SYLLABI AND SCHEME OF EXAMINATIONS
FOR
DISCIPLINE SPECIFIC COURSES OF
B.Sc. (Chemistry as Single Major)

(Based on Curriculum and Credit Framework for UG Programs under NEP)

(w.e.f. July, 2026)

MAHARSHI DAYANAND UNIVERSITY
ROHTAK (HARYANA)

SCHEME OF EXAMINATIONS FOR DISCIPLINE SPECIFIC COURSES OF B.SC. (CHEMISTRY AS SINGLE MAJOR)

Discipline Specific Courses/ Major Course			Credits Distribution			Total Credits	Workload			Total Workload	Marks				
	Nomenclature of Course	Course Code	L	T	P		L	T	P		Theory		Practical		Total Marks
											Internal	External	Internal	External	
Semester I (Session 2024-25)															
DSC - A1 @ 4 credits	General Chemistry-I	**24CHES401DS01**	2	0	0	**04**	2	0	0	**06**	15	35	---	---	**100**
	Chemistry Practical (SM)-I		0	0	2		0	0	4		---	---	50	---	
DSC – A2 @ 4 credits	General Chemistry-II	**24CHES401DS02**	2	0	0	**04**	2	0	0	**06**	15	35	---	---	**100**
	Chemistry Practical (SM)-II		0	0	2		0	0	4		---	---	50	---	
Semester II (Session 2024-25)															
DSC – A3 @ 4 credits	General Chemistry-III	**24CHES402DS01**	2	0	0	**04**	2	0	0	**06**	15	35	---	---	**100**
	Chemistry Practical (SM)-III		0	0	2		0	0	4		---	---	50	---	
DSC – A4 @ 4 credits	General Chemistry-IV	**24CHES402DS02**	2	0	0	**04**	2	0	0	**06**	15	35	---	---	**100**
	Chemistry Practical (SM)-IV		0	0	2		0	0	4		---	---	50	---	
Semester III (Session 2025-26)															
DSC – A5 @ 4 credits	General Chemistry-V	**25CHES403DS01**	2	0	0	**04**	2	0	0	**06**	15	35	---	---	**100**
	Chemistry Practical (SM)-V		0	0	2		0	0	4		---	---	50	---	
DSC – A6 @ 4 credits	General Chemistry-VI	**25CHES403DS02**	2	0	0	**04**	2	0	0	**06**	15	35	---	---	**100**
	Chemistry Practical (SM)-VI		0	0	2		0	0	4		---	---	50	---	

Semester IV (Session 2025-26)															
DSC – A7 @ 4 credits	Advance Chemistry-I	**25CHES404DS01**	4	0	0	**04**	4	0	0	**04**	30	70	---	---	**100**
DSC – A8 @ 4 credits	Advance Inorganic Chemistry-I	**25CHES404DS02**	2	0	0	**04**	2	0	0	**06**	15	35	---	---	**100**
	Chemistry Practical (SM)-VII		0	0	2		0	0	4		---	---	50	---	
DSC – A9 @ 4 credits	Advance Physical Chemistry-I	**25CHES404DS03**	2	0	0	**04**	2	0	0	**06**	15	35	---	---	**100**
	Chemistry Practical (SM)-VIII		0	0	2		0	0	4		---	---	50	---	
DSC – A10 @ 4 credits	Advance Organic Chemistry-I	**25CHES404DS04**	2	0	0	**04**	2	0	0	**06**	15	35	---	---	**100**
	Chemistry Practical (SM)-IX		0	0	2		0	0	4		---	---	50	---	
Semester V (Session 2026-27)															
DSC – A11 @ 4 credits	Advance Chemistry-II	**26CHES405DS01**	4	0	0	**04**	4	0	0	**04**	30	70	---	---	**100**
DSC – A12 @ 4 credits	Advance Inorganic Chemistry-II	**26CHES405DS02**	2	0	0	**04**	2	0	0	**06**	15	35	---	---	**100**
	Chemistry Practical (SM)-X		0	0	2		0	0	4		---	---	50	---	
DSC – A13 @ 4 credits	Advance Physical Chemistry-II	**26CHES405DS03**	2	0	0	**04**	2	0	0	**06**	15	35	---	---	**100**
	Chemistry Practical (SM)-XI		0	0	2		0	0	4		---	---	50	---	
DSC – A14 @ 4 credits	Advance Organic Chemistry-II	**26CHES405DS04**	2	0	0	**04**	2	0	0	**06**	15	35	---	---	**100**
	Chemistry Practical (SM)-XII		0	0	2		0	0	4		---	---	50	---	

Semester VI (Session 2026-27)															
DSC – A15 @ 4 credits	Advance Chemistry-III	**26CHES406DS01**	4	0	0	**04**	4	0	0	**04**	30	70	---	---	**100**
DSC – A16 @ 4 credits	Advance Inorganic Chemistry-III	**26CHES406DS02**	2	0	0	**04**	2	0	0	**06**	15	35	---	---	**100**
	Chemistry Practical (SM)-XIII		0	0	2		0	0	4		---	---	50	---	
DSC – A17 @ 4 credits	Advance Physical Chemistry-III	**26CHES406DS03**	2	0	0	**04**	2	0	0	**06**	15	35	---	---	**100**
	Chemistry Practical (SM)-XIV		0	0	2		0	0	4		---	---	50	---	
DSC – A18 @ 4 credits	Advance Organic Chemistry-III	**26CHES406DS04**	2	0	0	**04**	2	0	0	**06**	15	35	---	---	**100**
	Chemistry Practical (SM)-XV		0	0	2		0	0	4		---	---	50	---	
Semester VII (Session 2027-28)															
DSC – H1 @ 4 credits	Coordination and Crystal Chemistry	**27CHEH407DS01**	4	0	0	**04**	4	0	0	**04**	30	70	---	---	**100**
DSC – H2 @ 4 credits	Quantum, Thermodynamics and Electrochemistry	**27CHEH407DS02**	4	0	0	**04**	4	0	0	**04**	30	70	---	---	**100**
DSC – H3 @ 4 credits	Organic Bonding, Reactions and Stereochemistry	**27CHEH407DS03**	4	0	0	**04**	4	0	0	**04**	30	70	---	---	**100**
DSC – H4 @ 4 credits	Inorganic Chemistry Practical	**27CHEH407DS04**	0	0	4	**04**	0	0	8	**08**	---	---	30	70	**100**
DSC – H5 @ 4 credits	Physical Chemistry Practical	**27CHEH407DS05**	0	0	4	**04**	0	0	8	**08**	---	---	30	70	**100**

Semester VIII (Session 2027-28) **OPTION-I**															
DSC – H6 @ 4 credits	General Spectroscopy	**27CHEH408DS01**	4	0	0	**04**	4	0	0	**04**	30	70	---	---	**100**
DSC – H7 @ 4 credits	Research Methodology	**27CHEH408DS02**	4	0	0	**04**	4	0	0	**04**	30	70	---	---	**100**
DSC – H8 @ 4 credits	Special Chemistry	**27CHEH408DS03**	4	0	0	**04**	4	0	0	**04**	30	70	---	---	**100**
DSC – H9 @ 4 credits	Special Chemistry Practical-I	**27CHEH408DS04**	0	0	4	**04**	0	0	8	**08**	---	---	30	70	**100**
DSC – H10 @ 4 credits	Special Chemistry Practical –II	**27CHEH408DS05**	0	0	4	**04**	0	0	8	**08**	---	---	30	70	**100**
Semester VIII (Session 2027-28) **OPTION-II**															
DSC – H6 @ 4 credits	General Spectroscopy	**27CHEH408DS01**	4	0	0	**04**	4	0	0	**04**	30	70	---	---	**100**
DSC – H7 @ 4 credits	Research Methodology	**27CHEH408DS02**	4	0	0	**04**	4	0	0	**04**	30	70	---	---	**100**
DSC – H8 @ 4 credits	Research Project /Dissertation	**27CHE408PD01**	0	0	12	**12**	0	0	24	**24**	---	---	90	210	**300**

L: Lecture; T: Tutorial; P: Practical

****Internship Evaluation:**

After completion of internship, students need to prepare a comprehensive report highlighting their learning and takeaways during the internship period as per MDUR Internship Regulations 2025. The report shall be signed by the Internship Supervisor from respective UTD/Centre/College and Mentor from internship providing organizations. Evaluation of internship report and viva-voce will be jointly conducted by Internship Supervisor and Mentor on the time and date notified by the concerned HODs/Directors/Principals. The mentor from host organization may participate in the evaluation through online/offline mode. In case of non-availability of respective mentor, the available relevant mentor as decided by the concerned HOD/Director/Principal may be utilized for the purpose of evaluation.

****Evaluation of Project Report/ Dissertation:**

In case of the Project reports/Dissertation/Research Project, the assessment shall be jointly carried out by the internal and external examiners. There shall be no Internal assessment component for Dissertation / Project Report. External examiners shall be invited from amongst the panel of examiners (ordinarily not below the rank of Associate Professor) recommended by the concerned Board of Studies.

Semester-I (Session: 2024 - 25)

Name of Program	B.Sc. (Chemistry as Single Major)	Program Code	USCHE4
Paper No.	Paper-I	Nomenclature	General Chemistry-I
Name of the Course	Discipline Specific Course	Course Code	24CHES401DS01
Credits	02	Maximum Marks	50
Hours per Week	02	External Marks	35
Duration of Examination	02 Hrs.	Internal Marks	15

Course Objectives: The course reviews the structure of the atom which is a necessary pre-requisite in understanding the nature of chemical bonding in compounds. It discusses the periodicity in properties with reference to the *s* and *p* block which is necessary in understanding their group chemistry. It also discusses the ionic solids and gaseous states. It is infused with the recapitulation of fundamentals of organic chemistry and the introduction of a new concept of visualizing the organic molecules in a three-dimensional space.

Note: ***Examiner will set 09 questions and the candidates will be required to attempt 05 questions in all. Question number 01 will be compulsory containing 07 short answer type questions covering the entire syllabus. Further, examiner will set 02 questions from each section and the candidates will be required to attempt one question from each section. All questions will carry equal marks.***

Course Learning Outcomes (CLO): On completion of the course, students will be able to:

CLO1: Understand the structural idea and relevance in describing shapes of s, p and d orbitals.

CLO2: Interpret the periodicity in atomic and ionic radii, electronegativity, ionization energy, electron affinity of elements of the periodic table and anomalous behaviour of elements.

CLO3: Understand the packing and structures of ionic solids.

CLO4: Summarize semiconductors and classify them.

CLO5: Recall the gas laws and formulate kinetic gas equation and Vander Waal equation.

CLO6: Understand the concept of an ideal gas and the conditions under which real gases behave ideally. Explore deviations from ideal behavior and the factors that contribute to them.

CLO7: Understand and explain the different nature and behavior of organic compounds based on fundamental concepts learnt.

CLO8: Understand the fundamental concepts of stereochemistry.

Unit–I

Atomic Structure and Periodicity of Elements: Bohr's atomic model and its application, quantum numbers, their application and rules of electronic configuration, effective nuclear charge, shielding or screening effect, slater rules, variation of effective nuclear charge in periodic table. Periodic trends in atomic radii, ionic radii and its calculation, covalent radii, electronegativity, electron gain enthalpy, ionization enthalpy and factors affecting ionization energy. Pauling, Mullikan and Allred Rachow scales.

Unit–II

Ionic Solids: Ionic bond and its characteristics and factors affecting, types of Bravais lattice, voids, packing in solids, determination of radius ratio of all voids, radius ratio rule and its limitations. Packing of ions in crystals, calculation of density and crystal structures of ionic solids (NaCl, CsCl, ZnS, CaF_2, Na_2O), defect structures in crystal. Born-Landé equation with derivation, expression for lattice energy, Madelung constant, Born-Haber cycle and its application with examples, solvation energy. Semiconductors, types of semiconductors, valence bond and band theories (alloys excluded).

Unit-III

Gaseous State-I: Elementary treatment of gas laws, kinetic gas equation and its derivation, deviations from ideal gas behaviour, compressibility factor (Z) and its variation with pressure and temperature for different gases, Van der Waals equation of state, its derivation and application in explaining real gas behavior, mention other equations of state (Bertheolot, Dielectric or Dieterici), Van der Waals equation expressed in virial form and calculation of Boyle temperature, critical temperature, critical pressure, critical volume and their determination. Isotherms of real gases and their comparison with Van der Waals isotherms, continuity of states, relationship between critical constants and Van der Waals constants, law of corresponding states, reduced equation of state.

Unit-IV

Basics of Organic Chemistry and Stereochemistry: Electronic displacements and their applications, reactive intermediates, types of organic reactions and energy considerations. Methods of determination of reaction mechanism (product analysis, intermediates, isotope effects, kinetic and stereochemical studies).

Stereoisomerism: Optical activity and optical isomerism, asymmetry, chirality, enantiomers, diastereomers. Specific rotation, configuration and projection formulae: Newmann, Sawhorse, Fischer and their interconversion. Chirality in molecules with one and two stereocentres: meso configuration, racemic mixture and their resolution. Relative and absolute configuration: D/L and R/S designations. Geometrical isomerism: cis-trans, syn-anti and E/Z notations using CIP rules.

Books Recommended/References:

1. Concise Inorganic Chemistry by J.D. Lee
2. Inorganic Chemistry- Principles of Structure and Reactivity by J.E. Huheey, E.A. Keiter, R.L. Keiter and O. K. Medhi.
3. Concepts and Models of Inorganic Chemistry by B.E. Douglas, D.H. McDaniel and J.J. Alexander.
4. Inorganic Chemistry by Shriver and Atkins.
5. Principles of Inorganic Chemistry by B.W. Pfennig.
6. Physical Chemistry by P.W. Atkins.
7. A Textbook of Physical Chemistry by K.L. Kapoor (Vol-1)
8. Organic Chemistry by R.T. Morrison and R. N. Boyd.
9. Basic Organic Chemistry by R. Chandra and S. Singh.
10. Stereochemistry of Organic Compounds by E. L. Eliel and S. H. Wilen.

Name of Program	**B.Sc. (Chemistry as Single Major)**	**Program Code**	**USCHE4**
Paper No.	**Paper-I**	**Nomenclature**	**Chemistry Practical (SM)-I**
Name of the Course	**Discipline Specific Course**	**Course Code**	**24CHES401DS01**
Credits	**02**	**Maximum Marks (Internal)**	**50**
Hours per Week	**04**	**Duration of Examination**	**04 Hrs.**

Course Objectives: This course provides the basic knowledge of acid-base titrations and redox titrations. The objective of this course is to provide an understanding regarding basic principles of refractometer and its measurement. It further develops the clear understanding of purification of organic compounds and separation of organic mixture by chromatography.

Note: Examiner will set two experiments for practical examinations. ***(15×2) Marks***

Course Learning Outcomes(CLO): On completion of the course, students will be able to:

CLO1: Prepare solutions of different concentration.

CLO2: Gain knowledge about the principles underlying titration techniques, including how the reaction progresses to reach the equivalence point.

CLO3: Estimate the strength of various unknown solutions in acid-base and redox titrations.

CLO4: Determine refractive index and specific refraction using refractometer.

CLO5: Learn about the calibration of thermometer.

CLO6: Determine the boiling and melting point of organic compounds.

CLO7: Do the purification of organic compounds by crystallization

CLO8: Separate organic mixture by chromatography.

List of Experiments

Unit–I (Inorganic)

1. Acid-Base Titrations

(i) Determination of strength of HCl and CH_3COOH using NaOH.

(ii) Estimation of sodium carbonate using standardized HCl.

2. Oxidation Reduction Titrations

(i) Determination of Fe^{2+}, $C_2O_4^{2-}$ (using $KMnO_4$ and $K_2Cr_2O_7$).

Unit–II (Physical)

1. Refractometry

(i) Determine the refractive index of given solutions:
Ethyl acetate, benzene, ethylene dichloride, chloroform, water, hexane

(ii) Determine the specific refraction of given liquids:
Ethyl acetate, benzene, ethylene dichloride, chloroform, water, hexane

Unit-III (Organic)

1. Purification of organic compounds by crystallization using the following solvents:

(i) Water

(ii) Alcohol

(iii) Alcohol-Water

2. Separation of mixtures by chromatography: Measure the R_f value in each case (combination of two compounds to be given)

(i) Separate the components of a given mixture of 2 amino acids (glycine, aspartic acid, glutamic acid, tyrosine or any other amino acid) by radial/ascending paper chromatography.

(ii) Separation of a mixture of o-and p-nitrophenol or o-and p-aminophenol by thin layer chromatography (TLC).

Viva-Voce **(05 Marks)**

Note Book **(10 Marks)**

Attendance **(05 Marks)**

Books Recommended/References:

1. A text Book of Quantitative Inorganic Analysis by A.I. Vogel.
2. Applied Analytical Chemistry by O.P. Vermani.
3. Vogel's Quantitative Chemical Analysis by J. Mendham.
4. Vogel's Qualitative Inorganic Analysis by G. Svehla.
5. Practical Inorganic Chemistry by Marr & Rockett.
6. Senior Practical Physical Chemistry by B.D. Khosla.
7. Instrumental Methods of Analysis by B. K. Sharma.
8. Principles of Instrumental Analysis by Douglas A. Skoog, F. James Holler and Stanley R. Crouch.
9. Practical Physical Chemistry by R. Gupta.

Name of Program	B.Sc. (Chemistry as Single Major)	Program Code	USCHE4
Paper No.	Paper-II	Nomenclature	General Chemistry-II
Name of the Course	Discipline Specific Course	Course Code	24CHES401DS02
Credits	02	Maximum Marks	50
Hours per Week	02	External Marks	35
Duration of Examination	02 Hrs.	Internal Marks	15

Course Objectives: This course provides the basic knowledge about ionic and covalent bonding along with the bonding theories. It also reviews about the basic and advance concepts of the gaseous and liquid state. To establish the applications of the basic concepts of organic chemistry, the functional groups- alkanes, alkenes, alkynes and aromatic hydrocarbons are introduced. The constitution of the course strongly aids in the paramount learning of the concepts and their applications.

Note: ***Examiner will set 09 questions and the candidates will be required to attempt 05 questions in all. Question number 01 will be compulsory containing 07 short answer type questions covering the entire syllabus. Further, examiner will set 02 questions from each section and the candidates will be required to attempt one question from each section. All questions will carry equal marks.***

Course Learning Outcomes (CLO): On completion of the course, students will be able to:

CLO1: Understand the importance and application of chemical bonds, inter-molecular and intramolecular weak chemical forces and their effect.

CLO2: Develop the ability to predict and explain the shapes of simple inorganic molecules and ions using the valence bond theory, hybridization, and VSEPR theory.

CLO3: Develop the ability to interpret Maxwell-Boltzmann distribution curves and extract relevant information such as average kinetic energy, most probable speed, and root-mean-square speed.

CLO4: Gain a comprehensive understanding of the properties of liquids, including density, viscosity, surface tension, capillary action and vapor pressure.

CLO6: Gain a thorough understanding of hydrocarbons, including their classification into alkanes, alkenes, and alkynes based on their molecular structure and bonding.

CLO7: Explore the chemical reactions of alkanes, alkenes, and alkynes, including combustion, halogenation, hydrogenation, hydration, addition reactions, and substitution reactions, and understand the mechanisms involved.

CLO8: Learn and identify many organic reaction mechanisms including Free Radical Substitution, Electrophilic Addition and Electrophilic Aromatic Substitution.

Unit–I

Chemical Bonding: Covalent bonds and their types, valence shell electron pair repulsion theory (VSEPR- H_2O, NH_3, PCl_3, PCl_5, SF_4, SF_6, ClF_3, I_3^-, BrF_2^+, PCl_6^-, ICl_2^-, ICl_4^-, $XeOF_4$, XeO_3, ClF_3, BrF_5, SO_4^{2-}, CO_2, NH_3 etc.). Valence bond theory (Heitler-London approach), and its limitations. Bent rule, covalent character in ionic compounds, polarizing power and polarizability. Dipole moment and its applications, Fajan's rules and its applications. Molecular orbital theory and MO diagrams of heteronuclear diatomic molecules (CO, NO^+, CN^-, CO_3^{2-}, NO_2^-, HCl, CO_2, HF) (idea of s-p mixing and orbital interaction to be given).

Unit–II

Gaseous State II: Degree of freedom and principle of equipartition of energy, Maxwell's distribution law of molecular velocities and energies, root mean square velocity, average velocity and most probable velocity and their relationship. Mean free path and its derivation, collision diameter, collision number and collision frequency, viscosity of gases

and effect of temperature and pressure on viscosity of gases, relationship between mean free path and coefficient of viscosity, calculation of molecular diameter from coefficient of viscosity.

Liquid State: Structure of liquids, properties of liquids – surface tension, refractive index, viscosity, vapour pressure and optical rotation.

Unit-III

Alkanes and Alkenes

Carbon-Carbon Sigma Bond: Chemistry of alkanes, methods of preparation of alkanes, physical and chemical properties. Free radical substitution: Halogenation – relative reactivity and selectivity.

Carbon-Carbon Pi Bond: Structure and isomerism, general methods of preparation, mechanism of E_1, E_2, E1cB reactions, Saytzeff and Hoffmann eliminations. Reactions of alkenes: Electrophilic additions, Markownikoff rule, syn and anti-addition, addition of H_2, X_2, oxymercuration-demercuration, hydroboration-oxidation, ozonolysis, hydroxylation and polymerization.

Dienes: Classification, methods of preparation, chemical reaction: Diels Alder reaction, 1,2- and 1,4-addition reactions in conjugated dienes. Mechanism of allylic and benzylic bromination in propene, 1-butene, toluene, ethyl benzene.

Unit-IV

Alkynes: General methods of preparation, reactions of alkynes: acidity, electrophilic and nucleophilic additions, hydration to form carbonyls.

Aromatic Hydrocarbons: Concept of aromaticity, Huckel rule, aromatic character of arenes, cyclic carbocations and carbanions with suitable examples and heterocyclic compounds with suitable examples. Electrophilic aromatic substitution: halogenation, nitration, sulphonation, Friedel Crafts alkylation/acylation with their mechanism. Directing effects of groups in electrophilic substitution reactions.

Books Recommended/References:

1. Concise Inorganic Chemistry by J.D. Lee
2. Inorganic Chemistry- Principles of Structure and Reactivity by J.E. Huheey, E.A. Keiter, R.L. Keiter and O. K. Medhi.
3. Inorganic Chemistry by Shriver and Atkins.
4. Physical Chemistry by G. W. Castellan.
5. A Textbook of Physical Chemistry by K.L. Kapoor (Vol-1)
6. Principles of Physical Chemistry by B.R. Puri, L.R. Sharma and M.S. Pathania.
7. Organic Chemistry by P. Y. Bruice.
8. Organic Chemistry, J. Clayden, N. Greeves and S. Warren.
9. Intermediate for Organic Synthesis by V.K. Ahluwalia, P. Bhagat, R. Aggarwal and R. Chandra.

Name of Program	**B.Sc. (Chemistry as Single Major)**	**Program Code**	**USCHE4**
Paper No.	**Paper-II**	**Nomenclature**	**Chemistry Practical (SM)-II**
Name of the Course	**Discipline Specific Course**	**Course Code**	**24CHES401DS02**
Credits	**02**	**Maximum Marks (Internal)**	**50**
Hours per Week	**04**	**Duration of Examination**	**04 Hrs.**
Course Objectives: The course reviews the basic principles underlying acid-base and iodometric			

titrations including concepts of equivalence points, indicators and redox reactions. Objective of this course is to provide an understanding of viscosity and its measurement. Students will have an understanding of refractometer and its applications. It further develops a clear understanding of the purification of organic compounds by crystallization and the criteria of purity.

Note: Examiner will set two experiments for practical examinations. ***(15×2) Marks***

Course Learning outcomes (CLO): On completion of the course, students will be able to:

CLO1: Gain a comprehensive understanding of the principles underlying titration techniques.

CLO2: Prepare and estimate various ions present in a mixture of unknown concentration.

CLO3: Estimate the concentration of ions using iodometric titrations.

CLO4: Gain a comprehensive understanding of viscosity as a measure of a fluid's resistance to flow and its importance in various industrial, scientific, and engineering applications.

CLO5: Develop skills in performing viscosity measurements accurately.

CLO6: Determine the refractive index and molar refraction of various solution.

CLO7: Gain a comprehensive understanding of the principles underlying crystallization.

CLO8: Do the preparation and purification of various organic compounds.

List of Experiments

Unit–I (Inorganic)

1. Acid-Base Titrations

(i) Estimation of carbonate and hydroxide present together in a mixture.

(ii) Estimation of carbonate and bicarbonate present together in a mixture.

(iii) Estimation of free alkali present in different soaps/detergents.

2. Iodometric Titrations

(ii) Estimation of Cu (II) ions iodometrically using $Na_2S_2O_3$.

Unit–II (Physical)

1. Viscometry

(i) Find out the relative and absolute viscosity of given liquid at room temperature.

(ii) Determine the viscosity coefficient of given solution.

2. Refractometry

(i) Determine the molar refraction of given liquids:
Ethyl acetate, Benzene, Ethylene dichloride, Chloroform, Water, Hexane

(ii) Determine the refractive index of series of sugar solutions and determine the composition of unknown solution.

Unit-III (Organic)

1. Preparation and purification through crystallization or distillation and ascertaining their purity through melting point or boiling point.

(i) Iodoform from ethanol (or acetone)

(ii) m-dinitrobenzene from nitrobenzene

(iii) Benzoic acid from toluene

(iii) Aniline from nitrobenzene

Viva-Voce **(05 Marks)**

Note Book **(10 Marks)**

Attendance **(05 Marks)**

Books Recommended/References:

1. A Text Book of Quantitative Inorganic Analysis by A.I. Vogel.
2. Applied Analytical Chemistry by O.P. Vermani.
3. Vogel's Quantitative Chemical Analysis by J. Mendham.
4. Vogel's Qualitative Inorganic Analysis by G. Svehla.
5. Practical Inorganic Chemistry by Marr & Rockett.
6. Synthesis and Characterization of Inorganic Compounds by W. L. Jolly.
7. Instrumental Methods of Analysis by B. K. Sharma.

8. Principles of Instrumental Analysis by Douglas A. Skoog, F. James Holler, and Stanley R. Crouch.
9. Practical Physical Chemistry by R. Gupta.
10. Senior Practical Physical Chemistry by B.D. Khosla.

Semester-II (Session: 2024 - 25)

Name of Program	B.Sc. (Chemistry as Single Major)	Program Code	USCHE4
Paper No.	Paper-III	Nomenclature	General Chemistry-III
Name of the Course	Discipline Specific Course	Course Code	24CHES402DS01
Credits	02	Maximum Marks	50
Hours per Week	02	External Marks	35
Duration of Examination	02 Hrs.	Internal Marks	15

Course Objectives: The course reviews the general characteristics of s block elements. It further discusses the patterns and trends exhibited by s-block elements and their compounds with emphasis on synthesis, structure, bonding and uses. It also makes students understand the thermodynamic concepts, terminology, properties of thermodynamic systems. It encompasses the basic concepts of liquid crystal. The course is infused with the general methods of preparation and reactions of cycloalkanes and cycloalkenes.

Note: ***Examiner will set 09 questions and the candidates will be required to attempt 05 questions in all. Question number 01 will be compulsory containing 07 short answer type questions covering the entire syllabus. Further, examiner will set 02 questions from each section and the candidates will be required to attempt one question from each section. All questions will carry equal marks.***

Course Learning Outcomes (CLO): On completion of the course, students will be able to:

CLO1: Understand the basic properties of s-block elements and their compounds.
CLO2: Demonstrate the theory of precipitation.
CLO3: Understand thermodynamic concepts, terminology, properties of thermodynamic systems.
CLO4: Determine the various thermodynamic potentials for ideal and real gases.
CLO5: Learn the properties of liquids crystal & their types.
CLO6: Understand presence of defects in all crystals at equilibrium and transition in different phases.
CLO7: Understand, explain and predict various aspects of cycloalkanes and their preparational analysis.
CLO8: Understand the methods of preparation and reactions of cycloalkenes.

Unit–I

Chemistry of s-Block Elements: General characteristics of s-block elements, reactions of alkali and alkaline earth metals with oxygen, hydrogen, nitrogen, water and solutions of alkali metals in liquid ammonia and their properties. Common features such as ease of formation, thermal stability and solubility of the following alkali and alkaline earth metal compounds: hydrides, oxides, peroxides, super oxides, oxosalts- carbonates, bicarbonate, nitrates, nitrite, sulphates, solution of metal in liquid ammonia. Complex formation tendency of group-2 elements. Introduction to alkyls and aryls, structure of the following complexes: crown ethers and cryptates of group-2, basic beryllium acetate, beryllium nitrate, EDTA complexes of calcium and magnesium. Theory of precipitation, purification of precipitates, co-precipitation and post- precipitation.

Unit–II

Thermodynamics-I: Heat capacity, heat capacities at constant volume & pressure and their relationship. Joule's law- relation between Joule-Thomson coefficient and other thermodynamic parameters: Inversion temperature. Calculation of work, heat, ΔU & ΔH for the expansion of ideal gases and real gases under isothermal and adiabatic conditions for reversible and irreversible processes, Kirchhoff's equation.

Unit-III

Liquid Crystal: Difference between liquid crystal, solid and liquid, classification of liquid crystals, mesmorphic behaviour, thermotropic liquid crystals, positional order, bond orientational order, nematic and smectic mesophases, smectic-nematic transition and clearing temperature- homeotropic, planar and schlieren textures, twisted nematics, chiral snematics, molecular arrangement in smectic A and smectic C phases, optical properties of liquid crystals. Dielectric susceptibility and dielectric constants. Lyotropic phases and their description of ordering in liquid crystals.

Unit-IV

Cycloalkanes and Cycloalkenes

Cycloalkanes: Nomenclature, synthesis of cycloalkanes and their derivatives- addition of carbenes to olefins, Simmons-Smith reaction, photochemical (2+2) cycloaddition reactions, Diels-Alder reaction, dehalogenation of α,ω-dihalides, Dieckmann cyclization, pyrolysis of calcium or barium salts of dicarboxylic acids, Blanc's rule. Baeyer's strain theory and its limitations. Ring strain in small rings (cyclopropane and cyclobutane), theory of strainless rings. Case of cyclopropane ring: Banana bonds.

Cycloalkenes: Methods of preparation and chemical reactions of cycloalkenes.

Books Recommended/References:

1. Concise Inorganic Chemistry by J.D. Lee
2. Inorganic Chemistry- Principles of Structure and Reactivity by J.E. Huheey, E.A. Keiter, R.L. Keiter and O. K. Medhi.
3. Physical Chemistry by G. W. Castellan.
4. A Textbook of Physical Chemistry by K.L. Kapoor (Vol-2)
5. Liquid crystals: Concepts and Physical Properties by Patrick Oswald and Pawel Pieranski.
6. Organic Chemistry by R.T. Morrison and R. N. Boyd.
7. Organic Chemistry by I.L. Finar.
8. Organic Chemistry by T.W.G. Solomons.

Name of Program	**B.Sc. (Chemistry as Single Major)**	**Program Code**	**USCHE4**
Paper No.	**Paper-III**	**Nomenclature**	**Chemistry Practical (SM)-III**
Name of the Course	**Discipline Specific Course**	**Course Code**	**24CHES402DS01**
Credits	**02**	**Maximum Marks (Internal)**	**50**
Hours per Week	**04**	**Duration of Examination**	**04 Hrs.**

Course Objectives: This course aims to provide a fundamental knowledge of volumetric and redox analysis of acid and base. It further develops a clear understanding of surface tension and its determination. This course reviews the basic knowledge of viscosity measurement. Students will gain a comprehensive understanding of the fundamental principles of distillation. This course also provides an overview of the purification of organic compounds and the criteria of purity.

Note: Examiner will set two experiments for practical examinations. ***(15×2) Marks***

Course Learning Outcomes (CLO): On completion of the course, students will be able to:
CLO1: Determine the strength of various solutions volumetrically.
CLO2: Do the estimation of concentration of unknown solution by redox titration.
CLO3: Determine the surface tension of pure liquid and interfacial tension.
CLO4: Do the viscosity measurement.
CLO5: Do the preparation and purification of various organic compounds.
CLO6: Understand the process of crystallization and distillation thoroughly.

List of Experiments

Unit–I (Inorganic)

1. Volumetric Analysis

(i) Determination of acetic acid in commercial vinegar using NaOH.
(ii) Determination of alkali content-antacid tablet using HCl.
(iii) Estimation of hardness of water by EDTA.

2. Redox Titrations

(iii) Estimation of oxalic acid and sodium oxalate in a given mixture.

Unit–II (Physical)

1. Surface tension

(i) Determine the surface tension of given solutions using stalagmometer. Water, CH_3OH, C_2H_5OH, n-hexane etc. by drop number method.
(ii) Determine the interfacial tension between xylene and water.

2. Viscometry

(i) Determine the viscosity of sugar solution at different concentrations.
(ii) Find the concentration of given mixtures by viscosity measurement.

Unit-III (Organic)

1. Preparation and purification through crystallization or distillation and ascertaining their purity through melting point:

(i) m-nitroaniline from m-dinitrobenzene
(ii) Phenyl benzoate from phenol and benzoyl chloride.
(iii) Ethyl benzoate from benzoic acid and ethanol.
(iv) Methyl orange (azo dye)
(iv) Semicarbazone of any one of the following compounds: acetone, ethyl methyl ketone, cyclohexanone.

Viva-Voce **(05 Marks)**

Note Book **(10 Marks)**

Attendance **(05 Marks)**

Books Recommended/References:

1. Practical Inorganic Chemistry by Marr & Rockett.
2. Synthesis and Characterization of Inorganic Compounds by W. L. Jolly.
3. Instrumental Methods of Analysis by B. K. Sharma.
4. Advanced Physical Chemistry, Practical Handbook by G. Raj.
5. Advanced Practical Physical Chemistry by J. B. Yadav.
6. Practical Organic Chemistry by A. K. Manna.
7. Principles of Instrumental Analysis by D. A. Skoog, F. J. Holler and S. R. Crouch.

Name of Program	B.Sc. (Chemistry as Single Major)	Program Code	USCHE4
Paper No.	Paper-IV	Nomenclature	General Chemistry-IV
Name of the Course	Discipline Specific Course	Course Code	24CHES402DS02

Credits	02	Maximum Marks	50
Hours per Week	02	External Marks	35
Duration of Examination	02 Hrs.	Internal Marks	15

Course Objectives: The course discusses the patterns and trends exhibited by p-block elements and their compounds with emphasis on synthesis, structure, bonding and uses. It further describes the concept of acids and bases in aqueous and non-aqueous solvents. It also includes the second and third law of thermodynamics and derive the expressions of ΔU, ΔH, ΔS, ΔG, ΔA for ideal gases under different conditions. It gives a better understanding of halogenated hydrocarbons.

Note: ***Examiner will set 09 questions and the candidates will be required to attempt 05 questions in all. Question number 01 will be compulsory containing 07 short answer type questions covering the entire syllabus. Further, examiner will set 02 questions from each section and the candidates will be required to attempt one question from each section. All questions will carry equal marks.***

Course Learning Outcomes (CLO): On completion of the course, students will be able to:

CLO1: Understand the basic properties of p-block elements.
CLO2: Analyze the characteristics of different compounds of p-Block elements.
CLO3: Understand the concept of acid-base reactions in aqueous and non-aqueous solvents.
CLO4: Develop the concept of relative strength of acid and bases, hardness and softness and levelling effect.
CLO5: Understand the second and third law of thermodynamics
CLO6: Derive the expressions of ΔU, ΔH, ΔS, ΔG, ΔA for ideal gases under different conditions.
CLO7: Understand preparations, properties and reactions of haloalkanes and haloarenes.
CLO8: Use the synthetic chemistry learnt in this course to do functional group transformations.

Unit-I

Chemistry of p- Block Elements (groups 13-17): Inert pair effect, diagonal relationship, general characteristics of groups 13-17 elements, preparations, properties, structure and uses of compounds like oxides, oxy-acids (comparison of acidic strength) and halides of groups 13-17, hydrides of boron - diborane, borazine (preparation and uses), boric acids and borax. Chemistry of fullerenes, silicates and type of silicates on structural basis, silicones, phosphonitrilic halides $\{(PNCl_2)n$ where n = 3 and 4$\}$, basic properties of halogens, interhalogens, pseudohalogen and polyhalides.

Unit-II

Acids and Bases: Arrhenius, Bronsted-Lowry, Lux-flood, solvent system and Lewis concept of acids and bases, relative strength of acids and bases, levelling effect, classification of acids and bases as hard and soft. Pearson's HSAB concept, applications of HSAB principle (acid-base strength and hardness and softness. Symbiosis, theoretical basis of hardness and softness, electronegativity.

Non-Aqueous Solvents: Physical properties of a solvent, types of solvents and their general characteristics, reactions in non-aqueous solvents with reference to liquid HF, NH_3 and liquid SO_2.

Unit-III

Thermodynamics-II

Second Law: Concept of entropy, thermodynamic scale of temperature, statement of second law of thermodynamics. Carnot's cycles and its efficiency, Carnot's theorem, 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. Free Energy Functions: Gibbs and Helmholtz energy, variation of S, G, A with T, V, P, free energy change and spontaneity. Gibbs-Helmholtz equation, Maxwell relations, thermodynamic equation of state.

Unit-IV

Chemistry of Halogenated Hydrocarbons

Alkyl Halides: Methods of preparation and properties, nucleophilic substitution reactions- SN1, SN2 and SNi mechanisms with stereochemical aspects and factors affecting the rate of SN reactions. Elimination reactions- E1, E2 and E1cB mechanism, nucleophilic substitution vs elimination.

Aryl Halides: Preparations (including preparation from diazonium salts) and properties, nucleophilic aromatic substitution, SNAr, benzyne mechanism.

Relative reactivity of alkyl, allyl, benzyl, vinyl and aryl halides towards nucleophilic substitution reactions. Organometallic compounds of Mg (Grignard reagent)- use in synthesis of organic compounds.

Books Recommended/References:

1. Concise Inorganic Chemistry by J.D. Lee
2. Inorganic Chemistry- Principles of Structure and Reactivity by J.E. Huheey, E.A. Keiter, R.L. Keiter and O. K. Medhi.
3. Physical Chemistry by G. W. Castellan.
4. A Textbook of Physical Chemistry by K.L. Kapoor (Vol-2)
5. Principles of Physical Chemistry by B.R. Puri, L.R. Sharma and M.S. Pathania.
6. Organic Chemistry by R.T. Morrison and R. N. Boyd.
7. Organic Chemistry by I.L. Finar.

Name of Program	**B.Sc. (Chemistry as Single Major)**	**Program Code**	**USCHE4**
Paper No.	**Paper-IV**	**Nomenclature**	**Chemistry Practical (SM)-IV**
Name of the Course	**Discipline Specific Course**	**Course Code**	**24CHES402DS02**
Credits	**02**	**Maximum Marks (Internal)**	**50**
Hours per Week	**04**	**Duration of Examination**	**04 Hrs.**

Course Objectives: This course aims to develop an understanding of complexometric titrations. It is infused with the basic knowledge of conductance measurement and conductivity cell. It further provides the comprehensive idea about heat of reaction and its measurement. This course also reviews the process of sublimation of organic compounds and purification of brown sugar.

Note: Examiner will set two experiments for practical examinations. ***(15×2) Marks***

Course Learning Outcomes (CLO): On completion of the course, students will be able to:

CLO1: Estimate zinc and calcium ions by complexometric titrations.

CLO2: Do the titration of mohr salt and oxalic acid using $KMnO_4$.

CLO3: Understand the basic principle of conductometer and conductance measurements.

CLO4: Determine the heat of dilution of H_2SO_4

CLO5: Study the process of sublimation of organic compounds.

CLO6: Do purification of brown sugar.

List of Experiments

Unit–I (Inorganic)

1. Complexometric titrations using disodium salt of EDTA

(i) Estimation of Zn^{2+}, Ca^{2+} by substitution method.

(ii) Estimation of calcium content in milk.

2. Estimation of water of crystallization in mohr's salt and oxalic acid by titrating with $KMnO_4$.

Unit–II (Physical)

1. Conductometry

(i) Determine the cell constant of conductivity cell.

(ii) Determine the specific conductance, equivalent & molar conductance of given electrolyte solutions:
KCl, $BaCl_2$, NaCl, $CaCl_2$, NaOH, HCl etc.

2. Thermochemistry

(i) To find out the water equivalent of calorimeter and also find out the heat of dilution of H_2SO_4.

Unit-III (Organic)

1. To study the process of

(i) Sublimation of camphor and phthalic acid.

(ii) Decolourisation of brown sugar (sucrose) with animal charcoal.

Viva-Voce	**(05 Marks)**
Note Book	**(10 Marks)**
Attendance	**(05 Marks)**

Books Recommended/References:

1. Practical Inorganic Chemistry by Marr & Rockett.
2. Synthesis and Characterization of Inorganic Compounds by W. L. Jolly.
3. Instrumental Methods of Analysis by B. K. Sharma.
4. Advanced Physical Chemistry, Practical Handbook by G. Raj.
5. Advanced Practical Physical Chemistry by J. B. Yadav.
6. Practical Organic Chemistry by A. K. Manna.
7. Principles of Instrumental Analysis by D. A. Skoog, F. J. Holler and S. R. Crouch.

Semester-III (Session: 2025 - 26)

Name of Program	**B.Sc. (Chemistry as Single Major)**	**Program Code**	**USCHE4**
Paper No.	**Paper-V**	**Nomenclature**	**General Chemistry-V**
Name of the Course	**Discipline Specific Course**	**Course Code**	**25CHES403DS01**
Credits	**02**	**Maximum Marks**	**50**
Hours per Week	**02**	**External Marks**	**35**
Duration of Examination	**02 Hrs.**	**Internal Marks**	**15**

Course Objectives: The course is designed in a manner that gives the better understanding of bioinorganic chemistry and role of different ions in the biological system. It further explains the partial molar properties and Gibbs duhem equation. It develops insight about the Clausius Clapeyron equation and its applications. It also encompasses the methods of preparation and reactions of alcohol, phenols, ethers and epoxides along with their mechanistic path ways.

Note: ***Examiner will set 09 questions and the candidates will be required to attempt 05 questions in all. Question number 01 will be compulsory containing 07 short answer type questions covering the entire syllabus. Further, examiner will set 02 questions from each section and the candidates will be required to attempt one question from each section. All questions will carry equal marks.***

Course Learning Outcomes (CLO): On completion of the course, students will be able to:

CLO1: Have an idea of bioinorganic chemistry and role of different ions in the biological system.

CLO2: Gain an understanding of the role of inorganic compounds in biological systems including the structures and functions of metalloproteins and metalloenzymes.

CLO3: Understand the partial molar properties and Gibbs duhem equation.

CLO4: Gain insight about the Clausius Clapeyron equation and its applications.

CLO5: Understand the preparation and properties of alcohols.

CLO6: Understand the reactivity of alcohols including mechanisms for reactions such as dehydration, oxidation, esterification, and nucleophilic substitution.

CLO7: Understand the preparation and properties of phenols, ethers and epoxides.
CLO8: Use the synthetic chemistry learnt in this course to do functional group transformations.

Unit-I

Bioinorganic I: Metal ions present in biological system, classification based on action (essential, non- essential, trace, toxic), biological role of Na^+, K^+, Ca^{+2}, Mg^{+2}, Fe^{+2} ions, ionophores, active transport of cations across membrane, Na/K-pump. Vitamin B_{12}, carboxypeptidase A and chlorophyll (w.r.t. photosynthesis).

Unit-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. Clausius-Clapeyron equation and its applications to solid, liquid, liquid-vapour and solid-vapour equilibria.

Unit-III

Alcohols: Classification and nomenclature.
Monohydric Alcohols: Nomenclature, methods of preparation by reduction of aldehydes, ketones, carboxylic acids and esters, comparison of acidic behaviour, chemical reactions of alcohols. Industrial manufacture of methanol (from CO and H_2) and ethanol (flow sheet diagram).
Dihydric Alcohols: Nomenclature, methods of preparation, chemical reactions of vicinal glycols, oxidative cleavage ($PbOAc_4$ and HIO_4) and pinacol-pinacolone rearrangement.
Trihydric Alcohols: Nomenclature and methods of preparation, chemical reactions of glycerol.

Unit-IV

Phenols, Ethers and Epoxides
Phenols: Preparation and properties, acidity and affecting factors, ring substitution reactions, Reimer–Tiemann and Kolbe's–Schmidt reactions, Fries and Claisen rearrangements and their mechanism.
Ethers: Methods of preparation, physical properties and chemical reactions.
Epoxides: Synthesis of epoxides, acid and base- catalyzed ring opening of epoxides, orientation of epoxide ring opening, reactions of Grignard and organolithium reagents with epoxides.

Books Recommended/References:

1. Inorganic Chemistry- Principles of Structure and Reactivity by J.E. Huheey, E.A. Keiter, R.L. Keiter and O. K. Medhi.
2. Physical Chemistry by P.W. Atkins.
3. A Textbook of Physical Chemistry by K.L. Kapoor (Vol-2)
4. A Textbook of Physical Chemistry by K.L. Kapoor (Vol-3)
5. A Guide Book to Mechanism in Organic Chemistry by P. Sykes.
6. Organic Chemistry by R.T. Morrison and R. N. Boyd.
7. Organic Chemistry by I.L. Finar.
8. Organic Chemistry by T.W.G. Solomons.

Name of Program	**B.Sc. (Chemistry as Single Major)**	**Program Code**	**USCHE4**
Paper No.	**Paper-V**	**Nomenclature**	**Chemistry Practical (SM)-V**
Name of the Course	**Discipline Specific Course**	**Course Code**	**25CHES403DS01**
Credits	**02**	**Maximum Marks (Internal)**	**50**

Hours per Week	04	Duration of Examination	04 Hrs.

Course Objectives: The course provides the basic knowledge about complexometric and redox titration. It discusses about conductometric titrations. The course is infused with the basic understanding of thermochemistry. It acquaints the students with the qualitative analysis of unknown organic compounds.

Note: Examiner will set two experiments for practical examinations. ***(15×2) Marks***

Course Learning Outcomes (CLO): On completion of the course, students will be able to:

CLO1: Estimate the Fe(II) ions by titrating it with $K_2Cr_2O_7$.

CLO2: Do the estimation of various ions using volumetric and complexometric titrations.

CLO3: Operate conductometer and learn about fundamental principles behind conductivity measurements.

CLO4: Determine the heat of neutralisation of strong or weak acid and bases.

CLO5: Do the qualitative analysis of organic compounds.

CLO6: Determine the melting and boiling point and prepare the derivatives.

List of Experiments

Unit–I (Inorganic)

1. Estimation of Fe (II) ions by titrating it with $K_2Cr_2O_7$ using internal indicator.

2. **Complexometric Titrations**

(i) Determination of Mg^{2+}, Zn^{2+} by EDTA.

Unit–II (Physical)

1. **Conductometry**

(i) Determine the strength of HCl using NaOH conductometrically.

(ii) Determine the strength of CH_3COOH using NaOH conductometrically.

2. **Thermochemistry**

(i) Determine heat of neutralisation of strong acid and strong base using calorimeter.

(ii) Determine heat of neutralisation of weak acid and strong base using calorimeter.

(iii) Determine heat of neutralisation of weak acid and weak base using calorimeter.

Unit-III (Organic)

1. **Qualitative analysis of unknown organic compounds (detection of extra elements, functional groups, determination of melting point or boiling point and preparation of at least one pure solid derivative):**

Naphthalene, anthracene, acenaphthene, benzyl chloride, p-dichlorobenzene, m-dinitrobenzene, p-nitrotoluene, resorcinol, hydroquinone.

Viva-Voce	**(05 Marks)**
Note Book	**(10 Marks)**
Attendance	**(05 Marks)**

Books Recommended/References:

1. A Text Book of Quantitative Inorganic Analysis by A.I. Vogel.
2. Vogel's Qualitative Inorganic Analysis by G. Svehla.
3. Synthesis and Characterization of Inorganic Compounds by W. L. Jolly.
4. Senior Practical Physical Chemistry by B.D. Khosla.
5. Advanced Practical Physical Chemistry by J. B. Yadav.
6. Vogel's Textbook of Practical Organic Chemistry by A. I. Vogel, A. R. Tatchell, B. S. Furnis, A. J. Hanaford and P. W. G. Smith.

Name of Program	B.Sc. (Chemistry as Single Major)	Program Code	USCHE4
Paper No.	Paper-VI	Nomenclature	General Chemistry-VI
Name of the Course	Discipline Specific Course	Course Code	25CHES403DS02
Credits	02	Maximum Marks	50
Hours per Week	02	External Marks	35
Duration of Examination	02 Hrs.	Internal Marks	15

Course Objectives: The objective of this course is to introduce the students to d- block elements and highlight their unique properties. The students will also learn about the reaction rate, order, activation energy and theories of reaction rates. It also makes the students learn about the carbonyls and the important name reactions.

Note: ***Examiner will set 09 questions and the candidates will be required to attempt 05 questions in all. Question number 01 will be compulsory containing 07 short answer type questions covering the entire syllabus. Further, examiner will set 02 questions from each section and the candidates will be required to attempt one question from each section. All questions will carry equal marks.***

Course Learning Outcomes (CLO): On completion of the course, students will be able to:

CLO1: Understand the important properties of transition metals like variable oxidation states, colour, magnetic and catalytic properties.

CLO2: Learn about the structure and properties of transition metals complexes.

CLO3: Define rate of reactions and the factors that affect the rates of reaction.

CLO4: Understand the concept of rate laws e.g., order, molecularity, half-life and their determination

CLO5: Learn about various theories of reaction rates and how these account for experimental observations.

CLO6: Have understanding of catalysts- both chemical and enzymatic.

CLO7: Understand the preparation, physical properties and reactions of carbonyls.

CLO8: Learn the important name reactions.

Unit-I

Chemistry of d-Block Elements: Transition metal and their general characteristics, binary compounds illustrating relative stability of their oxidation states, stability of various oxidation states. Chemistry of Ti (oxides, oxyions, peroxides and halides), synthesis of oxo metallic salts of Cr, Mn and their chemical properties, Fe (oxides and iron compounds). Latimer and Frost diagrams, structure of some compounds of transition elements- TiO_2, $VOCl_2$, $FeCl_3$, $CuCl_2$ and $Ni(CO)_4$. Isopolyacids of Mo and W: Aqueous chemistry of Mo and W (VI), isopoly molybdates and isopoly tungustates.

Unit-II

Chemical Kinetics-I: Elementary idea of chemical kinetics, differential and integrated rate law expression for second order & third order and mathematical derivations for their rate constants, kinetics of complex reactions (integrated rate expressions up to first order only): (i) Opposing reactions (ii) Parallel reactions and (iii) Consecutive reactions.

Catalysis-Types of catalyst, specificity and selectivity, mechanisms of catalysed reactions at solid surfaces, acid-base catalysis.

Unit-III

Chemical Kinetics-II: Experimental methods of chemical kinetics: conductometric, potentiometric, optical method, polarimetry and spectrophotometer. Effect of temperature on the rate of reaction- Arrhenius equation. Theories of reaction rate- simple collision theory for unimolecular and bimolecular collision. Transition state theory of bimolecular reactions.

Unit-IV
Carbonyl Compounds: Structure, reactivity, preparation and properties, nucleophilic additions, nucleophilic addition-elimination reactions with ammonia derivatives with mechanism. Mechanisms of Aldol and Benzoin condensation, Knoevenagel condensation, Claisen-Schmidt, Perkin, Cannizzaro and Wittig reaction, Beckmann and Benzil-Benzilic acid rearrangements, haloform reaction and Baeyer Villiger oxidation, α-substitution reactions, oxidations and reductions (Clemmensen, Wolff- Kishner, $LiAlH_4$, $NaBH_4$, MPV, PDC), addition reactions of α, β- unsaturated carbonyl compounds: Michael addition.
Books Recommended/References:
1. Inorganic Chemistry- Principles of Structure and Reactivity by J.E. Huheey, E.A. Keiter, R.L. Keiter and O. K. Medhi. 2. Physical Chemistry by P.W. Atkins. 3. Physical Chemistry by G. W. Castellan. 4. A Textbook of Physical Chemistry by K.L. Kapoor (Vol-5) 5. Chemical Kinetics by K.J. Laidler. 6. Organic Chemistry by R.T. Morrison and R. N. Boyd. 7. Organic Chemistry by I.L. Finar. 8. Organic Chemistry by T.W.G. Solomons. 9. Intermediate for Organic Synthesis by V.K. Ahluwalia, P. Bhagat, R. Aggarwal and R. Chandra.

Name of Program	**B.Sc. (Chemistry as Single Major)**	**Program Code**	**USCHE4**
Paper No.	**Paper-VI**	**Nomenclature**	**Chemistry Practical (SM)-VI**
Name of the Course	**Discipline Specific Course**	**Course Code**	**25CHES403DS02**
Credits	**02**	**Maximum Marks (Internal)**	**50**
Hours per Week	**04**	**Duration of Examination**	**04 Hrs.**

Course Objectives: The course reviews the practical knowledge about gravimetric titrations and paper chromatography. It also makes students understand the effect of addition of acid or base on pH of solutions. It encompasses the basic concepts of preparation of buffer solution and critical solution temperature. The course is infused with the qualitative analysis of unknown organic compounds.

Note: Examiner will set two experiments for practical examinations. ***(15×2) Marks***

Course Learning Outcomes (CLO): On completion of the course, students will be able to:
CLO1: Estimate zinc and nickel ions gravimetrically.
CLO2: Get practical knowledge about gravimetric titrations and paper chromatography.
CLO3: Learn the effect of addition of HCl/NaOH on pH of given solutions.
CLO4: Prepare buffer solutions of different pH.
CLO5: Perform qualitative analysis of organic compounds.
CLO6: Determine melting & boiling point of given organic compound and prepare their derivatives.

List of Experiments

Unit–I

1. Estimation of Ni^{2+}, Zn^{2+} by gravimetric Method.

2. **Paper Chromatography**

Qualitative analysis of any one of the following inorganic cations (Pb^{2+}, Cu^{2+}, Ca^{2+}, Ni^{2+}) and anions (Pb^{2+}, Cu^{2+}, Ca^{2+}, Ni^{2+}, Cl^-, Br^-, I^- and PO_4^{3-} and NO_3^-) by paper chromatography.

Unit–II
1. pH metry (i) Study the effect of addition of HCl/NaOH on pH to solutions of acetic acid, sodium acetate and their mixtures. (ii) **Preparation of buffer solutions of different pH:** a) Sodium acetate-acetic acid b) Ammonium chloride-ammonium hydroxide **2. Solution** (i) **Determine critical solution temperature** a) Water - phenol system. b) Water - aniline system.
Unit-III
1. Qualitative analysis of unknown organic compounds containing (detection of extra elements, functional groups, determination of melting point or boiling point and preparation of at least one pure solid derivative): α-naphthol, β-naphthol, benzophenone, ethyl-methyl ketone, benzaldehyde, vanillin, oxalic acid.
Viva-Voce **(05 Marks)**
Note Book **(10 Marks)**
Attendance **(05 Marks)**
Books Recommended/References:
1. A Text Book of Quantitative Inorganic Analysis by A.I. Vogel. 2. Vogel's Qualitative Inorganic Analysis by G. Svehla. 3. Synthesis and Characterization of Inorganic Compounds by W. L. Jolly. 4. Senior Practical Physical Chemistry by B.D. Khosla. 5. Advanced Practical Physical Chemistry by J. B. Yadav. 6. Vogel's Textbook of Practical Organic Chemistry by A. I. Vogel, A. R. Tatchell, B. S. Furnis, A. J. Hanaford and P. W. G. Smith.

Semester-IV (Session: 2025 - 26)

Name of Program	B.Sc. (Chemistry as Single Major)	Program Code	USCHE4
Paper No.	Paper-VII	Nomenclature	Advanced Chemistry-I
Name of the Course	Discipline Specific Course	Course Code	25CHES404DS01
Credits	04	Maximum Marks	100
Hours per Week	04	External Marks	70
Duration of Examination	03 Hrs.	Internal Marks	30

Course Objectives: The course introduces the students to the electronic spectra of transition metal complexes. It aims to make the students understand phase, co-existence of phases, phase diagram. It is infused with the details of polynuclear hydrocarbons and carboxylic acids. The chemical synthesis, properties and reactions of these compounds will be discussed in detail. This course will also discuss some of the key applications of each class of compounds in diverse fields.

Note: ***Examiner will set 09 questions and the candidates will be required to attempt 05 questions in all. Question number 01 will be compulsory containing 07 short answer type questions covering the entire syllabus. Further, examiner will set 02 questions from each section and the candidates will be required to attempt one question from each section. All questions will carry equal marks.***

Course Learning Outcomes (CLO): On completion of the course, students will be able to:

CLO1: Learn about the electronic spectra of transition metal complexes.
CLO2: Become familiar with orgel energy diagram and JTD.
CLO3: Understand the phase rule and its thermodynamic deviation.
CLO4: Understand the phase equilibria for two component system with congruent and incongruent melting point.
CLO5: Understand the fundamentals of polynuclear hydrocarbons through the study of methods of preparation, properties and chemical reactions with underlying mechanism.
CLO6: Become familiar with their criterion of aromaticity with reference to polynuclear hydrocarbons.
CLO7: Understand preparation, properties and reactions of carboxylic acids.
CLO8: Propose plausible mechanisms for any relevant reaction.

Unit-I

Electron Spectra of Transition Metal Complexes: Types of electronic transitions, selection rules for d-d transitions, spectroscopic ground states, spectrochemical series. Orgel-energy level diagram for d^1 to d^9 states, discussion of electronic spectrum of $[Ti(H_2O)_6]^{3+}$complex ion, Jahn teller distortion with examples.

Unit-II

Phase Equilibrium: Statement and meaning of the terms: Phase, component and degree of freedom. Phase rule and its thermodynamic derivation, phase equilibria of one component system, water and sulphur system, phase equilibria of two component system, solid-liquid equilibria, simple eutectic (Bi-Cd, Pb-Ag) system, de-silverisation of lead.
Solid solution: Compound formation with congruent melting point (Mg-Cu) and incongruent melting point (NaCl-Cu), ($FeCl_3$ and $CuSO_4$ - H_2O) system freezing mixture, acetone, dry ice.

Unit-III

Polynuclear Hydrocarbons: Classification, structure and aromaticity of polynuclear hydrocarbons, general methods of preparation of naphthalene, phenanthrene and anthracene, relative reactivity of naphthalene, phenanthrene and anthracene in comparison to benzene. Reaction of naphthalene, anthracene and phenanthrene: Addition reactions, oxidation, electrophilic substitution- Friedel Craft reaction, chloromethylation, halogenation, formylation, nitration and sulphonation, reduction reaction and Diels Alder reaction.

Unit-IV

Carboxylic Acid and its Derivatives: General methods of preparation, physical properties (comparative study of acidic strengths). Chemical reactions of monocarboxylic acids: 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, Hoffmann bromamide degradation and Curtius rearrangement.

Books Recommended/References:

1. Concise Inorganic Chemistry by J.D. Lee
2. Inorganic Chemistry- Principles of Structure and Reactivity by J.E. Huheey, E.A. Keiter, R.L. Keiter and O. K. Medhi.
3. Inorganic Chemistry by Shriver and Atkins.
4. Physical Chemistry by G. W. Castellan.
5. Physical Chemistry by P.W. Atkins.
6. A Textbook of Physical Chemistry by K.L. Kapoor (Vol-3)
7. Organic Chemistry by R.T. Morrison and R. N. Boyd.
8. Organic Chemistry by I.L. Finar.
9. Organic Chemistry by T.W.G. Solomons.
10. Organic Chemistry, J. Clayden, N. Greeves and S. Warren.

Name of Program	B.Sc. (Chemistry as Single Major)	Program Code	USCHE4
Paper No.	Paper-VIII	Nomenclature	Advanced Inorganic Chemistry-I
Name of the Course	Discipline Specific Course	Course Code	25CHES404DS02
Credits	02	Maximum Marks	50
Hours per Week	02	External Marks	35
Duration of Examination	02 Hrs.	Internal Marks	15

Course Objectives: The objective of this course is to introduce the students with the coordination compounds which find manifold applications in diverse fields like qualitative and quantitative analysis, metallurgy, as catalysts in industrial processes as medicines, paints and pigments as well as in life.

Note: ***Examiner will set 09 questions and the candidates will be required to attempt 05 questions in all. Question number 01 will be compulsory containing 07 short answer type questions covering the entire syllabus. Further, examiner will set 02 questions from each section and the candidates will be required to attempt one question from each section. All questions will carry equal marks.***

Course Learning Outcomes (CLO): On completion of the course, students will be able to:

CLO1: Understand the terms, ligand, denticity of ligands, chelate, coordination number and use standard rules to name coordination compounds.

CLO2: Discuss the various types of isomerism possible in such compounds and understand the types of isomerism possible in a metal complex.

CLO3: Use Valence Bond Theory to predict the structure and magnetic behaviour of metal complexes and understand the terms inner and outer orbital complexes**.**

CLO4: Explain the meaning of the terms Δ_o, Δ_t, pairing energy, CFSE, high spin and low spin.

CLO5: Learn how CFSE affects thermodynamic properties like lattice enthalpy and hydration enthalpy**.**

CLO6: Explain magnetic properties and colour of complexes on basis of Crystal Field Theory.

CLO7: Understand the important properties of transition metals like variable oxidation states, colour, magnetic and catalytic properties.

CLO8: Understand reaction mechanisms of coordination compounds and differentiate between kinetic and thermodynamic stability.

Unit–I

Coordination Chemistry

Introduction: Ligands, denticity and concept of chelate, chelate effect. IUPAC system of nomenclature of coordination compounds (mononuclear and binuclear), co-ordination sphere, co-ordination number, structural and stereoisomerism in complexes with coordination numbers 4 and 6, facial and meridional isomerism.

Valence Bond Theory (VBT): Salient features of theory, concept of inner and outer orbital complexes.

Unit–II

Crystal field splitting theory: Crystal field stabilization energy (CFSE), concept of pairing energy, success of CFST, factors affecting the magnitude of Δ. Spectrochemical series. Splitting of d orbitals in tetrahedral symmetry. Comparison of CFSE for octahedral and tetrahedral fields, low spin and high spin complexes, tetragonal distortion of octahedral geometry. Jahn-Teller distortion, square planar coordination.

Unit-III

Inorganic Reaction Mechanism: Mechanisms of ligand substitution reactions in square

planer and octahedral complexes (SN1&SN2), acid hydrolysis, base hydrolysis, concept of reaction pathways, transition state, intermediate and activated complex. Factors affecting rate of substitution reaction. Trans- effect, theories of trans-effect. Thermodynamic and Kinetic stability (using VBT) of octahedral complexes regarding centre metal and ligand.

Unit-IV

Magnetic Properties of Transition Metal Complexes: Types of magnetic behaviour, methods of determining magnetic susceptibility, spin-only formula. L-S coupling, correlation of μ_s and μ_{eff} values for transition metal ions, orbital contribution to magnetic moments, application of magnetic moment data for 3d metal complexes.

Thermodynamic and Kinetic Aspects of Metal Complexes: A brief outline of thermodynamic stability of metal complexes and factors affecting the stability, substitution reactions of square planar complexes of Pt(II).

Books Recommended/References:

1. Concise Inorganic Chemistry by J.D. Lee
2. Inorganic Chemistry- Principles of Structure and Reactivity by J.E. Huheey, E.A. Keiter, R.L. Keiter and O. K. Medhi.
3. Concepts and Models of Inorganic Chemistry by B.E. Douglas, D.H. McDaniel and J.J. Alexander.

Name of Program	**B.Sc. (Chemistry as Single Major)**	**Program Code**	**USCHE4**
Paper No.	**Paper-VII**	**Nomenclature**	**Chemistry Practical (SM)-VII**
Name of the Course	**Discipline Specific Course**	**Course Code**	**25CHES404DS02**
Credits	**02**	**Maximum Marks (Internal)**	**50**
Hours per Week	**04**	**Duration of Examination**	**04 Hrs.**

Course Objectives: Objective of this course is to make students learn the principles of gravimetry. The course exposes students to learn the techniques for measuring the strength of solutions using colorimeter. It acquaints the students with systematic approach to verify Beer-Lambert law. It further introduces the preparation of some metal complexes and their conductance measurement.

Note: Examiner will set two experiments for practical examinations. ***(15×2) Marks***

Course Learning Outcomes (CLO): On completion of the course, students will be able to:

CLO1: Comprehend the fundamental principles underlying gravimetric analysis including stoichiometry, precipitation reactions, and mass measurement techniques.

CLO2: Acquire proficiency in various gravimetric techniques.

CLO3: Grasp the fundamental principles of colorimetry including the absorption and transmission of light, Beer-Lambert Law, and the relationship between absorbance and concentration.

CLO4: Verify Beer-Lambert law $KMnO_4$ and $K_2Cr_2O_7$ by using colorimetry.

CLO5: Become proficient in operating colorimeters.

CLO6: Prepare various complexes and measure their conductivities.

List of Experiments

1. Gravimetric Analysis

(i) Aluminium as oxinate.

(ii) Mg as $MgNH_4PO_4.6H_2O$

(iii) Ba as $BaSO_4$.

2. Colorimetry

(i) Verify Beer-Lambert law for $KMnO_4$ and $K_2Cr_2O_7$ and determine the concentration of given $KMnO_4$ and $K_2Cr_2O_7$ solution.

3.	**Preparation of the following complexes and measurement of their conductivity:** (i) tetraamminecarbonatocobalt (III) nitrate (ii) tetraamminecopper (II) sulphate (iii) $K_2[Mn(acac)_3]$
Viva-Voce	**(05 Marks)**
Note Book	**(10 Marks)**
Attendance	**(05 Marks)**
Books Recommended/References:	
1. A Text Book of Quantitative Inorganic Analysis by A.I. Vogel. 2. Vogel's Qualitative Inorganic Analysis by G. Svehla. 3. Synthesis and Characterization of inorganic compounds by W. L. Jolly. 4. Practical Chemistry by O. P. Pandey, D. N. Bajpai and S. Giri. 5. B.Sc. Chemistry practical by S. Goyal.	

Name of Program	**B.Sc. (Chemistry as Single Major)**	**Program Code**	**USCHE4**
Paper No.	**Paper-IX**	**Nomenclature**	**Advanced Physical Chemistry-I**
Name of the Course	**Discipline Specific Course**	**Course Code**	**25CHES404DS03**
Credits	**02**	**Maximum Marks**	**50**
Hours per Week	**02**	**External Marks**	**35**
Duration of Examination	**02 Hrs.**	**Internal Marks**	**15**

Course Objectives: The aim of this course is to make students understand the distribution law and concepts of electrochemical cells, working of electrochemical cells, galvanic cell and corrosion. It provides basic understanding of the behaviour of electrolytes and their solutions. The students will also get familiar with the qualitative treatment of acid –base titration curves.

Note: ***Examiner will set 09 questions and the candidates will be required to attempt 05 questions in all. Question number 01 will be compulsory containing 07 short answer type questions covering the entire syllabus. Further, examiner will set 02 questions from each section and the candidates will be required to attempt one question from each section. All questions will carry equal marks.***

Course Learning Outcomes (CLO): On completion of the course, students will be able to:

CLO1: Understand different types of galvanic cells.

CLO2: Understand the Nernst equation and Debye-Huckel–Onsager's equation

CLO3: Explain the factors that effect conductance, migration of ions and application of conductance measurement.

CLO4: Do the calculation of thermodynamic properties and other parameters from emf measurements.

CLO5: Understand the concept of ionization of electrolytes with emphasis on weak acid and base and hydrolysis of salt.

CLO6: Learn the concept of ionization in aqueous solution, pH, buffers and various applications of ionization.

CLO7: Acquire knowledge of Nernst distribution law.

CLO8: Determine the hydrolysis constant and solubility using Nernst distribution law.

Unit-I

Electrochemistry-I: Arrhenius theory of ionization, Ostwald's dilution law. Debye-Huckel–Onsager's equation for strong electrolytes (elementary treatment only), transport number, definition and determination by Hittorfs methods, (numerical included). Electrolytic conduction, factors affecting electrolytic conduction.

Unit-II
Electrochemistry II: Reversible and irreversible cells with examples, reversible electrodes – metal-metal ion electrode, metal-insoluble salt-anion electrode, gas electrode and redox electrodes. Applications of EMF measurements in determining (i) free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) pH values using hydrogen, quinone-hydroquinone, glass and SbO/Sb_2O_3 electrodes. Concentration cells with and without transference, liquid junction. Corrosion: Types, theories and methods of controlling it.
Unit-III
Ionic Equilibria: Introduction to ionic equilibria, ionization of weak acids and bases, pH scale, common ion effect, applications of conductivity measurements: Determination of degree of dissociation, dissociation constants of mono and diprotic acids. Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions, derivation of Henderson equation and its applications. Solubility and solubility product of sparingly soluble salts – applications of solubility product principle. Qualitative treatment of acid – base titration curves (calculation of pH at various stages). Theory of acid–base indicators, selection of indicators and their limitations.
Unit-IV
Distribution Law: Nernst distribution law, thermodynamic derivation of Nernst distribution law, conditions for validity of Nernst distribution law, derivation of molecular complexity from distribution law, application of distribution law i.e. calculation of solubility of solute in solvent, determination of extent of association and dissociation of solute in solvent, distribution indicator, process of extraction and determination of degree of hydrolysis and hydrolysis constant of aniline hydrochloride & process of extraction, determination of degree of hydrolysis and hydrolysis constant of potassium tri-iodide complex ion and its extraction.
Books Recommended/References:
1. Physical Chemistry by G. W. Castellan. 2. Physical Chemistry by D. W. Ball. 3. Physical Chemistry by P.W. Atkins. 4. A Textbook of Physical Chemistry by K.L. Kapoor (Vol-1)

Name of Program	**B.Sc. (Chemistry as Single Major)**	**Program Code**	**USCHE4**
Paper No.	**Paper-VIII**	**Nomenclature**	**Chemistry Practical (SM)-VIII**
Name of the Course	**Discipline Specific Course**	**Course Code**	**25CHES404DS03**
Credits	**02**	**Maximum Marks (Internal)**	**50**
Hours per Week	**04**	**Duration of Examination**	**04 Hrs.**
Course Objectives: Objective of this course is to make students learn the principles of pH metry and pH-metric titrations. The course exposes students to learn the techniques for measuring electrode potential and the strength of acid base solutions using potentiometer. It further introduces the practical based on basic concept of adsorption.			
Note: Examiner will set two experiments for practical examinations.			***(15×2) Marks***
Course Learning Outcomes (CLO): On completion of the course, students will be able to: **CLO1:** Determine the strength of strong or weak acid using pH meter. **CLO2:** Get the practical knowledge about pH-metric titrations.			

CLO3: Prepare salt bridge to use them in potentiometric titrations.
CLO4: Determine the cell voltage by setting galvanic cell.
CLO5: Understand the adsorption of acetic acid on activated charcoal.
CLO6: Apply equilibrium concepts to describe adsorption processes.

List of Experiments

1. pH metry

(i) Determine the strength of HCl using NaOH pH metrically.
(ii) Determine the strength of CH_3COOH using NaOH pH metrically.
(iii) Determine the dissociation constant of weak acid pH metrically.

2. Potentiometry

(i) Study the preparation of salt bridge using KCl and agar-agar.
(ii) Setting of a galvanic cell and determination of cell voltage.
(iii) Potentiometric titration of strong acid against strong base.
(iv) Potentiometric titration of weak acid against strong base.

3. Adsorption

(i) Study adsorption of acetic acid on the surface of activated charcoal.

Viva-Voce **(05 Marks)**

Note Book **(10 Marks)**

Attendance **(05 Marks)**

Books Recommended/References:

1. Senior Practical Physical Chemistry, B.D. Khosla, V.C. Garg and A. Gulati.
2. Experiments in Physical Chemistry, C.W. Garland, J.W. Nibler and D.P. Shoemaker.
3. Advanced Practical Physical Chemistry by J. B. Yadav.
4. Physical Chemistry: A Laboratory manual by S. K. Sinha

Name of Program	**B.Sc. (Chemistry as Single Major)**	**Program Code**	**USCHE4**
Paper No.	**Paper-X**	**Nomenclature**	**Advanced Organic Chemistry-I**
Name of the Course	**Discipline Specific Course**	**Course Code**	**25CHES404DS04**
Credits	**02**	**Maximum Marks**	**50**
Hours per Week	**02**	**External Marks**	**35**
Duration of Examination	**02 Hrs.**	**Internal Marks**	**15**

Course Objectives: The Core Course of advanced Organic Chemistry is infused with the details of Nitrogen containing functional groups. A comprehensive understanding of these topics will be developed by taking examples of representative members of each class. The chemical synthesis, properties and reactions of these compounds will be discussed in detail. It also introduces the learner to UV-Visible spectroscopy and its applications.

Note: ***Examiner will set 09 questions and the candidates will be required to attempt 05 questions in all. Question number 01 will be compulsory containing 07 short answer type questions covering the entire syllabus. Further, examiner will set 02 questions from each section and the candidates will be required to attempt one question from each section. All questions will carry equal marks.***

Course Learning Outcomes (CLO): On completion of the course, students will be able to:

CLO1: Gain theoretical understanding of chemistry of compounds having nitrogen containing functional Groups.

CLO2: Develop a comprehensive understanding of structures and reactivity of nitrogen-containing compounds.

CLO3: Become familiar with their particular properties, chemical reactions and trends in the basicity of amines and their behaviour at different pH.
CLO4: Understand the reaction mechanism of nitrogen containing functional groups.
CLO5: Learn about the chemical reactions of nitriles and isonitriles.
CLO6: Use the synthetic chemistry learnt in this course to do functional group transformations.
CLO7: Gain insight into the basic principles of UV.
CLO8: Become proficient in interpreting spectroscopic data to identify functional groups.

Unit–I

Nitrogen containing functional groups

Amines: Introduction, classification, chirality in amines (pyramidal inversion), importance and general methods of preparation.

Properties: Physical properties, basicity of amines: Effect of substituents, solvent and steric effects. Distinction between primary, secondary and tertiary amines using Hinsberg's method and nitrous acid. Discussion of following reactions with emphasis on the mechanistic pathway: Gabriel Phthalimide synthesis, Hoffmann-Bromamide reaction, Carbylamine reaction, Mannich reaction, Hoffmann's exhaustive methylation, Hofmann-elimination reaction and Cope elimination.

Unit–II

Diazonium Salts: Preparation and synthetic applications of diazonium salts including preparation of arenes, haloarenes, phenols, cyano and nitro compounds. Coupling reactions of diazonium salts (preparation of azo dyes).

Nitro compounds (Aliphatic and Aromatic): Nomenclature, classification and general methods of preparation: from alkyl halides, alkanes, oxidation of amines and oximes and diazonium salts. Properties: Physical properties, discussion on following reactions with mechanism: Reaction with alkali and its synthetic applications, condensation reaction, Mannich reaction, hydrolysis, reduction, reaction with nitrous acid. Electrophilic substitution: Halogenation, nitration and sulphonation reaction, and nucleophilic substitution on the ring.

Unit-III

Nitriles: Introduction, nomenclature, uses and methods of preparation. Properties: Physical properties, discussion on the following reactions of nitriles with mechanism: Reaction with Grignard reagent, hydrolysis, addition reaction with HX, NH_3, reaction with aqueous ROH, Reduction reactions-catalytic reduction and Stephen's reaction, Condensation reactions - Thorpe Nitrile Condensation.

Isonitriles: Introduction, nomenclature and uses, methods of preparation. Properties: Physical properties, discussion on the following reactions with mechanism: Hydrolysis, reduction, addition of– HX, X_2 and sulphur, Grignard reaction, oxidation and rearrangement.

Unit-IV

Ultraviolet Absorption Spectroscopy: Absorption law (Beer-Lambert law), molar absorptivity, presentation and analysis of UV spectra, types of electronic transitions, effect of conjugation. Concept of chromophores and auxochromes. Bathochromic, hypsochromic, hyperchromic and hypochromic shifts. UV spectra of conjugated dienes, enones, dienones, α, β-unsaturated acids, unsaturated esters, lactones, α, β-unsaturated amides and lactams.

Books Recommended/References:

1. Organic Chemistry by R.T. Morrison and R. N. Boyd.
2. Basic Organic Chemistry by R. Chandra and S. Singh
3. Organic Chemistry by T.W.G. Solomons.
4. Organic Chemistry, J. Clayden, N. Greeves and S. Warren.
5. Intermediate for Organic Synthesis by V.K. Ahluwalia, P. Bhagat, R. Aggarwal and R.

Chandra.
6. Basic Organic Chemistry by R. Chandra, S. Singh and A. Singh.
7. Introduction to Spectroscopy by D.L. Pavia.

Name of Program	B.Sc. (Chemistry as Single Major)	Program Code	USCHE4
Paper No.	Paper-IX	Nomenclature	Chemistry Practical (SM)-IX
Name of the Course	Discipline Specific Course	Course Code	25CHES404DS04
Credits	02	Maximum Marks (Internal)	50
Hours per Week	04	Duration of Examination	04 Hrs.

Course Objectives: The course reviews the basic concepts of qualitative analysis in organic chemistry and its importance in identifying functional groups and elements. This course aims to understand the principles of the neutralization and silver salt method for estimating equivalent weight of acid. It further makes students understand the principles of the bromide-bromate and acetylation method for estimating phenol and aniline.

Note: Examiner will set two experiments for practical examinations. ***(15×2) Marks***

Course Learning Outcomes (CLO): On completion of the course, students will be able to:

CLO1: Determine the physical properties of some organic compounds.
CLO2: Identify the functional group and extra elements of organic compounds.
CLO3: Do the estimation of equivalent weight of acid using various methods.
CLO4: Do the estimation of phenol and aniline using various methods.
CLO5: Determine the melting point and boiling point and prepare the derivatives.
CLO6: Understand the importance of proper sample preparation techniques in organic analysis.

List of Experiments

1. **Systematic identification (detection of extra elements, functional groups, determination of melting point or boiling point and preparation of at least one pure solid derivative) of following organic compounds:**
   Succinic acid, benzoic acid, salicyclic acid, aspirin, phthalic acid, cinnamic acid, benzamide, urea, acetanilide, benzamide, aniline hydrochloride, *p*-toluidine, phenyl salicylate (salol), glucose, fructose, sucrose, *o*-, *m*-, *p*-nitroanilines, thiourea.
2. Equivalent weight of acid (neutralization and silver salt method).
3. Estimation of phenol (bromide-bromate method) and aniline (bromide-bromate and acetylation method).

Viva-Voce **(05 Marks)**

Note Book **(10 Marks)**

Attendance **(05 Marks)**

Books Recommended/References:

1. Practical Organic Chemistry by F. G. Mann and B. C. Saunders.
2. Comprehensive Practical Organic Chemistry: Qualitative Analysis by V.K. Ahluwalia and S. Dhingra.
3. Vogel's Textbook of Practical Organic Chemistry by B.S. Furniss, A.J. Hannaford, P.W.G. Smith and A.R. Tatchell.
4. Advanced Practical Organic Chemistry by J. Leonard, B. Lygo and G. Procter.

Semester-V (Session: 2026 - 27)

Name of Program	B.Sc. (Chemistry as Single Major)	Program Code	USCHE4
Paper No.	Paper-XI	Nomenclature	Advanced chemistry-II
Name of the Course	Discipline Specific Course	Course Code	26CHES405DS01
Credits	04	Maximum Marks	100
Hours per Week	04	External Marks	70
Duration of Examination	03 Hrs.	Internal Marks	30

Course Objectives: The course introduces the students to the chemistry of lanthanides and actinides. It also makes the students familiar with the X-ray crystallography. It is infused with the details of organosulphur and organophosphorus compounds.

Note: ***Examiner will set 09 questions and the candidates will be required to attempt 05 questions in all. Question number 01 will be compulsory containing 07 short answer type questions covering the entire syllabus. Further, examiner will set 02 questions from each section and the candidates will be required to attempt one question from each section. All questions will carry equal marks.***

Course Learning Outcomes (CLO): On completion of the course, students will be able to:

CLO1: Develop a deep understanding of the electronic structure of lanthanoids and actinoids.
CLO2: Describe and explain the periodic trends in properties of lanthanoids and actinoids including atomic and ionic radii, ionization energy and oxidation states.
CLO3: Understand the inner transition metals stability in reactions, origin of colour and magnetic properties.
CLO4: Compare the properties of lanthanoids and actinoids with other transition elements.
CLO5: Learn about the basics of X-ray crystallography.
CLO6: Explain symmetry elements, crystal structure specially NaCl, KCl and CsCl.
CLO7: Understand the methods of preparation and reactions of organosulphur compounds.
CLO8: Understand the methods of preparation and reactions of organophosphorus compounds.

Unit–I

Lanthanides: A brief discussion of electronic configuration, oxidation states, complex formation, colour, ionic radii, spectral and magnetic properties, chemical properties of lanthanoids. Lanthanoid contraction (causes and effects), separation of lanthanoids by ion exchange method. Chemical properties of lanthanoids.

Unit–II

Actinides: A brief discussion of electronic configuration, general characteristics of actinides, transuranic elements, comparison of properties of lanthanides and actinides with transition elements. Chemical properties of actinides.

Unit-III

X-Ray Crystallography: Nature of solid state, law of constancy of interfacial angles, law of rational indices, miller indices, elementary ideas of symmetry, symmetry elements and symmetry operations, X-ray diffraction, Bragg's law, simple account of rotating crystal method and powder pattern method. Analysis of powder diffraction patterns of NaCl, CsCl and KCl. Defects in crystals.

Unit-IV

Organosulphur and Organophosphorous Compounds

Organosulphur Compounds: Nomenclature, structural features, methods of formation and chemical reactions of thiols, thioethers, sulphonic acids, sulphonamides and sulphaguanidine.

Organo Phosphorus Compounds: Nomenclature, trivalent phosphorus compounds -

trialkyl and triaryl phosphine (method of formation and reactions), organic phosphoranes, phosphorus ylides, Wittig reaction. Biological role of phosphorus.

Books Recommended/References:

1. Concise Inorganic Chemistry by J.D. Lee
2. Inorganic Chemistry- Principles of Structure and Reactivity by J.E. Huheey, E.A. Keiter, R.L. Keiter and O. K. Medhi.
3. A Textbook of Physical Chemistry by K.L. Kapoor (Vol-5)
4. Principles of Physical Chemistry by B.R. Puri, L.R. Sharma and M.S. Pathania.
5. Organic Chemistry by R.T. Morrison and R. N. Boyd.
6. Organic Chemistry by I.L. Finar.
7. Organic Chemistry by T.W.G. Solomons.

Name of Program	**B.Sc. (Chemistry as Single Major)**	**Program Code**	**USCHE4**
Paper No.	**Paper-XII**	**Nomenclature**	**Advanced Inorganic Chemistry-II**
Name of the Course	**Discipline Specific Course**	**Course Code**	**26CHES405DS02**
Credits	**02**	**Maximum Marks**	**50**
Hours per Week	**02**	**External Marks**	**35**
Duration of Examination	**02 Hrs.**	**Internal Marks**	**15**

Course Objectives: The course introduces organometallic chemistry including classification of organometallic compounds, the concept of hapticity and the 18-electron rule governing the stability of a wide variety of organometallic species. Specific organometallic compounds are studied in detail to further understand the basic concepts: metal carbonyls, metal alkyls, Zeise's salt and ferrocene. It also covers the catalysis- an important application of organometallic compounds.

Note: ***Examiner will set 09 questions and the candidates will be required to attempt 05 questions in all. Question number 01 will be compulsory containing 07 short answer type questions covering the entire syllabus. Further, examiner will set 02 questions from each section and the candidates will be required to attempt one question from each section. All questions will carry equal marks.***

Course Learning Outcomes (CLO): On completion of the course, students will be able to:

CLO1: Have an idea of classification of organometallic compounds.
CLO2: Apply 18-electron rule to rationalize the stability of metal carbonyls and related species.
CLO3: Learn the structure and bonding of mononuclear and polynuclear carbonyls of 3d metals.
CLO4: Understand the preparations and properties of metal carbonyls.
CLO5: Comprehend the synergic effect and compare it with that in carbonyls.
CLO6: Understand the nature of Zeise's salt and compare its synergic effect with that of carbonyls.
CLO7: Identify important structural features of the metal alkyls: tetrameric methyl lithium and dimeric trialkyl aluminium and explain the concept of multicentre bonding in these compounds.
CLO8: Get a general idea of catalysis and describe in detail the mechanism of Wilkinson's catalyst, Zeigler- Natta catalyst and synthetic gasoline manufacture by Fischer-Tropsch process.

Unit–I

Organometallic Compounds I: Definition, nature of metal carbon bond, classification of organometallic compounds by bond types viz. i) covalent ii) ionic iii) electron deficient iv) cluster compounds v) bond compounds including sandwich derivatives. Structure and bonding in metal- ethylenic, metal-acetylenic complexes, EAN rule as applied to carbonyls.

Unit–II

Organometallic Compounds II: Structure and bonding in metal carbonyls and

cyclopentadienyl derivative. Preparation, structure, bonding and properties of mononuclear and polynuclear carbonyls of 3d metals. Properties and bonding of alkyls of Li, Al, Hg and Sn, concept of hapticity of organic ligand [dibenzene chromium (0), Zeise's salt and ferrocene]. π-acceptor behaviour of carbon monoxide. Synergic effects (VB approach), (MO diagram of CO can be referred to for synergic effect to IR frequencies).

Unit-III

Preparation and Structure: Zeise's salt, metal alkyls, methyl lithium (tetramer) and trialkyl aluminium (dimer), ferrocene, evidences of synergic effect and comparison of synergic effect with that in carbonyls, acetylation, alkylation, metallation, Mannich condensation.

Unit-IV

Catalysis by Organometallic Compounds: General principles of catalysis, properties of catalysts, homogeneous and heterogeneous catalysis (catalytic steps, examples and industrial applications), deactivation and regeneration of catalysts, catalytic poison, promoter. Study of some industrial processes and their mechanism, alkene hydrogenation (Wilkinson's catalyst), synthetic gasoline (Fischer Tropsch reaction), polymerisation of ethene using Ziegler-Natta catalyst.

Books Recommended/References:

1. Concise Inorganic Chemistry by J.D. Lee
2. Inorganic Chemistry- Principles of Structure and Reactivity by J.E. Huheey, E.A. Keiter, R.L. Keiter and O. K. Medhi.
3. Concepts and Models of Inorganic Chemistry by B.E. Douglas, D.H. McDaniel and J.J. Alexander.
4. Inorganic Chemistry by Shriver and Atkins.
5. Principles of Inorganic Chemistry by B.W. Pfennig.
6. Inorganic Chemistry by C. E. Housecraft and A. G. Sharpe.

Name of Program	**B.Sc. (Chemistry as Single Major)**	**Program Code**	**USCHE4**
Paper No.	**Paper-X**	**Nomenclature**	**Chemistry Practical (SM)-X**
Name of the Course	**Discipline Specific Course**	**Course Code**	**26CHES405DS02**
Credits	**02**	**Maximum Marks (Internal)**	**50**
Hours per Week	**04**	**Duration of Examination**	**04 Hrs.**

Course Objectives: The aim of this course is to make students understand the principles of gravimetric analysis as a quantitative analytical technique. It encompasses with the preparation of some metal complexes and determination of their composition. It further provides an overview of qualitative analysis and its importance in identifying cations and anions in a given salt.

Note: Examiner will set two experiments for practical examinations. ***(15×2) Marks***

Course Learning Outcomes (CLO): On completion of the course, students will be able to:

CLO1: Understand the preparation of inorganic compounds and their composition determination.

CLO2: Gain a thorough understanding of the fundamental principles of gravimetric analysis.

CLO3: Understand theory of precipitation, the stoichiometry of precipitation reactions and the principles of gravimetric measurements.

CLO4: Perform the analysis of insoluble salt.

CLO5: Become proficient in various analytical techniques used for the qualitative and quantitative analysis of inorganic salts.

CLO6: Analyse the mixtures containing one anion and one cation qualitatively.

List of Experiments

1. **Inorganic Synthesis**
   (i) Preparation of sodium trisoxalato ferrate(III), $[Na_3[Fe(C_2O_4)_3]$ and determination of its composition by permanganometry.
   (ii) Preparation of cis and trans-bisoxalato diaqua chromate (III) ion.
2. **Gravimetric Analysis**
   (i) Copper as thiocyanate
   (ii) Fe as Fe_2O_3 (by precipitating iron as $Fe(OH)_3$).
3. **Analysis of insoluble salt:** Only one to be given $PbSO_4$, $BaSO_4$, $SrSO_4$, $CaSO_4$.
4. Analysis of one anion (Cl^-, Br^-, I^-, F^-, NO_2^-, NO_3^-, CO_3^{2-}, SO_3^{2-}, $S_2O_3^{2-}$, SO_4^{2-}, CH_3COO, $C_2O_4^{2-}$, S^{2-}) and one cation (Hg^{2+}, Hg_2^{2+}, Ag^+, Bi^{3+}, Cu^{2+}, Cd^{2+}, As^{3+}, Sb^{3+}, Sn^{2+}, Fe^{2+}, Fe^{3+}, Cr^{3+}, Al^{3+}, Co^{2+}, Ni^{2+}, Mn^{2+}, Zn^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, Mg^{2+}, NH_4^+, Pb^{2+}, Sr^{2+}, Na^+) in the mixture. (Note: Avoid interfering ions).

Viva-Voce	**(05 Marks)**
Note Book	**(10 Marks)**
Attendance	**(05 Marks)**

Books Recommended/References:

1. A Text Book of Quantitative Inorganic Analysis by A.I. Vogel.
2. Vogel's Qualitative Inorganic Analysis by G. Svehla.
3. Synthesis and Characterization of Inorganic Compounds by W. L. Jolly.
4. Practical Chemistry by O. P. Pandey, D. N. Bajpai and S. Giri.
5. B.Sc. Chemistry practical by S. Goyal.

Name of Program	**B.Sc. (Chemistry as Single Major)**	**Program Code**	**USCHE4**
Paper No.	**Paper-XIII**	**Nomenclature**	**Advanced Physical Chemistry-II**
Name of the Course	**Discipline Specific Course**	**Course Code**	**26CHES405DS03**
Credits	**02**	**Maximum Marks**	**50**
Hours per Week	**02**	**External Marks**	**35**
Duration of Examination	**02 Hrs.**	**Internal Marks**	**15**

Course Objectives: The aim of this course is to make students learn about surface phenomenon, adsorption isotherms, BET equation. It will also familiarize the students with the polymeric chemistry and polymeric techniques.

Note: ***Examiner will set 09 questions and the candidates will be required to attempt 05 questions in all. Question number 01 will be compulsory containing 07 short answer type questions covering the entire syllabus. Further, examiner will set 02 questions from each section and the candidates will be required to attempt one question from each section. All questions will carry equal marks.***

Course Learning Outcomes (CLO): On completion of the course, students will be able to:

CLO1: Learn about types of adsorption, BET equation and its application.
CLO2: Develop an understanding about colloids and Hardy-Schulze rule.
CLO3: Acquire knowledge about different adsorption isotherm including Freundlich, Gibbs and Langmuir.
CLO4: Develop an insight about magnetic susceptibility, magnetic properties- paramagnetism, diamagnetism and ferromagnetism.
CLO5: Gain knowledge about polymers and its applications.
CLO6: Comprehend different polymerisation techniques and concept of functionality.

CLO7: Determine the molecular weight of polymer using different techniques and methods.
CLO8: Have knowledge about criteria for polymer solubility and solubility parameter.

Unit–I

Surface chemistry and colloids

Adsorption: Types of adsorption, adsorption isotherms and adsorption isobars. Freundlich adsorption isotherms, Gibbs adsorption equation and its application, Langmuir adsorption isotherms and elementary idea of BET equation and its applications. Colloidal states, colloids, classification of colloids, solids in liquids (sols) properties: Kinetic, optical and electrical, stability of colloids, protective colloids, Hardy-Schulze rule, gold number. Emulsion, types of emulsion and their preparation, emulsifier.

Unit–II

Physical Properties and Molecular Structure: Measurement of dipole moment-temperature method and refractivity method, dipole moment and structure of molecules, magnetic permeability, magnetic susceptibility and its determination. Application of magnetic susceptibility, magnetic properties- paramagnetism, diamagnetism and ferromagnetism.

Unit-III

Polymer I

Introduction and history of polymeric materials: History of polymeric materials, different schemes of classification of polymers, polymer nomenclature, molecular forces and chemical bonding in polymers, texture of polymers, functionality and its importance, criteria for synthetic polymer formation, classification of polymerization processes, relationships between functionality, extent of reaction and degree of polymerization, bifunctional systems, mechanism of copolymerization, polymerization techniques.

Unit-IV

Polymer II: Determination of molecular weight of polymers (M_n, M_w, etc.) by end group analysis, viscometry, light scattering and osmotic pressure methods. Molecular weight distribution and its significance. Polydispersity index, polymer solution, criteria for polymer solubility and solubility parameter.

Books Recommended/References:

1. A Textbook of Physical Chemistry by K.L. Kapoor (Vol-1)
2. Seymour's Polymer Chemistry by Marcel Dekker.
3. Principles of Polymerization by G. Odian.
4. Text Book of Polymer Science by F.W. Billmeyer.
5. Polymer Science & Technology by P. Ghosh.
6. Principles of Physical Chemistry by B.R.Puri, L.R.Sharma and M.S.Pathania.

Name of Program	**B.Sc. (Chemistry as Single Major)**	**Program Code**	**USCHE4**
Paper No.	**Paper-XI**	**Nomenclature**	**Chemistry Practical (SM)-XI**
Name of the Course	**Discipline Specific Course**	**Course Code**	**26CHES405DS03**
Credits	**02**	**Maximum Marks (Internal)**	**50**
Hours per Week	**04**	**Duration of Examination**	**04 Hrs.**

Course Objectives: The purpose of this course is to make students familiarize with conductometric measurements. This course further introduces the potentiometric titrations. It further makes students understand about basic concepts of solubility, dissociation constants, equivalent

conductivity and mean ionic activity coefficient and their determination.

Note: Examiner will set two experiments for practical examinations. ***(15×2) Marks***

Course Learning Outcomes (CLO): On completion of the course, students will be able to:

CLO1: Determine the dissociation constant of weak acid conductometrically.

CLO2: Estimate the concentration, conductance and solubility product of unknown solution using conductometric titrations.

CLO3: Gain a thorough understanding of the fundamental principles of potentiometry including electrochemical cells, electrode potentials and Nernst equation.

CLO4: Learn about the principles of ion-selective electrodes.

CLO5: Understand the redox titrations using potentiometric titrations.

CLO6: Determine the mean ionic activity coefficient and strength of HCL and CH_3COOH in a given mixture.

List of Experiments

1. Conductometry

(i) Determine the dissociation constant of weak acid.

(ii) Determine the solubility and solubility product of sparingly soluble salts.

(iii) Determine the equivalent conductance of strong electrolyte at different dilution and plot the curve of equivalent conductance *vs* concentration.

2. Potentiometry

(i) Titrate the given mohr salt solution using $K_2Cr_2O_7$ as titrant and calculate redox potential of Fe^{2+}/Fe^{3+} system.

(ii) Titrate the given mohr salt solution using $KMnO_4$ as titrant and calculate redox potential of Fe^{2+}/Fe^{3+} system.

(iii) Determine the mean ionic activity coefficient of HCl solution at different concentrations.

(iv) Determine the strength of HCL and CH_3COOH in a given mixture potentiometrically.

Viva-Voce	**(05 Marks)**
Note Book	**(10 Marks)**
Attendance	**(05 Marks)**

Books Recommended/References:

1. Senior Practical Physical Chemistry, B.D. Khosla, V.C. Garg and A. Gulati.
2. Experiments in Physical Chemistry, C.W. Garland, J.W. Nibler and D.P. Shoemaker.
3. Advanced Practical Physical Chemistry by J. B. Yadav.
4. Physical Chemistry: A Laboratory manual by S. K. Sinha

Name of Program	**B.Sc. (Chemistry as Single Major)**	**Program Code**	**USCHE4**
Paper No.	**Paper-XIV**	**Nomenclature**	**Advanced Organic Chemistry-II**
Name of the Course	**Discipline Specific Course**	**Course Code**	**26CHES405DS04**
Credits	**02**	**Maximum Marks**	**50**
Hours per Week	**02**	**External Marks**	**35**
Duration of Examination	**02 Hrs.**	**Internal Marks**	**15**

Course Objectives: The purpose of the course is to introduce students to the active methylene compounds. The students will also be introduced to the chemistry and applications of heterocyclic compounds. The learners are introduced to IR spectroscopy, an important analytical tool which allows identification of organic compounds by correlating their spectra to structure.

Note: Examiner will set 09 questions and the candidates will be required to attempt 05 questions in all. Question number 01 will be compulsory containing 07 short answer type questions covering the entire syllabus. Further, examiner will set 02 questions from each section and the candidates will be required to attempt one question from each section. All questions will carry equal marks.

Course Learning Outcomes (CLO): On completion of the course, students will be able to:

CLO1: Understand about the synthesis of enolates and their applications.

CLO2: Acquire knowledge about keto-enol tautomerism and its mechanism.

CLO3: Gain insight into the basic principles of IR spectroscopy.

CLO4: Use spectroscopic techniques to determine structure of unknown compounds.

CLO5: Learn about heterocyclic compounds and their chemical reactions.

CLO6: Become familiar with their particular properties, chemical reactions, criterion of aromaticity with reference to heterocyclic compounds, trends in basicity of amines and heterocyclic compounds and their behaviour at different pH.

CLO7: Gain insight into concepts of amino acids, peptides and proteins.

CLO8: Understand and demonstrate how structure of biomolecules determines their reactivity and biological functions.

Unit–I

Organic Synthesis *via* Enolates: Active methylene group, enols and enolate ions, acidity of α-hydrogen. Ethylacetoacetate: synthesis, keto-enol tautomerism with its mechanism and synthetic applications. Diethylmalonate: synthesis and its synthetic applications.

Unit–II

Infrared Spectroscopy: Molecular vibrations, Hooke's law, selection rules, intensity and position of IR bands, measurement of IR spectrum, fingerprint region, characteristics, absorption of various functional groups: Hydrocarbons (saturated and unsaturated), hydroxyl compounds, aldehydes, ketones, esters, anhydrides, amides, amines and nitro compounds.

Unit-III

Heterocyclic Compounds: Classification and nomenclature, structure, aromaticity in 5- and 6-membered rings containing one heteroatom, basicity and relative reactivity towards electrophilic substitution reactions (amongst five membered and six membered rings). Synthesis, reactions and mechanism of substitution reactions of: Furan, pyrrole (Paal-Knorr synthesis, Knorr pyrrole synthesis, Hantzsch synthesis), thiophene, pyridine (Hantzsch synthesis), pyrimidine, indole (Fischer indole synthesis and Madelung synthesis), quinoline and isoquinoline, (Skraup synthesis, Friedlander's synthesis, Knorr quinoline synthesis, Doebner-Miller synthesis, Bischler-Napieralski reaction, Pictet-Spengler reaction, Pomeranz-Fritsch reaction). Derivatives of furan: Furfural and furoic acid.

Unit-IV

Amino Acids, Peptides and Proteins: Amino acids, peptides and their classification. α-Amino acids: Synthesis, ionic properties and reactions. Zwitterions, pK_a values, isoelectric point and electrophoresis. Study of peptides: Determination of their primary structure-end group analysis. Synthesis of peptides using N-protecting, C-protecting and C-activating groups, solid-phase synthesis, primary, secondary and tertiary structures of proteins, denaturation of proteins.

Books Recommended/References:

1. Introduction to Spectroscopy by D.L. Pavia.
2. Organic Spectroscopy by W. Kemp.
3. Spectrometric Identification of Organic Compounds by R.M. Silverstein, F.X. Webster, D.J. Kiemle and D.L. Bryce.
4. Heterocyclic Chemistry by T.L. Gilchrist.
5. The Chemistry of Heterocycles (Nomenclature and Chemistry of three to five membered

Hetero cycles) by V. J. Ram, A. Sethi, M. Nath and R. Pratap.
6. Organic Chemistry by I.L. Finar.
7. Biochemistry by J.M. Berg, J.L. Tymoczko, L. Stryer and W.H. Freeman.
8. Principles of Biochemistry by D.L. Nelson, M.M. Cox, A.L. Lehninger and W.H. Freeman.
9. Biochemistry by T.A. Brown.

Name of Program	**B.Sc. (Chemistry as Single Major)**	**Program Code**	**USCHE4**
Paper No.	**Paper-XII**	**Nomenclature**	**Chemistry Practical (SM)-XII**
Name of the Course	**Discipline Specific Course**	**Course Code**	**26CHES405DS04**
Credits	**02**	**Maximum Marks (Internal)**	**50**
Hours per Week	**04**	**Duration of Examination**	**04 Hrs.**

Course Objectives: The course comprehends the principles behind steam distillation and thin layer chromatography. This further makes students learn and practice the proper techniques for separation of green leaf pigments and a mixture of dyes by TLC.

Note: Examiner will set two experiments for practical examinations. ***(15×2) Marks***

Course Learning Outcomes: On completion of the course, students will be able to:
CLO1: Get knowledge about laboratory techniques: Steam distillation.
CLO2: Learn about thin layer chromatography and its use in daily life.
CLO3: Do the extraction of green leaf pigments.
CLO4: Separate the mixture of dyes using various compounds.

List of Experiments

1. Steam distillation
- (i) Naphthalene from its suspension in water.
- (ii) Separation of o-and p-nitrophenols.

2. Thin Layer Chromatography

Determination of R_f values and identification of organic compounds.
- a) Separation of green leaf pigments (spinach leaves may be used).
- b) Separation of a mixture of dyes using cyclohexane and ethyl acetate (8.5:1.5).

Viva-Voce **(05 Marks)**

Note Book **(10 Marks)**

Attendance **(05 Marks)**

Books Recommended/References:

1. Practical Organic Chemistry by F. G. Mann and B. C. Saunders.
2. Comprehensive Practical Organic Chemistry: Qualitative Analysis by V.K. Ahluwalia and S. Dhingra.
3. Vogel's Textbook of Practical Organic Chemistry by B.S. Furniss, A.J. Hannaford, P.W.G. Smith and A.R. Tatchell.
4. Advanced Practical Organic Chemistry by J. Leonard, B. Lygo and G. Procter.

Semester-VI (Session: 2026 - 27)

Name of Program	B.Sc. (Chemistry as Single Major)	Program Code	USCHE4
Paper No.	Paper-XV	Nomenclature	Advanced Chemistry-III
Name of the Course	Discipline Specific Course	Course Code	26CHES406DS01
Credits	04	Maximum Marks	100
Hours per Week	04	External Marks	70
Duration of Examination	03 Hrs.	Internal Marks	30

Course Objectives: The purpose of the course is to make students familiar with the chemistry of qualitative and quantitative analysis. It will also provide the knowledge of laws of absorption of light energy by molecules and the subsequent photochemical reactions. It is also infused with the statistical thermodynamics and mass spectrometry.

Note: ***Examiner will set 09 questions and the candidates will be required to attempt 05 questions in all. Question number 01 will be compulsory containing 07 short answer type questions covering the entire syllabus. Further, examiner will set 02 questions from each section and the candidates will be required to attempt one question from each section. All questions will carry equal marks.***

Course Learning Outcomes (CLO): On completion of the course, students will be able to:

CLO1: Learn about the chemistry of qualitative and quantitative analysis.
CLO2: Comprehend the concept of precipitations.
CLO3: Understand how matter interact with radiation and undergo photochemical processes.
CLO4: Explain the various laws including Grothus Drapper law, Stark Einstein law and Lambert-Beer's law.
CLO5: Get familiar with statistical thermodynamics.
CLO6: Understand thermodynamic probability and Maxwell Boltzmann distribution law.
CLO7: Have an idea of mass spectrometry.
CLO8: Understand the basic concept of molecular ion peak, fragmentations and even electron & nitrogen rule.

Unit–I

Theory of Qualitative and Quantitative Analysis: Chemistry of analysis of various groups of basic and acidic radicals, chemistry of identification of acid radicals in typical combination, common ion effect, solubility product, theory of precipitation, co-precipitation, post precipitation and purification of precipitates.

Unit–II

Photo Chemistry: Interaction of radiation with matter, photochemical reactions and their difference with thermal reaction law of photo chemistry. Grothus Drapper law, Stark Einstein law, Lambert law, Beer's law. Jablonski diagram depicting various processes occurring in the excited state, qualitative description of fluorescence, phosphorescence, non-radiation processes (internal conversion, inter system crossing), quantum yield photosensitized reactions, energy transfer processes (some simple examples).

Unit-III

Statistical Thermodynamics: Introduction to statistical thermodynamics, types of statistics: Maxwell-Boltzmann statistics, Bose- Einstein statistics and Fermi-Dirac statistics (derivation excluded). Maxwell-Boltzmann law, Maxwell-Boltzmann law of distribution of energy and velocity, evaluation of energy. Derivation of equation of states for a monatomic ideal gas.

Unit-IV

Mass Spectrometry: Introduction, basic principle, mass spectrum, molecular ion peak, base peak, metastable ions, recognition of molecular ion peak, nitrogen rule and even electron rule, fragmentation pattern of alkanes and alkenes.

Books Recommended/References:

1. Concise Inorganic Chemistry by J.D. Lee
2. Inorganic Chemistry- Principles of Structure and Reactivity by J.E. Huheey, E.A. Keiter, R.L. Keiter and O. K. Medhi.
3. Concepts and Models of Inorganic Chemistry by B.E. Douglas, D.H. McDaniel and J.J. Alexander.
4. Handbook of Thermal Analysis and Calorimetry by M. E. Brown.
5. Fundamentals of Photochemistry by K.K. Rohtagi & Mukherjee.
6. Photochemistry by J.G. Calvert and J.N. Pitts.
7. Principles and Applications of Photochemistry by B. Wardle.
8. Introduction to Statistical Mechanics by L.K. Nash.
9. Introduction to Spectroscopy by D.L. Pavia.
10. Organic Spectroscopy by W. Kemp.

Name of Program	**B.Sc. (Chemistry as Single Major)**	**Program Code**	**USCHE4**
Paper No.	**Paper-XVI**	**Nomenclature**	**Advanced Inorganic Chemistry-III**
Name of the Course	**Discipline Specific Course**	**Course Code**	**26CHES406DS02**
Credits	**02**	**Maximum Marks**	**50**
Hours per Week	**02**	**External Marks**	**35**
Duration of Examination	**02 Hrs.**	**Internal Marks**	**15**

Course Objectives: The objective of this paper is to provide basic understanding of the fundamental principles of metallurgy and get idea of metal-ligand equilibria in solutions. Students learn about the bioinorganic chemistry which are currently frontier areas of chemistry providing an interface between organic chemistry, inorganic chemistry and biology.

Note: ***Examiner will set 09 questions and the candidates will be required to attempt 05 questions in all. Question number 01 will be compulsory containing 07 short answer type questions covering the entire syllabus. Further, examiner will set 02 questions from each section and the candidates will be required to attempt one question from each section. All questions will carry equal marks.***

Course Learning Outcomes (CLO): On completion of the course, students will be able to:

CLO1: Understand about the metal-ligand equilibria in solution.

CLO2: Determine binary formation constants by pH-metry and spectrophotometry.

CLO3: Get a general idea of chief modes of occurrence of metals based on standard electrode potentials.

CLO4: Understand how electrolytic processes are used for the purification of metals.

CLO5: Learn about structures and applications of various metalloproteins.

CLO6: Understand the biological role of alkali and alkaline earth metal ions with nitrogen fixation.

CLO7: Get a general idea of excess and deficiency of some trace metals in the physiological system.

CLO8: Advantages and disadvantages of organic reagents in inorganic analysis.

Unit–I

Metal-Ligand Equilibria in Solution: Stepwise and overall formation constants and their interactions, trends in stepwise constants, factors affecting stability of metal complexes with reference to the nature of metal ion and ligand, chelate effect and its thermodynamic origin, determination of binary formation constants by pH-metry and spectrophotometry.

Unit–II

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 with reference to cyanide process for silver and gold. Methods of purification of metals: Electrolytic process, Van Arkel-De Boer process, zone refining.

Unit-III

Bioinorganic II: Metalloporphyrins with special reference to haemoglobin and myoglobin, hemocyanin, hemerythrin, storage and transfer of iron, biological role of alkali and alkaline earth metal ions with nitrogen fixation (special reference to Ca^{2+}). Cooperative effect, Bohr effect. Excess and deficiency of some trace metals.

Unit-IV

Organic Reagents in Inorganic Analysis: Criteria for choice of organic reagents, use of following reagents in inorganic analysis: DMG, cup ferron, 8-hydroxyquinoline, nitroso α-naphthol, EDTA, acetylacetone, dithiozone, dithiocarbamate. Advantages and disadvantages of organic reagents in inorganic analysis.

Books Recommended/References:

1. A Text Book of Quantitative Inorganic Analysis by A.I. Vogel.
2. Vogel's Qualitative Inorganic Analysis by G. Svehla.
3. Synthesis and Characterization of Inorganic Compounds by W. L. Jolly.
4. Practical Chemistry by O. P. Pandey, D. N. Bajpai and S. Giri.
5. B.Sc. Chemistry Practical by S. Goyal.

Name of Program	**B.Sc. (Chemistry as Single Major)**	**Program Code**	**USCHE4**
Paper No.	**Paper-XIII**	**Nomenclature**	**Chemistry Practical (SM)-XIII**
Name of the Course	**Discipline Specific Course**	**Course Code**	**26CHES406DS02**
Credits	**02**	**Maximum Marks (Internal)**	**50**
Hours per Week	**04**	**Duration of Examination**	**04 Hrs.**

Course Objectives: This course reviews the inorganic synthesis of metal complexes. This will make students learn about the principles behind separation techniques such as solvent extraction and colorimeter method. It further encompasses qualitative analysis and its importance in identifying cations and anions in a given salt.

Note: Examiner will set two experiments for practical examinations. ***(15×2) Marks***

Course Learning Outcomes (CLO): On completion of the course, students will be able to:

CLO1: Understand the preparation of inorganic compounds and their composition determination.

CLO2: Gain a thorough understanding of the fundamental principles of solvent extraction.

CLO3: Learn how to select appropriate extraction solvents based on the properties of the analyte.

CLO4: Perform the analysis of insoluble salt.

CLO5: Become proficient in various analytical techniques used for the qualitative and quantitative analysis of inorganic salts.

CLO6: Analyse the mixtures containing two anion qualitatively.

List of Experiments

1. Inorganic Synthesis

(i) Preparation of copper tetraamine complex $[Cu(NH_3)_4]SO_4$.

(ii) Mercuric tetrathiocyanatocobaltate(II), $Hg[Co(SCN)_4]$

2. Analysis of insoluble salt

(i) Only one to be given AgCl, AgBr, AgI, SiO_2 and Al_2O_3.

3. Solvent extraction

	(i) Separation and estimation of Fe(II) by colorimetrically.
4.	Analysis of two anions (Cl^-, Br^-, I^-, F^-, NO_2^-, NO_3^-, CO_3^{2-}, SO_3^{2-}, $S_2O_3^{2-}$, SO_4^{2-}, CH_3COO^-, $C_2O_4^{2-}$, S^{2-}) and two cations (Hg^{2+}, Hg_2^{2+}, Ag^+, Bi^{3+}, Cu^{2+}, Cd^{2+}, As^{3+}, Sb^{3+}, Sn^{2+}, Fe^{2+}, Fe^{3+}, Cr^{3+}, Al^{3+}, Co^{2+}, Ni^{2+}, Mn^{2+}, Zn^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, Mg^{2+}, NH_4^+, Pb^{2+}, Sr^{2+}, Na^+) in the mixture. (Note: Avoid interfering ions).
Viva-Voce	**(05 Marks)**
Note Book	**(10 Marks)**
Attendance	**(05 Marks)**

Books Recommended/References:

1. A Text Book of Quantitative Inorganic Analysis by A.I. Vogel.
2. Vogel's Qualitative Inorganic Analysis by G. Svehla.
3. Synthesis and Characterization of Inorganic Compounds by W. L. Jolly.
4. Practical Chemistry by O. P. Pandey, D. N. Bajpai and S. Giri.
5. B.Sc. Chemistry Practical by S. Goyal.

Name of Program	**B.Sc. (Chemistry as Single Major)**	**Program Code**	**USCHE4**
Paper No.	**Paper-XVII**	**Nomenclature**	**Advanced Physical Chemistry-III**
Name of the Course	**Discipline Specific Course**	**Course Code**	**26CHES406DS03**
Credits	**02**	**Maximum Marks**	**50**
Hours per Week	**02**	**External Marks**	**35**
Duration of Examination	**02 Hrs.**	**Internal Marks**	**15**

Course Objectives: The aim of this course is to make students understand the limitations of classical mechanics and the need of quantum chemistry, familiarize them with postulates of quantum chemistry and apply the same to derive equations for various models and hydrogen atom. It is also infused with MOT.

Note: Examiner will set 09 questions and the candidates will be required to attempt 05 questions in all. Question number 01 will be compulsory containing 07 short answer type questions covering the entire syllabus. Further, examiner will set 02 questions from each section and the candidates will be required to attempt one question from each section. All questions will carry equal marks.

Course Learning Outcomes (CLO): On completion of the course, students will be able to:

CLO1: Learn about limitations of classical mechanics and solution in terms of quantum mechanics for atomic/molecular systems.

CLO2: Develop an understanding of quantum mechanical operators, quantization, probability distribution and uncertainty principle.

CLO3: Understand the Schrodinger equation and its application for 1D box.

CLO4: Understand the concept of degeneracy and extend it to 2D, 3D box.

CLO5: Learn about the basic idea of MOT and LCAO principle.

CLO6: Understand the qualitative treatment of simple harmonic oscillator model of vibrational motion.

CLO7: Learn about the quantum mechanical treatment of hybrid orbitals.

CLO8: Perform quantitative calculations using molecular orbital theory including determining molecular orbital energies and electron occupancy etc.

Unit–I

Quantum Chemistry I: Bohr model of hydrogen atom (derivation excluded), black body radiation (without derivation), Planck's law, heat capacity of solids and its defects. Photoelectric effect, Compton effect, de-Broglie hypothesis, wave-particle duality,

Davisson-Germer experiment, Heisenberg uncertainty principle, complementarity.

Unit–II

Quantum Chemistry II: Postulates of quantum mechanics, quantum mechanical operators and commutation rules, Schrodinger wave equation and its applications to free particle and particle in 1D box (rigorous treatment), quantization of energy levels, zero-point energy and wave functions, probability distribution functions, nodal properties**.**

Unit-III

Quantum Chemistry III: 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 wave functions. Vibrational energy of diatomic molecules and zero-point energy.

Unit-IV

Molecular Orbitals Theory: Molecular orbital theory, basic idea, criteria for forming molecular orbital from atomic orbitals. Construction of molecular orbital by linear combination of atomic orbital, H_2^- ion. Calculation of energy levels from wave function, physical picture of bonding and antibonding wave function. Concept of π, π^* orbitals and their characteristics. Hybrid orbitals (sp, sp^2 and sp^3). Calculation of coefficients of atomic orbitals used in (sp, sp^2 and sp^3) hybrid orbitals. Introduction of valence bond model of H_2, comparison of molecular orbital and valence bond model.

Books Recommended/References:

1. Quantum Chemistry by D.A. McQuarrie.
2. Introductory Quantum Chemistry by A.K. Chandra.
3. Principles of Physical Chemistry by B.R.Puri, L.R.Sharma and M.S.Pathania.
4. A Textbook of Physical Chemistry by K.L. Kapoor (Vol-4)
5. Fundamentals of Quantum Chemistry by J.E. House.
6. Quantum Chemistry and Spectroscopy by T. Engel, P. Reid.
7. Physical Chemistry by P. W. Atkins.

Name of Program	**B.Sc. (Chemistry as Single Major)**	**Program Code**	**USCHE4**
Paper No.	**Paper-XIV**	**Nomenclature**	**Chemistry Practical (SM)-XIV**
Name of the Course	**Discipline Specific Course**	**Course Code**	**26CHES406DS03**
Credits	**02**	**Maximum Marks (Internal)**	**50**
Hours per Week	**04**	**Duration of Examination**	**04 Hrs.**

Course Objectives: This course bridges the theoretical knowledge of chemical kinetics with practical application. It further encompasses the adsorption process and the effect of temperature on adsorption. This course aims to understand partition coefficient and its application.

Note: Examiner will set two experiments for practical examinations. ***(15×2) Marks***

Course Learning Outcomes (CLO): On completion of the course, students will be able to:

CLO1: Have understanding of determining rate law, rate constant and rate of reaction.

CLO2: Determine the rate constant of hydrolysis of ester and compare the relative strength of acids.

CLO3: Understand the adsorption technique.

CLO4: Understand the effect of temperature on adsorption.

CLO5: Determine the partition coefficient and its applications.

CLO6: Apply equilibrium models to describe adsorption and partitioning processes.

List of Experiments

1. Chemical Kinetics

(i) Study the kinetics of hydrolysis of ester in the presence of acid.

(ii) Compare the relative strength of acids (HCl and H_2SO_4).

2. Adsorption

(i) Study the adsorption of iodine from alcoholic solution by charcoal.

(ii) Study the effect of temperature on adsorption.

3. Distribution

(i) Determine the partition coefficient of succinic acid between ether and water.

(ii) Determine the partition coefficient of iodine between CCl_4 and water.

Viva-Voce	**(05 Marks)**
Note Book	**(10 Marks)**
Attendance	**(05 Marks)**

Books Recommended/References:

1. Senior Practical Physical Chemistry, B.D. Khosla, V.C. Garg and A. Gulati.
2. Experiments in Physical Chemistry, C.W. Garland, J.W. Nibler and D.P. Shoemaker.
3. Advanced Practical Physical Chemistry by J. B. Yadav.
4. Physical Chemistry: A Laboratory manual by S. K. Sinha

Name of Program	**B.Sc. (Chemistry as Single Major)**	**Program Code**	**USCHE4**
Paper No.	**Paper-XVIII**	**Nomenclature**	**Advanced Organic Chemistry-III**
Name of the Course	**Discipline Specific Course**	**Course Code**	**26CHES406DS04**
Credits	**02**	**Maximum Marks**	**50**
Hours per Week	**02**	**External Marks**	**35**
Duration of Examination	**02 Hrs.**	**Internal Marks**	**15**

Course Objectives: The course introduces the learner to various tools and techniques for identifying and characterizing the organic compounds through their interactions with electromagnetic radiation *viz.* NMR spectroscopy. It also delivers the information about the nucleic acids, concept of genetic code and concept of heredity. This course extends the knowledge gained from synthetic organic chemistry to chemistry of biomolecules.

Note: Examiner will set 09 questions and the candidates will be required to attempt 05 questions in all. Question number 01 will be compulsory containing 07 short answer type questions covering the entire syllabus. Further, examiner will set 02 questions from each section and the candidates will be required to attempt one question from each section. All questions will carry equal marks.

Course Learning Outcomes (CLO): On completion of the course, students will be able to:

CLO1: Gain insight into the basic principles of NMR spectroscopy.

CLO2: Use the NMR spectroscopy in characterizing molecules.

CLO3: Acquire knowledge about purines and pyrimidines.

CLO4: Gain insight into concepts of heredity through the study of genetic code, replication, transcription and translation.

CLO5: Learn about the different types of simple and complex carbohydrates.

CLO6: Learn about the chemical reactions of carbohydrates.

CLO7: Explain the chemistry and structure of fats, oil and detergents.

CLO8: Learn about the theory of colour and constitution as well as the chemistry of dyeing.

Unit–I
NMR: Principle of nuclear magnetic resonance, NMR spectrum, number of signals, peak areas, equivalent and non-equivalent protons positions of signals and chemical shifts, shielding and deshielding of protons, protons counting, splitting of signals and coupling constants, magnetic equivalence of protons. Discussion of PMR spectra of the molecules: ethyl bromide, n-propyl bromide, isopropyl bromide, 1,1- diboromoethane, 1,1,2-tribromoethane. Simple problems on NMR spectroscopy for structure determination of organic compounds.
Unit–II
Nucleic Acids: Purines and pyrimidines: Introduction to purines and pyrimidines, preparation and reactions of adenine, guanine, cytosine, thymine and uracil. Structure of components of nucleic acids: Bases, sugars, nucleosides and nucleotides. Nomenclature of nucleosides and nucleotides, structure of polynucleotides (DNA and RNA), concept of DNA duplex preparation and its characterization. Biological roles of DNA and RNA. Concept of heredity: Genetic code, replication, transcription and translation.
Unit-III
Carbohydrates: Occurrence, classification and their biological importance. Monosaccharides: Constitution and absolute configuration of glucose and fructose, epimers and anomers, mutarotation, determination of ring size of glucose and fructose, Haworth projection and con preparational structures, interconversion of aldoses and ketoses, Killiani-Fischer synthesis and Ruff degradation, Disaccharides: Structure elucidation of maltose, lactose and sucrose. Polysaccharides: Elementary treatment of starch, cellulose and glycogen.
Unit-IV
Fats, Oil and Detergents: 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. Comparison of soap and detergents, classification and principle of cleansing action of detergents. **Synthetic Dyes:** Colour and constitution (electronic concept). Classification of dyes. Chemistry and synthesis of methyl orange, congo red, malachite green, crystal violet, phenolphthalein, fluorescein, alizarin and indigo.
Books Recommended/References:
1. Introduction to Spectroscopy by D.L. Pavia. 2. Organic Spectroscopy by W. Kemp. 3. Spectrometric Identification of Organic Compounds by R.M. Silverstein, F.X. Webster, D.J. Kiemle and D.L. Bryce. 4. Natural Product Chemistry by J. Singh, S.M. Ali and J. Singh. 5. Organic Chemistry by I.L.Finar. 6. Biochemistry by J.M. Berg, J.L.Tymoczko and L. Stryer. 7. Principles of Biochemistry by D.L. Nelson, M.M. Cox, A.L. Lehninger and W.H. Freeman. 8. Biochemistry by Lange Medical Books. 9. Biochemistry by T.A. Brown.

Name of Program	B.Sc. (Chemistry as Single Major)	Program Code	USCHE4
Paper No.	**Paper-XV**	**Nomenclature**	**Chemistry Practical (SM)-XV**
Name of the Course	**Discipline Specific Course**	**Course Code**	**26CHES406DS04**

Credits	02	Maximum Marks (Internal)	50
Hours per Week	04	Duration of Examination	04 Hrs.

Course Objectives: This course provides a structured approach to the synthesis of organic compounds covering various aspects such as reaction mechanisms, product characterization, safety considerations, and documentation practices. This course makes students understand the concept of acid value as a measure of the acidic content in a substance, iodine number as a measure of the unsaturation and grasp the concept of saponification value as a measure of the average molecular weight of esters in a substance.

Note: Examiner will set two experiments for practical examinations. ***(15×2) Marks***

Course Learning Outcomes (CLO): On completion of the course, students will be able to:

CLO1: Develop a thorough understanding of the fundamental principles of organic synthesis, including retrosynthetic analysis, functional group interconversions, and reaction mechanisms.

CLO2: Do synthesis of various organic compounds.

CLO3: Determine the acid value of given resin and plasticizers.

CLO4: Determine the iodine number and saponification value of various oil and polymers.

CLO5: Determine the melting point and boiling point of organic compounds synthesised.

List of Experiments

1. Synthesis of the following organic compounds:

(i) *m*-nitroaniline from nitrobenzene *via m*-dinitrobenzene.

(ii) Benzoic acid from benzoyl chloride *via* benzamide.

(iii) Picric acid from phenol *via* phenol sulphonic acid.

2. Determination of:

(i) **Acid value:** Resin, plasticizers

(ii) **Iodine number:** Linseed oil, castrol oil

(iii) **Saponification value:** Coconut oil, polyester.

Viva-Voce	**(05 Marks)**
Note Book	**(10 Marks)**
Attendance	**(05 Marks)**

Books Recommended/References:

1. Practical Organic Chemistry by F. G. Mann and B. C. Saunders.
2. Comprehensive Practical Organic Chemistry: Qualitative Analysis by V.K. Ahluwalia and S. Dhingra.
3. Vogel's Textbook of Practical Organic Chemistry by B.S. Furniss, A.J. Hannaford, P.W.G. Smith and A.R. Tatchell.
4. Advanced Practical Organic Chemistry by J. Leonard, B. Lygo and G. Procter.

B.Sc. 4th (4 year UG Hons with Research in Chemistry)
B.Sc. (Chemistry as Single Major)

Semester-VII (Session: 2027 - 28)

Name of Program	B.Sc. (Chemistry as Single Major)	Program Code	USCHE4
Paper No.	Paper-XIX	Nomenclature	Coordination and Crystal Chemistry
Name of the Course	Discipline	Course Code	27CHEH407DS01

	Specific Course		
Credits	**04**	**Maximum Marks**	**100**
Hours per Week	**04**	**External Marks**	**70**
Duration of Examination	**03 Hrs.**	**Internal Marks**	**30**

Course Objectives: The course aims to provide students with a profound theoretical understanding of metal-ligand bonding, transition metal complexes, and related reaction mechanisms. Additionally, the course seeks to develop practical skills in applying these theories to solve complex problems in inorganic chemistry. Students will gain insight into the structural aspects of isopoly and heteropoly acids, salts, and crystal structures of diverse compounds, fostering a comprehensive understanding of advanced inorganic chemistry concepts. Ultimately, the course prepares students for analytical and research roles in the field of inorganic chemistry.

Note: Examiner will set 09 questions, and the candidates must attempt 05 questions. Out of 09 questions, one question will be compulsory, containing 07 short answer type questions covering the entire syllabus. Further, the examiner will set two questions from each unit, and the candidates must attempt one question from each unit. All questions will carry equal marks.

Course Learning Outcomes (CLO): By the end of the course, students will be able to:

CLO1: Have a firm foundation in coordination chemistry.
CLO2: Understand metal-ligand bonding using molecular orbital diagrams.
CLO3: Explore the bonding in transition metal complexes and elucidates concepts such as crystal field theory, ligand field theory, and molecular orbital theory.
CLO4: Describe various thermodynamic aspects of coordination complexes.
CLO5: Introduce mechanism of ligand substitution in transition metal complexes.
CLO6: Get the knowledge of redox chemistry of coordination complexes.
CLO7: Understand the structures and properties of isopoly/heteropoly acids and salts.
CLO8: Explain crystal structures of selected binary and ternary compounds.

Unit–I

Metal-Ligand Bonding: Crystal field theory, spectrochemical series, calculation of CFSE for low and high spin complexes of 3d series elements, applications of CFSE, limitations of crystal field theory, Jahn-Teller effect and its applications, ligand field theory, molecular orbital theory, M.O. diagram of octahedral and square planar complexes including both σ and π bonding, factors affecting ΔE.

Unit–II

Reaction Mechanism of Octahedral Transition Metal Complexes-I: Inert and labile complexes, mechanisms for ligand replacement reactions, formation of complexes from aqua ions, ligand displacement reactions in octahedral complexes – acid hydrolysis, base hydrolysis, Anation reaction, H_2O ligand exchange reactions, factors affecting ligand substitution in octahedral complexes (leaving-group effects, effects of spectator ligands, steric effects), optical rotation, cotton effect, racemization of tris-chelate complexes, electrophilic attack on ligands.

Thermodynamic aspects: Factors affecting stability of metal complexes, Irving–Williams series.

Unit–III

Reaction Mechanism of Square-Planar Transition Metal Complexes-II: Mechanism of ligand displacement reactions in square planar complexes and related numerical, oxidative addition & reductive elimination reactions, trans effect and theories of trans effect, applications of trans effect.

Electron Transfer Processes: Types and mechanism of electron transfer reactions: outer sphere electron transfer and inner sphere electron transfer reactions, electron exchange reactions, factors affecting rate of electron transfer reactions and role of non-bridging

ligand on rate of electron transfer.

Unit–IV

Isopoly and Heteropoly Acids and Salts of Mo & W: Isopoly acids and isopoly ions, preparation and structure of paramolybdate and octamolybdate, heteropoly acids (only classification into six groups), Keggins's structure of 1:11 & 1:12–heteropoly acids and structure of 1:6 heteropoly acids and heteropoly blue.

Crystal Structures: Structures of some binary and ternary crystalline solid such as fluorite, anti-fluorite, rutile, anti-rutile, crystobalite, layered lattices – CdI_2, BiI_3, ReO_3, Mn_2O_3, NiAs, corundum, pervoskite, Ilmenite, calcite, normal spinel & inverse spinel minerals, Well equation and tolerance factor.

Books Recommended/References:

1. Inorganic Chemistry: Principles of Structure and Reactivity by J.E. Huheey, E.A. Keiter, R.L. Keiter and O.K. Medhi.
2. Inorganic Chemistry by Shriver and Atkins.
3. Inorganic Chemistry by C.E. Housecroft and A.G. Sharpe.
4. Advanced Inorganic Chemistry by Cotton and Wilkinson.
5. Inorganic Chemistry by G.L. Miessler, P.J. Fischer and D.A. Tarr.
6. Modern Aspects of Inorganic Chemistry by H.J. Emeleus and A.G. Sharpe.
7. Comprehensive Coordination and Organometallic Chemistry by D. Singh.
8. Coordination Chemistry by A. Kumar.
9. Structural Principles in Inorganic Compounds by W. E. Addison.
10. Chemical bonding & Crystal structure by R.K. Malik.

Name of Program	**B.Sc. (Chemistry as Single Major)**	**Program Code**	**USCHE4**
Paper No.	**Paper-XX**	**Nomenclature**	**Quantum, Thermodynamics and Electrochemistry**
Name of the Course	**Discipline Specific Course**	**Course Code**	**27CHEH407DS02**
Credits	**04**	**Maximum Marks**	**100**
Hours per Week	**04**	**External Marks**	**70**
Duration of Examination	**03 Hrs.**	**Internal Marks**	**30**

Course Objectives: This comprehensive course aims to provide students with an in-depth understanding of quantum mechanics, thermodynamics, chemical dynamics and electrochemistry. The overarching goal of this course is to equip students with a strong theoretical foundation and practical skills in these diverse areas of physical chemistry. The course objectives include fostering a deep understanding of quantum mechanics principles, thermodynamic concepts, chemical kinetics and electrochemical processes. Upon completion, students should be well prepared for advanced studies or applications in various fields of physical chemistry.

Note: Examiner will set 09 questions, and the candidates must attempt 05 questions. Out of 09 questions, one question will be compulsory, containing 07 short answer type questions covering the entire syllabus. Further, the examiner will set two questions from each unit, and the candidates must attempt one question from each unit. All questions will carry equal marks.

Course Learning Outcomes (CLO): By the end of the course, students will be able to:

CLO1: Understand the concept of quantum mechanics.

CLO2: Solve the Schrodinger equation for simple systems like rigid rotator, simple harmonic oscillator, hydrogen atom, particle in a box, etc.

CLO3: Understand the concept of different laws of thermodynamics.

CLO4: Study thermodynamics of dilute solutions-phase rule and its applications.

CLO5: Study the kinetics of complex reactions.

CLO6: Study the kinetics of chain reactions and enzymatic reactions.

CLO7: Discuss Debye-Huckel theory of ion-ion interaction and activity coefficient, its applicability, limitations and its modification for finite-sized ions, the effect of ion-solvent interaction on activity coefficient.

CLO8: Derive D-H-O equation, its applicability and limitations, Pair-wise association of ions (Bjerrum treatment) and its modifications for ion-pair formation.

Unit-I

Quantum Mechanics: Elementary idea of quantum mechanics, Schrodinger wave equation for a particle in 1D box and its pictorial representation, Schrodinger wave equation for a particle in a 3D box, concept of degeneracy, Schrodinger wave equation for a linear harmonic oscillator & its solution by polynomial method, zero-point energy of a particle possessing harmonic motion. Schrodinger wave equation for 3D rigid rotator, energy of rigid rotator, space quantization. Schrodinger wave equation for hydrogen atom, separation of variable in polar spherical coordinates and its solution.

Unit-II

Thermodynamics: Introduction to laws of thermodynamics, Law of mass action and its thermodynamic derivation. Classius-Clapeyron equation and its applications. Phase diagram for two completely miscible components system. Eutectic systems, calculation of eutectic point, systems forming solid compounds A_xB_y with congruent and incongruent melting points, phase diagram and thermodynamic treatment of solid solutions.

Unit-III

Chemical Dynamics: Rate law for consecutive & parallel reactions (first order), ionic reactions: single and double sphere models, influence of solvent and ionic strength, chain reactions: hydrogen-bromine reaction & hydrogen-chlorine reaction, ortho-para hydrogen conversion, chain length, apparent activation energy of chain reactions. Photochemical reactions (hydrogen-bromine & hydrogen-chlorine reactions). Rice- Herzfeld mechanism of organic molecules decomposition (ethane, acetaldehyde), enzyme kinetics, Michaelis-Menton treatment, Lineweaver-Burk plot and Eadie–Hofstee methods. Competitive and non-competitive inhibition.

Unit-IV

Electrochemistry: Debye-Hückel theory of ion-ion interaction and activity coefficient, applicability and limitations of Debye-Hückel limiting law, its modification for finite-sized ions, effect of ion-solvent interaction on activity coefficient. Physical significance of activity coefficients, mean activity coefficient of an electrolyte. Debye-Huckel-Onsager treatment for aqueous solutions and its limitations. Debye-Huckel Onsager theory for non-aqueous solutions, solvent effect on the mobility at infinite dilution, equivalent conductivity (λeq) vs. concentration $c^{1/2}$ as a function of solvent, effect of ion association upon conductivity (Debye-Huckel-Bjerrum equation).

Ion Transport in solutions: Ionic movement under the influence of an electric field, mobility of ions, ionic drift velocity and its relation with current density, Einstein relation between absolute mobility and diffusion coefficient, Stokes-Einstein relation, Nernst-Einstein equation, Walden's rule.

Books Recommended/References:

1. Thermodynamics for Chemists by S. Glasstone.
2. Physical Chemistry by G.M. Barrow.
3. Thermodynamics by R.C. Srivastava, S.K. Saha and A.K. Jain.
4. Modern Electrochemistry by J.O.M. Bockris and A.K.N. Reddy.
5. Chemical Kinetics by K.J. Laidler.
6. Kinetics & Mechanism of Reaction Rates by A. Frost and G. Pearson.
7. Theories of Reaction Rates by K.J. laidler, H. Eyring and S. Glasstone.

8. Theoretical Chemistry by S. Glasstone.
9. Introduction to Quantum Mechanics by R. Chandra.

Name of Program	**B.Sc. (Chemistry as Single Major)**	**Program Code**	**USCHE4**
Paper No.	**Paper-XXI**	**Nomenclature**	**Organic Bonding, Reactions and Stereochemistry**
Name of the Course	**Discipline Specific Course**	**Course Code**	**27CHEH407DS03**
Credits	**04**	**Maximum Marks**	**100**
Hours per Week	**04**	**External Marks**	**70**
Duration of Examination	**03 Hrs.**	**Internal Marks**	**30**

Course Objectives: The course aims to provide a comprehensive understanding of advanced concepts in organic chemistry, specifically focusing on the nature of bonding in organic molecules, stereochemistry, reaction mechanisms, elimination reactions and addition reactions. The course aims to equip students with a thorough understanding of advanced organic chemistry concepts, enabling them to apply this knowledge to analyse and design complex organic reactions.

Note: Examiner will set 09 questions, and the candidates must attempt 05 questions. Out of 09 questions, one question will be compulsory, containing 07 short answer type questions covering the entire syllabus. Further, the examiner will set two questions from each unit, and the candidates must attempt one question from each unit. All questions will carry equal marks.

Course Learning Outcomes (CLO): By the end of the course, students will be able to:

CLO1: Explain the nature of bonding in organic molecules.
CLO2: Develop an understanding of chirality, stereo centers, and the distinction between enantiomers and diastereomers.
CLO3: Learn about the Cram's rule and Prelog's rule.
CLO4: Know about host guest chemistry and supramolecular complexes.
CLO5: Understand the concept of chiral molecules and asymmetric synthesis.
CLO6: Compare different reaction mechanisms and reaction intermediates.
CLO7: Understand different types of elimination and addition reactions.
CLO8: Understand effects substrate structures, attacking base, leaving group and medium on reactivity.

Unit–I

Nature of Bonding in Organic molecules: Delocalized chemical bonding, conjugation, cross-conjugation, resonance, hyperconjugation and tautomerism.

Aromaticity in benzenoid and non-benzenoid compounds, Huckel's rule, energy level of π-molecular orbitals, annulenes, antiaromaticity, homoaromaticity, PMO approach, alternant and non-alternant hydrocarbons.

Bonds weaker than covalent, addition compounds, crown ether complexes and cryptands, inclusion compounds, cyclodextrins, catenanes and rotaxanes.

Unit-II

Stereochemistry: Chirality, elements of symmetry, molecules with more than one chiral center, diastereomerism, methods of resolution, optical purity. Prochirality, enantiotopic and diastereotopic atoms, groups and faces, asymmetric synthesis, Cram's rule and its modifications, Prelog's rule, conformational analysis of decalins. Optical activity in the absence of chiral carbon (Biphenyls, Allenes and Spiranes), chirality due to helical shape. Geometrical isomerism in alkenes and oximes, methods of determining the configuration.

Unit-III

Reaction Mechanism: Structure and Reactivity: types of mechanisms, thermodynamic and

kinetic requirements, kinetic and thermodynamic control, Hammond's postulate, Curtin-Hammett principle, potential energy diagrams, transition states and intermediates, methods of determining mechanisms, isotope effects. Generation, structure, stability and reactivity of carbocations, carbanions, free radicals, carbenes and nitrenes. effect of structure on reactivity, Hammett equation and linear free energy relationship, substituent and reaction constants, Taft equation.

Unit-IV

Elimination Reactions: The E1, E2 and E1cB mechanisms, orientation of the double bond. effects of substrate structures, attacking base, leaving group and medium on reactivity. Mechanism and orientation in pyrolytic elimination.

Addition to Carbon-Carbon Multiple Bonds: Mechanistic and stereochemical aspects of addition reactions involving electrophiles, nucleophiles and free radicals, orientation and reactivity, addition to cyclopropane ring. Hydrogenation of double and triple bonds, hydrogenation of aromatic rings, hydroboration reaction, Michael reaction, Sharpless asymmetric epoxidation.

Books Recommended/References:

1. Advanced Organic Chemistry: Reactions, Mechanism and Structure by J. March.
2. Advanced Organic Chemistry by F. A. Carey and R. J. Sundberg.
3. Structure and Mechanism in Organic Chemistry by C. K. Ingold.
4. Stereochemistry of Organic Compounds by P. S. Kalsi.
5. Organic Chemistry by R. T. Morrison and R. N. Boyd.
6. Principles of Organic Synthesis by R. O. C. Norman and J. M. Coxon.

Name of Program	**B.Sc. (Chemistry as Single Major)**	**Program Code**	**USCHE4**
Paper No.	**Chemistry Practical Paper (SM)-XVI**	**Nomenclature**	**Inorganic Chemistry Practical-I**
Name of the Course	**Discipline Specific Course**	**Course Code**	**27CHEH407DS04**
Credits	**04**	**Maximum Marks**	**100**
Hours per Week	**08**	**External Marks**	**70**
Duration of Examination	**08 Hrs.**	**Internal Marks**	**30**

Course Objectives: The course aims to provide students with a comprehensive understanding of analytical chemistry through the study of volumetric analysis and green methods of preparation. Through practical applications, students will develop essential laboratory skills, critical thinking abilities and an appreciation for the principles of green chemistry. The course aims to bridge theoretical knowledge with practical expertise, promoting a holistic understanding of analytical techniques and environmentally conscious synthesis methods.

***Note: Examiner will set two experiments for practical examinations*.**

Course Learning Outcomes (CLO): By the end of the course, students will be able to:

CLO1: Understand the principles underlying complexometric titrations

CLO2: Estimate Cu (II), $K_2Cr_2O_7$ using iodometric titrations.

CLO3: Determine aluminium, magnesium and zinc using potassium bromate.

CLO4: Learn how to select appropriate indicators for EDTA titrations.

CLO5: Determine calcium, copper and barium using EDTA (forward and back titrations).

CLO6: Determine the strength of metal ions in the presence of masking agents.

CLO7: Synthesize selected metal acetylacetonato complexes employing green methods.

CLO8: Face viva voce.

List of Experiments

1. Volumetric Analysis: **(30 Marks)**

(i) **Iodo/Iodimetric Titrations**

(a) Estimation of Cu(II) using sodium thiosulphate solution iodometrically.

(b) Estimation of $K_2Cr_2O_7$ using sodium thiosulphate solution iodometrically.

(ii) **Potassium Iodate Titrations:** Determination of iodide, hydrazine.

(iii) **Potassium Bromate Titrations**

(a) Determination of aluminium, magnesium, cobalt and zinc (by Oxine method).

(iv) **EDTA Titrations**

(a) Determination of magnesium, calcium, barium, nickel, copper.

(b) Back titration.

(c) Titration of mixtures using masking and demasking agents.

(d) Determination of hardness of water.

2. Green methods of preparation of the following: **(30 Marks)**

(i) Bis(acetylacetonato)copper(II)

(ii) Tris(acetylacetonato)iron(III)

(iii) Tris(acetylacetonato)manganese(III)

(iv) Synthesis of Ag nanoparticles by plant extract and characterization using UV-Visible spectrophotometer.

Viva-Voce **(10 Marks)**

Note Book **(25 Marks)**

Attendance **(05 Marks)**

Books Recommended/References:

1. A Text Book of Quantitative Inorganic Analysis by A.I.Vogel.
2. Applied Analytical Chemistry by O.P.Vermani.
3. Vogel's Quantitative Chemical Analysis by J. Mendham.
4. Vogel's Qualitative Inorganic Analysis by G. Svehla.
5. Practical Inorganic Chemistry by Marr and Rockett.
6. Synthesis and Characterization of Inorganic Compounds by W. L. Jolly.
7. Instrumental Methods of Analysis by B. K. Sharma.
8. Principles of Instrumental Analysis by D.A. Skoog, F.J. Holler and S.R. Crouch.

Name of Program	B.Sc. (Chemistry as Single Major)	Program Code	USCHE4
Paper No.	Chemistry Practical Paper (SM)-XVII	Nomenclature	Physical Chemistry Practical-I
Name of the Course	Discipline Specific Course	Course Code	27CHEH407DS05
Credits	04	Maximum Marks	100
Hours per Week	08	External Marks	70
Duration of Examination	08 Hrs.	Internal Marks	30

Course Objectives: This course is designed to provide students with a comprehensive understanding of various experimental techniques in physical chemistry, focusing on surface tension, conductometry, refractometry and thermochemistry. Through these experiments, students will develop practical laboratory skills, enhance their understanding of physical chemistry principles and gain valuable insight into the applications of these techniques in chemical analysis and research.

Note: Examiner will set two experiments for practical examinations.

Course Learning Outcomes (CLO): By the end of the course, students will be able to:

CLO1: Understand the concept of surface tension and its determination for various organic solvents.

CLO2: Understand the parachor value, molecular surface energy and association factor.

CLO3: Understand the principles and applications of conductometric titrations.

CLO4: Understand and master the fundamentals of conductometric titrations in aqueous media.

CLO5: Understand and master the fundamentals of refractometry experiments.

CLO6: Understand the concept of heat of solution and heat of hydration.

CLO7: Demonstrate ethical and professional conduct in all aspects of conductometry and refractometry work.

CLO8: Learn data handling and analysis.

List of Experiments

1. Surface Tension (30 Marks)

(i) Study the effect of soap concentration on the lowering of surface tension of water

(ii) Determine surface tension of methyl alcohol, ethyl alcohol, n-hexane at room temperature and also calculate the parachor of C, H and O.

(iii) Determine the composition of given mixture of two components A and B.

(iv) Determine the molecular surface energy and association factor of ethanol.

2. Conductometry

(i) Determine the strength of strong acid and weak acid in a mixture by conductometric titration with a strong base

(ii) Study precipitation titration between KCl and $AgNO_3$ conductometrically. Determine the strength of given solution of $AgNO_3$.

(iii) Determine the equivalent conductivity of strong electrolyte at different dilution and also find out the equivalent conductivity of weak electrolyte at infinite dilution.

(iv) Estimate conductometrically the quantities of NH_4OH and NH_4Cl in their mixture.

3. Refractometry (30 Marks)

(i) Determine atomic refractivities of C, H and O by methyl alcohol, ethyl alcohol and n-hexane.

(ii) Determine the percentage composition of liquids in the given binary mixture by using refractometry.

(iii) Determine the molecular refractivity of p-dichlorobenzene.

4. Heat of Solutions and Hydrations

(i) Determine heat of solution of potassium nitrate in water.

(ii) Determine heat of hydration of sodium sulphate and copper sulphate.

Viva-Voce (10 Marks)

Note Book (25 Marks)

Attendance (05 Marks)

Books Recommended/References:

1. Practical Physical Chemistry by A.M. James and F.E. Prichard, Longman.
2. Findley's Practical Physical Chemistry by B.P. Lavitt, Longman.
3. Practical Physical Chemistry by S.R. Palit and S.K. Science.
4. Experimental Physical Chemistry by R.C. Das, B. Behera and Tata McGraw Hill.

B.Sc. 4th (4 year UG Hons with Research in Chemistry)
B.Sc. (Chemistry as Single Major)

Semester — VIII (Session: 2027- 28)

(Option –I)

Name of Program	B.Sc. (Chemistry as Single Major)	Program Code	USCHE4
Paper No.	Paper-XXII	Nomenclature	General Spectroscopy
Name of the Course	Discipline Specific Course	Course Code	27CHEH408DS01
Credits	04	Maximum Marks	100
Hours per Week	04	External Marks	70
Duration of Examination	03 Hrs.	Internal Marks	30

Course Objectives: The course is designed to provide students with a comprehensive understanding of advanced topics in spectroscopy which include developing a strong theoretical foundation, enhancing practical skills in spectroscopic techniques and fostering the ability to apply these methods to solve complex problems in the structural elucidation of organic and inorganic compounds. The ultimate goal is to prepare students for advanced research and applications in the diverse and dynamic field of spectroscopy.

Note: The examiner will set 09 questions, and the candidates must attempt 05 questions. Out of 09 questions, one question will be compulsory, containing 07 short answer type questions covering the entire syllabus. Further, the examiner will set two questions from each unit, and the candidates must attempt one question from each unit. All questions will carry equal marks.

Course Learning Outcomes (CLO): By the end of the course, students will be able to:

CLO1: Develop a comprehensive understanding of the fundamental principles of group theory including the definition of groups, subgroups, group operations and group representations.
CLO2: Learn about point symmetry groups for various molecules.
CLO3: Explore different regions of the electromagnetic spectrum.
CLO4: Interpret various types of spectra and know about their application in structure elucidation.
CLO5: Analyse vibrational and vibrational-rotational spectra of polyatomic molecules.
CLO6: Understand basic principle of electronic, UV, IR, and NMR spectroscopy.
CLO7: Know about order of reactions by NMR spectroscopy.
CLO8: Apply NMR techniques in the characterization of inorganic compounds.

Unit–I

Symmetry and Group Theory in Chemistry: Symmetry elements and symmetry operation, point group and its properties, group multiplication table, Schonflies symbol, representation of groups by matrices (representation for the C_n, C_{nv}, C_{nh}, C_s, D_{nh} etc. groups to be worked out explicitly). Point groups of following molecules: H_2O, NH_3, CH_4, SF_6, $CHCl_3$, BF_3, C_6H_6, C_5H_5, NSF_3, C_2H_2, HCl, HCN, CO_2, *etc*. Irreducible representation of groups. The Great Orthogonality theorem (without proof) and its importance. Character tables and its applications in spectroscopy.

Unit–II

Introduction to Spectroscopy: Electromagnetic radiations, interaction of electromagnetic radiation with matter, regions of the spectrum, width and intensity of spectral transitions. Resolving power, transition probability.

Rotational Spectra: Rotational spectra of diatomic molecules (rigid rotator), spectrum of non-rigid rotator, effect of isotopic substitutions, rotational spectra of linear and symmetric top polyatomic molecules.

Vibrational and Vibrational-Rotational Spectra: Vibrating diatomic molecule (Simple harmonic vibrator), anharmonicity, diatomic vibrating rotator, interaction of rotations and vibrations, vibrational spectra of polyatomic molecules, analysis by infrared technique.

Electronics Spectra: Electronic spectra of diatomic molecules, vibrational course structure and rotational fine structure of electronic band. Frank-Condon principle (intensity of vibrational-electronic band, dissociation energy), Fortrat diagram.

Unit–III

Ultraviolet and Visible Spectroscopy: Principle, electronic energy levels and transitions, chromophores and auxochromes, bathochromic and hypsochromic shift, hypochromic and hyperchromic effect.

Infrared Spectroscopy: Principle, functional group and fingerprint regions, absorption of infrared radiation and molecular vibrations (stretching and bending), fundamental vibrations and overtones.

NMR Spectroscopy: Spin active nuclei, chemical shift, shielding and deshielding, spin-spin coupling, equivalent and non-equivalent protons, effect of changing solvents and hydrogen bonding on chemical shifts, anisotropic effect.

Applications of UV, IR, and NMR spectra in the structural elucidation of organic compounds.

Unit–IV

Electronic Absorption Spectroscopy: Energy levels in diatomic molecules, introduction to electronic transition, assignment of transitions, selection rules for EAS, p-d intermixing.

Nuclear Magnetic Resonance: Quantum concept of NMR, larmor frequency, coupling constant, applications of spin-spin coupling in structure determination of inorganic compounds, population excess and types of relaxation, standard references for inorganic compounds, calculation of rates from NMR-spectrum, determination of order by NMR, double resonance technique for inorganic compounds like B_2H_6, $Al(BH_4)_3$ etc. Characterization of metal hydrides complexes (counting signals), inorganic applications of NMR like ^{1}H NMR, ^{11}B NMR, ^{19}F NMR, ^{31}P NMR (dynamic and frozen spectra), fluxional behaviour of inorganic molecules.

Finger print regions of IR spectroscopy, Hooke's law & its applications for determination of stretching frequency. Application of infrared spectroscopy in the determination of inorganic compounds: Determination of coordination sites, identification of cis-and trans isomers, structure elucidation of covalent molecules, H-bonding etc.

Books Recommended/References:

1. Chemical Applications of Group Theory by F. A. Cotton.
2. Physical Methods in Inorganic Chemistry by R. S. Drago.
3. Infrared Spectra of Inorganic and Coordination Compound by K. Nakamoto.
4. Fundamentals of Molecules Spectroscopy by C. N. Banwel.
5. Introduction to Magnetic Resonance Spectroscopy ESR, NMR, NQR by D. N. Sathyanarayana.
6. Physical Chemistry by Peter Atkins and Julio de Paula.
7. Introduction to Spectroscopy by Donald L. Pavia, Gary M. Lampman, George S. Kriz and James R. Vyvyan.
8. Organic Spectroscopy: Principles and Applications by J. Mohan.
9. Spectroscopy (Vol. 2) by R.K. Malik.

Name of Program	B.Sc. (Chemistry as Single Major)	Program Code	USCHE4
Paper No.	Paper-XXIII	Nomenclature	Research Methodology
Name of the Course	Discipline	Course Code	27CHEH408DS02

	Specific Course		
Credits	**04**	**Maximum Marks**	**100**
Hours per Week	**04**	**External Marks**	**70**
Duration of Examination	**03 Hrs.**	**Internal Marks**	**30**

Course Objectives: This course aims to provide a comprehensive understanding of research fundamentals, including various types and methods. It focuses on effective data collection, documentation and ethical conduct in scientific research. Students will learn about literature review, laboratory procedures, publication processes and ethical considerations, equipping them with essential skills for conducting responsible and impactful research in diverse fields.

Note: Examiner will set 09 questions, and the candidates must attempt 05 questions. Out of 09 questions, one question will be compulsory, containing 07 short answer type questions covering the entire syllabus. Further, the examiner will set two questions from each unit, and the candidates must attempt one question from each unit. All questions will carry equal marks.

Course Learning Outcomes (CLO): By the end of the course, students will be able to:

CLO1: Understand different types of research.
CLO2: Understand research methods and methodology.
CLO3: Acquire knowledge of literature review and research.
CLO4: Understand the data collection and maintaining laboratory record.
CLO5: Understand the different research areas of chemistry.
CLO6: Understand various instruments to characterize the research.
CLO7: Understand publication of research.
CLO8: Gain knowledge regarding the journals, publication houses, publication ethics and misconduct.

Unit-I

Basic Concepts of Research: Research-definition and types of research (Descriptive vs analytical, applied vs fundamental, quantitative vs. qualitative, conceptual vs empirical). Research methods vs methodology.
Literature-review and its consolidation, library research, field research; laboratory research.

Unit-II

Data Collection and Documentation of Observations: Maintaining a laboratory record, tabulation and generation of graphs. Imaging of tissue specimens and application of scale bars. The art of field photography.

Unit-III

Basic Knowledge of Publication House, Journals and Instrumentation: Introduction, research publication, access to different publication house and journals associated with it, research articles. Code of conduct - while entering in the lab, while working with the chemicals, while disposal of chemicals, storage and disposal of chemical wastes – aqueous wastes, organic wastes and radioactive wastes, human contribution to reduce hazardous wastes. characterization of samples, instruments used for characterization.

Unit-IV

Ethics with respect to Science and Research
Scientific Misconducts – Falsification, fabrication and plagiarism (FFP),
Redundant Publications – Duplicate and overlapping publications, selective reporting and misrepresentation of data.
Publication Ethics – Definition, introduction and importance
Publication Misconduct – Definition, concept, problems that lead to unethical behaviour, conflicts of interest, violation of publication ethics authorship and contributionship.

Books Recommended/References:

1. Conducting Research Literature Reviews by A. Fink.
2. Research Methods: A Process of Inquiry by M. Graziano, A. M. Anthony and M. L. Raulin.
3. Research Methods: The Concise Knowledge Base by W. M. K. Trochim.

4. Practical Research: Planning and Design by P. D. Leedy and J. E. Ormrod.
5. An Introduction to Research Methodology by L. Garg, R. Karadia, F. Agarwal and U. K. Agarwal.
6. How to Write and Publish a Scientific Paper by R. A. Day.
7. Research Methodology: Methods and Techniques by C. R. Kothari.

Name of Program	**B.Sc. (Chemistry as Single Major)**	**Program Code**	**USCHE4**
Paper No.	**Paper-XXIV**	**Nomenclature**	**Special Chemistry**
Name of the Course	**Discipline Specific Course**	**Course Code**	**27CHEH408DS03**
Credits	**04**	**Maximum Marks**	**100**
Hours per Week	**04**	**External Marks**	**70**
Duration of Examination	**03 Hrs.**	**Internal Marks**	**30**

Course Objectives: The course aims to provide an in-depth understanding of advanced topics in organometallic chemistry, spectroscopy, electro-analytical methods and reaction mechanisms. The course aims to equip students with a robust foundation in these advanced topics, fostering their ability to analyse and comprehend complex chemical systems.

Note: The examiner will set 09 questions, and the candidates must attempt 05 questions. Out of 09 questions, one question will be compulsory, containing 07 short answer type questions covering the entire syllabus. Further, the examiner will set two questions from each unit, and the candidates must attempt one question from each unit. All questions will carry equal marks.

Course Learning Outcomes (CLO): By the end of the course, students will be able to:

CLO1: Apply 18-electron rule to rationalize the stability of metal carbonyls and related species.
CLO2: Understand the structure and bonding of various types of clusters.
CLO3: Provide a basic understanding of electronic spectra of metal complexes.
CLO4: Explain the colour of transition metal complexes.
CLO5: Understand the potentiometric methods.
CLO6: Know about the different types of electrodes and use ion selective electrode to determine various ions.
CLO7: Become familiar with the particular properties of aromatic compounds and criterion of aromaticity
CLO8: Get knowledge of basic organic reaction mechanism.

Unit-I

Organometallic: 18-electron rule, counting methods and ligand contributions, haptoligands with hapticity from two to eight.

Clusters: Multi-nuclear carbonyl clusters: Low nuclearity carbonyl clusters (LNCC), High nuclearity carbonyl clusters (HNCC), clusters having interstitial atom, electron counting schemes for high nuclearity clusters, polyhedral skeletal electron pair approach/Mingo's rules, structure and bonding in higher boranes, Wade's rules, carboranes, applications of Wade's rules, zintl-ions, isolobal analogy, dinuclear clusters (metal clusters containing M-M multiple bonds).

Unit-II

Electronic Spectra of Transition Metal Complexes: Spectroscopic ground states, spin-orbit coupling in free metal ions for 3d- series of transition metals, ground state terms for transition metals/ions, Racah parameters and nephalauxetic effect, orgel diagrams (d^1 to d^{10}) and Tanabe-Sugano diagrams for transition metal complexes (d^1 & d^2 states), elementary concept of Dq, B and β parameters, effect of Jahn-Teller distortion on electronic spectra of 3d-series metal complexes, charge transfer spectra, electronic spectra of molecular addition compounds of iodine.

Unit-III
Electro-Analytical & Potentiometric Methods: Polarization phenomenon and its theories, effect of concentration on cell potential. Concept of liquid-junction potential, reference electrodes (Calomel, Ag/AgCl, Tl/TlCl). Metallic redox indicator electrode: Membrane and ion-selective electrodes, electrical properties of membrane, glass electrode with special reference to H^+, Na^+, K^+ ions, operation of solid membrane electrode and liquid membrane electrode and coated type ion electrode. Applications of ion selective electrode in determination of some toxic metals and some anions(F^-, Cl^-, Br^-, I^- and NO_3^-).
Unit-IV
Bonding in Organic molecules: Aromaticity in benzenoid and non-benzenoid compounds, antiaromaticity, homoaromaticity, energy level of π-molecular orbitals, PMO approach, crown ether complexes and cryptands, inclusion compounds, cyclodextrins, phase transfer catalysis, catenanes and rotaxanes. **Reaction Mechanism:** Kinetic and thermodynamic control of reactions, Hammond's postulate, Curtin-Hammett principle, transition states and intermediates, methods of determining reaction mechanisms, generation, structure, stability and reactivity of carbocations, carbanions, free radicals, carbenes and nitrenes. The Hammett equation and linear free energy relationship, Taft equation.
Books Recommended/References:
1. Inorganic Chemistry by C. E. Housecroft and A. G. Sharpe. 2. Inorganic Chemistry by Shriver and Atkins. 3. Basic Organometallic Chemistry: Concepts, Syntheses and Applications by B.D. Gupta and A.J. Elias. 4. Comprehensive Coordination and Organometallic Chemistry by D. Singh. 5. Physical Methods of Chemists by R. S. Drago. 6. Electroanalytical Chemistry: A Series of Advances by A. J. Bard. 7. Organic Chemistry by J. Clayden, N. Greeves, and S. Warren. 8. Organic Chemistry by P. Y. Bruice. 9. Advanced Organic Chemistry: Reactions, Mechanisms, and Structure by M. B. Smith and J. March. 10. Advanced Organic Chemistry by F.A. Carey and R.J. Sundberg.

Name of Program	**B.Sc. (Chemistry as Single Major)**	**Program Code**	**USCHE4**
Paper No.	**Chemistry Practical Paper (SM)-XIX**	**Nomenclature**	**Inorganic Chemistry Practical-II**
Name of the Course	**Discipline Specific Course**	**Course Code**	**27CHEH408DS04**
Credits	**04**	**Maximum Marks**	**100**
Hours per Week	**08**	**External Marks**	**70**
Duration of Examination	**08 Hrs.**	**Internal Marks**	**30**

Course Objectives: The course on quantitative inorganic analysis is designed to equip students with comprehensive knowledge and practical skills in separating and determining metal ions through various analytical methods. Additionally, students will delve into the principles and applications of Cerimetry for determining Ferrous, Oxalate, and Nitrite ions. The course emphasizes hands-on experience in laboratory settings, ensuring proficiency in analytical techniques. Overall, the course aims to foster a deep understanding of inorganic analytical methods, enhance problem-solving skills, and promote awareness of sustainable practices in chemical analysis.

Note: Examiner will set two experiments for practical examinations.

Course Learning Outcomes (CLO): By the end of the course, students will be able to:

CLO1: Separate and determine binary mixtures of metal ions using gravimetric and volumetric methods.

CLO2: Perform calculations involved in gravimetric analysis.

CLO3: Explain the principle underlying the gravimetric determinations.

CLO4: Determine strengths of ferrous and oxalate using cerimetry.

CLO5: Determine the strengths of nitrite ions using cerimetry (also by indirect method).

CLO6: Synthesize some metal acetylacetonato complexes employing green methods.

CLO7: Realise the importance of green technologies in sustainable growth of industry and society.

CLO8: Develop cleaner production and treatment mechanisms for pollution prevention.

List of Experiments

1. Quantitative Inorganic Analysis (30 Marks)

(i) **Separation and determination of two metal ions *via* volumetric and gravimetric methods**

(a) Silver-Copper
(b) Iron-Nickel
(c) Copper-Zinc
(d) Nickel-Zinc
(e) Copper-Iron
(f) Copper-Nickel (Both gravimetrically)
(g) Barium-Calcium (Both gravimetrically)

2. Determination by Cerimetry (30 Marks)

(i) Ferrous
(ii) Oxalate
(iii) Nitrite

3. Green methods of preparation of the following

(i) Bis(acetylacetonato) zinc (II)
(ii) Bis(acetylacetonato) chromium (II)

Viva-Voce (10 Marks)

Note Book (25 Marks)

Attendance (05 Marks)

Books Recommended/References:

1. A Text Book of Quantitative Inorganic Analysis by A.I. Vogel.
2. Applied Analytical Chemistry by O.P. Vermani.
3. Vogel's Quantitative Chemical Analysis by J. Mendham.
4. Vogel's Qualitative Inorganic Analysis by G. Svehla.
5. Practical Inorganic Chemistry by Marr and Rockett.
6. Principles of Instrumental Analysis by D.A. Skoog, F.J. Holler and S.R. Crouch.
7. Quantitative Chemical Analysis by D.C. Harris.

Name of Program	B.Sc. (Chemistry as Single Major)	Program Code	USCHE4
Paper No.	Chemistry Practical Paper (SM)-XX	Nomenclature	Physical Chemistry Practical-II
Name of the Course	Discipline Specific Course	Course Code	27CHEH408DS05
Credits	04	Maximum Marks	100
Hours per Week	08	External Marks	70
Duration of	08 Hrs.	Internal Marks	30

Examination			

Course Objectives: The course on experimental techniques in physical chemistry aims to provide students with a thorough understanding of various experimental methods used in the study of physical chemistry principles. The objectives include developing hands-on experimental skills in physical chemistry techniques and enhancing the understanding of fundamental principles governing physical and chemical processes. This course aims to prepare students for advanced studies or careers in physical chemistry, research and industrial applications by combining theoretical knowledge with practical skills in experimental techniques.

Note: Examiner will set two experiments for practical examinations.

Course Learning Outcomes (CLO): By the end of the course, students will be able to:

CLO1: Know the concept of viscosity and determine the viscosity of various liquids.

CLO2: Compare the viscosity of various liquids.

CLO3: Study the conductometric and pH metric titration for determination of normality and strength of acids.

CLO4: Study the potentiometric titration of the given acids.

CLO5: Determine strength and thermodynamic properties of given acids.

CLO6: Determine the partition coefficient of a solute between two immiscible solvents using distribution law.

CLO7: Study the kinetics of hydrolysis of ethyl or methyl acetate and calculation of thermodynamic parameters.

CLO8: Develop the ability to compile interpreted information in the form of lab record.

List of Experiments

1. Viscosity **(30 Marks)**

(i) Study the variation of viscosity with concentration for a glycerol/ amyl alcohol solution using Ostwald viscometer and thereafter determine the concentration of unknown solution of glycerol and amyl alcohol.

(ii) Determination of molar mass of a polymer by using viscometer.

(iii) Determine the temperature coefficient of given liquid.

2. Conductometry

(i) Study the equivalent conductance versus square root of concentration relationship of a strong electrolyte (KCl or NaCl) and weak electrolyte (acetic acid).

(ii) Determine the strength of NaOH and NH_4OH in a given mixture by titrating it against HCl.

(iii) Estimate conductometrically the quantities of HCl and NH_4Cl in their mixture.

3. pH-metry

(i) Titration of a mixture of (HCl + CH_3COOH) against NaOH pH-metrically and comment on the shape of the curve.

4. Potentiometry **(30 Marks)**

(i) Determine the strength of acetic acid by titrating it against NaOH potentiometrically. Also calculate dissociation constant of acid using quinhydrone electrode.

(ii) Study the effect of ionic strength on mean activity coefficient of HCl in a given solution.

(iii) Determine the standard free energy change and equilibrium constant for the reaction.

$$Cu + 2Ag^{+} \longrightarrow Cu^{2+} + 2Ag$$

5. Distribution Law

(i) Study the complex formation of cuprammonium ion or study the complex formation between copper sulphate and ammonia solution.

(ii) Determination of Equilibrium constant for $I_2 + I^- = I^-_3$ **6. Chemical Kinetics** (i) Determination of the rate constant and activation energy for hydrolysis of ethyl or methyl acetate. (ii) Determination of the temperature coefficient for hydrolysis of ethyl or methyl acetate and calculation of thermodynamic parameters.
Viva-Voce **(10 Marks)**
Note Book **(25 Marks)**
Attendance **(05 Marks)**
Books Recommended/References:
1. Practical Physical Chemistry by A.M. James and F.E. Prichard. 2. Findley's Practical Physical Chemistry by B.P. Lavitt. 3. Practical Physical Chemistry by S.R. Palit and S.K. De. 4. Experimental Physical Chemistry by R.C. Das and B. Behera.

B.Sc. 4th (4 year UG Hons with Research in Chemistry)
B.Sc. (Chemistry as Single Major)

Semester — VIII (Session: 2027- 28)

(Option –II)

Name of Program	B.Sc. (Chemistry as Single Major)	Program Code	USCHE4
Paper No.	Paper-XXII	Nomenclature	General Spectroscopy
Name of the Course	Discipline Specific Course	Course Code	27CHEH408DS01
Credits	04	Maximum Marks	100
Hours per Week	04	External Marks	70
Duration of Examination	03 Hrs.	Internal Marks	30

Course Objectives: The course is designed to provide students with a comprehensive understanding of advanced topics in spectroscopy which include developing a strong theoretical foundation, enhancing practical skills in spectroscopic techniques and fostering the ability to apply these methods to solve complex problems in the structural elucidation of organic and inorganic compounds. The ultimate goal is to prepare students for advanced research and applications in the diverse and dynamic field of spectroscopy.

Note: The examiner will set 09 questions, and the candidates must attempt 05 questions. Out of 09 questions, one question will be compulsory, containing 07 short answer type questions covering the entire syllabus. Further, the examiner will set two questions from each unit, and the candidates must attempt one question from each unit. All questions will carry equal marks.

Course Learning Outcomes (CLO): By the end of the course, students will be able to:

CLO1: Develop a comprehensive understanding of the fundamental principles of group theory including the definition of groups, subgroups, group operations and group representations.

CLO2: Learn about point symmetry groups for various molecules.

CLO3: Explore different regions of the electromagnetic spectrum.

CLO4: Interpret various types of spectra and know about their application in structure elucidation.

CLO5: Analyse vibrational and vibrational-rotational spectra of polyatomic molecules.

CLO6: Understand basic principle of electronic, UV, IR, and NMR spectroscopy.
CLO7: Know about order of reactions by NMR spectroscopy.
CLO8: Apply NMR techniques in the characterization of inorganic compounds.

Unit-I

Symmetry and Group Theory in Chemistry: Symmetry elements and symmetry operation, point group and its properties, group multiplication table, Schonflies symbol, representation of groups by matrices (representation for C_n, C_{nv}, C_{nh}, C_s, D_{nh} etc. groups to be worked out explicitly). Point groups of following molecules: H_2O, NH_3, CH_4, SF_6, $CHCl_3$, BF_3, C_6H_6, C_5H_5, NSF_3, C_2H_2, HCl, HCN, CO_2, *etc*. Irreducible representation of groups. The Great Orthogonality theorem (without proof) and its importance. Character tables and its applications in spectroscopy.

Unit-II

Introduction to Spectroscopy: Electromagnetic radiations, interaction of electromagnetic radiation with matter, regions of the spectrum, width and intensity of spectral transitions. Resolving power, transition probability.

Rotational Spectra: Rotational spectra of diatomic molecules (rigid rotator), spectrum of non-rigid rotator, effect of isotopic substitutions, rotational spectra of linear and symmetric top polyatomic molecules.

Vibrational and Vibrational-Rotational Spectra: Vibrating diatomic molecule (simple harmonic vibrator), anharmonicity, diatomic vibrating rotator, interaction of rotations and vibrations, vibrational spectra of polyatomic molecules, analysis by infrared technique.

Electronics Spectra: Electronic spectra of diatomic molecules, vibrational course structure and rotational fine structure of electronic band. Frank-Condon principle (intensity of vibrational-electronic band, dissociation energy), Fortrat diagram.

Unit-III

Ultraviolet and Visible Spectroscopy: Principle, electronic energy levels and transitions, chromophores and auxochromes, bathochromic and hypsochromic shift, hypochromic and hyperchromic effect.

Infrared Spectroscopy: Principle, functional group and fingerprint regions, absorption of infrared radiation and molecular vibrations (stretching and bending), fundamental vibrations and overtones.

NMR Spectroscopy: Spin active nuclei, chemical shift, shielding and deshielding, internal standards, spin-spin coupling, equivalent and non-equivalent protons, effect of changing solvents and hydrogen bonding on chemical shifts, anisotropic effect.

Applications of UV, IR, and NMR spectra in the structural elucidation of organic compounds.

Unit-IV

Electronic Absorption Spectroscopy: Energy levels in diatomic molecules, introduction to electronic transition, assignment of transitions, selection rules for EAS, p-d intermixing.

Nuclear Magnetic Resonance: Quantum concept of NMR, larmor frequency, coupling constant, applications of spin-spin coupling in structure determination of inorganic compounds, population excess and types of relaxation, standard references for inorganic compounds, calculation of rates from NMR-spectrum, determination of order by NMR, double resonance technique for inorganic compounds like B_2H_6, $Al(BH_4)_3$ etc. Characterization of metal hydrides complexes (counting signals), inorganic applications of NMR like ^{1}H NMR, ^{11}B NMR, ^{19}F NMR, ^{31}P NMR (dynamic and frozen spectra), fluxional behaviour of inorganic molecules.

Finger print regions of IR spectroscopy, Hooke's law & its applications for determination of stretching frequency. Application of infrared spectroscopy in the determination of inorganic compounds: Determination of coordination sites, identification of cis-and trans isomers, structure elucidation of covalent molecules, H-bonding etc.

Books Recommended/References:

1. Chemical Applications of Group Theory by F. A. Cotton.
2. Physical Methods in Inorganic Chemistry by R. S. Drago.
3. Infrared Spectra of Inorganic and Coordination Compound by K. Nakamoto.
4. Fundamentals of Molecules Spectroscopy by C. N. Banwel.
5. Introduction to Magnetic Resonance Spectroscopy ESR, NMR, NQR by D.N. Sathyanarayana.
6. Physical Chemistry by Peter Atkins and Julio de Paula.
7. Introduction to Spectroscopy by Donald L. Pavia, Gary M. Lampman, George S. Kriz and James R. Vyvyan.
8. Organic Spectroscopy: Principles and Applications by J. Mohan.
9. Spectroscopy (Vol-2) by R.K. Malik.

Name of Program	**B.Sc. (Chemistry as Single Major)**	**Program Code**	**USCHE4**
Paper No.	**Paper-XXIII**	**Nomenclature**	**Research Methodology**
Name of the Course	**Discipline Specific Course**	**Course Code**	**27CHEH408DS02**
Credits	**04**	**Maximum Marks**	**100**
Hours per Week	**04**	**External Marks**	**70**
Duration of Examination	**03 Hrs.**	**Internal Marks**	**30**

Course Objectives: This course aims to provide a comprehensive understanding of research fundamentals, including various types and methods. It focuses on effective data collection, documentation and ethical conduct in scientific research. Students will learn about literature review, laboratory procedures, publication processes and ethical considerations, equipping them with essential skills for conducting responsible and impactful research in diverse fields.

Note: The examiner will set 09 questions, and the candidates must attempt 05 questions. Out of 09 questions, one question will be compulsory, containing 07 short answer type questions covering the entire syllabus. Further, the examiner will set two questions from each unit, and the candidates must attempt one question from each unit. All questions will carry equal marks.

Course Learning Outcomes (CLO): By the end of the course, students will be able to:

CLO1: Understand different types of research.
CLO2: Understand research methods and methodology.
CLO3: Acquire knowledge of literature review and research.
CLO4: Understand the data collection and maintaining laboratory record.
CLO5: Understand the different research areas of chemistry.
CLO6: Understand various instruments to characterize the research.
CLO7: Understand publication of research.
CLO8: Gain knowledge regarding the journals, publication houses, publication ethics and misconduct.

Unit-I

Basic Concepts of Research: Research-definition and types of research (Descriptive vs analytical, applied vs fundamental, quantitative vs. qualitative, conceptual vs empirical). Research methods vs methodology.

Literature-review and its consolidation, library research, field research; laboratory research.

Unit-II

Data Collection and Documentation of Observations: Maintaining a laboratory record, tabulation and generation of graphs. Imaging of tissue specimens and application of scale bars. The art of field photography.

Unit-III
Basic Knowledge of Publication House, Journals and Instrumentation: Introduction, research publication, access to different publication house and journals associated with it, research articles. Code of conduct - while entering in the lab, while working with the chemicals, while disposal of chemicals, storage and disposal of chemical wastes – aqueous wastes, organic wastes and radioactive wastes, human contribution to reduce hazardous wastes. characterization of samples, instruments used for characterization.
Unit-IV
Ethics with respect to Science and Research **Scientific Misconducts** – Falsification, fabrication and plagiarism (FFP), **Redundant Publications** – Duplicate and overlapping publications, selective reporting and misrepresentation of data. **Publication Ethics** – Definition, introduction and importance **Publication Misconduct** – Definition, concept, problems that lead to unethical behaviour, conflicts of interest, violation of publication ethics authorship and contributionship.
Books Recommended/References:
1. Conducting Research Literature Reviews by A. Fink. 2. Research Methods: A Process of Inquiry by M. Graziano, A. M. Anthony and M. L. Raulin. 3. Research Methods: The Concise Knowledge Base by W. M. K. Trochim. 4. Practical Research: Planning and Design by P. D. Leedy and J. E. Ormrod. 5. An Introduction to Research Methodology by L. Garg, R. Karadia, F. Agarwal and U. K. Agarwal. 6. How to Write and Publish a Scientific Paper by R. A. Day. 7. Research Methodology: Methods and Techniques by C. R. Kothari.

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