SYLLABI AND SCHEME OF EXAMINATIONS FOR

(DISCIPLINE SPECIFIC COURSE OF LIFE SCIENCES/PHYSICAL SCIENCES PROGRAM WITH HONS. IN ONE MAJOR DISCIPLINE)

B.Sc. (Life Sciences/Physical Sciences) with Hons. in Chemistry

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

WITH EFFECT FROM THE SESSION 2024-25

MAHARSHI DAYANAND UNIVERSITY ROHTAK (HARYANA)

SCHEME OF EXAMINATIONS FOR DISCIPLINE SPECIFIC COURSE OF LIFE SCIENCES/PHYSICAL SCIENCES PROGRAM WITH HONS. IN ONE MAJOR DISCIPLINE

B.Sc. (Life Sciences/Physical Sciences) with Hons. in CHEMISTRY

Semester I (Session 2024-25)															
Discipline Specific Courses/ Major Course			**Credits Distribution**			**Total Credits**	**Workload**			**Total Workload**	**Marks**				
	Nomenclature	**Course Code**	**L**	**T**	**P**		**L**	**T**	**P**		**Theory**		**Practical**		**Total Marks**
											Internal	**External**	**Internal**	**External**	
DSC - A1 @ 4 credits	Fundamental Chemistry-I	**24CHEM401DS01**	2	0	0	**04**	2	0	0	**06**	15	35	---	---	**100**
	Chemistry Practical (MD)-I		0	0	2		0	0	4		---	---	15	35	
Semester II (Session 2024-25)															
DSC - A2 @ 4 credits	Fundamental Chemistry-II	**24CHEM402DS01**	2	0	0	**04**	2	0	0	**06**	15	35	---	---	**100**
	Chemistry Practical (MD)-II		0	0	2		0	0	4		---	---	15	35	
Semester III (Session 2025-26)															
DSC – A3 @ 4 credits	Fundamental Chemistry-III	**25CHEM403DS01**	2	0	0	**04**	2	0	0	**06**	15	35	---	---	**100**
	Chemistry Practical (MD)-III		0	0	2		0	0	4		---	---	15	35	
Semester IV (Session 2025-26)															
DSC - A4 @ 4 credits	Fundamental Chemistry-IV	**25CHEM404DS01**	2	0	0	**04**	2	0	0	**06**	15	35	---	---	**100**
	Chemistry Practical (MD)-IV		0	0	2		0	0	4		---	---	15	35	
Semester V (Session 2026-27)															
DSC - A5 @ 4 credits	Fundamental Chemistry-V	**26CHEM405DS01**	2	0	0	**04**	2	0	0	**06**	15	35	---	---	**100**
	Chemistry Practical (MD)-V		0	0	2		0	0	4		---	---	15	35	

Semester VI (Session 2026-27)															
DSC -A6 @ 4 credits	Fundamental Chemistry-VI	**26CHEM406DS01**	2	0	0	**04**	2	0	0	**06**	15	35	---	---	**100**
	Chemistry Practical (MD)-VI		0	0	2		0	0	4		---	---	15	35	
Semester VII (Session 2027-28)															
DSC – H1 @ 4 credits	Coordination and Crystal Chemistry	**24CHE201DS01**	4	0	0	**04**	4	0	0	**04**	30	70	---	---	**100**
DSC – H2 @ 4 credits	Quantum, Thermodynamics and Electrochemistry	**24CHE201DS02**	4	0	0	**04**	4	0	0	**04**	30	70	---	---	**100**
DSC – H3 @ 4 credits	Organic Bonding, Reactions and Stereochemistry	**24CHE201DS03**	4	0	0	**04**	4	0	0	**04**	30	70	---	---	**100**
DSC – H4 @ 4 credits	Inorganic Chemistry Practical – I	**24CHE201DS04**	0	0	4	**04**	0	0	8	**08**	---	---	30	70	**100**
DSC – H5 @ 4 credits	Physical Chemistry Practical – I	**24CHE201DS05**	0	0	4	**04**	0	0	8	**08**	---	---	30	70	**100**

STUDENT SHOULD SELECT ANYONE OPTION FOR THE 8TH SEM. OF THE UG PROGRAMME Semester VIII (Session 2027-28) **OPTION-I**															
DSC – H6 @ 4 credits	Inorganic Spectroscopy and Advanced Inorganic Chemistry	**24CHE202DS01**	4	0	0	**04**	4	0	0	**04**	30	70	---	---	**100**
DSC – H7 @ 4 credits	Physical Spectroscopy and Advanced Physical Chemistry	**24CHE202DS02**	4	0	0	**04**	4	0	0	**04**	30	70	---	---	**100**
DSC – H8 @ 4 credits	Organic Spectroscopy and Advanced Organic Chemistry	**24CHE202DS03**	4	0	0	**04**	4	0	0	**04**	30	70	---	---	**100**
DSC – H9 @ 4 credits	Inorganic Chemistry Practical - II	**24CHE202DS04**	0	0	4	**04**	0	0	8	**08**	---	---	30	70	**100**
DSC – H10 @ 4 credits	Physical Chemistry Practical - II	**24CHE202DS05**	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**
Research Project/ Dissertation @12 credits	Research Project /Dissertation	**27CHE408PD01**	0	0	12	**12**	0	0	24	**24**	---	---	---	---	**300**

Note: The Syllabi and Scheme of Examinations (SOE) for Discipline Specific Courses/Major Courses for UG Semester- VII and Semester VIII will be same as applicable for Syllabi and S.O.E. for Post Graduate semester-I and semester-II respectively.

Note:

1) Health Risk Allowance may be recommended.

2) Practical Groups: 15 students per Group (B.Sc. 1st, 2nd and 3rd Year)

3) Workload: B.Sc. Physical Sciences – 20 Hours/Week

Syllabi for Discipline Specific Course offered by Department of Chemistry

B.Sc. (Life Sciences/Physical Sciences) with Hons. in Chemistry

Semester — I (Session: 2024- 25)

Name of Program	**B.Sc. (Life Sciences/Physical Sciences)**	**Program Code**	**UMLS4 or UMPS4**
Paper No.	**Paper – I**	**Nomenclature**	**Fundamental Chemistry – I**
Name of the Course	**Discipline Specific Course**	**Course Code**	**24CHEM401DS01**
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 basic knowledge about ionic, covalent and metallic bonding and explains that chemical bonding is best regarded as a continuum between the three cases. It further discusses the patterns and trends exhibited by p-block elements and their compounds with emphasis on structure, synthesis, bonding and uses. The aim of this course is also to make students understand the ideal and real gas behaviour. 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 nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing seven short answer type questions covering the entire syllabus. Further, examiner will set two questions from each unit and the candidates will be required to attempt one question from each unit. All questions will carry equal marks.

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

CLO1: Develop the ability to predict and explain the shapes of simple inorganic molecules and ions using the hybridization, VB and MO theories.

CLO2: Demonstrate problem-solving skills related to ionic bonding, including the calculation of percentage ionic character from dipole moment and electronegativity difference.

CLO3: Discuss the structure, bonding and properties of important compounds and complexes of p-block elements.

CLO4: Understand the concept of acid-base reactions in aqueous and non-aqueous solvents.

CLO5: Derive mathematical expressions for different properties of real and ideal gases and also understand their physical significance.

CLO6: Explain the behaviour of real gases and the concept of gas equations.

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

Chemical Bonding and Molecular Structure

Ionic bond, lattice energy, Born-Haber cycle and its applications, Fajan's rules, hydration energy, bond moment, dipole moment and percentage ionic character. Resonance and resonance energy: study of some inorganic and organic compounds. Molecular Orbital Approach: LCAO method, bonding and antibonding MOs and their characteristics for s-s, s-p and p-p combination of atomic orbitals, non- bonding combination

of orbitals, MO treatment of homonuclear diatomic molecules of 1st and 2nd periods (including idea of s-p mixing) and heteronuclear diatomic molecules such as O_2^-, O_2^{2-}, N_2^-, CO, NO^+, CN^-. Comparison of VB and MO approaches.

Unit–II

p-Block Elements

Oxides – structures of oxides of N, P. Oxyacids – structure and relative acid strengths of oxyacids of nitrogen and phosphorus. Structure of white, yellow and red phosphorus. Oxyacids of sulphur – structures and acidic strength, H_2O_2–structure, properties and uses. Basic properties of halogen, interhalogen compounds-types and properties, halogen-acids and oxyacids of chlorine – structure and comparison of acidic strength.

Acids and Bases: Brönsted–Lowry concept, conjugate acids and bases, relative strengths of acids and bases, effects of substituent and solvent, differentiating and levelling solvents. Lewis acid-base concept, classification of Lewis acids and bases, Lux-Flood concept.

Unit–III

Gaseous States

Maxwell's distribution of velocities and energies (derivation excluded), calculation of root mean square velocity, average velocity and most probable velocity. Collision diameter, collision number, collision frequency and mean free path, deviation of real gases from ideal behaviour, derivation of Van der Waals Equation of state and its applications in the calculation of Boyle's temperature (compression factor), explanation of behavior of real gases using Van der Waals equation.

Critical Phenomenon: Critical temperature, critical pressure, critical volume and their determination. PV isotherms of real gases, continuity of states, isotherms of Van der Waals equation, relationship between critical constants and Van der Waals constants, compressibility factor. Law of corresponding states.

Unit–IV

Basics of Organic Chemistry and Stereochemistry

Electronic displacements and its applications, reaction intermediates and concept of aromaticity. Concept of isomerism, types of isomerism, optical isomerism, optical activity, elements of symmetry, molecular chirality, enantiomers, stereogenic centre, properties of enantiomers, chiral and achiral molecules with two stereogenic centres, diastereomers, threo and erythro diastereomers, meso compounds, resolution of enantiomers, inversion, retention and racemization, relative and absolute configuration, sequence rules, R & S system of nomenclature.

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. Mc Daniel and J. J. Alexander.
4. Physical Chemistry by P. W. Atkins and J. de Paula.
5. A Textbook of Physical Chemistry (Vol. 1) by K. L. Kapoor.
6. Organic Chemistry by R. T. Morrison and R. N. Boyd.
7. Basic Organic Chemistry by R. Chandra, S. Singh and A. Singh.
8. Stereochemistry of Organic Compounds by E. L. Eliel and S. H. Wilen.

Name of Program	B.Sc. (Life Sciences/Physical Sciences)	Program Code	UMLS4 or UMPS4
Paper No.	Paper – I	Nomenclature	Chemistry Practical (MD) – I
Name of the Course	Discipline Specific Course	Course Code	24CHEM401DS01
Credits	02	Maximum Marks	50
Hours per Week	04	External Marks	35
Duration of Examination	04 Hrs.	Internal Marks	15

Course Objectives: This course aims to provide a fundamental knowledge of acidity, basicity and redox reaction. It further develops a clear understanding of principle of Abbe's refractometer, refractive index and its determination. 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*.** **(12×2) Marks**

Course Learning Outcomes (CLO): By the end of the course, the students will be able to:
CLO1: Prepare different types of solutions.
CLO2: Estimate the strength of various unknown solution in acid-base and redox titrations.
CLO3: Explain the principle, calibration and procedure of Abbe's refractometer for determining the refractive index.
CLO4: Determine the refractive index by using Abbe's refractometer.
CLO5: Calibrate thermometer and can determine the B.P. and M.P. of organic compounds.
CLO6: Learn preparation and purification of organic compounds.

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. Redox titrations: 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 and n-hexane by using Abbe's refractometer.

(ii) Determine the specific refraction of given liquids: Ethyl acetate, benzene, ethylene dichloride, chloroform, water and n-hexane by using Abbe's refractometer.

Unit–III (Organic)

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

(i) Water

(ii) Alcohol

(iii) Alcohol-Water

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

(i) Dibenzalacetone from acetone and benzaldehyde.

(ii) Phenylhydrazone of cyclohexanone.

Viva-Voce **(06 Marks)**

Note Book **(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 D. A. Skoog, F. J. Holler, and S. R. Crouch. 9. Senior Practical Physical Chemistry by B. D. Khosla.

Semester — II (Session: 2024- 25)

Name of Program	**B.Sc. (Life Sciences/Physical Sciences)**	**Program Code**	**UMLS4 or UMPS4**
Paper No.	**Paper – II**	**Nomenclature**	**Fundamental Chemistry – II**
Name of the Course	**Discipline Specific Course**	**Course Code**	**24CHEM402DS01**
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 develop basic understanding of the non-aqueous solvents, noble gases, laws of thermodynamics & hydrocarbons. It discusses about the structure of noble gases, their properties and their use in daily life as well as industrial applications. This makes students understand thermodynamic concepts, terminology, properties of thermodynamic systems, laws of thermodynamics and their correlation with other branches of physical chemistry. This also includes the concept, structure, methods of preparation and reactions for the following classes of compounds: alkanes, alkenes, alkynes, dienes and aromatic hydrocarbons.

Note: Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing seven short answer type questions covering the entire syllabus. Further, examiner will set two questions from each unit and the candidates will be required to attempt one question from each unit. All questions will carry equal marks.

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

CLO1: Understand the basic characteristics and reactions in non-aqueous solvents.

CLO2: Learn about the structure of noble gases, their properties and discuss their use in daily life as well as industrial applications.

CLO3: Derive the expressions of various thermodynamic potentials for ideal and real gases under different conditions.

CLO4: Understand the concept of entropy and change in entropy by changing different thermodynamic variables.

CLO5: Understand basic chemistry of alkanes and alkenes and alkynes.

CLO6: Describe the structure of alkenes, including the concept of cis-trans isomerism and geometric isomerism.

CLO7: Define and explain the concept of aromaticity and apply Huckel's rule to determine the aromatic character of various compounds.

CLO8: Learn and identify many organic reaction mechanisms including free radical substitution, electrophilic addition and electrophilic aromatic substitution.

Unit–I

Non-aqueous Solvents

Physical properties of a solvent, types of solvents and their general characteristics, solvent system concept, reactions in non-aqueous solvents with reference to liquid NH_3 and liquid SO_2. Hard and soft acids and bases (HSAB concept), applications of HSAB principle.

Noble Gases

Occurrence and uses, rationalization of inertness of noble gases, clathrates, preparation and properties, chemical properties of the noble gases, chemistry of xenon: structure and bonding in xenon fluorides, oxides and oxyfluorides (XeF_2, XeF_4, XeF_6, XeO_3, XeO_4, $XeOF_2$, XeO_2F_2, $XeOF_4$, XeF_5^+, XeF_5^-), nature of bonding in noble gas compounds (valence bond treatment and MO treatment for XeF_2 and XeF_4), molecular shapes of noble gas compounds (VSEPR theory).

Unit–II

Thermodynamics

Brief discussion upto first law of thermodynamics, heat capacity, heat capacities at constant volume and pressure and their relationship. Joule's law, Joule–Thomson coefficient for ideal gases and real gases and inversion temperature, calculation of work and heat, dU & dH for the expansion of ideal gases and real gases under isothermal and adiabatic conditions for reversible and irreversible processes, enthalpy and internal energy change at constant P, V &T, Kirchhoff's equation.

Second law of thermodynamics and its limitations, different statements of the law, Carnot's cycle and its efficiency, Carnot's theorem, thermodynamics scale of temperature. Concept of entropy– entropy as a state function, entropy change in ideal gases, entropy as a function of V & T, entropy as a function of P & T, entropy as a function of P & V, entropy as a criterion of spontaneity and equilibrium.

Unit–III

Hydrocarbons

Alkanes: Physical and chemical properties of alkanes, free radical substitutions, halogenation, concept of relative reactivity v/s selectivity.

Alkenes: Structure and isomerism, general methods of preparation, physical and chemical properties. Mechanism of E1, E2, E1cb reactions, Saytzeff and Hoffmann elimination, electrophilic addition (mechanism with suitable examples), Markownikoff rule, *syn* and *anti*-addition, addition of H_2, X_2 oxymercuration-demercuration, hydroboration- oxidation, ozonolysis, hydroxylation.

Alkynes: General methods of preparation, reactions of alkynes: acidity, electrophilic and nucleophilic additions, hydration to form carbonyl compounds, alkylation of terminal alkynes.

Unit–IV

Aromatic Hydrocarbons and Dienes

Concept of aromaticity, Huckel's 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, nomenclature and classification of dienes: isolated, conjugated and cumulated dienes. Structure of butadiene, chemical reactions- 1, 2 and 1, 4 additions (electrophilic and free radical mechanism), Diels – Alder reaction.

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. Principles of Inorganic Chemistry by B. R. Puri, L. R. Sharma and K. C. Kalia.
4. Principles of Physical Chemistry by B. R. Puri, L. R. Sharma and M. S. Pathania.

5. An Introduction to Chemical Thermodynamics by R. P. Rastogi and R. R. Mishra.
6. A Textbook of Physical Chemistry (Vol. 2) by K. L. Kapoor.
7. Organic Chemistry by T. W. G. Solomons, C. B. Fryhle and S. A. Snyder.
8. Organic Chemistry by P. Y. Bruice.
9. Organic Chemistry by J. Clayden, N. Greeves and S. Warren.

Name of Program	**B.Sc. (Life Sciences/Physical Sciences)**	**Program Code**	**UMLS4 or UMPS4**
Paper No.	**Paper – II**	**Nomenclature**	**Chemistry Practical (MD) – II**
Name of the Course	**Discipline Specific Course**	**Course Code**	**24CHEM402DS01**
Credits	**02**	**Maximum Marks**	**50**
Hours per Week	**04**	**External Marks**	**35**
Duration of Examination	**04 Hrs.**	**Internal Marks**	**15**

Course Objectives: The objective of this paper is to provide basic understanding of the fundamental principles of iodometric, complexometric and redox titrations. The course illustrates the diversity and fascination of physical chemistry through the study of viscosity and refractive index measurements. The students will learn about the preparation and purification of organic compounds through crystallization. This course also disseminates the concepts and methodology of sublimation process.

***Note: Examiner will set two experiments for practical examinations*.** **(12×2) Marks**

Course Learning Outcomes (CLO): By the end of the course, the students will be able to:
CLO1: Learn preparation of various solutions.
CLO2: Estimate the ions by iodometric and complexometric titrations.
CLO3: Understand the principle of viscometry and the concepts of relative and absolute viscosity.
CLO4: Determine the viscosity and molar refraction.
CLO5: Explore preparation and purification of organic compounds through crystallization method.
CLO6: Explain the concept and principle of sublimation, including the conditions under which sublimation occurs.

List of Experiments

Unit–I (Inorganic)

1. Volumetric Analysis

(i) **Iodometric titrations:** Determination of Cu^{2+} (using standard hypo solution).

(ii) **Complexometric titrations:** Determination of Ca^{2+}, Mg^{2+}, Zn^{2+} by EDTA.

2. Determination of water of crystallization in mohr's salt and oxalic acid by redox titration with $KMnO_4$.

Unit–II (Physical)

1. Viscometry

(i) Determine the relative and absolute viscosity of given liquid at room temperature by using Wilhelm Ostwald viscometer.

(ii) Determine the viscosity coefficient of given solution by using Wilhelm Ostwald viscometer.

2. Refractometry

(i) Determine the molar refraction of given liquids: Ethyl acetate, benzene, ethylene dichloride, chloroform, water, n-hexane by using Abbe's refractometer.

Unit–III (Organic)

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

(i) *m*-Dinitrobenzene from nitrobenzene.

(ii) Iodoform from ethanol (or acetone).

2. Study the process of sublimation of camphor and phthalic acid. 3. Determination of boiling point of liquid compounds (by distillation method).
Viva-Voce **(06 Marks)**
Note Book **(05 Marks)**

Semester — III (Session: 2025- 26)

Name of Program	**B.Sc. (Life Sciences/Physical Sciences)**	**Program Code**	**UMLS4 or UMPS4**
Paper No.	**Paper – III**	**Nomenclature**	**Fundamental Chemistry – III**
Name of the Course	**Discipline Specific Course**	**Course Code**	**25CHEM403DS01**
Credits	**02**	**Maximum Marks**	**50**
Hours per Week	**02**	**External Marks**	**35**
Duration of Examination	**02 Hrs.**	**Internal Marks**	**15**

Course Objectives: The students will learn about general characteristics of transition metal and about the concept of partial molar properties. In electrochemical cells, the students will learn about electrolytic and galvanic cells, measurement of conductance and its applications, measurement of emf and its applications. It is designed in a manner to give a better understanding of the organic functional groups, which include halogenated hydrocarbons. This course helps the students to relate the structure of an organic compound to its physical and chemical properties.

Note: Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing seven short answer type questions covering the entire syllabus. Further, examiner will set two questions from each unit and the candidates will be required to attempt one question from each unit. All questions will carry equal marks.

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

CLO1: Understand the general characteristics of transition metals.
CLO2: Analyse spectral and magnetic properties of transition metal compounds.
CLO3: Explain the concept of partial molar properties and use the concepts learned to predict the feasibility of chemical reactions.
CLO4: Analyse how Gibbs function (G) and Helmholtz function (A) vary with pressure (P), volume (V) and temperature (T).
CLO5: Explain the factors that affect conductance, migration of ions and application of conductance measurement.
CLO6: Understand concept of pH and its effect on the various physical and chemical properties of the compounds.
CLO7: Learn the working of electrochemical cells using different electrodes.
CLO8: Understand preparation, properties and reactions of haloalkanes and haloarenes.

Unit–I

Chemistry of Transition series elements

General characteristics of transition metals, brief discussion of differences between the first, second and third transition series, stability of various oxidation states, magnetic and spectral properties. Binary compounds and complexes illustrating relative stability of their oxidation states. Chemistry of Ti, V, Cr, Mn, Fe, Co, Mo and W in various oxidation states, some important compounds as laboratory reagents: potassium dichromate, potassium permanganate, potassium ferrocyanide, potassium ferricyanide, sodium nitroprusside and sodium cobaltinitrite.

Unit–II

Thermodynamics-II

Third law of thermodynamics: Nernst heat theorem, concept of residual entropy, evaluation of absolute entropy from heat capacity data. Gibbs and Helmholtz functions, Gibbs function (G) and Helmholtz function (A) as thermodynamic quantities, A & G as criteria for spontaneity, thermodynamic equilibrium and their advantage over entropy change. Variation of G and A with P, V and T. Partial molar quantities.

Unit–III

Electrochemistry

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 Hittorf's methods. Electrolytic conduction, factors affecting electrolytic conduction. Applications of conductivity measurements: determination of dissociation constant (Ka) and degree of dissociation, determination of solubility product of sparingly soluble salts, conductometric titrations. Definition of pH and pKa, buffer solution, buffer action, Henderson – Hasselbalch equation, buffer mechanism of buffer action.

Reversible electrodes – Metal- metal ion gas electrode, metal – metal insoluble salt- anion electrode and redox electrode.

Unit–IV

Alkyl and aryl halides

Alkyl halide: Nomenclature and classes of alkyl halides, general methods of preparation, physical properties and chemical reactions, mechanisms (SN1, SN2, E1, E2 and E1cb) and stereochemistry of nucleophilic substitution reactions of alkyl halides with energy profile diagrams, elimination vs substitution reactions.

Aryl halides: Methods of preparation, Reactions: Aromatic nucleophilic substitution and effect of substituents on reactivity. Benzyne Mechanism: KNH_2/NH_3 (or $NaNH_2/NH_3$), reactivity and relative strength of C-halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides.

Books Recommended/References:

1. Principal of Inorganic Chemistry- P. S. Kalia, B. R. Puri, L. R. Sharma and K. C. Kalia.
2. Coordination Chemistry by A. Kumar.
3. Inorganic Chemistry- Principles of Structure and Reactivity by J. E. Huheey, E. A. Keiter, R. L. Keiter and O. K. Medhi.
4. An Introduction to Chemical Thermodynamics by R. P. Rastogi and R. R. Mishra.
5. Principles of Physical Chemistry by B. R. Puri, L. R. Sharma and M. S. Pathania.
6. A Textbook of Physical Chemistry (Vol. 3) by K. L. Kapoor.
7. Organic Chemistry by R. T. Morrison and R. N. Boyd.
8. Organic Chemistry by I. L. Finar.
9. Intermediate for Organic Synthesis by V. K. Ahluwalia, P. Bhagat, R. Aggarwal and R. Chandra.
10. Organic Chemistry by T. W. G. Solomons, C. B. Fryhle and S. A. Snyder.

Name of Program	**B.Sc. (Life Sciences/Physical Sciences)**	**Program Code**	**UMLS4 or UMPS4**
Paper No.	**Paper – III**	**Nomenclature**	**Chemistry Practical (MD) – III**
Name of the Course	**Discipline Specific Course**	**Course Code**	**25CHEM403DS01**
Credits	**02**	**Maximum Marks**	**50**
Hours per Week	**04**	**External Marks**	**35**

Duration of Examination	**04 Hrs.**	**Internal Marks**	**15**

Course Objectives: This course aims to make the students understand gravimetric analysis, inorganic synthesis, surface tension and conductometric measurements. It aims to build the concept of identification of simple organic compounds including the detection of extra elements, functional groups, determination of melting or boiling points and preparation of their derivatives.

***Note: Examiner will set two experiments for practical examinations*.** **(12×2) Marks**

Course Learning Outcomes (CLO): By the end of the course, the students will be able to:
CLO1: Understand quantitative estimation of ions using gravimetric analysis.
CLO2: Describe the chemical reactions involved in the preparation some inorganic compounds.
CLO3: Determine the surface tension by using drop number method.
CLO4: Measure the specific conductance, equivalent and molar conductance of given electrolyte solutions.
CLO5: Determine the solubility and enthalpy of neutralization.
CLO6: Learn identification of organic compounds and preparation of their derivatives.

List of Experiments

Unit–I (Inorganic)

1. Gravimetric Analysis

(i) Quantitative estimations of Cu^{2+} as copper thiocyanate and Ni^{2+} as Nickel bis(dimethylglyoxime).

2. Preparations:

(i) Tetra ammine copper (II) sulphate.

(ii) Chromium (III) potassium sulphate (chrome alum).

(iii) Potassium tris (oxalato) chromate (III).

Unit–II (Physical)

1. Surface tension

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

2. Conductometry

(i) Determine the cell constant of the conductivity cell.

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

Unit–III (Organic)

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 the following simple organic compounds:

Naphthalene, anthracene, acenaphthene, benzyl chloride, *p*-dichlorobenzene, *m*-dinitrobenzene, *p*-nitrotoluene, resorcinol, hydroquinone, α-naphthol, β-naphthol, benzophenone, ethyl methyl ketone.

Viva-Voce **(06 Marks)**

Note Book **(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. (Life Sciences/Physical Sciences)**	**Program Code**	**UMLS4 or UMPS4**
Paper No.	**Paper – IV**	**Nomenclature**	**Fundamental Chemistry – IV**
Name of the Course	**Discipline Specific Course**	**Course Code**	**25CHEM404DS01**
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 students to coordination compounds, their magnetic properties and thermodynamic and kinetic aspects of metal complexes. It includes the kinetics of chemical reaction and chemical equilibrium. It acquaints the students with the functional group approach to study organic chemistry. This course helps the students to understand preparation, properties and reactions of oxygen containing functional groups.

Note: Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing seven short answer type questions covering the entire syllabus. Further, examiner will set two questions from each unit and the candidates will be required to attempt one question from each unit. All questions will carry equal marks.

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

CLO1: Explain the coordination compounds–its nomenclature, theories, d-orbital splitting in complexes, chelate.
CLO2: Understand the qualitative ideas of valence bond theory.
CLO3: Understand the crystal field splitting theory and spectrochemical series.
CLO4: Know about the magnetic, spectral properties and stereochemistry of transition metals.
CLO5: Learn about various theories of reaction rates and how these account for experimental observations.
CLO6: Understand the law of chemical equilibrium, applications of Le Chatelier's principle and the Clapeyron and Clausius-Clapeyron equations.
CLO7: Have understand about chemical equilibrium and its various equations.
CLO8: Understand preparation, properties and reactions of oxygen containing functional groups.

Unit–I

Coordination Compounds

Coordination compounds, ligands, coordination number, oxidation states, coordination entity, IUPAC nomenclature of coordination compounds, isomerism in coordination compounds with coordination numbers 4 and 6. Chelates and chelate effect, Valence bond theory and its application to complexes of coordination numbers 4 and 6. Examples of inner and outer orbital complexes, limitations of VBT. Basic idea of Crystal field theory.

Unit–II

Magnetic Properties of Transition Metal Complexes

Types of magnetic behavior, methods of determining magnetic susceptibility, spin-only formula. L-S coupling, correlation of μ_s and μ_{eff} values, orbital contribution to magnetic moments, applications 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).

Unit–III

Kinetics and Chemical Equilibrium

Integrated rate expression for first, second and third order reaction and their half-life period. Methods of determination of order of reaction. 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.

Equilibrium constant and free energy, concept of chemical potential, thermodynamic derivation of law of chemical equilibrium. Temperature dependence of equilibrium constant, Van't Hoff reaction isochores, Van't Hoff reaction isotherm. Le-Chatelier's principle and its applications, Clapeyron equation and Clausius – Clapeyron equation & its applications.

Unit–IV

Alcohols, Phenols and Ethers

Alcohols: General methods of preparation using Grignard reagent, ester hydrolysis, reduction of aldehydes, ketones, carboxylic acid and esters. Reactions: with sodium, HX (Lucas test), esterification, oxidation (with PCC, alk. $KMnO_4$, acid. dichromate, con. HNO_3). Oppeneauer oxidation. Diols: Oxidation of diols. Pinacol-Pinacolone rearrangement.

Phenols: Methods of preparation, physical properties and acidic character. Reactions: electrophilic substitution (nitration, halogenation and sulphonation). Reimer-Tiemann reaction, Gattermann-Koch reaction, Houben-Hoesch condensation, Schotten-Baumann reaction.

Ethers (aliphatic and aromatic): Cleavage of ethers with HI.

Books Recommended/References:

1. Coordination Chemistry by A. Kumar.
2. Inorganic Chemistry- Principles of Structure and Reactivity by J. E. Huheey, E. A. Keiter, R. L. Keiter and O. K. Medhi.
3. Chemical Kinetics by K. J. Laidler.
4. A Textbook of Physical Chemistry (Vol. 5) by K. L. Kapoor.
5. Physical Chemistry by P. W. Atkins and J. Paula.
6. Organic Chemistry by R. T. Morrison and R. N. Boyd.
7. Organic Chemistry by I. L. Finar.
8. Intermediate for Organic Synthesis by V. K. Ahluwalia, P. Bhagat, R. Aggarwal, R. Chandra.
9. Organic Chemistry by T. W. G. Solomons, C. B. Fryhle, S. A. Snyder.

Name of Program	**B.Sc. (Life Sciences/Physical Sciences)**	**Program Code**	**UMLS4 or UMPS4**
Paper No.	**Paper – IV**	**Nomenclature**	**Chemistry Practical (MD) – IV**
Name of the Course	**Discipline Specific Course**	**Course Code**	**25CHEM404DS01**
Credits	**02**	**Maximum Marks**	**50**
Hours per Week	**04**	**External Marks**	**35**
Duration of Examinations	**04 Hrs.**	**Internal Marks**	**15**

Course Objectives: The objective of this course is to make students aware of the concept of Beer-Lambert law, complexometric titration, conductometer and critical solution temperature (CST). Students will be able to identify the extra elements and functional groups in the organic compounds. The practicals expose students to latest instrumentation and they learn to detect analytes in a mixture.

***Note: Examiner will set two experiments for practical examination*.** **(12×2) Marks**

Course Learning Outcomes (CLO): By the end of the course, the students will be able to:
CLO1: Understand practical handling of colorimeter.
CLO2: Get practical knowledge about complexometric titrations and inorganic preparations.
CLO3: Determine strength of given acid by conductometrically.
CLO4: Determine critical solution temperature (CST) of given solution.
CLO5: Explore identification of organic compounds.
CLO6: Understand the significance of derivative formation in confirming the identity of organic compounds.

List of Experiments

Unit–I (Inorganic)

1. Colorimetry

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

2. Complexometric titrations: Determination of Zn^{2+}, Ca^{2+} by EDTA.

3. Preparations: Preparation of cuprous chloride, prussian blue from iron fillings.

Unit–II (Physical)

1. Conductometry

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

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

2. Solution: Determine critical solution temperature

(i) Water - phenol system.

(ii) Water - aniline system.

Unit–III (Organic)

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 the following simple organic compounds:

Benzaldehyde, vanillin, oxalic acid, succinic acid, benzoic acid, salicylic acid, aspirin, phthalic acid, cinnamic acid, benzamide, urea, acetanilide, benzanilide, aniline hydrochloride, p-toluidine, phenyl salicylate (salol), glucose, fructose, sucrose, o-, m-, p-nitroanilines, thiourea.

Viva-Voce **(06 Marks)**

Note Book **(05 Marks)**

Books Recommended/References:

1. B.Sc. Chemistry Practical by S. Goyal
2. Vogel's Qualitative Inorganic Analysis by G. Svehla.
3. Synthesis and Characterization of Inorganic Compounds by W. L. Jolly.
4. Advanced Practical Physical Chemistry by J. B. Yadav.
5. 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 — V (Session: 2026- 27)

Name of Program	**B.Sc. (Life Sciences/Physical Sciences)**	**Program Code**	**UMLS4 or UMPS4**
Paper No.	**Paper – V**	**Nomenclature**	**Fundamental Chemistry – V**
Name of the Course	**Discipline Specific Course**	**Course Code**	**26CHEM405DS01**
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 organometallic compounds which are currently frontier areas of chemistry providing an interface between organic chemistry & inorganic chemistry. This also makes the students understand the limitations of classical mechanics and the need of quantum chemistry. The functional group approach to organic chemistry introduced in the previous courses is reinforced through the study of the chemistry of carbonyl compounds and carboxylic acids. This course also deals with some classes of organic compounds finding applications in everyday life namely carbohydrates and dyes.

Note: Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing seven short answer type questions covering the entire syllabus. Further, examiner will set two questions from each unit and the candidates will be required to attempt one question from each unit. All questions will carry equal marks.

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

CLO1: Apply 18-electron rule to rationalize the stability of metal carbonyls and related species.
CLO2: Understand the nature of Zeise's salt and compare its synergic effect with that of carbonyls.
CLO3: Learn about limitations of classical mechanics in terms of quantum mechanics for atomic/molecular systems.
CLO4: Develop an understanding of quantum mechanical operators, quantization, probability distribution, uncertainty principle.
CLO5: Understand the preparation and chemical reactions of carbonyl compounds and carboxylic acids.
CLO6: Understand and describe the mechanisms of important carbonyl compound reactions.
CLO7: Gain an understanding of the types, structures, properties and fundamental chemistry of carbohydrates.
CLO8: Explain the classification, chemistry, synthesis and applications of synthetic dyes.

Unit–I

Organometallic Chemistry

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) π bond compounds including sandwich derivatives. Structure and bonding in metal-ethylenic, metal-acetylenic complexes, metal carbonyls and cyclopentadienyl derivative. Properties and bonding of alkyls of Li, Al, Hg and Sn, concept of hapticity of organic ligand, Zeise salt and ferrocene. EAN rule applied to carbonyls. Preparation, structure, bonding and properties of mononuclear and polynuclear carbonyls of 3d metals. π – acceptor behavior of carbon monoxide. Synergic effects (VB approach, MO diagram of CO can be referred for synergic effect to IR frequencies). Applications of organometallic compounds.

Unit–II

Quantum Mechanics-I

Black-body radiation, Plank's radiation law, photoelectric effect, heat capacity of solids, Compton effect, wave function and its significance, postulates of quantum mechanics, quantum mechanical operator, commutation relations, Hamiltonian operator, Hermitian operator, average value of square of Hermitian as a positive quantity, role of operators in quantum mechanics, Heisenberg uncertainty principle.

Unit–III

Carbonyl Compounds and Carboxylic acid derivatives

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). 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.

Unit–IV

Carbohydrates

Classification and nomenclature. Monosaccharides, mechanism of osazone formation, interconversion of glucose and fructose, chain lengthening and chain shortening of aldoses. Configuration of monosaccharides, erythro and threo diastereomers. Conversion of glucose into mannose. Formation of glycosides, ethers and esters. Determination of ring size of glucose and fructose. Open chain and cyclic structure of D(+) glucose & D(-) fructose. Mechanism of mutarotation, structures of ribose and deoxyribose.

An introduction to disaccharides (maltose, sucrose and lactose) and polysaccharides (starch and cellulose) without involving structure determination.

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. Coordination Chemistry by A. Kumar.
2. Inorganic Chemistry- Principles of Structure and Reactivity by J. E. Huheey, E. A. Keiter, R. L. Keiter; O. K. Medhi.
3. Concise Inorganic Chemistry by J. D. Lee.
4. Quantum Chemistry Classical to Computational by A. Dua.
5. Quantum Chemistry by R. K. Prasad.
6. Organic Chemistry by L. Finar.
7. Organic Chemistry by R. T. Morrison & R. N. Boyd.
8. Advanced Organic Chemistry by A. Bahl and B. S. Bahl.
9. A Guide Book to Mechanism in Organic Chemistry by P. Sykes.

Name of Program	**B.Sc. (Life Sciences/Physical Sciences)**	**Program Code**	**UMLS4 or UMPS4**
Paper No.	**Paper – V**	**Nomenclature**	**Chemistry Practical (MD) – V**
Name of the Course	**Discipline Specific Course**	**Course Code**	**26CHEM405DS01**
Credits	**02**	**Maximum Marks**	**50**
Hours per Week	**04**	**External Marks**	**35**
Duration of Examination	**04 Hrs.**	**Internal Marks**	**15**

Course Objectives: The aim of this course is to make students understand the concept of qualitative analysis, paper chromatography, pH metry and adsorption. Students are exposed to important separation methods like steam distillation and chromatography. The practicals expose the students to latest instrumentation and they learn to detect analytes in a mixture.

***Note: Examiner will set two experiments for practical examinations*.** **(12×2) Marks**

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

CLO1: Identify the cation and anion present in the salt sample using systematic qualitative analysis techniques.
CLO2: Explore estimation of various ions present in salt.
CLO3: Standardize the pH meter and can prepare the buffer solution.
CLO4: Learn about the adsorption phenomenon and its industrial applications.
CLO5: Get knowledge about laboratory techniques such as thin layer chromatography.
CLO6: Learn the various techniques and methodologies utilized in the preparation of organic compounds.

List of Experiments

Unit–I (Inorganic)

1. Analysis of one cation (NH_4^+, Ba^{2+}, Al^{3+}, Fe^{2+}, Pb^{2+}, Ni^{2+}, Zn^{2+}, Sr^{2+}, Na^+) **and one anion** (Cl^-, Br^-, I^-, F^-, NO_3^-, SO_4^{2-}, CH_3COO^-, $C_2O_4^{2-}$, NO_2^-, PO_4^{3-}, S^{2-}) in the salt.

2. Paper Chromatography

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

Unit–II (Physical)

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. Adsorption

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

Unit–III (Organic)

1. Chromatography

(i) Determination of R_f values and identification of organic compounds:

Separation of a mixture of coloured organic compounds using common organic solvents by TLC.

2. Synthesis of the following organic compounds

(i) Synthesize benzoic acid from ethyl benzoate.

(ii) Synthesize benzanilide from aniline.

(iii) Selective reduction of *m*-dinitrobenzene to *m*-nitroaniline.

(iv) Hydrolysis of amides and esters.

Viva-Voce **(06 Marks)**

Note Book **(05 Marks)**

Books Recommended/References:

1. B.Sc. Chemistry Practical by S. Goyal.
2. Vogel's Qualitative Inorganic Analysis by G. Svehla.
3. Advanced Practical Physical Chemistry by J. B. Yadav.
4. Advanced Physical Chemistry, Practical Handbook by G. Raj.
5. 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.
6. Practical Organic Chemistry by A. K. Manna.

Semester — VI (Session: 2026- 27)

Name of Program	**B.Sc. (Life Sciences/Physical Sciences)**	**Program Code**	**UMLS4 or UMPS4**
Paper No.	**Paper – VI**	**Nomenclature**	**Fundamental Chemistry – VI**
Name of the Course	**Discipline Specific Course**	**Course Code**	**26CHEM406DS01**
Credits	**02**	**Maximum Marks**	**50**
Hours per Week	**02**	**External Marks**	**35**
Duration of Examination	**02 Hrs.**	**Internal Marks**	**15**

Course Objectives: The student is familiarized with the d and f block elements and get an idea about horizontal similarity in a period in addition to vertical similarity in a group. Students also learn about bioinorganic chemistry. This course introduces the knowledge of the laws of absorption of light energy by molecules and the subsequent photochemical reactions. It will also make students understand the basics of molecular thermodynamics. This course introduces the learner to various tools and techniques for identifying and characterizing the organic compounds through their interactions with electromagnetic radiation viz. UV-Visible and IR spectroscopy.

Note: Examiner will set nine questions and the candidates will be required to attempt five questions in all. Question number one will be compulsory containing seven short answer type questions covering the entire syllabus. Further, examiner will set two questions from each unit and the candidates will be required to attempt one question from each unit. All questions will carry equal marks.

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

CLO1: Explore the role of metal ions in biological processes and their significance in living organisms.
CLO2: Understand the chemistry of f-block elements.
CLO3: Explain the different laws of photochemistry and photochemical processes.
CLO4: Understand the concept of quantum yield as a measure of the efficiency of photochemical reactions.
CLO5: Learn the basics of statistical thermodynamics.
CLO6: Explore the three main types of statistics used in statistical thermodynamics.
CLO7: Gain insight into the basic principles and applications of UV and IR.
CLO8: Analyse spectra, identify spectral features and comprehend molecular structure and bonding.

Unit–I

Bioinorganic Chemistry

Metal ions present in biological system, classification based on action (essential, non-essential, trace, toxic), Na/K-pump, carbonic anhydrase and carboxypeptidase. Excess and deficiency of some trace metals. Toxicity of metal ions (Hg, Pb, Cd and As), reasons for toxicity, use of chelating agents in medicine. Metalloporphyrins with special reference to hemoglobin and myoglobin. Biological role of Na^{+}, K^{+}, Ca^{+2}, Mg^{+2}, Fe^{+2} ions.

Chemistry of f-Block Elements

Lanthanides: Electronic structure, oxidation states and ionic radii and lanthanide contraction, complex formation, occurrence and isolation, lanthanide compounds.

Actinides: General features and chemistry of actinides, chemistry of separation of Np, Pu and Am from U, comparison of properties of lanthanides and actinides and transition elements.

Unit–II

Photochemistry

Interaction of radiation with matter, difference between thermal and photochemical processes. Laws of photochemistry: Grothus - Drapper law, Stark-Einstein law (law of photochemical equivalence) Jablonski diagram depicting various processes occurring in excited state, qualitative description of fluorescence,

phosphorescence, non-radiative processes (internal conversion, intersystem crossing), quantum yield, photosensitized reactions-energy transfer processes (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

Ultraviolet and Infra-Red spectroscopy

Ultraviolet absorption spectroscopy-absorption laws (Beer-Lambert law), molar absorptivity, presentation and analysis of UV spectra, types of electronic transitions, effect of conjugation, concept of chromophore and auxochrome. Bathochromic, hypsochromic, hyperchromic and hypochromic shifts.

Molecular vibrations, Hooke's law, selection rules, intensity and position of IR bands, measurement of IR spectrum, fingerprint region, characteristic absorptions of various functional groups and interpretation of IR spectra of simple organic compounds.

Books Recommended/References:

1. Coordination Chemistry by A. Kumar.
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 (Vol. 5) by K. L. Kapoor.
4. Principles of physical Chemistry by B. R. Puri, L. R. Sharma and M. S. Pathania.
5. Textbook of physical Chemistry by H. K. Moudgil.
6. Fundamentals of Photochemistry by K. K. Rohtagi and Mukherjee.
7. Introduction to Spectroscopy- A Guide for Students of Organic Chemistry by D. L. Pavia, G. M. Lampman and G. S. Kriz.

Name of Program	**B.Sc. (Life Sciences/Physical Sciences)**	**Program Code**	**UMLS4 or UMPS4**
Paper No.	**Paper – VI**	**Nomenclature**	**Chemistry Practical (MD) – VI**
Name of the Course	**Discipline Specific Course**	**Course Code**	**26CHEM406DS01**
Credits	**02**	**Maximum Marks**	**50**
Hours per Week	**04**	**External Marks**	**35**
Duration of Examination	**04 Hrs.**	**Internal Marks**	**15**

Course Objectives: This course encompasses detailed instruction on systematic mixture analysis, gravimetric analysis, preparation of salt bridge, setting of a galvanic cell, determination of its cell voltage, pH and potentiometric titration. Furthermore, students will be exposed to the synthesis of organic compounds and important separation methods like chromatography.

***Note: Examiner will set two experiments for practical examinations*.** **(12×2) Marks**

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

CLO1: Analyse the anion and cation present in unknown mixture.
CLO2: Get practical knowledge about gravimetric titrations.
CLO3: Prepare different types of salt bridge.
CLO4: Set the galvanic cell and can determine its cell voltage.
CLO5: Understand the principle, procedure and applications of steam distillation technique.

CLO6: Learn separation of mixtures of coloured organic compounds by using thin layer chromatography.

List of Experiments

Unit–I (Inorganic)

1. Analysis of mixture containing any 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 anion radicals).

2. Gravimetry

(i) Estimation of copper as CuSCN.

(ii) Estimation of iron as Fe_2O_3 by precipitating iron as $Fe(OH)_3$.

(iii) Estimation of Al (III) by precipitating with oxine and weighing as $Al(oxine)_3$ (aluminium oxinate).

Unit–II (Physical)

1. pH metry

(i) Determine the strength of HCl using NaOH pH metrically.

(ii) Determine the strength of CH_3COOH using NaOH 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/weak acid against strong base.

Unit–III (Organic)

1. Steam distillation (non evaluative)

(i) Naphthalene from its suspension in water.

(ii) Separation of o-and p-nitrophenols.

2. Chromatography Method

Determination of R_f values and identification of organic compounds:

(i) Separation of green leaf pigments (spinach leaves may be used) by paper chromatographic method.

Viva-Voce **(06 Marks)**

Note Book **(05 Marks)**

Books Recommended/References:

1. Vogel's Quantitative Chemical Analysis by J. Mendham.
2. Vogel's Qualitative Inorganic Analysis by G. Svehla.
3. Practical Chemistry by O. P. Pandey, D. N. Bajpai and S. Giri.
4. Senior Practical Physical Chemistry by B.D. Khosla.
5. Advanced Practical Physical Chemistry by J. B. Yadav.
6. Practical Organic Chemistry – A Primer by V. Peesapati.
7. Practical Organic Chemistry by A. K. Manna.
8. Principles of Instrumental Analysis: D. A. Skoog, F. J. Holler and S. R. Crouch.

B.Sc. 4th (4 Year UG Hons with Research in Chemistry)

Semester — VII (Session: 2027- 28)

Name of Program	**B.Sc. (Life Sciences/Physical Sciences)**	**Program Code**	**UMLS4 or UMPS4**
Paper No.	**Paper – VII**	**Nomenclature**	**Coordination and Crystal Chemistry**
Name of the Course	**Discipline Specific Course**	**Course Code**	**24CHE201DS01**
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 nine questions, and the candidates must attempt five questions. Out of nine questions, one question will be compulsory, containing seven 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, the 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. diagrams 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-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, 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. (Life Sciences/Physical Sciences)**	**Program Code**	**UMLS4 or UMPS4**
Paper No.	**Paper – VIII**	**Nomenclature**	**Quantum, Thermodynamics and Electrochemistry**
Name of the Course	**Discipline Specific Course**	**Course Code**	**24CHE201DS02**
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 nine questions, and the candidates must attempt five questions. Out of nine questions, one question will be compulsory, containing seven 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, the 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 1-D box and its pictorial representation, Schrodinger wave equation for a particle in a 3-D 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 3-D 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 solution 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 Vol.1 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. Modern chemical kinetics by H. Eyring.
8. Theories of Reaction Rates by K. J. laidler, H. Eyring and S. Glasstone.
9. Theoretical Chemistry by S. Glasstone.
10. Introduction to Quantum Mechanics by R. Chandra.

Name of Program	**B.Sc. (Life Sciences/Physical Sciences)**	**Program Code**	**UMLS4 or UMPS4**
Paper No.	**Paper – IX**	**Nomenclature**	**Organic Bonding, Reactions and Stereochemistry**
Name of the Course	**Discipline Specific Course**	**Course Code**	**24CHE201DS03**
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 nine questions, and the candidates must attempt five questions. Out of nine questions, one question will be compulsory, containing seven 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, the 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. (Life Sciences/Physical Sciences)**	**Program Code**	**UMLS4 or UMPS4**
Paper No.	**Chemistry Practical Paper – VII**	**Nomenclature**	**Inorganic Chemistry Practical – I**
Name of the Course	**Discipline Specific Course**	**Course Code**	**24CHE201DS04**
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, the 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: **(25 Marks)**

(a) Iodo/Iodimetric Titrations

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

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

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

(c) Potassium Bromate Titrations

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

(d) EDTA Titrations

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

(ii) Back titration.

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

(iv) Determination of hardness of water.

2. Green methods of preparation of the following: **(25 Marks)**

(i) Bis(acetylacetonato)copper(II)

(ii) Tris(acetylacetonato)iron(III)

(iii) Tris(acetylacetonato)managnese(III)

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

Viva-Voce **(10 Marks)**

Note Book **(10 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. (Life Sciences/Physical Sciences)	Program Code	UMLS4 or UMPS4
Paper No.	Chemistry Practical Paper – VIII	Nomenclature	Physical Chemistry Practical – I
Name of the Course	Discipline Specific Course	Course Code	24CHE201DS05
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, the 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 **(25 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 **(25 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 Solution 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 **(10 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. 3. Practical Physical Chemistry by S. R. Palit and S. K. Science. 4. Experimental Physical Chemistry by R. C. Das, B. S. Behera.

B.Sc. 4th (4 Year UG Hons with Research in Chemistry)

Semester — VIII (Session: 2027- 28)

(Option –I)

Name of Program	**B.Sc. (Life Sciences/Physical Sciences)**	**Program Code**	**UMLS4 or UMPS4**
Paper No.	**Paper – X**	**Nomenclature**	**Inorganic Spectroscopy and Advanced Inorganic Chemistry**
Name of the Course	**Discipline Specific Course**	**Course Code**	**24CHE202DS01**
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 and foster the ability to apply these methods to solve complex problems in the structural elucidation of inorganic compounds. It also introduces the important area of organometallic chemistry, including clusters. It is also infused with the magnetic properties and electronic spectra of transition metal complexes.

Note: Examiner will set nine questions, and the candidates must attempt five questions. Out of nine questions, one question will be compulsory, containing seven 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: Learn about the selection rules for electron absorption spectroscopy.
CLO2: Apply NMR techniques in the characterization of inorganic compounds.
CLO3: Understand the structure and bonding of various types of clusters.
CLO4: Know about the mingo's rule and wade's rule.
CLO5: Have the basic understanding of the electronic spectra of metal complexes.
CLO6: Explain the colour of transition metal complexes.
CLO7: Understand the elementary theory of magneto-chemistry.
CLO8: Explore the application of magneto-chemistry in structure determination.

Unit–I

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}HNMR, ^{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 site, identification of cis and trans isomers, structure elucidation of covalent molecules, H-bonding etc.

Unit–II

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 atoms, 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–III

Magnetic Properties of transition metal complexes: Elementary theory of magneto-chemistry, dia, para, ferro and antiferro magnetism, concept of magnetic susceptibility, methods for determination of magnetic susceptibility, Curie and Curie-Weiss law for temperature dependence of magnetic susceptibility, temperature independent paramagnetic, calculation of magnetic moments of metal ions $Cr^{3+,}$ Co^{3+}, Mn^{2+} and Fe^{2+}, Linde factor, μ_J and μ_{eff}, orbital contribution to the magnetic moment, quenching of magnetic moment by crystal-field, application of magneto-chemistry in structure determination, magnetic exchange coupling and spin state crossover in coordination compounds.

Unit–IV

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^2states), 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.

Books Recommended/References:

1. Physical Methods in Inorganic Chemistry by R.S. Drago.
2. Infrared Spectra of Inorganic and Coordination Compound by K. Nakamoto.
3. Inorganic Chemistry by C.E. Housecroft and A.G. Sharpe.
4. Inorganic Chemistry by Shriver and Atkins.
5. Basic Organometallic Chemistry: Concepts, Syntheses and Applications by B.D. Gupta and A.J. Elias.
6. Comprehensive Coordination and Organometallic Chemistry by D. Singh.
7. Spectroscopy (Vol. 2) by R.K. Malik.
8. Journal of Magnetic Resonance published by Elsevier, USA.
9. Magneto Chemistry by R.L. Carlin.
10. Introduction to Magneto Chemistry by A. Earnshasw.

Name of Program	**B.Sc. (Life Sciences/Physical Sciences)**	**Program Code**	**UMLS4 or UMPS4**
Paper No.	**Paper – XI**	**Nomenclature**	**Physical Spectroscopy and Advanced Physical Chemistry**
Name of the Course	**Discipline Specific Course**	**Course Code**	**24CHE202DS02**
Credits	**04**	**Maximum Marks**	**100**
Hours per Week	**04**	**External Marks**	**70**
Duration of Examination	**03 Hrs.**	**Internal Marks**	**30**

Course Objectives: This paper aims to learn how to analyse the fundamental principles of group theory and its applications in spectroscopy. It will also help the students gain proficiency in interpreting various spectroscopic techniques such as rotational, vibrational and electronic spectroscopy. This syllabus is also infused with the basic concepts of photochemistry. It also familiarizes the students with the principles of ion-selective electrodes and potentiometric methods in analytical chemistry.

Note: Examiner will set nine questions, and the candidates must attempt five questions. Out of nine questions, one question will be compulsory, containing seven 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: Learn about point symmetry groups for various molecules.
CLO2: Understand The Great Orthogonality theorem and its importance.
CLO3: Learn the basic principles of different types of spectroscopy.
CLO4: Understand and use basic rotational, vibrational and electronic spectroscopy concepts to interpret spectra.
CLO5: Know about the fundamentals of photochemistry.
CLO6: Understand the formation and decay of excimer and exciplex.
CLO7: Discuss applications of Lasers in photochemical kinetics.
CLO8: Understand the potentiometric methods and ion-selective electrodes.

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 forCn, Cnv, Cnh, Cs, Dnh, 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 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

Photochemistry: Basic concepts of photochemistry, rate constant & life time of excited electronic states of atoms and molecules, charge transfer transitions. Frank-Condon principle, emission spectra, environment effect on absorption and emission spectra, Wigner's spin conservation rule. Modes of decay of excited states, quenching of fluorescence, delayed fluorescence, kinetics of collisional quenching, Stern–Volmer equation. Excimer and exciplex formation and decay. Techniques for the study of transient species in photochemical reactions. Applications of Lasers in photochemical kinetics.

Unit–IV

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 the 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^-).

Books Recommended/References:

1. Chemical Applications of Group Theory by F. A. Cotton.
2. Fundamentals of Molecule Spectroscopy by C.N. Banwell.
3. Introduction to Magnetic Resonance Spectroscopy ESR, NMR, NQR by D. N. S. Narayana.
4. Physical Chemistry by P. Atkins and J. de Paula.
5. Fundamentals of Photochemistry by K.K. Rohtagi and Mukherjee.
6. Photochemistry by J.G. Calvert and J.N. Pitts.
7. Photochemistry and Spectroscopy by J.P. Simons.
8. Principles and Applications of Photochemistry by B. Ward.

Name of Program	**B.Sc. (Life Sciences/Physical Sciences)**	**Program Code**	**UMLS4 or UMPS4**
Paper No.	**Paper – XII**	**Nomenclature**	**Organic Spectroscopy and Advanced Organic Chemistry**
Name of the Course	**Discipline Specific Course**	**Course Code**	**24CHE202DS03**
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 learner to various tools and techniques for identifying and characterizing organic compounds through their interactions with electromagnetic radiation using UV-Visible, IR and NMR spectroscopy. It is also infused with a comprehensive understanding of diverse aliphatic and aromatic nucleophilic/electrophilic substitution reactions and their mechanisms. This course also deals with the reactions of carbonyl compounds with different reagents and pericyclic reactions, which have found significant applications in synthetic and industrial chemistry.

Note: Examiner will set nine questions, and the candidates must attempt five questions. Out of nine questions, one question will be compulsory, containing seven 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: On completion of the course, students will be able to:
CLO1: Gain insight into the basic principles of UV, IR and NMR spectroscopic techniques.
CLO2: Solve the problems based on UV, IR and NMR Spectroscopy to interpret structure.
CLO3: Identify and differentiate the aromatic and aliphatic nucleophilic substitution reactions.
CLO4: Learn about the different reaction mechanisms of substitution reactions.
CLO5: Compare the aliphatic and aromatic electrophilic substitution reactions.
CLO6: Understand reactions of carbonyl compounds with different reagents.
CLO7: Learn about the classification of pericyclic reactions.
CLO8: Understand and apply the Woodward-Hoffmann rules governing pericyclic reactions.

Unit–I

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–II

Aliphatic Nucleophilic Substitution: SN1, SN2, mixed SN1 and SN2, SNi, SN1', SN2', SNi' and SET mechanisms. Effects of substrate structure, attacking nucleophile, leaving group and reaction medium on reactivity. Neighbouring group mechanism, neighbouring group participation by σ- and π-bonds, anchimeric assistance. Ambident nucleophiles, regioselectivity and chemoselectivity.
Aromatic Nucleophilic Substitution: ArSN1, ArSN2, Benzyne and SRN1 mechanisms. Effect of substrate structure, leaving group and attacking nucleophile on reactivity. Von Richter and Smiles rearrangements.
Aliphatic Electrophilic Substitution: SE1, SE2 and SEi mechanism. Effect of substrates, leaving group and solvent polarity on the reactivity.
Aromatic Electrophilic Substitution: Reactivity in substrates and electrophiles, Vilsmeier reaction, Gattermann-Koch reaction.

Unit–III

Pericyclic Reactions: Molecular orbital symmetry, Frontier orbitals of ethylene, 1,3-butadiene, 1,3,5-hexatriene and allyl system. Classification of pericyclic reactions, Woodward Hoffmann correlation diagrams. Electrocyclic reactions - conrotatory and disrotatory motions, 4n, 4n+2, and allyl systems. Cycloadditions - antarafacial and suprafacial additions, 4n and 4n+2 systems. Sigmatropic rearrangements - suprafacial and antarafacial shifts of H, sigmatropic shifts involving carbon moieties, 3,3- and 5,5-sigmatropic rearrangements, Claisen and Cope rearrangements.

Unit-IV

Addition to Carbon-Hetero Multiple Bonds: Mechanism of metal hydride reduction of saturated and unsaturated carbonyl compounds. Addition of Grignard reagents, organozinc and organolithium reagents to carbonyl and unsaturated carbonyl compounds, Wittig reaction. Mechanism of condensation reactions involving enolates: Aldol, Knoevenagel, Claisen, Mannich, Benzoin, Perkin and Stobbe reactions. Hydrolysis of esters and amides, ammonolysis of esters.

Books Recommended/References:

1. Spectroscopic Identification of Organic Compounds by R. M. Silverstein, G. C. Bassler and T. C. Morrill.
2. Organic Spectroscopy Principles and Applications by Jag Mohan.
3. Organic Spectroscopy by D. L. Pavia, G. M. Lampman, G. A. Kriz and J. R. Vyvyan.

4. Advanced Organic Chemistry: Reactions, Mechanism and Structure by J. March.
5. Advanced Organic Chemistry by F. A. Carey and R. J. Sundberg.
6. Structure and Mechanism in Organic Chemistry by C. K. Ingold.
7. Principles of Organic Synthesis by R. O. C. Norman and J. M. Coxon.
8. Pericyclic Reactions: A Mechanistic Study by S. M. Mukherji.
9. The Conservation of Orbital Symmetry by R. B. Woodward and R. Hoffmann.

Name of Program	**B.Sc. (Life Sciences/Physical Sciences)**	**Program Code**	**UMLS4 or UMPS4**
Paper No.	**Chemistry Practical Paper – IX**	**Nomenclature**	**Inorganic Chemistry Practical – II**
Name of the Course	**Discipline Specific Course**	**Course Code**	**24CHE202DS04**
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, the 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 **(25 Marks)**

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

(i) Silver-Copper
(ii) Copper-Nickel
(iii) Copper-Zinc
(iv) Nickel-Zinc
(v) Copper-Iron
(vi) Copper-Nickel (Both gravimetrically)
(vii) Barium-Calcium (Both gravimetrically)

2. (a) Determination by Cerimetry **(25 Marks)**

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

(b) Green methods of preparation of the following

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

Viva-Voce **(10 Marks)**

Note Book **(10 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. (Life Sciences/Physical Sciences)**	**Program Code**	**UMLS4 or UMPS4**
Paper No.	**Chemistry Practical Paper – X**	**Nomenclature**	**Physical Chemistry Practical – II**
Name of the Course	**Discipline Specific Course**	**Course Code**	**24CHE202DS05**
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 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, the 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 **(25 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 **(25 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.
(i) Determination of the temperature coefficient for hydrolysis of ethyl or methyl acetate and calculation of thermodynamic parameters.

Viva-Voce **(10 Marks)**

Note Book **(10 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)

Semester — VIII (Session: 2027- 28)

(Option –II)

Name of Program	B.Sc. (Life Sciences/Physical Sciences)	Program Code	UMLS4 or UMPS4
Paper No.	Paper – X	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: Examiner will set nine questions, and the candidates must attempt five questions. Out of nine questions, one question will be compulsory, containing seven 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, the 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 site, 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. Banwell.
5. Introduction to Magnetic Resonance Spectroscopy ESR, NMR, NQR by D. N. Sathyanarayana.
6. Physical Chemistry by P.W. Atkins and J. Paula.
7. Introduction to Spectroscopy by D. L. Pavia, G. M. Lampman, G. S. Kriz and J. R. Vyvyan.
8. Organic Spectroscopy: Principles and Applications by J. Mohan.
9. Spectroscopy (Vol. 2) by R. K. Malik.

Name of Program	**B.Sc. (Life Sciences/Physical Sciences)**	**Program Code**	**UMLS4 or UMPS4**
Paper No.	**Paper – XI**	**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: Examiner will set nine questions, and the candidates must attempt five questions. Out of nine questions, one question will be compulsory, containing seven 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, the 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 publications, 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 contributorship.
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.