
Component of the course: **L=2, T=1, P=0**
Total Credit assigned: **2**
Contact Hours: **45**
Distribution of Marks: **End Semester=42; In Semester =18 (Total= 60)**

Course Objectives:

CO-1: **Explain** the major sources of water pollution, key pollutants, and the associated health and environmental hazards, including WHO guidelines for potable water.

CO-2: Describe and evaluate modern remediation techniques for water purification, including adsorption, filtration, reverse osmosis, and bioremediation.

CO-3: Analyse the importance of water conservation and the mechanisms of soil erosion and control, with an emphasis on sustainable watershed modeling and agronomical methods.

Course Contents

Unit	Content	Marks	L	P	T
I	**Introduction:** Sources of water pollutants, pollutants, Industrial and human contribution, WHO recommendation about potable water, current scenario of drinking water quality, chemistry of toxicants like arsenic, fluoride, chromium, lead and mercury, causes and effects of water pollution.	14	10	0	5
II	**Remediation:** Remediation, techniques involved such as adsorption, coagulation-filtration, Nalgonda techniques, reverse osmosis, activated charcoal detoxification, applications of non-toxic oxides and mixed oxides, regeneration and recycling, mechanisms of detoxification, bioremediation, need of green chemistry, future scope.	14	10	0	5
III	**Conservation:** Introduction to water conservation and erosion of soil, forms of water erosion, factors affecting water erosion, types of water erosion, mechanics of water erosion control, agronomical measures of water erosion control, Terraces for water erosion control: Modeling of watershed processes.	14	10	0	5
Total		42	30	0	15

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

Mode of In-Semester Assessment: (18 Marks)

I.	**Sessional Test:**	**Marks: 11**
J.	**Other Sessional Activities:**	**Marks: 7**

In- Semester Assessment **Marks: 18**

G. Sessional Activity

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

Course Learning Outcomes:

CLO-1

1.1 **To identify and classify** various sources and types of water pollutants, including industrial and human contributions.

1.2 **To explain** the chemistry and toxic effects of pollutants such as arsenic, fluoride, chromium, lead, and mercury.

1.3 **To understand** the WHO guidelines on potable water and assess the current scenario of drinking water quality.

CLO-2

2.1 **To describe** physical and chemical methods used for water remediation including adsorption, coagulation, and reverse osmosis.

2.2 **To explain** the mechanisms and applications of non-toxic and mixed oxides, activated charcoal detoxification, and recycling.

2.3 **To discuss** the role and potential of bioremediation and green chemistry in water detoxification and future developments.

CLO-3

3.1 **To understand** the principles of water conservation and recognize various forms and factors of water erosion.

3.2 **To explain** the mechanics and agronomic measures for water erosion control, including the design of terraces.

3.3 **To apply** basic concepts of watershed process modeling for integrated conservation planning.

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-1, CO-2, CO-3	CO-1			
Conceptual Knowledge		CO-2, CO-3	CO-2, CO-3	CO-2		
Procedural Knowledge			CO-2, CO-3	CO-3	CO-3	
Metacognitive Knowledge					CO-3	

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

CLO / PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CLO-1	3	1	2	2	2	2	3	2
CLO-2	3	2	3	2	2	2	3	3
CLO-3	2	2	3	2	3	3	3	2
Average	2.67	1.67	2.67	2	2.33	2.33	3	2.33

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

Suggested Readings:

1. Cittenden J. C., Trussell J. R., Hand D. W., Howe K. J., Tchobanoglous G., Water treatment: Principles and Design MWH publication.
2. De A. K. Environmental Chemistry, Wiley Eastern
3. Clarson D., Dara S. S. A textbook of Environmental chemistry and pollution control, S Chand Co.
4. Soil and water analytical method; Edzwald J., Water Quality & Treatment: A Handbook on Drinking Water (Water Resources and Environmental Engineering Series)

Course Title: **Environmental Monitoring and Assessment-III**
Course Code: **SEC-3-CHE-301**
Nature of the course: **Skill Enhancement Course (SEC)**
Component of the course: **L=1, T=0, P=2**
Total Credit assigned: **3 (Theory1+Practical 2)**
Contact Hours: **15(Theory) + 60 (Practical)**

Distribution of Marks:

Theory	**Credit=1**	**End Semester=28**	**In Semester =12**	**Total =40**
Practical	**Credit=2**	**End Semester=40**	**In Semester =0**	**Total =40**

Course Objectives:

CO-1: To develop a comprehensive understanding of biodiversity, including its distribution, significance, hotspots, endemism, degradation, and the impacts of biodiversity loss and climate change on ecosystems and future evolution.

CO-2: To provide knowledge and practical skills in environmental quality monitoring through Spectro analytical and chromatographic techniques, including spectrophotometry, Atomic Absorption Spectroscopy (AAS), flame photometry, paper chromatography, thin-layer chromatography, and column chromatography for environmental analysis.

Unit 1: Biodiversity and its degradation, Marks 18, 10 Lectures

1. What is Biological Diversity
2. Speciation, natural longevity of a species and optimum biodiversity
3. Uneven distribution of biological wealth on our planet
4. Megadiversity countries of the world
5. Endemism and: Hot Spots of biological diversity
6. Importance of Biological diversity
7. Reduction in Biological diversity
8. Major causes of reduction in biological diversity
9. Biological diversity and future changes in climate
10. Repercussions of the current degeneration of biological diversity on future evolution

Unit 2: Methods of analysis used in monitoring environmental quality, Marks 10, 5 Lectures

1. Spectro analytical methods: types of electromagnetic radiation, absorption and emission spectra, the basis of Spectro analytical methods
2. Frequency used in Spectro analytical methods, spectrophotometry, Atomic Absorption Spectroscopy (AAS), Flame photometry

3. Chromatography: Paper Chromatography, Thin Layer Chromatography, Column Chromatography

Suggested Readings

1. De. A. K. Environmental Chemistry
2. Verma. R. M. (2020). *Analytical Chemistry: Theory and Practice*.
3. Chattopadhyay. K and Mandal. M. Analytical Chemistry.
4. Primack, R. B. (2014). *Essentials of Conservation Biology,* Oxford University Press, USA.
5. Raven, P.H, Hassenzahl, D.M., Hager, M.C, Gift, N.Y. and Berg, L.R. (2015). *Environment,* 9th Edition. Wiley Publishing, USA.
6. Singh, J.S., Singh, S.P. and Gupta, S.R. (2017). *Ecology, Environmental Science andConservation.* S. Chand Publishing, New Delhi.
7. Divan, S. and Rosencranz, A. (2002). Environmental Law and Policy in India: Cases, Material& Statutes, 2nd Edition. Oxford University Press, India.
8. Singh, J.S., Singh, S.P. and Gupta, S.R. (2017). Ecology, Environmental Science and Conservation. S. Chand Publishing, New Delhi.
9. D K Asthana, Meera Ashthana (2016) Environment: Problems and solutions, S Chand Company and Ltd., New Delhi.

Practical/Exercises/Experiential activities/Outreach activities

1. Study and identification of common plant and animal species to understand biological diversity.

2. Determination of water quality parameters using spectrophotometric method.

3. Separation of organic compounds by Thin Layer Chromatography (TLC) and calculation of R_f values.

4. Separation and identification of pigments or amino acids by Paper Chromatography.

e.

SEMESTER IV

Course Title: **Inorganic Chemistry**
Course Code: **MAJ-4-CHE-401**
Nature of the course: **Major Course**
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 describe the general trends and properties of transition elements, including their ability to form complexes and various oxidation states.

CO-2: To explain the chemistry of lanthanoids and actinoids, with emphasis on their electronic configurations, magnetic properties, and complex formation.

CO-3: To rationalize the inertness of noble gases and explain the bonding and molecular geometry of xenon fluorides.

CO-4: To analyse nuclear stability, decay processes, and applications of nuclear chemistry in medicine, industry, and dating techniques.

Course Contents

Unit	Content	Marks	L	P	T
I	**Transition Elements:** General group trends with special reference to electronic configuration, colour, variable valency, magnetic and catalytic properties, ability to form complexes. Stability of various oxidation states and e.m.f. (Latimer and Frost diagrams). Difference between the first, second and third transition series. Chemistry of Ti, V, Cr, Mn, Fe and Co in various oxidation states (excluding their metallurgy)	20	10	0	5
II	**Lanthanoids and Actinoids:** Electronic configuration, oxidation states, colour, spectral and magnetic properties, Lanthanide contraction and its consequences, separation of lanthanides, Complex formation by Lanthanides and actinides.	10	10	0	2
III	**Noble Gases:** Occurrence and uses, rationalization of inertness of noble gases, Clathrates; preparation and properties of XeF2, XeF4 and XeF6; Nature of bonding in noble gas compounds (Valence b ond treatment and MO	10	10	0	3

	treatment for XeF2). Molecular shapes of noble gas compounds (VSEPR theory).				
IV	**Nuclear Chemistry**: Nuclear structure, Mass defect, Packing Fraction, Binding energy and stability of nuclei, Nuclear transmutations and Artificial radioactivity, Laws of radioactive decay, Nuclear reactions including fission and fusion reactions, Nuclear reactor and its components, Measurement of radioactivity, Analytical applications of Nuclear Reactions and Radioactive tracers - in **s**tudying reaction mechanism, in diagnosis and treatment of diseases, in industry, in agriculture, in analytical chemistry, in determination of the age of the earth by rock dating method and determination of the age of recent objects by radio carbon dating method.	16	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)

A. Sessional Test:	**Marks: 14**
B. Other Sessional Activities:	**Marks: 10**

In- Semester Assessment **Marks: 24**

Sessional Activity

Activities selected from above mentioned list:

a) Home Assignments
b) Class Assignments
c) Seminars
d) Group Discussions
e) Sudden Tests
f) Class Attendance.

Course Learning Outcomes:

CLO-1

1.1 **Explain** the periodic trends of transition elements related to colour, valency, and magnetism.
1.2 **Compare** and contrast the first, second, and third transition series in terms of their chemistry.
1.3 **Interpret** Latimer and Frost diagrams to evaluate oxidation states and emf values of transition metals.

CLO-2

2.1 **Describe** the electronic configurations and oxidation states of lanthanoids and actinoids.

2.2 **Analyse** the effects and implications of lanthanide contraction.

2.3 **Explain** methods of separation and complex formation involving f-block elements.

CLO-3

3.1 **Justify** the chemical inertness of noble gases and their limited reactivity.

3.2 **Discuss** the preparation and bonding in xenon fluorides using VBT and MOT.

3.3 **Predict** molecular shapes of noble gas compounds using VSEPR theory.

CLO-4

4.1 **Define** key nuclear concepts such as mass defect, binding energy, and nuclear stability.

4.2 **Differentiate** between types of radioactive decay and nuclear reactions.

4.3 **Apply** nuclear techniques in medical diagnostics, industrial applications, and age-dating methods.

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-4	CO-4			
Conceptual Knowledge		CO-1, CO-2, CO-3, CO-4	CO-3, CO-4	CO-2, CO-3		
Procedural Knowledge			CO-4	CO-1, CO-2, CO-4	CO-4	
Metacognitive Knowledge					CO-4	

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

CLO / PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CLO-1	3	1	2	2	1	2	2	1
CLO-2	3	1	3	2	2	2	2	2
CLO-3	3	1	2	2	1	2	2	2
CLO-4	3	1	3	3	2	2	3	3
Average	**3.0**	**1.0**	**2.5**	**2.25**	**1.5**	**2.0**	**2.25**	**2.0**

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

Suggested Readings:

1. Inorganic Chemistry, Shriver & Atkins, 5th Edition Oxford
2. Inorganic Chemistry, W.W. Porterfield, 2nd Edition, Academic Press
3. Inorganic Chemistry: Principles of structure and reactivity, 4th Edition; J.E. Huheey, E.A. Keiter, R.L. Keiter, O.K. Medhi
4. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; *Organic Chemistry,* Oxford University Press.

SEMESTER IV

Course Title: **Organic Chemistry**
Course Code: **MAJ-4-CHE-402**
Nature of the course: **Major**
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 explain the structure, reactivity, and synthetic applications of carboxylic acids and their derivatives, including mechanistic understanding of key named reactions.

CO-2: To describe the preparation, chemical behaviour, and functional importance of sulphur-containing organic compounds.

CO-3: To illustrate the structural features, physiological activity, and synthetic strategies for key alkaloids with medicinal importance.

CO-4: To discuss the classification and structural elucidation of terpenes using the isoprene rule and selected examples.

CO-5: To identify and explain the structural features, therapeutic actions, and synthesis of important pharmaceutical and natural medicinal compounds.

Course Contents

Unit	Content	Marks	L	P	T
I	**Carboxylic Acids and their Derivatives:** Preparation, physical properties and reactions of monocarboxylic acids (Acidity and factors affecting it): Typical reactions of dicarboxylic acids, hydroxy acids and unsaturated acids: succinic, phthalic, lactic, malic, tartaric, citric, maleic and fumaric acids; Preparation and reactions of acid chlorides, anhydrides, esters and amides; Comparative study of nucleophilic substitution at acyl group -Mechanism of acidic and alkaline hydrolysis of esters, Claisen condensation, Dieckmann and Reformatsky reactions, Hofmannbromamide degradation and Curtius rearrangement.	16	20		5
II	**Sulphur containing compounds:** Preparation and reactions of thiols, thioethers and sulphonic acids.	6	5	0	1
III	**Alkaloids:**	12	10	0	4

	Natural occurrence, General structural features, Isolation and their physiological action. Hoffmann's exhaustive methylation, Emde's modification, Structure elucidation and synthesis of Hygrine and Nicotine. Medicinal importance of Nicotine, Hygrine, Quinine, Morphine, Cocaine, and Reserpine**.**				
IV	**Terpenes:** Occurrence, classification, isoprene rule; Elucidation of structure and synthesis of Citral, Neral and α-terpineol.	6	5		2
V	**Pharmaceutical Compounds: Structure and Importance:** Classification, structure, and therapeutic uses of antipyretics: Paracetamol (with synthesis), Analgesics: Ibuprofen (with synthesis), Antimalarials: Antacids: Ranitidine; Antibacterial: Povidone—Iodine Solution, Synthesis, and mode of action of Sulphanilamide's and other Sulpha drugs (sulphapyridine, sulphathiazole) Chloroquine (with synthesis). An elementary treatment of Antibiotics and detailed study of chloramphenicol, Medicinal values of curcumin (Haldi), azadirachtin (neem), vitamin C.	16	10		3
Total		56	45	0	15

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

Mode of In-Semester Assessment: (24 Marks)

A. Sessional Test: **Marks: 14**

B. Other Sessional Activities: **Marks: 10**

In- Semester Assessment **Marks: 24**

Sessional Activity

Activities selected from above mentioned list:

a) Home Assignments
b) Class Assignments
c) Seminars
d) Group Discussions
e) Sudden Tests
f) Class Attendance.

Course Learning Outcomes:

CLO-1

1.1. **To explain** the acidity of carboxylic acids and factors influencing it.

1.2 To describe the preparation, reactions, and physical properties of mono- and dicarboxylic acids, hydroxy acids, and unsaturated acids.

1.3. To compare the reactivity of acid derivatives (chlorides, anhydrides, esters, amides) and their nucleophilic substitution mechanisms.

1.4 To outline mechanisms for ester hydrolysis (acidic and alkaline), Claisen condensation, Dieckmann and Reformatsky reactions, and rearrangements like Hofmann bromamide and Curtius.

CLO-2

2.1 To describe methods of preparation and typical reactions of thiols, thioethers, and sulphonic acids.

2.2 To explain the role of sulphur-containing compounds in organic synthesis.

CLO-3

1.1 **To identify** natural sources, structural features, and isolation methods for alkaloids.
1.2 **To apply** Hoffmann's exhaustive methylation and Emde's modification in structure elucidation.
1.3 **To explain** the synthesis and physiological roles of Hygrine and Nicotine, and to understand the medicinal significance of other alkaloids like Quinine, Morphine, Cocaine, and Reserpine.

CLO-4

4.1 To classify terpenes and apply the isoprene rule for structural understanding.
4.2 To elucidate the structure and synthesis of Citral, Neral, and α-terpineol.

CLO-5

5.1 To classify pharmaceutical compounds by function and therapeutic use.
5.2 To explain the structure, synthesis, and mode of action of key drugs like paracetamol, Ibuprofen, Ranitidine, and Sulpha drugs.
5.3 To discuss the structure and importance of antibiotics (e.g., chloramphenicol) and medicinal natural products like curcumin, azadirachtin, and vitamin C.

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-4, CO-5	CO-2, CO-3			
Conceptual Knowledge		CO-1, CO-3, CO-4, CO-5	CO-3, CO-4, CO-5	CO-1, CO-3		
Procedural Knowledge			CO-1, CO-3, CO-5	CO-1, CO-3, CO-5	CO-3, CO-5	
Metacognitive Knowledge					CO-5	

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

CLO / PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CLO-1	3	2	3	2	2	2	2	2
CLO-2	3	2	3	2	2	2	2	2
CLO-3	3	2	3	2	2	2	3	2
CLO-4	3	1	2	2	2	2	2	1
CLO-5	3	2	3	2	3	3	3	2
Average	**3.0**	**1.8**	**2.8**	**2.0**	**2.2**	**2.2**	**2.4**	**1.8**

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

Suggested Readings:

1. Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

2. Finar, I. L. *Organic Chemistry* (*Volume 1*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

3. Graham Solomons, T.W. *Organic Chemistry,* John Wiley & Sons, Inc.

4. Kalsi, P. S. *Textbook of Organic Chemistry 1st Ed.*, New Age International (P)Ltd. Pub.

5. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; *Organic Chemistry,* Oxford University Press.

6. Singh, J.; Ali, S.M. & Singh, J. *Natural Product Chemistry*, Prajati Parakashan 2010.

SEMESTER IV

Course Title: **Physical Chemistry**
Course Code: **MAJ-4-CHE-403**
Nature of the course: **Major**
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 explain the kinetics of chemical reactions, including order, molecularity, complex reaction mechanisms, and temperature dependence.

CO-2: To apply thermodynamic concepts to analyse colligative properties and determine molar masses of solutes in dilute solutions.

CO-3: To describe the principles, mechanisms, and applications of catalysis, including enzyme catalysis and heterogeneous reactions.

CO-4: To understand adsorption phenomena and apply adsorption isotherms to evaluate surface area and practical applications.

Course Contents

Unit	Content	Marks	L	P	T
I	**Chemical Kinetics:** Order and molecularity of a reaction, Differential and integrated form of rate expressions up to second order reactions, experimental methods of the determination of rate laws, kinetics of complex reactions (integrated rate expressions up to second order reactions only): (i) Opposing reactions (ii) parallel reactions and (iii) consecutive reactions and their differential rate equations (steady-state approximation in reaction mechanisms) (iv) chain reactions, Explosion Limits. Temperature dependence of reaction rates; Arrhenius equation; activation energy. Collision theory of reaction rates, Lindemann mechanism	20	15	0	5
II	**Solutions and Colligative Properties:** Dilute solutions; lowering of vapour pressure, Raoult's and Henry's Laws and their applications. Thermodynamic derivation using chemical potential to derive relations between the four colligative properties [(i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) Depression of freezing point, (iv) osmotic pressure] and amount of solute. Applications in	15	15	0	5

	calculating molar masses of normal, dissociated, and associated solutions. Van't Hoff Factor.				
III	**Catalysis:** Types of catalyst, specificity and selectivity, mechanisms of catalyzed reactions at solid surfaces; Homogeneous and Heterogeneous Catalytic reactions, Enzyme catalysis, Michaelis-Menten mechanism, acid-base catalysis.	10	8	0	3
IV	**Adsorption:** Physical adsorption, chemisorption, adsorption isotherms. Freundlich and Langmuir adsorption isotherms, Determination of surface area of adsorbents using Langmuir adsorption isotherm, Applications of adsorptions.	11	7	0	2
Total		56	45	0	15

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

Mode of In-Semester Assessment: (24 Marks)

A. Sessional Test: **Marks: 14**

B. Other Sessional Activities: **Marks: 10**

In- Semester Assessment **Marks: 24**

Sessional Activity

Activities selected from above mentioned list:

a) Home Assignments
b) Class Assignments
c) Seminars
d) Group Discussions
e) Sudden Tests
f) Class Attendance.

CLO-1

1.1: To derive and interpret differential and integrated rate laws for reactions up to second order.
1.2: To analyse the kinetics of complex reactions including opposing, parallel, and consecutive reactions using appropriate mechanisms.
1.3: To explain temperature dependence of reaction rates using Arrhenius equation, collision theory, and Lindemann mechanism.

CLO-2

2.1: To apply Raoult's and Henry's laws to study the behaviour of dilute solutions.
2.2: To derive thermodynamic relations for colligative properties and use them to evaluate solution characteristics.
2.3: To calculate molar masses of solutes in normal, dissociated, and associated solutions using colligative property data and the Van't Hoff factor.

CLO-3

3.1: To classify different types of catalysis and explain the principles of catalyst specificity and selectivity.
3.2: To describe mechanisms of homogeneous and heterogeneous catalytic reactions.
3.3: To explain enzyme catalysis using the Michaelis-Menten model and discuss the role of acid-base catalysis.

CLO-4

4.1: To distinguish between physical and chemical adsorption based on characteristic properties.
4.2: To apply Freundlich and Langmuir adsorption isotherms to evaluate adsorption data.
4.3: **To determine** surface area of adsorbents using adsorption isotherms and describe practical applications of adsorption.

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-4	CO-1, CO-2			
Conceptual Knowledge		CO-1, CO-2, CO-3, CO-4	CO-2, CO-3, CO-4	CO-1, CO-3		
Procedural Knowledge			CO-2, CO-3, CO-4	CO-1, CO-2, 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	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CLO-1	3	1	3	2	1	2	2	1
CLO-2	3	2	3	2	2	2	2	2
CLO-3	3	2	3	2	2	2	3	2
CLO-4	3	2	3	2	2	2	3	2
Average	**3.0**	**1.75**	**3.0**	**2.0**	**1.75**	**2.0**	**2.5**	**1.75**

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

Suggested Readings:

1. G. M. Barrow: Physical Chemistry Tata McGraw-Hill (2007).
2. G. W. Castellan: Physical Chemistry 4th Edn. Narosa (2004)
3. Chemical Kinetics – K. J. Laidler, Pearson Education India.
4. Physical Chemistry of Surfaces – A. W. Adamson, Wiley India Pvt. Ltd.
5. Physical Chemistry – P.W. Atkins, Oxford University Press.

SEMESTER IV

Course Title: **Chemistry Practical**
Course Code: **MAJ-4-CHE-401A**
Nature of the course: **Major**
Component of the course: **L=0, T=0, P=4**
Total Credit assigned: **4**
Contact Hours: **120**
Distribution of Marks: **End Semester=80; In Semester =0 (Total= 80)**

Course Objectives:

C**O-1: To perform** gravimetric estimations of metal ions using classical techniques and appropriate precipitation methods.

CO-2: To synthesize coordination compounds and understand their composition, structure, and stability.

CO-3: To determine reaction kinetics and adsorption characteristics using experimental and graphical methods.

CO-4: To carry out organic preparations using conventional and green chemistry approaches, including functional group transformations.

Course Contents

Unit	Content	Marks	L	P	T
I	**Gravimetric Analysis:** i. Estimation of nickel (II) using Dimethylglyoxime. ii. Estimation of copper as CuSCN. iii. Estimation of iron as Fe_2O_3 by precipitating iron as $Fe(OH)_3$	18	0	30	0
II	**Inorganic Preparation:** i. Tetraamminecopper(II) sulphate ii. Tetraamminecarbonatocobalt (III) ion iii. Potassium tris(oxalate)ferrate (III)	18	0	30	0
III	i. Study the kinetics of acid hydrolysis of methyl acetate with hydrochloric acid. (Integrated rate method) ii. Saponification of ethyl acetate. iii. Verify the Freundlich and Langmuir isotherms for adsorption of acetic acid/oxalic acid on activated charcoal.	18	0	30	0
IV	**Organic preparations:** i. Acetylation of one of the following compounds: amines (aniline, *o*-, *m*-, *p*- toluidines and *o*-, *m*-, *p*-anisidine) and phenols (β-naphthol, vanillin,	18	0	30	0

	salicylic acid) by method: Using conventional method and green approach. ii. Benzolyation of one of the following amines (aniline, *o*-, *m*-, *p*-toluidines and *o*-, *m*-, *p*-anisidine) and one of the following phenols (β-naphthol, resorcinol, p- cresol) by Schotten-Baumann reaction. iii. Oxidation of ethanol/ isopropanol (Iodoform reaction). iv. Nitration of the following: Acetanilide/nitrobenzene by conventional method And Salicylic acid by green approach (using ceric ammonium nitrate).				
	Viva	8			
Total		**80**	**0**	**120**	**0**

Mode of Transaction: Laboratory Works, Experiments.

Mode of In-Semester Assessment: NONE

Course Learning Outcomes:

CLO-1

1.1 **To estimate** nickel (II) gravimetrically using dimethylglyoxime as a precipitating agent.
1.2 **To determine** copper quantitatively by converting it into CuSCN.
1.3 **To estimate** iron as Fe_2O_3 by precipitating it as $Fe(OH)_3$.

CLO-2

2.1 **To prepare** and isolate tetraamminecopper(II) sulphate and understand its coordination geometry.

2.2 **To synthesize** tetraamminecarbonatocobalt(III) ion and study ligand substitution in cobalt complexes.

2.3 **To prepare** potassium tris(oxalato)ferrate (III) and understand its chelation and stability.

CLO-3

3.1 **To study** the kinetics of acid hydrolysis of methyl acetate using the integrated rate method.
3.2 **To investigate** the saponification of ethyl acetate and determine rate parameters.

3.3 **To verify** Freundlich and Langmuir adsorption isotherms using activated charcoal and acetic/oxalic acid.

CLO-4

4.1 **To perform** acetylation of amines and phenols using both conventional and green methods.

4.2 **To carry out** benzoylation reactions of amines and phenols via the Schotten–Baumann reaction.

4.3 **To conduct** oxidation and nitration reactions, comparing conventional and green chemistry approaches.

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-1, CO-2	CO-1, CO-2			
Conceptual Knowledge		CO-2, CO-3, CO-4	CO-2, CO-3, CO-4	CO-3	CO-4	
Procedural Knowledge			CO-1, CO-2, CO-3, CO-4	CO-3, CO-4	CO-4	
Metacognitive Knowledge					CO-4	

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

CLO / PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CLO-1	3	3	3	2	2	2	2	2
CLO-2	3	3	3	2	2	2	2	2
CLO-3	3	3	3	2	2	2	3	3
CLO-4	3	3	3	2	3	3	3	2
Average	**3.0**	**3.0**	**3.0**	**2.0**	**2.25**	**2.25**	**2.5**	**2.25**

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

Suggested Reading:

i. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi (2011).

ii. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry 8th Ed.*; McGraw-Hill: New York (2003).

iii. Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry 3rd Ed.;* W.H. Freeman & Co.: New York (2003).

iv. Yadav, J.B., *Advanced Practical Physical Chemistry 32nd Ed*; Goel Publishing House

v. Mendham, J., A. I. Vogel's *Quantitative Chemical Analysis 6th Ed.,* Pearson, 2009.

vi. Das, Subhas C, Advanced Practical Chemistry for 3-Year Honours Course.

vii. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education (2009)

viii. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.,* Pearson (2012)

ix. Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis,* University Press (2000).

x. Ahluwalia, V.K. & Dhingra, S. *Comprehensive Practical Organic Chemistry: Qualitative Analysis,* University Press (2000)

SEMSTER IV

Course Title: **Chemistry Practical (Computational Chemistry Practical I)**
Course Code: **MAJ-4-CHE-401B**
Nature of the course: **Major**
Component of the course: **L=0, T=0, P=4**
Total Credit assigned: **4**
Contact Hours: **120**
Distribution of Marks: **End Semester=80; In Semester =0 (Total= 80)**

Course Objectives:

CO-1: To construct molecular models using molecular graphics programs such as AVOGADRO, ARGUSLAB, and PCMODEL, and generate Gaussian input files for computational analysis.

CO-2: To operate Gaussian software to perform geometry optimization and determine molecular parameters such as electronic energy, bond lengths, dipole moments, quadrupole moments, Mulliken charges, and frontier orbital energies.

CO-3: To apply Gaussian to study molecular systems, including simple molecules and reactive intermediates, perform thermodynamic calculations, compare computational methods (HF, DFT, MP2, CCSD), and analyse the effect of conjugation on stability and UV-Visible absorption.

Course Contents

Unit	Content	Marks	L	P	T
I	Use of molecular graphics programme like AVOGADRO, ARGUSLAB, PCMODEL (Serena software series) in the construction of molecular models, generation of gaussian input files.	18	0	20	0
II	Handling of Gaussian programme for optimization and the determination of molecular parameters like electronic energy, bond distances, dipole moments, quadruple moments, Point Groups, Mulliken Charges, Frontier orbitals and their energies etc. Visualization of molecules using visualization software.	18	0	20	0
III	Use of Gaussian in the study of i. Simple molecules like CH_4, C_2H_6, H_2O, BF_3, C_6H_6, NH_3, H_3O+, BF_4 etc. ii. Study of reactive intermediates and their stability orders.	36	0	80	0

	iii. Thermochemical calculations, enthalpy, entropy, and Gibbs free energy. Determination of enthalpy of formation, enthalpy of combustions of molecules like CH_4, C_2H_6, Benzene and comparison of the results with the experimental results. iv. Binding energies of molecules. v. Comparation of results in the *ab initio* Hartee-Fock and Density functional theory methods using different basis sets. vi. Effect of conjugation on the stabilities of molecules. Hence the study of possible absorptions of molecules in the UV-Visible region. vii. Correlated calculations using MP2 and CCSD for small molecules.				
	Viva	8			
Total		80	0	120	0

Mode of Transaction: Laboratory Works, Experiments.

Mode of In-Semester Assessment: NONE

Course Learning Outcomes:

By the end of this course, students will be able to

CLO-1

1.1 **Use** molecular graphics software to build and manipulate molecular structures.
1.2 **Generate** Gaussian input files tailored for a range of computational chemistry tasks.

CLO-2

2.1 **Perform** geometry optimization and interpret Gaussian output files.

2.2 **Calculate** molecular properties such as electronic energy, dipole moments, quadrupole moments, Mulliken charges, and frontier orbital energies.

2.3 **Identify** molecular point groups based on optimized structures.

CLO-3

3.1 **Analyse** the stability of simple molecules and reactive intermediates using computational methods.

3.2 **Determine** thermodynamic parameters like enthalpy, entropy, and Gibbs free energy, and compare theoretical values with experimental data.

3.3 **Evaluate** binding energies and interpret results from HF and DFT calculations using different basis sets.

3.4 **Assess** the effect of conjugation on molecular stability and predict UV-Visible absorption characteristics.

3.5 **Conduct** MP2 and CCSD calculations for selected small molecules to explore electron correlation effects.

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-1, CO-2, CO-3	CO-1, CO-2			
Conceptual Knowledge		CO-2, CO-3	CO-2, CO-3	CO-2, CO-3	CO-3	
Procedural Knowledge			CO-1, CO-2, CO-3	CO-3	CO-3	
Metacognitive Knowledge					CO-3	

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

CLO / PSO	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**	**PSO6**	**PSO7**	**PSO8**
CLO-1	3	3	3	2	2	2	2	3
CLO-2	3	3	3	2	2	2	2	3
CLO-3	3	3	3	2	3	3	3	3
Average	**3.0**	**3.0**	**3.0**	**2.0**	**2.33**	**2.33**	**2.33**	**3.0**

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

Suggested Reading:

1. Essentials of Computational Chemistry: Theories and Models by Christopher J. Cramer.
2. Exploring chemistry with electronic structure methods: a guide to using Gaussian by Foresman, James B.

SEMESTER-V

Course Title: **Inorganic Chemistry**
Course Code: **MAJ-5-CHE-501**
Nature of the course: **Major**
Component of the course: **L=4, T=1, P=0**
Total Credit assigned: **5**
Distribution of Marks: **End Semester=70; In Semester =30 (Total= 100)**

Course Objectives:

CO-1: To recall and apply IUPAC nomenclature, stereochemistry, and bonding theories in coordination chemistry.

CO-2: To analyse crystal field stabilization energy (CFSE) and predict geometries and electronic configurations of coordination complexes.

CO-3: To compare inorganic polymers with organic polymers based on synthesis, structure, and applications.

CO-4: To explain the role of metal ions in biological systems and their physiological and toxicological effects.

CO-5: To apply theoretical principles of qualitative analysis to identify and separate ions based on group reagents and solubility rules.

Course Contents

Unit	Content	Marks	L	P	T
I	**Coordination Chemistry I:** IUPAC nomenclature of coordination compounds, isomerism in coordination compounds. Stereochemistry of complexes with 4 and 6 coordination numbers. Chelate effect, polynuclear complexes. Labile and inert complexes. Werner's theory, valance bond theory (inner and outer orbital complexes), electroneutrality principle and back bonding.	16	12	0	3
II	**Coordination Chemistry II:** Crystal field theory, measurement of 10Dq (Δo), CFSE in weak and strong fields, pairing energies, factors affecting the magnitude of 10Dq (Δo, Δt). Octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometry, Jahn-Teller theorem, square planar geometry. Qualitative aspect of Ligand field and MO Theory.	15	12	0	5

III	**Inorganic Polymers:** Types of inorganic polymers, comparison with organic polymers, synthesis, structural aspects and applications of silicones and siloxanes. Borazines, silicates and phosphazenes, and polysulphates.	12	12	0	2
IV	**Bioinorganic Chemistry I**: Metal ions are present in biological systems, classification of elements according to their action in biological system. Geo chemical effect on distribution of metals. Sodium/ K-pump, carbonic anhydrase and carboxypeptidase. Excess and deficiency of some trace metals. Toxicity of metal ions (Hg, Pb, Cd and As), reasons for toxicity, use of chelating agents in medicine. Iron and its application in bio-systems, Haemoglobin, storage and transfer of iron.	15	12	0	3
V	**Theoretical Principles in Qualitative Analysis (H_2S Scheme):** Basic principles involved in analysis of cations and anions and solubility products, common ion effect. Principles involved in separation of cations into groups and choice of group reagents. Interfering anions (fluoride, borate, oxalate and phosphate) and need to remove them after Group II**.**	12	12	0	2
Total		70	60	0	15

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

Mode of In-Semester Assessment: (30 Marks)

E. Sessional Test: **Marks: 18**

F. Other Sessional Activities: **Marks: 12**

In- Semester Assessment **Marks: 30**

Sessional Activity

Activities selected from the above-mentioned list:

1. Home Assignments
2. Class Assignments
3. Seminars
4. Group Discussions
5. Sudden Tests
6. Class Attendance.

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

CLO-1:

1.1. **Recall** IUPAC nomenclature and isomerism in coordination compounds and **list** different types of coordination numbers and stereochemistry of complexes.
1.2. **Explain** the concepts of chelate effect, polynuclear complexes, and stereochemistry with 4 and 6 coordination numbers.
1.3. **Describe** Werner's theory and the valence bond theory for coordination compounds.
1.4. **Apply** concepts of bonding to predict the geometry and reactivity of coordination complexes.
1.5. **Differentiate** between labile and inert complexes using bonding theories.
1.6. **Analyse** the inner and outer orbital complexes using electronic configuration.

CLO-2:

2.1. **Identify** key terms such as CFSE, 10 Dq, and crystal field theory.
2.2. **Summarize** the factors affecting the magnitude of 10 Dq in weak and strong fields.
2.3. **Calculate** pairing energies and CFSE values for various coordination complexes.
2.4. **Distinguish** between octahedral, tetrahedral, and square planar geometries.
2.5. **Analyse** effects such as the Jahn-Teller distortion and its implications.

CLO-3:

3.1 **Define** inorganic polymers and list their types.
3.2 **Explain** the structural aspects and synthesis methods of silicones, siloxanes, borazines, and phosphazenes.
3.3 **Compare** inorganic polymers with organic polymers in terms of properties and applications.
3.4 **Assess** the industrial and practical significance of selected inorganic polymers.

CLO-4:

4.1 **List** essential and toxic metals in biological systems.
4.2 **Describe** the role of sodium-potassium pump and enzymes like carbonic anhydrase in biological systems.
4.3 **Apply** knowledge of metal ion roles to understand diseases or treatments (e.g., iron in hemoglobin).
4.4 **Examine** the toxicity and biological role of trace metals (e.g., Hg, Pb, As).
4.5 **Interpret** the action of chelating agents in metal ion toxicity management.

CLO-5:

5.1 Identify common ions and solubility products relevant to qualitative analysis.
5.2 Explain group separation principles and the common ion effect.
5.3 Use solubility rules to predict precipitation reactions.
5.4 Differentiate interfering ions and devise strategies for their removal.
5.5 Analyse group-specific reagents and their chemical interactions.

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

Knowledge Dimension	**Remember**	**Understand**	**Apply**	**Analyse**	**Evaluation**	**Create**
Factual Knowledge	CO1, CO3, CO4, CO5	CO1, CO3, CO4, CO5	CO4, CO5	CO2, CO4, CO5		
Conceptual Knowledge	CO2	CO2, CO3	CO1, CO2	CO1, CO2	CO3	
Procedural Knowledge		CO4, CO5	CO5			
Metacognitive Knowledge					CO4	

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	-	1
CLO_2	3	-	1	2	2	2	-	1
CLO_3	3	-	2	1	2	2	2	1
CLO_4	3	-						
CLO_5	3	-						
Average	**3**	**-**	**2**	**1.7**	**2**	**2**	**0.7**	**1**

(3=High, 2=Moderate, 1=Low)

Suggested Readings:

1. Bioinorganic Chemistry by K. Hussain Reddy, New Age International Publisher.

2. The Inorganic Chemistry of Biological Processes, Hughes, M.N., 2nd edition, Wiley (1981)
3. Bio-coordination Chemistry, D.E. Fenton, Oxford University Monograph Series 1995.
4. Inorganic Chemistry, Gary L.Miessler & Donald A. Tarr 3rd Ed, Pearson
5. Inorganic Chemistry, C.E. Housecraft & A.G. Sharpe, 2nd Ed, Pearson
6. Huheey, J.E., Inorganic Chemistry, Prentice Hall,1993

7. Cotton, F.A. & Wilkinson,G, Advanced Inorganic Chemistry, 5th Ed. Wiley-VCH,1999
8. Greenwood, N.N. & Earnshaw A., Chemistry of Elements, Butterworth-Heinemann,1977
9. Atkin, P. Shriver & Atkins' Inorganic Chemistry 5th Ed. Oxford University Press (2010).
10. R. Sarkar. General Inorganic Chemistry (Part-2), New Central Book Agency(P) Ltd.

SEMESTER-V

Course Title: **Organic Chemistry**
Course Code: **MAJ-4-CHE-502**
Nature of the course: **Major**
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 preparation, properties, and reactivity of nitrogen-containing functional groups, including amines, diazonium salts, and related compounds.

CO-2: To analyse the structure and chemical behavior of polynuclear aromatic hydrocarbons such as naphthalene, phenanthrene, and anthracene.

CO-3: To apply principles of heterocyclic chemistry to synthesize and explain the reactivity of compounds like pyrrole, furan, pyridine, and quinoline.

CO-4: To evaluate different types of polymers based on their synthesis methods, properties, and industrial applications.

Course Contents

Unit	Content	Marks	L	P	T
I	**Nitrogen Containing Functional Groups:** Preparation and important reactions of nitro and nitrite compounds, nitriles and isonitriles **Amine**s: Effect of substituent and solvent on basicity; Preparation and properties: Gabriel phthalimide synthesis, Hoffmann degradation, Carbylamine reaction, Mannich reaction; Distinction between 1°, 2° and 3° amines with Hinsberg reagent and nitrous acid, Liberman Test. Diazonium Salts: Preparation and their synthetic applications. Diazomethane & Diazoacetic Ester with synthetic application.	16	10		5
II	**Polynuclear Aromatic Hydrocarbons:** Preparation and structure elucidation & Reactions of Polynuclear hydrocarbons: naphthalene, phenanthrene and anthracene, and important derivatives of naphthalene and anthracene.	12	10	0	2
III	**Heterocyclic Compound:** Classification and nomenclature, Structure, aromaticity in 5-numbered and 6-membered ring containing one heteroatom; Synthesis, reactions and mechanism of	16	10	0	3

	substitution reactions of Furan, Pyrrole (Paal-Knorr synthesis, Knorr pyrrole synthesis, Hantzsch synthesis), Thiophene, Derivatives of furan: Furfural and furoic acid. Pyridine (Hantzsch synthesis), Pyrimidine, Indole (Fischer indole synthesis and Madelung synthesis), Quinoline and isoquinoline (Skraup synthesis, Friedlander's synthesis).				
IV	**Polymers:** Introduction and classification of polymers. Polymerisation reactions -Addition and condensation - Mechanism of cationic, anionic and free radical addition polymerization; Ziegler-Natta polymerisation of alkenes; Preparation and applications of plastics – thermosetting (phenol-formaldehyde, Polyurethanes) and thermos softening (PVC, polythene); Fabrics – natural and synthetic (acrylic, polyamido, polyester); Rubbers – natural and synthetic: Buna-S, Chloroprene and Neoprene; Vulcanization; Polymer additives; Biodegradable polymers with examples.	12	15		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: 14**

Other Sessional Activities: **Marks: 10**

In- Semester Assessment **Marks: 24**

Sessional Activity

Activities selected from the above-mentioned list:

a) Home Assignments
b) Class Assignments
c) Seminars
d) Group Discussions
e) Sudden Tests
f) Class Attendance.

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

CLO-1:

1.1. **Remember** the preparation methods and key reactions of nitro, nitrite, nitrile, and amine compounds.
1.2. **Understand** the effects of substituents and solvents on amine basicity and the distinction between amine types using diagnostic reagents.
1.3. **Apply** organic synthesis routes (e.g., Hoffmann degradation, Gabriel synthesis).
1.4. **Analyse** the synthetic utility of diazonium salts and esters

CLO-2:

2.1. **Remember** the structures of naphthalene, phenanthrene, and anthracene.
2.2. **Understand** the electronic structure and stability of polynuclear aromatics.
2.3. **Apply** the preparation methods and predict outcomes of their chemical reactions.
2.4. **Analyse** derivative formation and structural elucidation of these compounds.

CLO-3:

3.1 **Remember** the names and structures of common heterocycles (pyrrole, furan, thiophene, pyridine, etc.).
3.2 **Understand** aromaticity and substitution patterns in 5- and 6-membered heterocycles.
3.3 **Apply** synthesis mechanisms (e.g., Paal-Knorr, Hantzsch, Skraup, Friedländer).
3.4 **Analyse** the structure–activity relationships in heterocyclic chemistry.

CLO-4:

4.1 **Remember** types of polymers, monomers, and key polymerization methods.
4.2 **Understand** the mechanisms of cationic, anionic, and free radical polymerization.
4.3 **Apply** Ziegler-Natta polymerization and identify polymer uses in industry.
4.4 **Evaluate** the properties of thermoplastics vs. thermosetting plastics and biodegradable polymers.

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

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluation	Create
Factual Knowledge	CO1, CO2, CO3, CO4	CO1, CO2, CO3				
Conceptual Knowledge		CO1, CO2, CO3, CO4	CO1, CO2	CO1, CO2	CO4	
Procedural Knowledge			CO1, CO3, CO4	CO1, CO2, CO3, CO4	CO4	
Metacognitive Knowledge						

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	-	-
CLO_2	3	-	1	-	-	2	-	-
CLO_3	3	-	1	-	-	2	-	-
CLO_4	3	-	1	-	-	2	3	-
Average	**3**	**-**	**1**	**-**	**-**	**2**	**0.75**	**-**

(3=High, 2=Moderate, 1=Low)

Suggested Readings:

1. Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India)Pvt. Ltd. (Pearson Education).
2. Finar, I. L. *Organic Chemistry* (*Volume 1*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Finar, I. L. *Organic Chemistry* (*Volume 2: Stereochemistry and the Chemistry ofNatural Products*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Acheson, R.M. *Introduction to the Chemistry of Heterocyclic compounds*, JohnWiley & Sons (1976).
4. Graham Solomons, T.W. *Organic Chemistry*, John Wiley & Sons, Inc.
5. Kalsi, P. S. *Textbook of Organic Chemistry 1st Ed.*, New Age International (P)Ltd. Pub.
6. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; *Organic Chemistry*, OxfordUniversity Press.

SEMESTER-V

Course Title: **Physical Chemistry**
Course Code: **MAJ-4-CHE-503**
Nature of the course: **Major**
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 ionic conductance and electrochemical measurements.

CO-2: To provide students with knowledge of electrochemical cell behavior and their applications.

CO-3: To develop conceptual and practical understanding of phase equilibria in single and multi-component systems and to introduce thermodynamic principles relevant to phase transitions and distribution laws.

Course Contents

Unit	Content	Marks	L	P	T
I	**Conductance:** Conductivity, equivalent and molar conductivity, and their variation with dilution for weak and strong electrolytes. Molar conductivity at infinite dilution. Kohlrausch law of independent migration of ions. Debye-Hückel-Onsager equation, Wien effect, Debye-Falkenhagen effect, Walden's rules. Ionic velocities, mobilities and their determinations, transference numbers and their relation to ionic mobilities, determination of transference numbers using Hittorf and Moving Boundary methods. Applications of conductance measurement: (i) degree of dissociation of weak electrolytes, (ii) ionic product of water (iii) solubility and solubility product of sparingly soluble salts, (iv) conductometric titrations, and (v) hydrolysis constants of salts.	20	15	0	5
II	**Electrochemistry:** Quantitative aspects of Faraday's laws of electrolysis, rules of oxidation/reduction of ions based on half-cell potential. Reversible and irreversible cells with examples. Electromotive force of a cell and its measurement, Nernst equation; Standard electrode (reduction) potential and its application to different kinds of half-cells. Application of EMF measurements	20	15	0	5

	in determining (i) free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) PH values, using hydrogen, quinone-hydroquinone. Concentration cells with and without transference, liquid junction potential; determination of activity coefficients and transference numbers. Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation).				
III	**Phase Equilibria:** Concept of phases, components and degrees of freedom, derivation of Gibbs Phase Rule for nonreactive and reactive systems; Clausius-Clapeyron equation and its applications to solid liquid, liquid-vapour and solid-vapour equilibria, phase diagram for one component systems, with applications. Phase diagrams for systems of solid-liquid equilibria involving eutectic, congruent and incongruent melting points, solid solutions. Three component systems, water-chloroform-acetic acid system, triangular plots. *Binary solutions:* Gibbs-Duhem-Margules equation, its derivation, and applications to fractional distillation of binary miscible liquids (ideal and nonideal), azeotropes, lever rule, Steam distillation. Nernst distribution law: its derivation and applications, partial miscibility of liquids, CST.	16	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: 14**
Other Sessional Activities:	**Marks: 10**

In- Semester Assessment **Marks: 24**

Sessional Activity

Activities selected from above mentioned list:

1. Home Assignments
2. Class Assignments
3. Seminars
4. Group Discussions
5. Sudden Tests
6. Class Attendance.

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

CLO-1:

1.1. **Define** key terms such as molar conductivity, ionic mobility, and transference number.
1.2. **Explain** Kohlrausch's law, Onsager equation, and Walden's rule.
1.3. **Use** Moving Boundary and Hittorf methods to calculate transference numbers.
1.4. **Analyse** the variation of conductivity with dilution in weak vs. strong electrolytes.
1.5. **Interpret** conductivity data to evaluate the degree of dissociation and solubility product.
1.6. **Design** experiments for conductometric titrations and measurement of hydrolysis constants.

CLO-2:

2.1. **State** Faraday's laws and Nernst equation.
2.2. **Describe** the functioning of reversible and irreversible electrochemical cells.
2.3. **Apply** Nernst equation to calculate electrode potentials under various conditions.
2.4. **Differentiate** between cells with and without transference.
2.5. **Assess** EMF data to deduce thermodynamic parameters such as ΔG, ΔH, and entropy.
2.6. **Develop** protocols for potentiometric titrations and interpretation of titration curves.

CLO-3:

3.1 **List** the types of phase diagrams and rules like Gibbs Phase Rule.
3.2 **Explain** the Clausius-Clapeyron equation and its applications.
3.3 **Use** triangular plots for three-component system analysis.
3.4 **Analyse** phase diagrams to identify eutectic, congruent, and incongruent melting points.
3.5 **Compare** the behavior of ideal vs. nonideal binary solutions using the Gibbs-Duhem equation.
3.6 **Construct** phase diagrams for binary and ternary systems and apply steam distillation concepts to real-world mixtures.

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

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluation	Create
Factual Knowledge	CO1, CO2, CO3					
Conceptual Knowledge		CO1, CO2, CO3	CO1, CO2	CO1, CO2, CO3	CO3	
Procedural Knowledge			CO1, CO2, CO3		CO1, CO2	
Metacognitive Knowledge						CO1, CO2, CO3

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	-	1
CLO_2	3	3	2	2	2	2	-	1
CLO_3	3	-	2	1	2	2	2	1
Average	**3**	**2**	**2**	**1.7**	**2**	**2**	**0.7**	**1**

(3=High, 2=Moderate, 1=Low)

Suggested Readings:

1. Atkins, P.W & Paula, J.D. Physical Chemistry, 9th Ed., Oxford University Press (2011).
2. Castellan, G. W. Physical Chemistry 4th Ed., Narosa (2004).
3. Mortimer, R. G. Physical Chemistry 3rd Ed., Elsevier: NOIDA, UP (2009).
4. Barrow, G. M., Physical Chemistry 5th Ed., Tata McGraw Hill: New Delhi (2006).
5. Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012).
6. Rogers, D. W. Concise Physical Chemistry Wiley (2010).
7. Silbey, R. J.; Alberty, R. A. & Bawendi, M. G. Physical Chemistry 4th Ed., John Wiley & Sons, Inc. (2005).
8. Negi, A.S; Anand, S.C. A Textbook of Physical Chemistry New Age International Publishers
9. Puri, Sharma, Pathania Principles of Physical Chemistry Vishal Publishing Co

SEMESTER-V

Course Title: **Chemistry Practical (General Chemistry)**
Course Code: **DSE-3-CHE-501A**
Nature of the course: **Major**
Component of the course: **L=0, T=0, P=3**
Total Credit assigned: **3**
Distribution of Marks: **End Semester=60; In Semester =0 (Total= 60)**

Course Objectives:

CO-1: To develop an understanding of conductometric and potentiometric titration techniques and phase equilibrium principles through experimental analysis.

CO-2: To develop students with the skills required for systematic qualitative analysis and identification of inorganic anions and cations in mixtures.

CO-3: To provide hands-on experience in biochemical estimations, enzymatic activity studies, and biomolecule isolation techniques.

Course Contents

Unit	Content	Marks	L	P	T
I	**Physical Chemistry:** **Conductometry:** Perform the following conductometric titrations: i. Strong acid vs. strong base ii. Weak acid vs. strong base iii. Mixture of strong acid and weak acid vs. strong base iv. Strong acid vs. weak base **Potentiometry:** Perform the following potentiometric titrations: i. Strong acid vs. strong base ii. Weak acid vs. strong base iii. Dibasic acid vs. strong base iv. Potassium dichromate vs. Mohr's salt **Phase Equilibrium:** • Determination of critical solution temperature and composition of the phenol-water system and to study the effect of impurities on it. • Distribution of acetic/ benzoic acid between water and cyclohexane.	18	0	30	0

II	**Inorganic Chemistry:** **Qualitative Inorganic Analysis:** Qualitative analysis of mixtures containing 2 anions and 3 cations. Emphasis should be given to the understanding of the chemistry of different reactions. The following radicals are suggested: NO_2^-, S^{2-}, SO_3^{2-}, $S_2O_3^{2-}$, CH_3COO^-, F^-, Cl^-, Br^-, I^-, NO_3^-, BO_3^{3-}, $C_2O_4^{2-}$,PO_4^{3-}, NH_4^+, K^+, Pb^{2+}, Cu^{2+}, Cd^{2+}, Bi^{3+}, Sn^{2+}, Sb^{3+}, Fe^{3+}, Al^{3+}, Cr^{3+}, Zn^{2+}, Mn^{2+},Co^{2+}, Ni^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, Mg^{2+}Mixtures should preferably contain one interfering anion, or insoluble component e.g., $BaSO_4$, $SrSO_4$, $PbSO_4$, CaF_2 or Al_2O_3 or combination of anions e.g. CO_3^{2-} and SO_3^{2-},NO_2^- and NO_3^-, Cl^- and Br^-, Cl^- and I^-, B^- rand I^-, NO_3^- and Br^-, NO_3^- and I^-.	18	0	30	0
III	**Organic Chemistry:** 1. Estimation of glycine by Sorenson's formalin method. 2. Study of the titration curve of glycine. 3. Estimation of proteins by Lowry's method. 4. Study of the action of salivary amylase on starch at optimum conditions. 5. Effect of temperature on the action of salivary amylase. 6. Saponification value of oil or a fat. 7. Determination of Iodine number of oil/ fat. 8. Isolation and characterization of DNA from onion/ cauliflower/peas.	18	0	30	0
	Viva	6			
Total		60	0	90	0

Mode of Transaction: Laboratory Works, Experiments.

Mode of In-Semester Assessment: NONE

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

CLO-1:

1.1. **Understand** the principles of conductometric and potentiometric titrations.

1.2. **Apply** conductometric and potentiometric techniques to titrate various combinations of acids and bases.

1.3. **Analyse** titration curves to determine equivalence points and interpret differences between strong/weak acid-base combinations.

1.4. **Evaluate** experimental results to determine the accuracy and reliability of titration methods.

1.5. **Understand** the concept of critical solution temperature and phase behavior.

1.6. **Apply** binary and ternary phase concepts to determine miscibility and impurity effects.

1.7. **Analyse** the distribution of solutes (e.g., benzoic acid) between solvents using partition law.

CLO-2:

2.1. **Remember** common cation and anion radicals and their reactions.

2.2. **Understand** group separation principles and the logic of analytical schemes.

2.3. **Apply** systematic procedures to identify ions in complex mixtures.

2.4. **Analyse** observations to deduce the presence of specific ions in unknown samples.

CLO-3:

1.4 **Understand** the principles behind biochemical estimations and enzymatic reactions.

1.5 **Apply** methods such as Sorenson's, Lowry's, and iodine value determination to analyse organic compounds.

1.6 **Analyse** the effect of variables like temperature and pH on enzymatic activity.

1.7 **Evaluate** experimental data in protein estimation and lipid analysis for biological relevance.

1.8 **Create** methods for isolation and characterization of biomolecules such as DNA from natural sources.

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

Knowledge Dimension	**Remember**	**Understand**	**Apply**	**Analyse**	**Evaluation**	**Create**
Factual Knowledge	CO1, CO2	CO1, CO2, CO3				
Conceptual Knowledge		CO1, CO2	CO1, CO2, CO3	CO1, CO3	CO1, CO3	
Procedural Knowledge			CO1, CO2	CO1, CO2	CO3	
Metacognitive Knowledge						CO3

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	3	2	2	1	1	-
CLO_2	3	3	3	2	-	1	-	-
CLO_3	3	3	3	2	2	2	2	-
Average	**3**	**3**	**3**	**2**	**1.3**	**1.3**	**1**	**-**

(3=High, 2=Moderate, 1=Low)

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.

SEMESTER-V

Course Title: **Chemistry Practical (Computational Chemistry Practical II)**
Course Code: **DSE-3-CHE-501B**
Nature of the course: **Discipline Specific Elective Course**
Component of the course: **L=0, T=0, P=3**
Total Credit assigned: **3**
Distribution of Marks: **End Semester=60; In Semester =0 (Total= 60)**

Course Objective:

CO-1: To apply computational chemistry tools to visualize molecular structures, orbitals, and electron densities, and **analyse** their chemical significance using appropriate software.

Course Contents

Unit	Content	Marks	L	P	T
I	A. Tools and techniques for data analysis and visualization in computational chemistry. Visualization of molecular structures, orbitals, and electron densities using software like VMD, Gauss view, Avogadro. B. Mapping PES and transition state search for simple reactions C. Solvent effect on molecular properties using implicit solvation models (PCM, COSMO) D. Computational prediction of IR, UV-Vis, NMR spectra and comparison with experimental data. E. Basics of molecular docking, scoring functions, and applications in drug design. Performing docking studies using AutoDock or similar software. F. Applications of computational chemistry in materials science and nanotechnology. Simulating properties of materials and nanostructures. G. Independent project involving computational study of a chosen chemical problem.	54	0	90	0
	Viva	6			
Total		60	0	90	0

Mode of Transaction: Laboratory Works, Experiments.
Mode of In-Semester Assessment: NONE

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

CLO-1:
1.1. **Understand** tools and software used for data analysis and molecular visualization (e.g., VMD, Gauss View, Avogadro).
1.2. **Apply** computational models such as PCM and COSMO to predict solvent effects on molecular properties.
1.3. **Analyse** computational spectra (IR, UV-Vis, NMR) and compare them with experimental data for interpretation.
1.4. **Evaluate** molecular docking results and scoring functions for drug design using tools like AutoDock.
1.5. **Create** a computational solution to a chemical problem through an independent research project.

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

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluation	Create
Factual Knowledge		CO1				
Conceptual Knowledge		CO1	CO1	CO1	CO1	
Procedural Knowledge			CO1	CO1	CO1	
Metacognitive Knowledge						CO1

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	3	1	2	2	1	3
Average	**3**	**3**	**3**	**1**	**2**	**2**	**1**	**3**

(3=High, 2=Moderate, 1=Low)

Suggested Readings:

1. Introduction to Computational Chemistry by Frank Jensen, WILEY.
2. Practical Aspects of Computational Chemistry: Methods, Concepts and Applications edited by Jerzy Leszczynski and Manoj K. Shukla, SPRINGER

3. Essentials of Computational Chemistry: Theories and Models, 2nd Edition, By Christopher J. Cramer, WILEY.

SEMESTER-V

Course Title: **Internship**
Course Code: **MAJ-4-CHE-501**
Nature of the course: **Major**
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 Objective:

CO-1: To provide students with practical exposure to the chemical industry and research environments, enabling them to apply theoretical knowledge, **develop** professional skills, adhere to safety standards, collaborate effectively, and reflect on their personal and professional growth through a structured internship experience.

Course Contents

Unit	Content	Marks	L	P	T
I	**Completion of Internship Project** [Internship Completion Certificate to be provided]	10	0	120	0
	Distribution of Marks in the Report: Objective of the Internship Project	10			
	About the Works/Responsibilities/Tasks/Experiments done	10			
	Challenges and Problem-Solving	10			
	Skills Developed	10			
	Conclusion	10			
	Viva	20			
Total		80	0	120	0

[Students will go for internships immediately after their Semester Examinations including Semester breaks.]

Mode of Transaction: Field Works, Laboratory Works, Experiments, Skill based works under the supervision of experts in the selected field or authorities.

Mode of In-Semester Assessment: NONE

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

CLO-1:
1.1. **Describe** the structure, function, and safety protocols of the chemical industry.
1.2. **Explain** the objectives and scope of the assigned internship project
1.3. **Apply** chemical knowledge and laboratory skills to perform tasks and experiments in real settings.

1.4. **Analyse** tasks undertaken, challenges faced, and strategies used during the internship.
1.5. **Evaluate** the outcomes of the internship experience in terms of skills developed and lessons learned.
1.6. **Create** a structured internship report documenting responsibilities, experiences, and conclusions.
1.7. **Demonstrate** improved self-confidence, self-efficacy, and collaborative skills in a professional environment.

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

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluation	Create
Factual Knowledge	CO1					
Conceptual Knowledge		CO1			CO1	
Procedural Knowledge			CO1	CO1	CO1	CO1
Metacognitive Knowledge					CO1	CO1

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	3	2	2	1	2
Average	**3**	**3**	**2**	**3**	**2**	**2**	**1**	**2**

(3=High, 2=Moderate, 1=Low)

SEMESTER VI

Course Title: **Inorganic Chemistry**
Course Code: **MAJ-5-CHE-601**
Nature of the course: **Major**
Component of the course: **L=4, T=1, P=0**
Total Credit assigned: **5**
Contact Hours: **75**
Distribution of Marks: **End Semester=70; In Semester =30 (Total= 100)**

Course Objectives:
CO-1: To understand and analyse the kinetics and mechanisms of inorganic substitution reactions, with emphasis on square planar and octahedral complexes.

CO-2: To explain the bonding, structure, and reactivity of organometallic compounds including carbonyls, metal alkyls, and metallocene's using molecular orbital concepts and electron counting principles.

CO-3: To evaluate catalytic cycles involving organometallic complexes and their applications in industrial processes such as hydrogenation and hydroformylation.

CO-4: To describe the structure, bonding, and classification of cluster compounds, including boranes and metallocarboranes, and recognize the unique properties of fullerenes like C_{60}.

Course Contents

Unit	Content	Marks	L	P	T
I	**Reaction Kinetics and Mechanism I:** Introduction to inorganic reaction mechanisms. Substitution reactions in square planar complexes, Trans-effect, theories of trans-effect, mechanism of nucleophilic substitution in square planar complexes, Thermodynamic and kinetic stability, kinetics of octahedral substitution, ligand field effects and reaction rates, Mechanism of substitution in octahedral complexes.	20	15	0	5
II	**Organometallic compounds:** Definition and classification of organometallic compounds based on bond type. Concept of hapticity of organic ligands. **Metal carbonyls**: 18 electron rules, electron count of mononuclear, polynuclear and substituted metal carbonyls of 3d series. General methods of preparation (direct combination, reductive carbonylation, thermal and photochemical decomposition) of mono and binuclear carbonyls of 3d series. Structures of	25	15	0	5

	mononuclear and binuclear carbonyls of Cr, Mn, Fe,Co and Ni using VBT. π-acceptor behavior of CO (MO diagram of CO to be discussed), synergic effect and use of IR data to eplain extent of back bonding. **Zeise's salt**: preparation and structure, evidence of synergic effect and comparison of synergic effect with that in carbonyls. **Metal Alkyls**: Important structural features of methyl lithium (tetramer) and trialkyl aluminium (dimer), concept of multicentre bonding in these compounds. Role of triethylaluminium in polymerization of ethane (Ziegler-Natta Catalyst). Species present in ether solution of Grignard reagent and their structures, Schlenk equilibrium. **Ferrocene**: Preparation and reactions (acetylation, alkylation, metallation, Mannich condensation). Structure and aromaticity. Comparison of aromaticity and reactivity with that of benzene.				
III	**Catalysis by Organometallic Compounds:** Study of the following industrial processes and their mechanism 1. Alkene hydrogenation (Wilkinson's Catalyst) 2. Hydroformylation (Co salts) 3. Wacker Process 4. Synthetic Gasoline (Fisher Tropsch reaction) 5. Synthesis gas by metal carbonyl complexes	10	15	0	2
IV	**Clusters:** Definition of clusters, Low and high nuclearity metal carbonyl and metal halide clusters, bimetallic clusters. sed shell electronic requirements for cluster compounds, introduction to tensor surface harmonic theory of clusters. Organization of neutral boron hydrides, anionic borane, carboranes and metallocarboranes. Synthesis and properties of C60.	15	15	0	3
Total		70	60	0	15

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

Mode of In-Semester Assessment: (30 Marks)

Sessional Test:	**Marks: 18**
Other Sessional Activities:	**Marks: 12**

In- Semester Assessment **Marks: 30**

Sessional Activity

Activities selected from above mentioned list:

g) Home Assignments
h) Class Assignments
i) Seminars
j) Group Discussions
k) Sudden Tests
l) Class Attendance.

Course Learning Outcomes:
By the end of this course, students will be able to

CLO-1

1.1 Identify and explain substitution mechanisms in square planar complexes, including the trans-effect and its theoretical basis.

1.2 Evaluate thermodynamic and kinetic stability of coordination complexes.

1.3 Analyse reaction mechanisms of nucleophilic substitution in octahedral complexes, incorporating ligand field effects.

CLO-2

2.1 Classify organometallic compounds based on bond type and hapticity of ligands.

2.2 Apply the 18-electron rule and perform electron counting in mono- and polynuclear metal carbonyls.

2.3 Explain the synergic bonding in metal carbonyls using MO diagrams and IR data.

2.4 Describe structural aspects and bonding in metal alkyls and Grignard reagents, including the role in polymerization (Ziegler-Natta catalyst).

2.5 Interpret the aromaticity, structure, and reactivity of ferrocene in comparison to benzene.

CLO-3

3.1 Illustrate and **evaluate** mechanisms of organometallic catalysts in key industrial reactions: hydrogenation, hydroformylation, Wacker process, and Fischer-Tropsch synthesis.

3.2 Explain the role of metal carbonyl complexes in synthesis gas production.

CLO-4

4.1 Define and classify metal clusters and describe their electronic requirements.

4.2 Discuss the organization and bonding in boranes, carboranes, and metallocarboranes.

4.3 Explain the synthesis, structure, and unique properties of C_{60} (Buckminsterfullerene).

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-4	CO-1, CO-2			
Conceptual Knowledge		CO-1, CO-2, CO-3, CO-4	CO-2, CO-3, CO-4	CO-1, CO-2, CO-3, CO-4	CO-2, CO-3	
Procedural Knowledge			CO-2, CO-3, CO-4	CO-1, 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	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CLO-1	3	1	3	2	2	2	2	2
CLO-2	3	2	3	2	3	2	2	3
CLO-3	3	2	3	2	3	2	2	3
CLO-4	3	2	3	2	3	2	3	3
Average	3.0	1.75	3.0	2.0	2.75	2.0	2.25	2.75

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

Suggested Readings:

1. Vogel, A. I. Qualitative Inorganic Analysis, Longman, 1972.
2. Svehla, G. Vogel's Qualitative Inorganic Analysis, 7th Ed., Prentice Hall.

3. Cotton, F. A. G.; Wilkinson & Gaus, P. L. Basic Inorganic Chemistry 3rd Ed.; Wiley India,
4. Huheey, J. E.; Keiter, E. A. & Keiter, R. L. Inorganic Chemistry, Principles of Structure and Reactivity 4th Ed., Harper Collins 1993, Pearson, 2006.
5. Sharpe, A. G. Inorganic Chemistry, 4th Indian Reprint (Pearson Education) 2005
6. Douglas, B. E.; McDaniel, D. H. & Alexander, J. J. Concepts and Models in Inorganic Chemistry 3rd Ed., John Wiley and Sons, NY, 1994.
7. Greenwood, N. N. & Earnshaw, A. Chemistry of the Elements, Elsevier 2nd Ed, 1997 (Ziegler Natta Catalyst and Equilibria in Grignard Solution).
8. Lee, J. D. Concise Inorganic Chemistry 5th Ed., John Wiley and sons 2008.

SEMESTER VI

Course Title: **Organic Chemistry**
Course Code: **MAJ-4-CHE-602**
Nature of the course: **Major**
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 principles and applications of UV, IR, and NMR spectroscopy for the identification and structural elucidation of organic compounds.

CO-2: To examine the classification, synthesis, and application of synthetic and natural dyes with emphasis on their chemical constitution.

CO-3: To explore the chemistry and biological roles of amino acids, peptides, proteins, and nucleic acids, including their synthesis and structural features.

CO-4: To explain enzyme classification, mechanisms, and specificity along with factors influencing enzyme activity and the role of cofactors and inhibitors.

CO-5: To understand the chemical composition, physical properties, and analytical parameters of fats and oils, including their degradation processes.

CO-6: To analyse the structure, configuration, and interconversion of carbohydrates and their biological significance.

Course Contents

Unit	Content	Marks	L	P	T
I	**Organic Spectroscopy:** General principles Introduction to absorption and emission spectroscopy. ***UV Spectroscopy****:* Types of electronic transitions, λmax, Chromophores and Auxochromes, Bathochromic and Hypsochromic shifts, Intensity of absorption; distinction between cis and trans isomers. ***IR Spectroscopy****:* IR absorption positions of O, and N containing functional groups; Effect of H-bonding, conjugation, resonance, and ring size on IR absorptions; Fingerprint region and its significance.	12	10	0	5

	NMR Spectroscopy*:* Basic principles of Proton Magnetic Resonance, chemical shift and Interpretation of NMR spectra of simple compounds. Applications of IR, UV, and NMR for identification of simple organic molecules.				
II	**Dyes:** Classification, Colour and constitution; **Mordant and Vat Dyes**; Chemistry of dyeing; Synthesis and applications of: **Azo dyes** – Methyl Orange and Congo Red; **Triphenyl Methane Dyes** -Malachite Green, and Crystal Violet; **Phthalein Dyes** – Phenolphthalein and Fluorescein; **Natural dyes** –synthesis of Alizarin and Indigotin; Edible Dyes with examples.	8	5	0	2
III	**Amino Acids, Peptides, Proteins and Nucleic Acids:** Amino acids, Peptides and their classification. α-Amino Acids - Synthesis, ionic properties and reactions. Zwitterions, p*K*a values, isoelectric point, and Study of peptides: methods of peptide synthesis. Structure of DNA (Watson &Model) and RNA, Genetic Code, Replication, Transcription and Translation (elementary idea only)	8	5	0	3
IV	**Enzymes:** Introduction, classification, and characteristics of enzymes. Mechanism of enzyme action (taking trypsin as example), factors affecting enzyme action, coenzymes and cofactors, specificity of enzyme action (including stereo specificity), enzyme inhibitors and their importance.	8	10	0	3
V	**Lipids:** Introduction to oils and fats; common fatty acids present in oils and fats, Hydrogenation of fats and oils, Saponification value, acid value, iodine number. Reversion and rancidity.	8	5	0	2
VI	**Carbohydrates:** Occurrence, classification and their biological importance. Monosaccharides: Constitution and absolute configuration of glucose and fructose, epimersand anomers, mutarotation, Ring structure of glucose and fructose, Haworth projections and conformational structures; Ascending and descending in monosaccharide; Interconversions of aldoses and ketoses; Killiani- Fischer synthesis and Ruff degradation	12	10	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: 14**
Other Sessional Activities:	**Marks: 10**
In- Semester Assessment	**Marks: 24**

Sessional Activity

Activities selected from above mentioned list:

m) Home Assignments
n) Class Assignments
o) Seminars
p) Group Discussions
q) Sudden Tests
r) Class Attendance.

Course Learning Outcomes:

CLO-1

1.1 **To describe** the principles and types of electronic, vibrational, and magnetic transitions in UV, IR, and NMR spectroscopy.

1.2 **To interpret** UV, IR, and NMR spectra for the identification of functional groups and isomers in organic molecules.

1.3 **To apply** spectroscopic techniques to determine the structure of simple organic compounds.

CLO-2

2.1 **To classify** dyes based on structure and function and explain the relation between colour and constitution.

2.2 **To outline** the synthesis and applications of common azo, triphenylmethane, phthalein, and natural dyes.

2.3 **To evaluate** the chemistry of dyeing and the significance of mordant, vat, and edible dyes.

CLO-3

3.1 **To explain** the synthesis, classification, and chemical behavior of α-amino acids and peptides.

3.2 **To interpret** the structure and function of nucleic acids including DNA and RNA.

3.3 **To describe** genetic processes such as replication, transcription, and translation at an elementary level.

CLO-4
4.1 **To classify** enzymes and explain their characteristics and mechanisms of action.

4.2 **To analyse** the role of cofactors, coenzymes, and inhibitors in enzymatic reactions.

4.3 **To evaluate** factors influencing enzyme activity and the specificity of enzyme-substrate interactions.

CLO-5
5.1 **To describe** the composition and common types of fatty acids in fats and oils.

5.2 **To explain** chemical parameters such as saponification value, acid value, and iodine number.

5.3 **To interpret** the chemical changes involved in hydrogenation, rancidity, and reversion of lipids.

CLO-6
6.1 **To classify** carbohydrates and explain their biological significance.

6.2 **To analyse** the structures and stereochemistry of glucose and fructose, including epimerization and mutarotation.

6.3 **To apply** synthetic and degradation reactions such as Killiani-Fischer synthesis and Ruff degradation for monosaccharide interconversions.

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-5	CO-1, CO-2, CO-3, CO-4, CO-5, CO-6	CO-1, CO-2, CO-3, CO-5, CO-6	CO-3, CO-4, CO-6		
Conceptual Knowledge		CO-1, CO-2, CO-3, CO-4, CO-5, CO-6	CO-2, CO-3, CO-4, CO-5, CO-6	CO-4, CO-6	CO-2, CO-4, CO-5	
Procedural Knowledge			CO-1, CO-2, CO-3, CO-6	CO-3, CO-5, CO-6	CO-4, CO-5, CO-6	
Metacognitive Knowledge					CO-4, CO-5	

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

CLO / PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CLO-1	3	2	3	2	2	2	2	2
CLO-2	3	2	2	2	2	2	2	2
CLO-3	3	2	3	2	2	2	3	2
CLO-4	3	2	3	2	2	3	3	2
CLO-5	3	2	2	2	2	3	3	2
CLO-6	3	2	3	2	2	2	2	2
Average	**3.0**	**2.0**	**2.67**	**2.0**	**2.0**	**2.33**	**2.5**	**2.0**

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

Suggested Readings:

1. Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India)Pvt. Ltd. (Pearson Education).
2. Finar, I. L. *Organic Chemistry* (*Volume 1*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Finar, I. L. *Organic Chemistry* (*Volume 2: Stereochemistry and the Chemistry ofNatural Products*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

4. Acheson, R.M. *Introduction to the Chemistry of Heterocyclic compounds,* JohnWiley & Sons (1976).
5. Graham Solomons, T.W. *Organic Chemistry,* John Wiley & Sons, Inc.
6. Kalsi, P. S. *Textbook of Organic Chemistry 1st Ed.*, New Age International (P)Ltd. Pub.
7. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; *Organic Chemistry,* OxfordUniversity Press.
8. Singh, J.; Ali, S.M. & Singh, J. *Natural Product Chemistry*, PrajatiParakashan(2010).

SEMESTER VI

Course Title: **Physical Chemistry**
Course Code: **MAJ-4-CHE-603**
Nature of the course: **Major**
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 foundational concepts and mathematical framework of quantum mechanics and apply them to simple molecular systems such as particle-in-a-box, harmonic oscillator, rigid rotator, and hydrogen-like atoms.

CO-2: To explore the principles of molecular spectroscopy, including rotational, vibrational, electronic, and NMR techniques, and interpret their applications in molecular structure determination.

Course Contents

Unit	Content	Marks	L	P	T
I	**Quantum Chemistry-I:** Background of quantum mechanics, Postulates of quantum mechanics, quantum mechanical operators, Angular momentum: Commutation rules. Schrödinger equation and its application to free particle and "particle-in-a-box" (rigorous treatment), quantization of energy levels, zero-point energy and Heisenberg Uncertainty principle; wavefunctions, probability distribution functions, nodal properties, Extension to two- and three-dimensional boxes, separation of variables, degeneracy. Qualitative treatment of simple harmonic oscillator model of vibrational motion: Setting up of Schrödinger equation and discussion of solution and wavefunctions. Vibrational energy of diatomic molecules and zero-point energy. Rigid rotator model of rotation of diatomic molecule. Schrödinger equation, transformation to spherical polar coordinates.	28	25	0	8

	Qualitative treatment of hydrogen atom and hydrogen-like ions: setting up of Schrödinger equation in spherical polar coordinates, radial part, quantization of energy (only final energy expression).				
II	**Molecular Spectroscopy-I:** Interaction of electromagnetic radiation with molecules and various types of spectra. **Rotation spectroscopy**: Selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution. **Vibrational spectroscopy**: Classical equation of vibration, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibration, concept of group frequencies. **Electronic spectroscopy:** Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, dissociation and predissociation, calculation of electronic transitions of polyenes using free electron model. **Nuclear Magnetic Resonance (NMR) spectroscopy**: Principles of NMR spectroscopy, Larmor precession, chemical shift and low-resolution spectra, different scales, spin-spin coupling and high-resolution spectra, interpretation of PMR spectra of organic molecules.	28	20	0	7
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: 14**
Other Sessional Activities:	**Marks: 10**
In- Semester Assessment	**Marks: 24**

Sessional Activity

Activities selected from above mentioned list:

s) Home Assignments

t) Class Assignments
u) Seminars
v) Group Discussions
w) Sudden Tests
x) Class Attendance.

Course Learning Outcomes:

CLO-1

1.1 **To describe** the postulates and operators of quantum mechanics, including the Schrödinger equation and angular momentum.

1.2 **To apply** the Schrödinger equation to systems such as particle-in-a-box, harmonic oscillator, and rigid rotator to explain quantization and wavefunctions.

1.3 **To interpret** the physical significance of quantum mechanical models in molecular systems, including energy levels, degeneracy, and probability distributions.

CLO-2

2.1 **To explain** the interaction of electromagnetic radiation with matter and the principles behind various types of molecular spectra.

2.2 **To analyse** rotational, vibrational, and electronic spectra to extract molecular parameters such as bond length, force constant, and electronic transitions.

2.3 **To interpret** nuclear magnetic resonance (NMR) spectra using concepts like chemical shift, spin-spin coupling, and spectral patterns in organic molecules.

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-1, CO-2	CO-1, CO-2			
Conceptual Knowledge		CO-1, CO-2	CO-1, CO-2	CO-2		
Procedural Knowledge			CO-1, CO-2	CO-1, CO-2		
Metacognitive Knowledge					CO-2	

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

CLO / PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CLO-1	3	2	3	2	2	2	2	2
CLO-2	3	2	3	2	2	2	2	2
Average	3.0	2.0	3.0	2.0	2.0	2.0	2.0	2.0

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

Suggested Readings:

1. Banwell, C. N. & McCash, E. M. Fundamentals of Molecular Spectroscopy 4th Ed. Tata McGraw-Hill: New Delhi (2006).
2. Chandra, A. K. Introductory Quantum Chemistry Tata McGraw-Hill (2001).
3. House, J. E. Fundamentals of Quantum Chemistry 2nd Ed. Elsevier: USA (2004).
4. Lowe, J. P. & Peterson, K. Quantum Chemistry, Academic Press (2005).
5. Kakkar, R. Atomic & Molecular Spectroscopy, Cambridge University Press (2015).
6. Sen, B. K, Quantum Chemistry including Spectroscopy Kalyani Publishers.

SEMESTER VI

Course Title: **Chemistry Practical (General Chemistry)**
Course Code: **MAJ-4-CHE-601**
Nature of the course: **Major**
Component of the course: **L=0, T=0, P=4**
Total Credit assigned: **4**
Contact Hours: **120**
Distribution of Marks: **End Semester=80; In Semester =0 (Total= 80)**

Course Objectives:
CO-1: To understand and apply UV-Visible spectroscopy for the analysis of transition metal ions and the structural study of organic molecules.

CO-2: To perform colorimetric and spectrophotometric experiments for quantitative analysis and determination of reaction kinetics and equilibrium constants.

CO-3: To carry out basic organic chemistry experiments involving extraction, qualitative analysis of carbohydrates, and identification using IR and NMR spectra.

CO-4: To apply classical titration methods and instrumental techniques for the analysis of chlorine, alkalinity, and dissolved gases in water samples.

Course Contents

Unit	Content	Marks	L	P	T
I	**UV/Visible spectroscopy** I. Study the 200-500 nm absorbance spectra of $KMnO_4$ and $K_2Cr_2O_7$ (in 0.1 M H_2SO_4) and λ determine the max values. Calculate the energies of the two transitions in different units (J molecule-1, kJ mol-1, cm-1, eV). II. Study the pH-dependence of the U V-Vis spectrum (200-500 nm) of $K_2Cr_2O_7$. III. Record the 200-350 nm UV spectra of the given compounds (acetone, acetaldehyde, 2-propanol, acetic acid) in water. Comment on the effect of structure on the UV spectra of organic compounds.	15	0	30	0
II	**Colorimetry:** • Verify Lambert-Beer's law and determine the concentration of $CuSO_4$/ $KMnO_4$/ $K_2Cr_2O_7$ in a solution of unknown concentration. • Determine the concentrations of $KMnO_4$ and $K_2Cr_2O_7$ in a mixture. • Study the kinetics of iodination of propanone in acidic medium. • Determine the amount of iron present in a sample using 1,10-phenathroline.	20	0	30	0

	• Determine the dissociation constant of an indicator (phenolphthalein/ methyl red). • Determine phosphate concentration in a soft drink. • Analysis of the given vibration-rotation spectrum of HCl(g)				
III	**Organic Chemistry:** 1. Extraction of caffeine from tea leaves. 2. Analysis of Carbohydrate: aldoses and ketoses, reducing and non-reducing sugars. 3. Identification of simple organic compounds by IR spectroscopy and NMR Spectroscopy (Spectra to be provided).	20	0	30	0
IV	**Inorganic Chemistry:** 1. Percentage of available chlorine in bleaching powder. 2. Estimation of total alkalinity of water samples (CO_3^{-2}, HCO_3^-) using double titration method. 3. Measurement of dissolved CO_2	17	0	30	0
	Viva-voce	8			
Total		**80**	**0**	**120**	**0**

Mode of Transaction: Laboratory Works, Experiments.

Mode of In-Semester Assessment: NONE

Course Learning Outcomes:

CLO-1
1.1 **To record and interpret** UV-Visible spectra for metal complexes and organic compounds.

1.2 **To determine** λmax and calculate transition energies.

1.3 **To analyse** the effect of pH and molecular structure on UV-Visible absorption behaviour.

CLO-2
2.1 **To verify** Lambert-Beer's law and determine the concentration of analytes in single and mixed solutions.

2.2 **To perform** kinetic studies and calculate reaction rates using colorimetric methods.

2.3 **To estimate** analytes such as iron, phosphates, and indicators using appropriate spectrophotometric techniques.

CLO-3

3.1 **To extract** and isolate caffeine from natural sources using solvent extraction techniques.

3.2 **To analyse** carbohydrates for aldose/ketose classification and reducing properties.

3.3 **To interpret** IR and NMR spectra for the identification of simple organic compounds.

CLO-1V

4.1 **To determine** the available chlorine content in bleaching powder by iodometric titration.

4.2 **To estimate** the total alkalinity of water samples using acid-base titration methods.

4.3 **To measure** dissolved CO_2 content in water and assess its significance in environmental samples.

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

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

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

CLO / PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CLO-1	3	3	3	2	2	2	2	3
CLO-2	3	3	3	2	2	2	3	3
CLO-3	3	3	3	2	2	2	2	2
CLO-4	3	3	3	2	2	2	3	2
Average	**3.0**	**3.0**	**3.0**	**2.0**	**2.0**	**2.0**	**2.5**	**2.5**

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

Suggested Reading:

1. K.De, *Environmental Chemistry*: New Age International Pvt. Ltd., New Delhi
2. S. M. Khopkar, *Environmental Pollution Analysis*: Wiley Eastern Ltd, New Delhi
3. Khosla, B. D.; Garg, V. C. & Gulati, A., *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi (2011).
4. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry 8th Ed.;* McGraw-Hill: New York (2003).
5. Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry 3rd Ed.;* W.H. Freeman & Co.: New York (2003).
6. Yadav, J.B., *Advanced Practical Physical Chemistry 32nd Ed*; Goel Publishing House.

SEMESTER VI

Course Title: **Chemistry and Environment**
Course Code: **DSE-3-CHE-601A**
Nature of the course: **DISCIPLINE SPECIFIC ELECTIVE COURSE (OPTION 1)**
Component of the course: **L=2, T=1, P=0**
Total Credit assigned: **3**
Contact Hours: **45**
Distribution of Marks: **End Semester=42; In Semester =18 (Total= 60)**

Course Objectives:
CO-1: To understand the composition of the environment, sources and types of pollution, and analytical and treatment methods for air and water pollution.

CO-2: To evaluate various energy sources, understand the environmental consequences of their use, and assess nuclear pollution and waste management.

CO-3: To explore the role of biocatalysis in green chemistry and its applications in the chemical industry.

Course Contents

Unit	Content	Marks	L	P	T
I	**Environment and its segments:** Ecosystem, Biogeochemical cycles of carbon, nitrogen and sulphur. *Air Pollution*: Major regions of atmosphere. Chemical and photochemical reactions in the atmosphere. Air pollutants: types, sources, particle size and chemical nature. Photochemical smog: its constituents and photochemistry. Environmental effects of ozone, major sources of air pollution. Pollution by SO_2, CO_2, CO, NOx, H_2S and other foul smeling gases, Methods of estimation of CO, NOx, SOx and control procedures. Effects of air pollution on living organisms and vegetation. Greenhouse effect and Global warming, Ozone Letion by oxides of nitrogen, chlorofluorocarbons and halogens, removal of sulphur from coal. Control of particulates. *Water pollution*: Hydrological cycle, water resources, aquatic ecosystems, Sources and nature of water pollutants, Techniques for measuring water pollution, Impacts of water pollution on hydrological and ecosystems. Water purification methods. Effluent treatment plants (primary, secondary	30	20	0	10

	and tertiary treatment). Industrial effluents from the following industries and their treatment: electroplating, textile. Tannery, diary, petroleum and petrochemicals, agro, fertilizers etc. Sludge disposal. Industrial waste management, incineration of waste. Water treatment and purification (Reverse osmosis, electro dialysis, ion-exchange). Water quality parameters for wastewater, industrial water and domestic water.				
II	**Energy & Environment:** *Sources of energy*: Coal, petrol and natural gas. Nuclear Fusion/ Fission, Solar energy, Hydrogen, Geothermal, Tidal and Hydel etc. *Nuclear pollution*: Disposal of nuclear waste, nuclear disaster, and its management.	8	5	0	3
III	**Biocatalysis** *Introduction to biocatalysis*: Importance in "Green Chemistry" and "Chemical Industry"	4	5	0	2
Total		42	30	0	15

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

Mode of In-Semester Assessment: (18 Marks)

Sessional Test:	**Marks: 11**
Other Sessional Activities:	**Marks: 7**
In- Semester Assessment	**Marks: 18**

Sessional Activity

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

Course Learning Outcomes:

CLO-1

1.1 **To explain** the structure of ecosystems and the biogeochemical cycles of carbon, nitrogen, and sulphur.

1.2 **To analyse** the sources, chemical nature, and control methods of air and water pollutants.

1.3 **To evaluate** techniques for pollution monitoring, wastewater treatment, and industrial effluent management.

CLO-2

2.1 **To classify** conventional and non-conventional sources of energy and assess their environmental impact.

2.2 **To describe** the principles of nuclear energy and the challenges of nuclear waste disposal.

2.3 **To evaluate** the causes and consequences of nuclear pollution and discuss management strategies for nuclear disasters.

CLO-3

3.1 **To define** biocatalysis and explain its significance in sustainable chemical processes.

3.2 **To identify** the role of biocatalysts in green chemistry and environmentally friendly industrial applications.

3.3 **To illustrate** how biocatalysis contributes to reducing environmental pollution in chemical manufacturing.

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-2, CO-3	
Procedural Knowledge			CO-1, CO-2	CO-1, CO-2	CO-1, CO-2, CO-3	
Metacognitive Knowledge					CO-3	

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

CLO / PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CLO-1	3	2	3	3	2	2	3	2
CLO-2	3	2	3	3	2	2	3	2
CLO-3	**3**	**2**	**2**	**2**	**3**	**2**	**3**	**2**
Average	**3.0**	**2.0**	**2.67**	**2.67**	**2.33**	**2.0**	**3.0**	**2.0**

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

Reference Books:

1. S.S.Dara: *A Textbook of Engineering Chemistry*, S. Chand & Company Ltd, New Delhi
2. K.De, *Environmental Chemistry*: New Age International Pvt. Ltd., New Delhi
3. S. M. Khopkar, *Environmental Pollution Analysis*: Wiley Eastern Ltd, New Delhi
4. S.E. Manahan, *Environmental Chemistry*, CRC Press (2005)
5. G. T. Miller, *Environmental Science*, 11th Ed. Brooks/ Cole (2006)
6. A. Mishra, *Environmental Studies*. Selective and Scientific Books, New Delhi (2005)

SEMESTER VI

Course Title: **CHEMISTRY IN ANCIENT INDIA**
Course Code: **DSE-3-CHE-601B**
Nature of the course: **DISCIPLINE SPECIFIC ELECTIVE COURSE (OPTION 2)**
Component of the course: **L=2, T=1, P=0**
Total Credit assigned: **3**
Contact Hours: **45**
Distribution of Marks: **End Semester=42; In Semester =18 (Total= 60)**

Course Objectives:

CO-1: To explore the foundational concepts of chemistry as developed in ancient India through literature, philosophy, and early scientific practices.

CO-2: To understand the evolution and decline of metallurgical techniques and the types, properties, and processing of metals in ancient India.

CO-3: To examine the knowledge and techniques related to chemicals used in daily life in ancient India, including cosmetics, inks, and alcoholic preparations.

CO-4: To analyse the Ayurvedic medical system and the preparation and application of Bhasmas in traditional Indian medicine.

CO-5: To study traditional textile technologies including natural fibers, fabric treatment, dyeing, and weaving methods in ancient India.

Course Contents

Unit	Content	Marks	L	P	T
I	**HISTORY OF CHEMISTRY IN ANCIENT INDIA:** Chemistry in early literature, Knowledge of Fundamental Concepts of Chemistry in Ancient India, Early Chemical Techniques, Technology and Arts, Concept of Atom, Nano particles, Chemistry in India, Vatsyayana, Nagarjuna, Khanda, Al-Biruni, Vagbhaṭa –building of the Rasa-shala (laboratory), working arrangements of Rasa -shala, material and equipment, Yaśodhara Bhaṭṭa-process of distillation, apparatus, saranasamskara, saranataila	5	5	0	3
II	**METALLURGY IN ANCIENT INDIA:** Chemistry and Metallurgy in India: Disappearance of Metallurgical Skills, 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.	15	7		3
III	**CHEMICALS IN ANCIENT INDIA**	5	5		3

	Paper and ink making, Paints and Dyes, Perfumes and Cosmetics, Paper and Ink Making, Alcoholic Liquors.				
IV	**ĀYURVEDIC MEDICAL SYSTEM:** Ayurveda for Life, Health, and Well-being**:** Introduction to Ayurveda: From Alchemy to Chemistry. Rasayana in Ayurvedic texts, Preparation of different types of Bhasmas (Gold Bhasma, Silver Bhasma, Copper Bhasma and Lead Bhasma) and their medicinal values.	10	5		3
V	**TEXTILE TECHNOLOGY IN INDIA:** Cotton (natural cellulose fiber), silk, wool (natural protein fibers), bast and leaf fibers, mridhu dhauta dhupitambaram (meaning a practice of fumigating the fabric with incense smoke before use as a part of the finishing process), sitadhautavasanayugala (bleached white–a finishing process); suchhastah, sutradharah (needle and thread – tools for stitching). dyeing, washing spinning and weaving technology.	7	8		3
Total		42	30	0	15

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

Mode of In-Semester Assessment: (18 Marks)

Sessional Test:	**Marks: 11**
Other Sessional Activities:	**Marks: 7**
In- Semester Assessment	**Marks: 18**

Sessional Activity

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

Expected Learner Outcomes:

CLO-1

1.1 **To identify** key contributions of Indian scholars and texts to the development of early chemical concepts.

1.2 **To describe** the techniques, tools, and materials used in ancient Indian laboratories (Rasa-shala).

1.3 **To explain** early Indian understanding of atomic theory, nanoparticles, and alchemical practices.

CLO-2
2.1 **To classify** the major metals used in ancient India and describe their properties and methods of extraction.

2.2 **To analyse** ancient metallurgical processes and understand their historical context and decline.

2.3 **To describe** traditional Indian techniques of glass making and alloy preparation, including brass and gold-silver alloys.

CLO-3
3.1 **To describe** the traditional methods for making paper, ink, and dyes in ancient India.

3.2 **To explain** the preparation and uses of perfumes, cosmetics, and alcoholic beverages in ancient Indian culture.

3.3 **To evaluate** the significance of these chemical practices in the social and technological history of ancient India.

CLO-1V
4.1 **To outline** the basic principles and scope of Ayurveda from a chemical and alchemical perspective.
4.2 **To explain** the preparation and properties of medicinal Bhasmas used in Ayurvedic treatments.
4.3 **To evaluate** the role of Rasayana and related chemical processes in promoting health and longevity.

CLO-V
5.1 **To identify** natural fibers used in ancient Indian textiles and explain traditional methods of their processing.

5.2 **To describe** fabric finishing practices such as bleaching and fumigation mentioned in ancient texts.

5.3 **To explain** the technologies involved in spinning, dyeing, weaving, and stitching in ancient India.

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-5	CO-1, CO-2, CO-3, CO-4, CO-5	CO-1, 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-2, CO-3, CO-4, CO-5	CO-3, CO-4	
Procedural Knowledge			CO-2, CO-3, CO-4, CO-5	CO-2, CO-4, CO-5	CO-3, CO-4, CO-5	
Metacognitive Knowledge					CO-4, CO-5	

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

CLO / PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CLO-1	3	1	2	2	2	2	2	2
CLO-2	3	2	2	2	2	2	2	2
CLO-3	3	2	2	2	2	2	3	2
CLO-4	3	2	2	2	3	2	3	2
CLO-5	3	2	2	2	3	2	3	2
Average	**3.0**	**1.8**	**2.0**	**2.0**	**2.4**	**2.0**	**2.6**	**2.0**

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

Reference Books:

1. P.C. Ray, History of Chemistry in ancient and medieval India, Chowkhambha Krishnadas Academy, Reprint Edition, 1 January 2004.
2. Textbook on IKS by Prof. B Mahadevan, IIM Bengaluru
3. 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.
4. The Cultural Heritage of India. Vol.I. Kolkata:Ramakrishna Mission Publication, 1972.
5. Nair, Shantha N. Echoes of Ancient Indian Wisdom. New Delhi: Hindology Books, 2008.

6. Dr. R. C. Majumdar, H. C. Raychaudhuri and Kalikinkar Datta: An Advanced History of India (Second Edition) published by Macmillan & Co., Limited, London, 1953.
7. Rao, N. 1970. The Four Values in Indian Philosophy and Culture. Mysore: University of Mysore.
8. Avari, B. 2016. India: The Ancient Past: A History of the Indian Subcontinent from *7000* BCE to CE 1200. London: Routledge.

SEMESTER-VII

Course Title: **Inorganic Chemistry**
Course Code: **MAJ-4-CHE-701**
Nature of the course: **Major**
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 II:** Recapitulation of 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 (O2, N2, 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 surroundings: Crystal Field Theory; Covalent surrounding: Transition metal MO	26	15	0	5

	and ligand field Theory, Transition metal complexes with σ and π bonding ligands. Molecular orbital model, General view of ML6 and ML_4 structures: $ML_6(Oh)$, $ML_4(D_{4h})$ and $ML_4(Td)$. Chemical periodicity, Chemical hardness, Application of electronegativity.				
II	**Acid Base and Redox Chemistry II:** Acid-Base in water. Non-aqueous solvent, aprotic solvent and superacid. 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		5
III	**Bioinorganic Chemistry II** 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		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**

Sessional Activity

Activities selected from above mentioned 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:

2.1. **Apply** the Valence Shell Electron Pair Repulsion (VSEPR) theory to predict molecular shapes.
2.2. **Understand** the various theories of chemical bonding, including valence bond theory (VBT) and molecular orbital theory (MOT).
2.3. **Analyse** bonding in heteronuclear diatomic and polyatomic molecules (e.g., CO, NO, O_2).
2.4. **Evaluate** electron-deficient compounds and multicenter bonding such as in boranes.
2.5. **Evaluate** the bonding in coordination compounds, including the role of ligands and the application of crystal field theory (CFT) and ligand field theory (LFT).

CLO-2:

a. **Explain** acid-base theories in aqueous and non-aqueous solvents.
b. **Apply** redox principles and electrode potential concepts in electrochemical cells.
c. **Interpret** electrochemical series, Nernst equation and use of Latimer and Frost diagrams to deduce redox pathways.
d. **Discuss** the factors affecting corrosion, its prevention, and practical applications of redox reactions.

CLO-3:

3.1 **Understand** the structure and function of metalloproteins such as hemoglobin, myoglobin, and cytochromes.
3.2 **Explain** the role of metal ions in biological redox reactions and electron transfer processes.
3.3 **Analyse** the functions of bioinorganic systems such as iron-sulfur proteins and vitamin B12.
3.4 **Discuss** recent advances and future perspectives in bioinorganic chemistry, including medicinal and catalytic applications.

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

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluation	Create
Factual Knowledge	CO1, CO2	CO1, CO4	CO2, CO3	CO2, CO4		
Conceptual Knowledge		CO1, CO2, CO3, CO4	CO3	CO3, CO4	CO2	
Procedural Knowledge		CO3	CO2, CO3	CO1, CO2,	CO2	

				CO3, CO4		
Metacognitive Knowledge		CO4			CO3	

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	-	-	-
CLO_2	3	-	2	-	-	-	-	-
CLO_3	3	-	2	-	-	-	1	-
Average	**3**	**-**	**2**	**-**	**2**	**-**	**0.25**	**-**

(3=High, 2=Moderate, 1=Low)

Suggested Readings:

1. Vogel, A. I. Qualitative Inorganic Analysis, Longman, 1972.
2. Svehla, G. Vogel's Qualitative Inorganic Analysis, 7th Ed., Prentice Hall.
3. Cotton, F. A. G.; Wilkinson & Gaus, P. L. Basic Inorganic Chemistry 3rd Ed.; Wiley India,
4. Huheey, J. E.; Keiter, E. A. & Keiter, R. L. Inorganic Chemistry, Principles of Structure and Reactivity 4th Ed., Harper Collins 1993, Pearson, 2006.
5. Sharpe, A. G. Inorganic Chemistry, 4th Indian Reprint (Pearson Education) 2005
6. Douglas, B. E.; McDaniel, D. H. & Alexander, J. J. Concepts and Models in Inorganic Chemistry 3rd Ed., John Wiley and Sons, NY, 1994.
7. Greenwood, N. N. & Earnshaw, A. Chemistry of the Elements, Elsevier 2nd Ed, 1997 (Ziegler Natta Catalyst and Equilibria in Grignard Solution).
8. Lee, J. D. Concise Inorganic Chemistry 5th Ed., John Wiley and sons 2008.
9. Powell, P. Principles of Organometallic Chemistry, Chapman and Hall, 1988.
10. Jonathan W. Steed and Jerry L Atwood, Supramolecular Chemistry, 3rd Edition.
11. Shriver, D. D. & P. Atkins, Inorganic Chemistry 2nd Ed., Oxford University Press, 1994.

SEMESTER-VII

Course Title: **Organic Chemistry**
Course Code: **MAJ-4-CHE-702**
Nature of the course: **Major**
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, Electrocyclic reactions, Stereoselectivity and regioselectivity 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.	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.	15	10	0	2

	Phase transfer catalyst. Hammet equation, Taft equation. Influence of reaction medium on rates.				
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. Organic Chemistry, Subrata Sengupta, 1st Edition, Oxford University Press
3. Reaction Mechanism in Organic Chemistry, Subrata Sengupta, 1st Edition, Oxford University Press
4. Stereochemistry and Mechanism through Solved Problems- P.S. Kalsi, New Age International Publishers
5. Introduction to Spectroscopy – by Donald L. Pavia, Cengage Learning India Private Limited
6. A Guidebook to Mechanism in Organic Chemistry– Peter Sykes, Longman, New York.
7. Organic Chemistry – R. T. Morrison, R. N. Boyd and S. K. Bhattacharjee, Prentice Hall India Limited
8. Organic Chemistry – Paula Yurkanis Bruice, Pearson

9. Advanced Organic Chemistry: Reaction Mechanism and Structure – Jerry March, Wiley Eastern.
10. Disconnection Approach in Organic Synthesis – S. Warren, Wiley
11. Organic Reaction Mechanism, Christine Willis and martin Willis, Oxford chemistry Primers (No. 74)
12. Disconnection Approach in Organic Synthesis – S. Warren, Wiley
13. Designing Organic Synthesis – S. Warren, Wiley, Chichester
14. The Logic of Organic Synthesis – E.J. Corey and Xue Min Chen, Wiley, New York

SEMESTER-VII

Course Title: **Physical Chemistry**
Course Code: **MAJ-4-CHE-703**
Nature of the course: **Major**
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.	20	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	20	15	0	5

	theory of heat capacity of solids. Numerical calculations of thermodynamic quantities for monoatomic, diatomic, and polyatomic molecules.				
III	**Photochemistry:** Light absorption: Jablonski Diagram, concept of quantum yield and its determination; Fluorescence emission and structure; Triplet state and phosphorescence emission; delayed fluorescence; Photochemical Equilibrium Study of kinetics of H_2-Cl_2 reaction, H_2-Br_2 reaction, photo dimerization of anthracene, Photosensitization and quenching, Stern Volmer equation, Role of photochemical reactions in bio-chemical processes.	16	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**

Sessional Activity

Activities selected from the above-mentioned 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. **Define** and **explain** the concepts of fugacity, activity, and activity coefficients in ideal and non-ideal systems.

1.2. **Calculate** partial molar quantities such as chemical potential, volume, and excess thermodynamic functions.

1.3. **Explain** and **analyse** the Third Law of Thermodynamics and **determine** absolute entropy and residual entropy experimentally.

CLO-2:

2.1. **Describe** the Maxwell-Boltzmann, Bose-Einstein, and Fermi-Dirac distributions and their relation to thermodynamic properties.

2.2. **Calculate** thermodynamic quantities (energy, entropy, heat capacity) from translational, rotational, and vibrational partition functions.
2.3. **Analyse** the Sackur-Tetrode equation and apply it to ideal monoatomic gases.
2.4. **Perform** numerical calculations of thermodynamic properties for monoatomic, diatomic, and polyatomic molecules using statistical models.

CLO-3:

3.1. **Explain** the Jablonski diagram and the mechanism of absorption and emission of radiation.
3.2. **Analyse** electronic transitions including singlet-triplet transitions, fluorescence, and phosphorescence.
3.3. **Calculate** quantum yield and understand its experimental determination.
3.4. **Evaluate** photochemical reactions (e.g., H_2–Cl_2, H_2–Br_2) and factors affecting quenching and photosensitization.

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

Knowledge Dimension	Remember	Understand	Apply	Analyse	Evaluation	Create
Factual Knowledge	CO1	CO1, CO3	CO1, CO2	CO2	CO3	
Conceptual Knowledge		CO1, CO2, CO3	CO2	CO1, CO3	CO3	
Procedural Knowledge		CO3	CO1, CO2, CO3	CO2, CO3	CO3	
Metacognitive Knowledge			CO3		CO3	

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	1	-	3	-	-	1
CLO_2	3	1	2	-	3	-	-	1
CLO_3	3	1	2	-	3	-	1	2
Average	**3**	**0.33**	**1.67**	**-**	**3**	**-**	**0.33**	**1.33**

(3=High, 2=Moderate, 1=Low)

Suggested Readings:

1. Physical Chemistry by P.W. Atkins, Oxford University Press
2. Quantum Chemistry, by Ira N. Levine, Pentice Hall
3. Fundamentals of Molecular Spectroscopy by C.N. Banwell and E.M. McCash, Tata McGraw Hill.
4. Physical Chemistry by I. N. Levine
5. Thermodynamics for Chemist by S. Glasstone

SEMESTER-VII

(OPTION 1)

Course Title: **Laboratory Course-I**
Course Code: **DSE-4-CHE-701A**
Nature of the course: **Major**
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 $[Co\ (NH_3)_5Cl]\ Cl_2$ 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.	20	0	30	0

	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.				
III	**Physical Lab I** (any two) 1. To determine the rate constant of hydrolysis of methyl acetate catalyzed by an acid and 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.	20	0	30	0
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

H. 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-VII

Course Title: **Laboratory Course-I**
Course Code: **DSE-4-CHE-701B**
Nature of the course: **Major (DSE OPTION 2)**
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 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.	20	0	40	0

	2. Study the complex formation between Cu2+ ion and ammonia by distribution method and find the 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

SEMESTER VII

Course Title: **Analytical Methods in Chemistry**
Course Code: **MIN-4-CHE-701**
Nature of the course: **Minor Course**
Component of the course: **L=3, T=0, P=1**
Total Credit assigned: **4**
Contact Hours: **(45 hr) +(30hr): 75 hrs**
Distribution of Marks: **Theory:** End Semester=42; In Semester =18 (Total= 60)
Practical: End Semester=20; In Semester =0 (Total= 20)

THEORY

Course Objectives:

CO-1: **To understand** the principles of sampling, error analysis, and statistical methods for the evaluation of analytical data.

CO-2: To study the theoretical and instrumental aspects of UV-Visible, IR and their importance in chemical analysis.

CO-3: To understand solvent extraction and chromatographic separation techniques and apply them to the qualitative and quantitative analysis of chemical species.

Course Contents

Unit	Content	Marks	L	P	T
I	**Qualitative and quantitative aspects of analysis:** Sampling, evaluation of analytical data, errors, accuracy and precision, methods of their expression, normal law of distribution if indeterminate errors, statistical test of data; F, Q and t test, rejection of data, and confidence intervals**.**	10	10	0	0
II	**UV-Visible and IR Spectrometry:** Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, validity of Beer-Lambert's law. *UV-Visible Spectrometry*: Basic principles of instrumentation (choice of source, monochromator, and detector) for single and double beam instrument; Basic principles of quantitative analysis: estimation of metal ions from aqueous solution, geometrical isomers, keto-enol tautomers. Determination of composition of metal complexes using Job's method of continuous variation and mole ratio method.	16	20	0	0

	Infrared Spectrometry: Basic principles of instrumentation (choice of source, monochromator & detector) for single and double beam instruments; sampling techniques. Structural illustration through interpretation of data, effect, and importance of isotope substitution.				
III	**Separation techniques** *Solvent extraction*: Classification, principle, and efficiency of the technique. Mechanism of extraction: extraction by solvation and chelation. Technique of extraction: batch, continuous and counter current extractions. Qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and non-aqueous media. *Chromatography*: Classification, principle, and efficiency of the technique. Mechanism of separation: adsorption, partition & ion exchange. Development of chromatograms: frontal, elution, and displacement methods. Qualitative and quantitative aspects of chromatographic methods of analysis: TLC and HPLC.	16	15	0	0
Total		42	45	0	0

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

Mode of In-Semester Assessment: (18 Marks)

Sessional Test:	**Marks: 12**
Other Sessional Activities:	**Marks: 6**
In- Semester Assessment	**Marks: 18**

Sessional Activity

Activities selected from above mentioned list:

a) Home Assignments
b) Class Assignments
c) Seminars
d) Group Discussions
e) Sudden Tests
f) Class Attendance.

Course Learning Outcomes:

CLO-1
To describe types of sampling errors, their evaluation, and the expression of accuracy and precision.

CLO-2
2.1 **To explain** the origin of spectra, interaction of radiation with matter, and fundamental spectroscopic laws.

2.2 **To describe** the instrumentation and analytical applications of UV-Visible and IR spectroscopy in quantitative and structural analysis.

CLO-3
3.1 **To describe** the principles, classifications, and mechanisms of solvent extraction and chromatography.

3.2 **To differentiate** between types of extraction and chromatographic techniques such as TLC, and HPLC.

3.3 **To apply** separation techniques for the analysis of metal ions and organic compounds from aqueous and non-aqueous media.

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-1, CO-3	
Procedural Knowledge			CO-1, CO-2, CO-3	CO-1, CO-2, 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	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CLO-1	3	3	3	2	2	2	3	2
CLO-2	3	3	3	2	3	2	3	2
CLO-3	3	3	3	2	2	2	3	2

CLO / PSO	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
Average	3.0	3.0	3.0	2.0	2.5	2.0	3.0	2.0

[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. Ditts, R.V. Analytical Chemistry - Methods of separation.

PRACTICAL
Credit: 1. Marks: 20

Any **three** of the following experiments should be done

i. Paper chromatographic separation of Fe^{3+}, Al^{3+}, Cr^{3+}, Ag^{+} and Pb2+

ii. Separation and identification of the monosaccharides present in the given mixture (glucose & fructose) by paper chromatography. Reporting the R_f values.

iii. Separate a mixture of Sudan yellow and Sudan Red by TLC technique and identify them based on their Rf values.

iv. Chromatographic separation of the active ingredients of plants, flowers and juices by TLC.

v. Study the 200-500 nm absorbance spectra of $KMnO_4$ and $K_2Cr_2O_7$ (in 0.1 M H_2SO_4) and λ determine the max values.

vi. Record the 200-350 nm UV spectra of the given compounds (acetone, acetaldehyde, 2-propanol, acetic acid) in water. Comment on the effect of structure on the UV spectra of organic compounds.

vii. Extraction of caffeine from tea leaves.

viii. Identification of simple organic compounds by IR spectroscopy and NMR Spectroscopy (Spectra to be provided).

Suggested Reading:

7. Khosla, B. D.; Garg, V. C. & Gulati, A., *Senior Practical Physical Chemistry,* R. Chand & Co.: New Delhi (2011).
8. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry 8th Ed.;* McGraw-Hill: New York (2003).
9. Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry 3rd Ed.;* W.H. Freeman & Co.: New York (2003).
10. Yadav, J.B., *Advanced Practical Physical Chemistry 32nd Ed*; Goel Publishing House.

SEMESTER VIII

Course	Course Title	Course Code	Credit	Marks	End Sem Marks	Internal Assessment
Major	Spectroscopy II	MAJ-4-CHE-801	4	80	56	24
Major	Research Methodology	MAJ-4-CHE-802	4	80	56	24
Major	Inorganic Chemistry	MAJ-4-CHE-803	4	80	56	24
Major	Organic Chemistry	MAJ-4-CHE-804	4	80	56	24
Major	Laboratory Course II	MAJ-4-CHE-805	4	80	80	0
			20			

COMPULSORY PAPER

Course Title: **Spectroscopy II**
Course Code: **MAJ-4-CHE-801**
Nature of the course: **Major Course**
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 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**	8	8	0	2

	Introduction to Photoelectron Spectroscopy, Auger electron spectroscopy. Chemical information from ESCA				
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

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
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.

SEMESTER-VIII

Course Title: **Tools and Techniques in Research Methodology**
Course Code: **MAJ-4-CHE-802**
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

(OPTIONAL PAPERS)

[Students will take either three 4 credit papers

MAJ-4-CHE-803, MAJ-4-CHE-804, MAJ-4-CHE-805 or one 12 credit research project paper]

SEMESTER VIII

Course Title: **Inorganic Chemistry**
Course Code: **MAJ-4-CHE-803**
Nature of the course: **Major Course**
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 stability, kinetics, and mechanisms of ligand substitution and electron transfer reactions in coordination complexes.

CO-2: **To apply** group theory and symmetry operations to analyse molecular structures and construct character tables for chemical applications.

CO-3: To apply theoretical principles to analyse molecular symmetry, construct hybrid orbitals determine vibrational modes and predict IR and Raman spectral activity using symmetry selection rules.

Course Contents

Unit	Content	Marks	L	P	T
I	**Inorganic reaction mechanism II:** 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	20	15	0	5

	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 group, construction of C_{2v} and C_{3v} Character table. Direct product representation. Projection operator, symmetry adapted linear combination (SALC) for C_{2v}, C_{3v}, D_{4h} and T_d point group molecules.				
III	**Chemical Applications of Group Theory: Chemical Application of Group Theory** Use of group theory in construction of hybrid Orbitals (dsp^2 and sp3 hybrids). Infrared absorption and Raman scattering spectroscopy, vibrational modes as bases for group representation, Symmetry selection rules for IR and Raman Spectra.	16	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**

Sessional Activity

Activities selected from above mentioned list:

a) Home Assignments
b) Class Assignments
c) Seminars
d) Group Discussions
e) Sudden Tests
f) Class Attendance.

Course Learning Outcomes:

CLO-1
1.1 **To explain** the concepts of stability constants, chelate effect, and thermodynamic vs. kinetic stability in coordination chemistry.

1.2 **To analyse** substitution reactions in octahedral and square planar complexes, including mechanisms and rate-determining factors.

1.3 **To describe** the theories of trans effect and distinguish between inner and outer sphere electron transfer mechanisms.

CLO-2

2.1 **To perform** symmetry operations and represent them using matrices and define the group theoretical framework.

2.2 **To construct and interpret** character tables for molecular point groups such as C_2v and C_3v using orthogonality and projection operators.

2.3 **To apply** group theory concepts to molecular orbitals and describe symmetry-adapted linear combinations (SALCs) in molecules like C_2v, C_3v, D_4h.

CLO-3

3.1 **To apply** group theoretical principles to construct and analyse hybrid orbitals as sp^3 and dsp^2 accuracy, precision, and various types of errors in chemical analysis.

3.2 **To determine** the symmetry species of molecular vibrational modes and classify them using character tables.

3.3 **To evaluate** symmetry-based selection rules to predict IR and Raman activity of molecular vibrations.

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-3	
Procedural Knowledge			CO-1, CO-2, CO-3	CO-1, CO-2, 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	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CLO-1	3	2	3	2	2	2	2	2
CLO-2	3	2	3	2	2	2	2	2
CLO-3	3	2	3	2	2	2	2	2
Average	**3.0**	**2.0**	**3.0**	**2.0**	**2.0**	**2.0**	**2.0**	**2.0**

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

Suggested Readings:

Textbooks:

1. Inorganic Chemistry: Principles of structure and reactivity, 4thEdition; J.E. Huheey, E.A. Keiter, R.L. Keiter, O.K. Medhi.

Recommended Books:

1. Advanced Inorganic Chemistry, 6thEdition, F.A. Cotton, G. Wilkinson, C.A. Murillo and M. Bochmann.
2. Inorganic Chemistry, K.F. Purcell and J.C. Kotz.

SEMESTER VIII

Course Title: **Organic Chemistry**
Course Code: **MAJ-4-CHE-804**
Nature of the course: **Major**
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** 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	**Alkaloids and Terpenoids** 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. Monocyclic monoterpenoid -Terpineol, Menthol.	12	9	0	2
II	**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
III	**Heterocyclic Chemistry**	8	9	0	2

	Heterocyclic Chemistry: Synthesis and properties heterocycles containing one and two heteroatoms viz., N, O and S (aziridine, oxirane, pyrazole, isoxazole, imidazole, oxazole and thiazole).				
IV	**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
V	**Structure elucidation by IR and NMR spectroscopic techniques** 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
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 VIII

Course Title: **Laboratory Course II**
Course Code: **MAJ-4-CHE-805**
Nature of the course: **Major Course**
Component of the course: **L=0, T=0, P=4**
Total Credit assigned: **4**
Contact Hours: **120**
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 Mg^{2+} and Ca^{2+} 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) 3. Oxidation of p-nitrotoluene to p-nitrobenzoic acid 4. Reduction of benzophenone to benzhydrol 5. Phthalic anhydride to phthalimide One –step preparation	24	0	40	0
III	**Physical Lab 2**	24	0	40	0

	1. To study hydrolysis of methyl acetate in presence of HCl and H_2SO_4 and hence analytically 2. To determine Polarimetrically the relative strength of the acids (use Guggenheim method) 3. To determine the equivalent conductivity of acetic acid at infinite dilution by Kohlrausch's method. 4. To determine the relative strength of acetic acid and mono chloro acetic acid by conductance measurement. 5. To determine the specific rotation of sucrose and hence determine the unknown concentration of supplied solution by polarimetric measurements. 6. To determine the pH of a mixture of CH_3COOH and CH_3COONa and hence determine the dissociation constant of the acid.				
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 analyse** 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 analyse** 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			

Knowledge Dimension	Remember	Understand	Apply	Analyze	Evaluate	Create
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 Edition; Goel Publishing House.

SEMESTER-VIII
CHEMISTRY
(Major)
Course Title: (*Research Project*)
Course Code: RP-12-CHE-801
Credit: 12, Contact Hours: 360
[L=0, T=0, P=12]

[The project being of 12 credits, a student will have to devote minimum 360 hours for the project work, Students will begin the project work immediately after the 7th semester examination, will continue to work for a maximum of 65 days including 5 days required for all sorts of communications with the host institution. During the tenure the student will have to attend online classes/interactions being taken by the faculties of the Department of the parent institution in free hours. The existing guidelines as approved by the Academic Council shall continue to be followed.]

Objective and Expected Course outcome:

1. Students would learn how to correctly conduct scientific research.
2. They would acquire knowledge regarding how to assess and use sources of information.
3. They would understand scientific methods of data collection and analysis.
4. There would be development of specific laboratory skills, research methodology, and critical thinking abilities.

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.

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. Existing guidelines