

Structure and Detailed Syllabus of the Four Year
Undergraduate Programme (FYUGP)
of
MAJOR COURSE (MJ)
under NEP-2020



Department of Chemistry

JAGANNATH BAROOAH UNIVERSITY

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This syllabus for the Four-Year Undergraduate Programme (FYUGP) in Chemistry (Major Course) at Jagannath Barooah University, is designed to equip students with a robust understanding and practical skills in chemistry.

The overarching aim is to foster a firm foundation in the fundamentals and applications of current chemical and basic sciences, including Physical, Organic, Inorganic, and Analytical Chemistry, as well as the chemistry of life.

Program Specific Outcomes (PSO)

Upon successful completion of the B.Sc. in Chemistry program, students will be able to:

- **PSO 1: Foundational Knowledge:** Demonstrate a firm foundation in the fundamental principles and applications across various branches of chemistry, including physical, organic, inorganic, analytical chemistry, and bio-chemistry.
- **PSO 2: Research Aptitude:** Develop awareness of major issues in chemical research and acquire competence in initiating, developing, and pursuing scientific research.
- **PSO 3: Information Management & Lifelong Learning:** Acquire the ability to seek new knowledge and skills, and effectively manage relevant scientific information.
- **PSO 4: Laboratory Proficiency:** Work effectively and safely in a laboratory environment, both independently and as part of a team, demonstrating practical expertise.
- **PSO 5: Experimental Design & Analysis:** Design and execute scientific experiments, critically analyze experimental data, and draw logical and sound inferences.

These program outcomes are further supported by specific learning outcomes for each semester and individual courses, ensuring a progressive development of knowledge and skills throughout the undergraduate program.

Semester-wise Course structure

Semester	Course No	Paper Code	Paper title	Course Type	Credit		Total Marks
					Theory	Practical	
SEM-I	C-01	CHMMJ-011	General Chemistry-I	Theory+ Practical	3	1	100
	Total Credit in Major Course				4 (3Pr+1Pr)		
SEM-II	C-02	CHMMJ-021	General Chemistry-II	Theory+ Practical	3	1	100
	Total Credit in Major Course				4 (3Pr+1Pr)		
SEM-III	C-03	CHMMJ-031	Inorganic Chemistry-I	Theory+ Practical	3	1	100
	C-04	CHMMJ-032	Organic Chemistry-I	Theory+ Practical	3	1	100
	C-05	CHMMJ-033	Physical Chemistry-I	Theory+ Practical	3	1	100
	Total Credit in Major Course				12 (9TH+3PR)		

SEM-IV	C-06	CHMMJ-041	Inorganic Chemistry-II	Theory+ Practical	3	1	100
	C-07	CHMMJ-042	Organic Chemistry-II	Theory+ Practical	3	1	100
	C-08	CHMMJ-043	Physical Chemistry-II	Theory+ Practical	3	1	100
	C-09	CHMMJ-044	Polymer Chemistry	Theory+ Practical	3	1	100
	Total Credit in Major Course					16 (12TH + 4PR)	
SEM-V	C-10	CHMMJ-051	Inorganic Chemistry-III	Theory+ Practical	3	1	100
	C-11	CHMMJ-052	Organic Chemistry-III	Theory+ Practical	3	1	100
	C-12	CHMMJ-053	Physical Chemistry-III	Theory+ Practical	3	1	100
	C-13	CHMMJ-054	Group Theory & Spectroscopy-I	Theory+ Practical	3	1	100
	Total Credit in Major Course					16 (12TH + 4PR)	
SEM-VI	C-14	CHMMJ-061	Inorganic Chemistry-IV	Theory+ Practical	3	1	100
	C-15	CHMMJ-062	Organic Chemistry-IV	Theory+ Practical	3	1	100
	C-16	CHMMJ-063	Physical Chemistry-IV	Theory+ Practical	3	1	100
	C-17	CHMMJ-064	Spectroscopy-II	Theory+ Practical	3	1	100
	C-18	CHMMJ-065	Quantum Chemistry	Theory	2	-	50
	Total Credit in Major Course					18 (14TH + 4PR)	

FYUGP with Honors/ PG Course							
UG SEM VII/ PG SEM I	C-19	CHMMJ-071	Inorganic Chemistry-V	Theory+ Practical	3	1	100
	C-20	CHMMJ-072	Physical Chemistry-IV	Theory+ Practical	3	1	100
	C-21	CHMMJ-073	Research Methodology	Theory	4	-	100
	D-22	CHMMJ-074	Organic Chemistry-V	Theory+ Practical	3	1	100
	Total Credit in Major Course					16 (13TH+3PR)	
UG SEM VIII/ PG SEM II	C-23	CHMMJ-081	Inorganic Chemistry-VI	Theory+ Practical	3	1	100
	C-24	CHMMJ-082	Organic Chemistry-VI	Theory+ Practical	3	1	100
	D-25	CHMMJ-083	Physical Chemistry-VI	Theory+ Practical	3	1	100
	Total Credit in Major Course					12 (9TH+3PR)	
Total Credit in Major Course					98 (76TH+23PR)		

SEMESTER I

Paper Title	: GENERAL CHEMISTRY-I (THEORY)
Paper Code	: CHMMJ-011
Course No	: C- 01
Credits	: 03
No. of Classes	: 45
Total Theory Marks	: 45

Course Objectives:

- To understand the important features of the quantum mechanical model of atom.
- To know the position and properties of elements, predict chemical reactions, understand trends in periodic properties among different elements.
- To introduce with a variety of structural aspects of organic molecules that are designed to lay the foundations for the study of the organic molecule.
- To impart basic knowledge of the gaseous state of matter; to understand the basic properties of liquids and their application.

Learner Outcome: Learner will gain an understanding of

- Quantum mechanical model of atom; concept of wave function, contour diagram, probability diagram etc.
- Properties of elements, atomic radii, ionic radii, size effect of ionic bond, solvation energy, covalent character of ionic bond, redox equations etc.
- Organic compounds, their classification, nomenclature; reaction of aliphatic hydrocarbons.
- Kinetic molecular model of a gas, behaviour of real gases etc.; various physical properties of liquids with special reference to surface tension and viscosity.

SECTION A: INORGANIC CHEMISTRY - I

UNIT-I: Atomic Structure: Wave mechanics: de Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, significance of ψ and ψ^2 . Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Contour boundary and probability diagrams and orbital.

(7 Lectures; Marks: 7)

UNIT-II: Periodicity of Elements: Effective nuclear charge, shielding or screening effect and their variation, Slater rules, atomic radii (van der Waals), Ionic and crystal radii, Covalent radii (octahedral and tetrahedral), Applications of ionization enthalpy, Electron gain enthalpy. Electronegativity, Pauling's/ Mulliken's/ Allred Rachow's/ and Mulliken-Jaffé's electronegativity scales. Variation of electronegativity with bond order, partial charge. Covalent character in ionic compounds, Polarising power and polarizability, Fajan's rules and

consequences of polarization, Ionic character in covalent compounds: Bond moment and dipole moment. Percentage ionic character from dipole moment and electronegativity difference.

(8 Lectures; Marks: 8)

SECTION B: ORGANIC CHEMISTRY- I

UNIT-III: Basics of Organic Chemistry: Organic Compounds: Classification, and Nomenclature, Hybridization and shapes of molecules. Electronic effects: (Inductive, resonance and hyperconjugation) and steric effect and their applications (acid/base property). Homolytic and Heterolytic fission. Electrophiles and Nucleophiles; Nucleophilicity and basicity; Chemistry of reactive intermediates (carbocations, free radical, carbenes and nitrene).

(6 Lectures; Marks: 6)

UNIT-IV: Chemistry of Aliphatic Hydrocarbons: Formation of alkanes, Halogenation - relative reactivity and selectivity. Carbon-Carbon pi Bonds: Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, E1cb reactions. Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/ Anti Markownikoff addition), mechanism of oxymercuration-demercuration, hydroborationoxidation, ozonolysis, reduction (catalytic and chemical), hydroxylation of alkenes with simple effect of stereo selectivity and specificity. 1,2-and 1,4-addition reactions in conjugated dienes and, Diels-Alder reaction; Allylic and benzylic bromination and mechanism. Reactions of alkynes: Acidity, Electrophilic and Nucleophilic additions. Hydration to form carbonyl compounds, Alkylation of terminal alkynes.

(9 Lectures; Marks: 9)

SECTION C: PHYSICAL CHEMISTRY

UNIT-V: Gaseous State: Kinetic molecular model of a gas: postulates and derivation of the kinetic gas equation; collision frequency; collision diameter; mean free path and viscosity of gases, including their temperature and pressure dependence, relation between mean free path and coefficient of viscosity, calculation of σ from η ; variation of viscosity with temperature and pressure. Maxwell distribution and its use in evaluating molecular velocities (average, root mean square and most probable) and average kinetic energy, law of equipartition of energy, degrees of freedom and molecular basis of heat capacities. Behaviour of Real Gases: Deviations from ideal gas behaviour, compressibility factor, Z , and its variation with pressure for different gases. Causes of deviation from ideal behaviour. Van der Waals equation of state, its derivation and application in explaining real gas behavior; virial equation of state; van der Waals equation expressed in virial form and calculation of Boyle temperature. Isotherms of real gases and their comparison with van der Waals isotherms, continuity of states, critical state, relation between critical constants and van der Waals constants, law of corresponding states.

(15 Lectures; Marks: 15)

Paper Title	: GENERAL CHEMISTRY-I (PRACTICAL)
Paper Code	: CHMMJ-011
Course No	: C- 01
Credits	: 01
No. of Classes	: 30
Total Marks	: 15

EXPERIMENTAL WORK

- (a) Preparation of normal and molar solution, for example KCl, Na₂C₂O₄, HCl, H₂SO₄ etc. (Verification by conductometric measurement).
- (b) Determination of water of crystallisation of hydrated salt by ignition and weighing.
- (c) Primary and secondary standard solution. Determination of strength of secondary standard solution by volumetric method (Titration of KMnO₄ vs oxalic acid; Na₂S₂O₄ Vs K₂Cr₂O₇)
- (d) Acid-Base titration
1. Estimation of carbonate and hydroxide present in a mixture.
 2. Estimation of carbonate and bicarbonate present in a mixture.

MODES OF IN-SEMESTER ASSESSMENT:

40 Marks

- Two Internal Examination - **20 Marks**
- Others (any one) - **20 Marks**
 - Home Assignment
 - Seminar presentation on any of the relevant topics
 - Practical Notebook/Viva

Course Outcomes (COs) & Bloom's Mapping:

After the completion of this course, the learner will be able to:

CO 1: Apply the quantum mechanical model of the atom by applying the Schrödinger wave equation, de Broglie relation, and uncertainty principles to interpret orbital shapes, radial/angular distribution curves, and electron probability densities.

CO 2: Understand periodic trends and use Fajan's rules to predict the degree of covalent or ionic character in chemical bonds based on dipole moments.

CO 3: Explain the structural features, IUPAC nomenclature, and electronic effects of organic molecules to determine the stability of reactive intermediates and relative acid-base strengths.

CO 4: Apply mechanistic pathways (such as E1/E2 elimination) to predict the major stereoselective or regioselective products in the synthesis and reactions of aliphatic hydrocarbons.

CO 5: Understand molecular properties of gases by utilizing the kinetic molecular model and **analyse** deviations of real gases from ideal behaviour by deriving and utilizing the van der Waals and virial equations of state to correlate critical constants with intermolecular forces.

CO 6: Execute the quantitative using two-indicator acid-base titrations, and **analyse** the volumetric data to calculate the individual mass concentrations of each component in the solution.

Knowledge Dimensions	Remember L1	Understand L2	Apply L3	Analyze L4	Evaluate L5	Create L6
Factual						
Conceptual		CO2, CO3, CO5	CO1, CO4	CO5		
Procedural		CO6		CO6		
Metacognitive						

Suggested Books:

- Lee, J.D. *Concise Inorganic Chemistry* ELBS, 1991.
- Finar, I. L. *Organic Chemistry (Volume 1)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Atkins, P. W. & Paula, J. de *Atkin's Physical Chemistry* 10th Ed., Oxford University Press (2014).

Reference Books:

- Douglas, B.E. and McDaniel, D.H. *Concepts & Models of Inorganic Chemistry* Oxford, 1970.
- Day, M.C. and Selbin, J. *Theoretical Inorganic Chemistry*, ACS Publications, 1962.
- Morrison, R. N. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.
- Ball, D. W. *Physical Chemistry* Thomson Press, India (2007).
- Kapoor, K. L. *A Textbook of Physical Chemistry*, Vol. 1

SEMESTER-II

Paper Title	: GENERAL CHEMISTRY-II (THEORY)
Paper Code	: CHMMJ-021
Course No	: C- 02
Credits	: 03
No. of Classes	: 45
Total Theory Marks	: 45

Course Objectives:

- To understand the different types of bonds formed by atoms and their chemical approaches of bonding and shape of molecules.
- To impart basic knowledge on transition metals and their applications.
- To impart knowledge on stereochemistry and importance of alkyl and aryl halides.
- To introduce with a variety of laws of thermodynamics, thermo-chemistry and their applications.

Learner Outcome: Learner will gain an understanding of

- Molecular geometries, physical and chemical properties of the molecules; Current bonding models for simple inorganic and organic molecules in order to predict structures and important bonding parameters.
- Catalytic, magnetic and redox properties of transition elements.
- Stereochemistry; 2D, 3D structures of molecules and their interconversion; E/Z, R/S nomenclature, Conformational analysis of alkanes.
- Chemistry of alkyl halides aryl halides; their preparation and reactions.
- Different thermodynamic functions; First, second & third law of thermodynamics.

SECTION A: INORGANIC CHEMISTRY - II

UNIT-I: Chemical Bonding: Ionic Bonding: General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals. Born-Landé and Kapustinskii expression and its application (no derivation). Madelung constant, Born-Haber cycle and its application, Solvation energy. Covalent Bonding: Lewis structure, Valence Bond theory (Heitler-London approach). Energetics of hybridization, equivalent and non-equivalent hybrid orbitals. Bent's rule, Resonance and resonance energy, Molecular orbital theory. Molecular orbital diagrams of diatomic and simple polyatomic molecules N_2 , O_2 , C_2 , B_2 , F_2 , CO , NO , and their ions; HCl , BeF_2 , CO_2 , (idea of s-p mixing and orbital interaction to be given). Formal charge, Valence shell electron pair repulsion theory (VSEPR), shapes of simple molecules and ions containing lone pairs and bond pairs of electrons, multiple bonding (σ and π bond approach) and bond lengths. Metallic Bonding: Qualitative idea of valence bond and band theories. Semiconductors and insulators, defects in solids.

(10 Lectures; Marks: 10)

Unit II: Intermolecular Forces: van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interactions, Instantaneous dipole-induced dipole interactions. Repulsive forces, Hydrogen bonding. Effects of chemical force, melting and boiling points, solubility energetics of dissolution processes.

(5 Lectures; Marks: 5)

SECTION B: ORGANIC CHEMISTRY- II

UNIT-III: Stereochemistry-I: Fischer, Newmann and Sawhorse Projection formulae and their interconversions; Geometrical isomerism: E/Z notations with C.I.P rules. Optical Isomerism in compounds with or without chiral centers (allenes, spirans and biphenyls): Optical Activity, Specific Rotation, Enantiomers, Molecules with two or more chiral-centres, Distereoisomers, meso structures, Racemic mixture, resolution and enantiomeric excess. Relative and absolute configuration.

Conformational Analysis: Types of cycloalkanes and their relative stability, Baeyer strain theory, Conformation analysis of alkanes (ethane and n-butane): Relative stability: Energy diagrams of cyclohexane; Relative stability of cyclohexanes.

(15 Lectures; Marks: 15)

SECTION C: PHYSICAL CHEMISTRY– II

UNIT-IV: Chemical Thermodynamics-I: Intensive and extensive variables; state and path functions; isolated, closed and open systems; zeroth law of thermodynamics. **First law:** Concept of heat, q, work, w, internal energy, U, and statement of first law; enthalpy, H, relation between heat capacities, calculations of q, w, U and H for reversible, irreversible and free expansion of gases (ideal and van der Waals) under isothermal and adiabatic conditions, Joule-Thomson effect.

(7 Lectures; Marks: 7)

UNIT- V: Liquid State: Molecular forces and general properties of liquids. **Surface Tension:** surface tension, surface energy, effect of temperature on surface tension, shapes of liquid drops and soap bubbles, capillary action, determination of surface tension by capillary rise method drop number methods using stalagmometer. Effect of temperature on surface tension. Parachor, Additive and constitutive properties: atomic and structural parachor. Elucidation of structure of benzene and benzoquinone. **Viscosity:** Definition, viscosity coefficient, fluidity, determination of coefficient of viscosity using Ostwald viscometer. Effect of temperature, size, weight, shape of molecules and intermolecular forces.

(8 Lectures; Marks: 8)

Paper Title	: GENERAL CHEMISTRY-II (PRACTICAL)
Paper Code	: CHMMJ-021
Course No	: C- 02
Credits	: 01
No. of Classes	: 30
Total Theory Marks	: 15

EXPERIMENTAL WORK

1. Surface tension measurements: Determine the surface tension by (i) drop number (ii) drop weight method.
2. Viscosity measurement using Ostwald's viscometer

MODES OF IN-SEMESTER ASSESSMENT:

	40 Marks
• Two Internal Examination -	20 Marks
• Others (any one) -	20 Marks
○ Home Assignment	
○ Seminar presentation on any of the relevant topics	
○ Practical Notebook/Viva	

Course Outcomes (COs) & Bloom's Mapping

After the completion of this course, the learner will be able to:

CO 1: Apply bonding theories (VSEPR, VBT, MOT) to predict molecular geometry, explain s-p mixing, construct molecular orbital diagrams for homo/heteronuclear diatomic and simple polyatomic species, and evaluate properties like bond order and magnetism.

CO 2: Understand the factors governing crystalline solids and solution chemistry by utilizing the Born-Haber cycle, lattice energy expressions, and comparing the effects of different intermolecular forces on physical properties.

CO 3: Examine structural and optical isomerism by converting between spatial projection formulae, assigning absolute configurations.

CO 4: Understand the relative stability and structural constraints of cyclic and acyclic hydrocarbons by utilizing conformational analysis energy profiles.

CO 5: Calculate the thermodynamic parameters for ideal and van der Waals gases undergoing reversible, irreversible, or free expansion under isothermal and adiabatic conditions based on the First Law of Thermodynamics.

CO 6: Explain the macromolecular behaviour of liquids by interpreting the physical significance of surface tension, viscosity, and parachor, and **determine** the surface tension and coefficient of viscosity of unknown liquid systems by executing experimental protocols.

Knowledge Dimensions	Remember L1	Understand L2	Apply L3	Analyze L4	Evaluate L5	Create L6
Factual		CO2				
Conceptual		CO4, CO6	CO1, CO5	CO3		
Procedural			CO6			
Metacognitive						

Suggested Books:

- Lee, J.D. *Concise Inorganic Chemistry* ELBS, 1991.
- Finar, I. L. *Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products)*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Kapoor K. L. *A Textbook of Physical Chemistry* Sixth Ed., Vol. 2, Macmillan, India

Reference Books:

- Douglas, B.E. and McDaniel, D.H. *Concepts & Models of Inorganic Chemistry* Oxford, 1970
- Rodger, G.E. *Inorganic and Solid State Chemistry*, Cengage Learning India Edition, 2002.
- Eliel, E. L. & Wilen, S. H. *Stereochemistry of Organic Compounds*, Wiley: London, 1994.
- Kalsi, P. S. *Stereochemistry Conformation and Mechanism*, New Age International, 2005.
- McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.
- McQuarrie, D. A. & Simon, J. D. *Molecular Thermodynamics* Viva Books Pvt. Ltd.:New Delhi (2004).
- Levine, I.N. *Physical Chemistry* 6th Ed., Tata Mc Graw Hill (2010).

SEMESTER-III

Paper Title	: INORGANIC CHEMISTRY-I
Paper Code	: CHMMJ-031
Course No.	: C- 03
Credits	: 03
No. of Classes	: 45
Total Theory Marks	: 45

Course Objectives:

- To introduce students to the various theories of acid and bases, hard and soft concept of ions & molecules and acid-base indicators
- To understand the principle and application of oxidation and reduction
- To enable students with diverse range of principles underlying qualitative and quantitative analysis, separation of cations, impact of interfering radicals etc.
- To introduce the principle of volumetric and gravimetric analysis with application
- To give basic concept of polymer chemistry with special reference to inorganic polymer and its applications
- To introduce the main group chemistry of hydrides, compounds of boron and their applications

Learners Outcome: Learners will gain an understanding of

- Acid-Base concepts, principle of oxidation- reduction.
- Analysis of inorganic salt mixture including interfering radicals.
- Principle of volumetric and gravimetric analysis and its application.
- Basics of polymer chemistry including inorganic polymer and its diverse application in modern sciences

UNIT-I: Acid-Base Concepts: Bronsted-Lowry Definition, Lux Flood Definition, Solvent System Definition, Solvated Proton, Relative Strength of Acids, Leveling Solvents, Types of Acid-Base Reactions, Pearson's Hard and Soft Acids and Bases (HSAB) Concept, Application of HSAB Principle, Theory of Acid-Base Indicators, Selection of Indicators and their Limitations.

(10 Lectures; 10 Marks)

UNIT-II: Oxidation-Reduction: Oxidation and Reduction Reactions, Oxidation Number Concept, Balancing Redox Equations by Ion-electron Method, Equivalent Weight of Oxidizing and Reducing agents, Standard Electrode Potential and its Application to Inorganic Reactions. Redox Stability in Water – Disproportionation and Comproportionation, Frost and Latimer diagrams

(08 Lectures; 08 Marks)

UNIT-III: Theoretical Principles in Qualitative Analysis (H₂S Scheme): Basic Principles Involved in Analysis of Cations and Anions, Different types of equilibrium, solubility products, common ion effect (with example). Confirmatory test for chloride, bromide, nitrate,

Principles involved in separation of cations into groups and choice of group reagents. Interfering anions (fluoride, borate, oxalate and phosphate: Detection and removal) and need to remove them after Group II. Detection of anions with mixture (Carbonate & Sulphite), (Nitrate & Bromide), (Bromide & Iodide).

(8 Lectures; 8 Marks)

UNIT-IV: Principles of Volumetric Analysis and Gravimetric Analysis: Principle involved in volumetric (Redox & Complexometry) and Gravimetric analysis. Application in analytical chemistry: Estimation of Ni (II) by DMG, Al (III) as oxinate in a given solution, Estimation of Ca (II), Mg (II) and Zn (II) by complexometric titrations using EDTA. Hardness of a given sample of water by complexometric titration. Iodometry and Iodimetry.

(07 Lectures; 7 Marks)

UNIT-V: Nuclear Chemistry & Radioactivity: Law of Radioactive disintegration, Half – life period, Average life period, Stability of nucleus: Mass defect and nuclear binding energy, Packing fraction., n/p ratio, Meson theory, Nuclear shell model, Chain reaction: Nuclear fission and fusion, Nuclear Reactor, Breeder Reactions, Artificial Nuclear Transmutation or Transformation.

(05 Lectures; 12 Marks)

Paper Title	: INORGANIC PRACTICAL-I
Paper Code	: CHMMJ-031
Course No.	: C- 03
Credits	: 01
No. of Classes	: 30
Total Marks	: 15

EXPERIMENTAL WORK

Qualitative semimicro analysis of mixtures containing 5 radicals. The following radicals are suggested:

CO_3^{2-} , NO_2^- , S^{2-} , SO_3^{2-} , $\text{S}_2\text{O}_3^{2-}$, CH_3COO^- , F^- , Cl^- , Br^- , I^- , NO_3^- , BO_3^{3-} , $\text{C}_2\text{O}_4^{2-}$, PO_4^{3-} , NH_4^+ , K^+ , Pb^{2+} , Cu^{2+} , Cd^{2+} , Bi^{3+} , Sn^{2+} , Sb^{3+} , Fe^{3+} , Al^{3+} , Cr^{3+} , Zn^{2+} , Mn^{2+} , Co^{2+} , Ni^{2+} , Ba^{2+} , Sr^{2+} , Ca^{2+} , Mg^{2+}

Mixtures should preferably contain one interfering anion, or Insoluble component.

MODES OF IN-SEMESTER ASSESSMENT:	40 Marks
• Two Internal Examination	- 20 Marks
• Others (any one)	- 20 Marks
○ Home Assignment	
○ Seminar presentation on any of the relevant topics	
○ Practical Notebook/Viva	

Course Outcomes (COs) & Bloom's Mapping

After the completion of this course, the learner will be able to:

CO 1: Explain the behaviour of acids and bases in both aqueous and non-aqueous media by applying various definitions and utilize the HSAB principle to predict the stability, reactivity, and indicator selection for chemical systems.

CO 2: Analyse the thermodynamic stability and reactivity of inorganic redox systems by balancing complex equations, calculating equivalent weights, and interpreting Frost, Latimer, and standard electrode potential diagrams.

CO 3: Apply chemical equilibrium principles—including the solubility product and common ion effect—to systematically separate cationic groups, eliminate interfering anions, and resolve complex mixtures of anions.

CO 4: Explain the underlying principles of gravimetric and complexometric estimations, and assess parameters like water hardness using EDTA and iodometric titrations.

CO 5: Understand nuclear stability and energy transformations by utilizing nuclear models calculating mass defects and binding energies.

CO 6: Systematically isolate and identify 5 chemical radicals from an unknown inorganic mixture containing insoluble components, or interfering anions by executing a semimicro qualitative analysis scheme.

Knowledge Dimension	Remember L1	Understand L2	Apply L3	Analyze L4	Evaluate L5	Create L6
Factual		CO4	CO1			
Conceptual		CO5	CO3, CO4	CO2		
Procedural				CO6		
Metacognitive						

Suggested Books:

- Huheey, J. E.; Keiter, E.A. & Keiter, R.L. *Inorganic Chemistry*, Pearson, 2006
- Atkin, P. *Shriver & Atkins' Inorganic Chemistry*, 5th Ed., Oxford University Press (2010)
- Lee, J. D. *Concise Inorganic Chemistry*, 5th Ed., Wiley India Pvt. Ltd., 2008

Reference Books:

- Douglas, B.E. and McDaniel, D.H. *Concepts & Models of Inorganic Chemistry* Oxford, 1970.
- Cotton, F.A., Wilkinson, G. and Gaus, P.L., *Basic Inorganic Chemistry 3rd Ed.*; Wiley India.
- Sharpe, A.G., *Inorganic Chemistry*, 4th Ed. Indian Reprint (Pearson Education) 2005.
- Mingos, D.M.P., *Essential trends in inorganic chemistry*. Oxford University Press (1998)
- General and Inorganic Chemistry (Part-1 & 2), RP Sarkar, NCBA, 2015
- Harvey, B. G. *Nuclear Chemistry*. Prentice-Hall (1965)
- SWAYAM
- N-LIST
- E-PATHSALA

Paper Title	: ORGANIC CHEMISTRY-I (THEORY)
Paper Code	: CHMMJ-032
Course No	: C- 04
Credits	: 03
No. of Classes	: 45
Total Theory Marks	: 45

Course Objectives:

- To impart basic knowledge on chemistry of alcohols, phenols and ethers,
- To understand chemistry of Thiols & Thioethers.
- To gain insight in carbonyl compounds, carboxylic acids and their derivatives.
- To understand chemistry of different classes nitrogen containing compounds.

Learner Outcome: Learner will gain an understanding of

- An idea of alcohols, phenols, carbonyl compounds, acids and their derivatives etc.
- The prediction of mechanism for organic reactions.
- How to describe and classify organic compounds in terms of their functional groups and reactivity.
- Identification and classification of different types of N-based derivatives

UNIT-I: Aromatic Hydrocarbons: Huckel's rule, aromatic characters of arenes, benzenoid, non-benzenoid- aromatic compounds and heterocyclic and polynuclear hydrocarbons with suitable examples. Antiaromaticity and nonaromaticity Electrophilic Aromatic Substitutions and their mechanism. Activation/deactivation of aromatic ring and directing effects of groups. Partial rate factor (O/P ratio).

(06 Lectures; Marks: 6)

UNIT-II: Alkyl and Aryl Halides: Alkyl Halides (Upto 5 Carbons) Types of Nucleophilic Substitution (S_N1 , S_N2 and S_Ni) reactions. Preparation: from alkenes and alcohols. Reactions: hydrolysis, nitrite & nitro formation, nitrile & isonitrile formation. Williamson's ether synthesis: Elimination vs substitution. Aryl Halides Preparation: (Chloro, bromo and iodo-benzene case): from phenol, Sandmeyer & Gattermann reactions. Reactions (Chlorobenzene): Aromatic nucleophilic substitution (replacement by $-OH$ group) and effect of nitro substituent. Benzyne Mechanism: 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.

(07 Lectures; Marks: 7)

Unit-III: Alcohols, Phenols, Ethers and Epoxides: Alcohols: preparation, properties and relative reactivity of 1° , 2° , 3° alcohols, Bouvaelt-Blanc Reduction; Preparation and properties of glycols: Oxidation by periodic acid and lead tetraacetate, Pinacol-Pinacolone rearrangement. Phenols: Preparation and properties; Acidity and factors effecting it, Ring

substitution reactions, Reimer–Tiemann and Kolbe’s-Schmidt Reactions, Fries and Claisen rearrangements with mechanism; Ethers and Epoxides: Preparation (Simmons-Smith reaction) and reactions with acids. Reactions of epoxides with alcohols, ammonia derivatives and LiAlH_4 . **Sulphur containing compounds:** Thiols & Thioethers: Preparation and reactions

(10 Lectures; Marks: 10)

Unit-IV: Carbonyl Compounds: Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanism; Mechanisms of Aldol, Benzoin, Knoevenagel condensation, Claisen-Schmidt, Darzens, McMurray, Perkin, Cannizzaro and Wittig reaction, Beckmann, Favorskii and Benzil-Benzilic acid rearrangements, haloform reaction and Baeyer Villiger oxidation, α -substitution reactions, oxidations and reductions; Michael addition.

Active Methylene Compounds: Keto-enol tautomerism. Preparation and synthetic applications of diethyl malonate and ethyl acetoacetate.

Organometallic compounds of Mg and Li: Use in synthesis of organic compounds.

(14 Lectures; Marks: 14)

Unit-V: Carboxylic Acids and their Derivatives: Preparation, physical properties and reactions of monocarboxylic acids: Typical reactions of dicarboxylic acids, hydroxy acids and unsaturated acids: succinic/phthalic, lactic, malic, tartaric, citric, maleic and fumaric acids; Preparation and reactions of acid chlorides, anhydrides, esters and amides; Comparative study of nucleophilic substitution at acyl group -Mechanism of acidic and alkaline hydrolysis of esters, Claisen condensation, Dieckmann and Reformatsky reactions, Hofmann and Curtius rearrangement.

(8 Lectures; Marks: 8)

Paper Title	: ORGANIC CHEMISTRY-I (Practical)
Paper Code	: CHMMJ-032
Course No	: C- 04
Credits	: 01
No. of Classes	: 30
Total Marks	: 15

EXPERIMENTAL WORK

1. Purification of organic compound and determination of melting point: Purification of organic compounds by crystallization using the following solvents: Water, Alcohol, Alcohol-Water.
2. Chromatographic separation:
 - (i) Separation of a mixture of two amino acids by ascending and horizontal paper chromatography.

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

MODES OF IN-SEMESTER ASSESSMENT:

40 Marks

- Two Internal Examination - **20 Marks**
- Others (any one) - **20 Marks**
 - Home Assignment
 - Seminar presentation on any of the relevant topics
 - Practical Notebook/Viva

Course Outcomes (COs) & Bloom's Mapping

After the completion of this course, the learner will be able to:

CO 1: Understand the electronic structures of benzenoid, non-benzenoid, heterocyclic using Hückel's rule, and **analyse** the regiochemical outcome of electrophilic aromatic substitution.

CO 2: Differentiate between the mechanistic pathways of alkyl and aryl halides, and predict how structural changes in allyl, benzyl, vinyl, and aryl systems impact C-Halogen bond reactivity.

CO 3: Apply named transformations and to synthesize and functionalize oxygen- and sulfur-containing organic frameworks.

CO 4: Illustrate the reaction steps and mechanisms of carbon-carbon bond-forming processes.

CO 5: Compare the relative reactivity of acyl derivatives toward nucleophilic acyl substitution, and execute mechanistic pathways for ester hydrolyses, condensation reactions, and Curtius/Hofmann migrations.

CO 6: Isolate and analyze target organic molecules by executing recrystallization techniques using pure or mixed solvents, and validate their purity using melting point determinations and chromatographic separation methods.

Knowledge Dimension	Remember L1	Understand L2	Apply L3	Analyze L4	Evaluate L5	Create L6
Factual		CO1				
Conceptual			CO3, CO4	CO2, CO5		
Procedural				CO6		
Metacognitive						

Text Book(s):

- Clayden, J.; Greeves, N.; Warren, S.; Wothers, P. *Organic Chemistry*, 2nd Edn., Oxford University Press, 2012.
- Morrison, R. T.; Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. *Organic Chemistry* (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Graham Solomons, T.W. *Organic Chemistry*, John Wiley & Sons, Inc.

Reference Book(s):

- Keeler, J.; Wothers, P. *Chemical Structure and Reactivity – An Integrated approach*, Oxford University Press.
- Smith, J. G. *Organic Chemistry*, Tata McGraw-Hill Publishing Company Ltd.
- Carey, F. A.; Sundberg, R. J. *Advanced Organic Chemistry: Reactions and Synthesis* (Part B), Springer.

Paper Title	: PHYSICAL CHEMISTRY-I (THEORY)
Paper Code	: CHMMJ-033
Course No.	: C- 05
Credits	: 03
No. of Classes	: 45
Total Marks	: 45

Course Objectives

- To introduce the laws governing dilute solutions and the thermodynamic basis of colligative properties.
- To explain ionic equilibria, pH scales, buffer behavior, and solubility products in electrolyte solutions.
- To impart knowledge on the Second and Third laws of thermodynamics, focusing on entropy and engine efficiency.
- To familiarize students with free energy functions, criteria for chemical spontaneity, and Maxwell relationships.

Learner Outcomes: The learner will be able to:

- Calculate the molar masses of normal, associated, and dissociated solutes using colligative property equations.
- Determine the pH, hydrolysis constant, and solubility product of various electrolyte and buffer systems.
- Compute entropy changes for ideal gases, phase transitions, and cyclic pathways like the Carnot cycle.
- Predict chemical equilibrium and spontaneity by applying the Gibbs-Helmholtz equation and free energy functions.

UNIT I: Solutions and Colligative Properties: Dilute solutions; lowering of vapour pressure, Raoult's and Henry's Laws and their applications. Thermodynamic derivation using chemical potential to derive relations between the four colligative properties [(i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) Depression of freezing point, (iv) osmotic pressure] and amount of solute. Applications in calculating molar masses of normal, dissociated and associated solutes in solution.

(14 Lectures; Marks: 14)

Unit-II: Ionic Equilibria: Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect; dissociation constants of mono-protic acid (exact treatment). Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions; derivation of Henderson equation and its applications; buffer capacity, buffer range. Solubility and solubility product of sparingly soluble salts – applications of solubility product principle.

(15 Lectures; Marks: 15)

UNIT-III: Chemical Thermodynamics II: Second law of thermodynamics, Carnot's theorem, Carnot cycle, efficiency of heat engines, thermodynamic scale of temperature, concept of entropy, entropy change in a cyclic, reversible, irreversible processes, calculation of entropy changes of an ideal gas with change in P,V,T, entropy change in physical transformation, entropy of mixing. Helmholtz free energy (A) and Gibb's free energy (G), variation of A and G with P,V,T, criteria for spontaneity and equilibrium, Maxwell's relationship, Gibb's–Helmholtz equation. Nernst heat theorem consequence of the theorem, third law of thermodynamics, and its verification. Determination of absolute entropies of pure substance.

(16 Lectures; Marks: 16)

Paper Title	: PHYSICAL CHEMISTRY-I (PRACTICAL)
Paper Code	: CHMMJ-033
Course No.	: C- 05
Credits	: 01
No. of Classes	: 30
Total Marks	: 15

EXPERIMENTAL WORK

1. Study the effect on pH upon addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their mixtures.

2. Preparation of buffer solutions of different pH: (i) Sodium acetate-acetic acid (ii) Ammonium chloride-ammonium hydroxide
3. pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base. Determination of dissociation constant of a weak acid.

MODES OF IN-SEMESTER ASSESSMENT:**40 Marks**

- Two Internal Examination - **20 Marks**
- Others - **20 Marks**
 - Home Assignment
 - Seminar presentation on any of the relevant topics
 - Practical Notebook/Viva
 -

Course Outcomes (COs) & Bloom's Mapping

After the completion of this course, the learner will be able to:

CO 1: Apply the laws of dilute and colligative properties to calculate the molar masses of normal, associated, and dissociated solutes.

CO 2: Explain the behaviour of weak and strong electrolytes by analysing factors that influence the degree of ionization, the pH scale, and the common ion effect.

CO 3: Calculate the pH, hydrolysis constants, buffer capacity, and solubility products of various salt and buffer systems.

CO 4: Analyse the second and third laws of thermodynamics to interpret entropy changes in ideal gases, cyclic processes (Carnot cycle), and physical transformations.

CO 5: Examine chemical spontaneity and equilibrium state variations by utilizing Maxwell's relationships, the Gibbs-Helmholtz equation, and free energy functions.

CO 6: Measure and analyse the pH behaviour, buffering capacity, and titration profiles of various acid-base systems using indicators and pH meters to determine the dissociation constant of a weak acid.

Knowledge Dimension	Remember L1	Understand L2	Apply L3	Analyze L4	Evaluate L5	Create L6
Factual						
Conceptual		CO2	CO1, CO3, CO5	CO4		
Procedural				CO6		
Metacognitive						

Suggested Books:

- Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.
- Furniss, B. S., Ford, A. J. H., Smith, P. W. H., Tatchell, A. R. Vogel's Textbook of Practical Organic Chemistry, 5th Edn., (Wiley, 1989).
- Jadav, J. B. Advanced Practical Physical Chemistry, (Krishna Prakashan, 2015).

- Mendham, J., Danney, R. C., Barnes, J. D., Thomas, M. Vogel's Textbook of
- Quantitative Chemical Analysis, 6th Edn., (Prentice Hall, 2009).
- Gurdeep, R. Advanced Practical Inorganic Chemistry, (Krishna Prakashan, 2013).

SEMESTER-IV

Paper Title	: INORGANIC CHEMISTRY-II
Paper Code	: CHMMJ-041
Course No	: C- 06
Credits	: 03
No. of Classes	: 45
Total Theory Marks	: 45

Course Objectives:

- To introduce concept of coordination complex, its developmental theory, ligands, nomenclature and isomerism
- To understand various bonding theories of coordination complexes, and their applications in different geometries and the chelate effect and its applications
- To understand the magnetic properties, colour in complexes, charge transfer complexes and L-S coupling
- To give basic concept of lanthanoids and actinoids, their separation techniques and applications
- To introduce the main group chemistry of 14th and 15th group elements and their applications

Learner Outcome: Learner will gain an understanding of

- Coordination complexes, their bonding, magnetic properties.
- d-d transition, L-S coupling.
- Chemistry of inner transition elements and their applications
- Chemistry of 14th and 15th group elements

UNIT-I: Transition Elements: General group trends with special reference to electronic configuration, catalytic properties, ability to form complexes. Stability of various oxidation states and e.m.f. (Latimer & Bsworth diagrams). Difference between the first, second and third transition series. Chemistry of Ti, V, Cr Mn, Fe and Co in various oxidation states (excluding their metallurgy)

(05 Lectures; Marks: 5)

UNIT-II: Coordination Chemistry-I: Ligands classification, Ambidentate ligands, chelates, Coordination numbers, IUPAC nomenclature of coordination complexes (up to two metal centers), Isomerism in coordination compounds, constitutional and stereo isomerism, Geometrical and optical isomerism in square planar and octahedral complexes.

Elementary Crystal Field Theory: splitting of dⁿ configurations in octahedral, square planar and tetrahedral fields, crystal field stabilization energy (CFSE) in weak and strong fields; pairing energy. Spectrochemical series. Jahn- Teller distortion. Chelate effect, polynuclear complexes, Labile and inert complexes.

(18 Lectures, 15 Marks)

UNIT-III: Coordination Chemistry-II: MOT applied to ML_6 type complexes (only σ -bonding). Magnetism and Colour: Orbital and spin magnetic moments, spin only moments of d^n ions and their correlation with effective magnetic moments, including orbital contribution; anti-ferromagnetic interactions (elementary idea with examples only); d-d transitions; concept of microstates, L-S coupling; qualitative Orgel diagrams for $3d^1$ to $3d^9$ ions. Racah parameter. Selection rules for electronic spectral transitions; spectrochemical series of ligands.

(15 Lectures, 10 Marks)

UNIT-IV: Lanthanoids and Actinoids: General Comparison on Electronic configuration, oxidation states, colour, spectral and magnetic properties; lanthanide contraction, separation of lanthanides (including ion-exchange method). Analytical applications

(07 Lectures, 07 Marks)

UNIT-V: Chemistry of Group 15 Elements: Hydrazine, Oxides of Nitrogen, Oxo acids and anions, nitrogen compounds as ligands, Halides of Phosphorous, Oxides of Phosphorous, Phosphonium, P-N Compounds. Compounds with element-element bonds, Oxo anions of Phosphorous, Phosphorous compounds as ligands.

(10 Lectures, 8 Marks)

Paper Title	: INORGANIC CHEMISTRY-II (Practical)
Paper Code	: CHMMJ-041
Course No	: C- 06
Credits	: 01
No. of Classes	: 30
Total Theory Marks	: 15

EXPERIMENTAL WORK

1. Redox Titration

- Estimation of Fe (II) and oxalic acid using standardized $KMnO_4$ solution.
- Estimation of oxalic acid and sodium oxalate in a given mixture.

2. Iodo / Iodimetric Titrations

- Estimation of Cu(II) and $K_2Cr_2O_7$ using sodium thiosulphate solution iodimetrically.
- Estimation of available chlorine in bleaching powder iodometrically.

3. Inorganic Preparations

- Cuprous Chloride, Cu_2Cl_2
- Preparation of Manganese (III) phosphate, $MnPO_4 \cdot H_2O$
- Preparation of Aluminium potassium sulphate $KAl(SO_4)_2 \cdot 12H_2O$ (Potash Alum) or Chrome alum.

MODES OF IN-SEMESTER ASSESSMENT: 40 Marks

- Two Internal Examination - 20 Marks
- Others - 20 Marks
 - Home Assignment
 - Seminar presentation on any of the relevant topics
 - Practical Notebook/Viva

Course Outcomes (COs) & Bloom's Mapping

After the completion of this course, the learner will be able to:

CO 1: Understand the properties of the first, second, and third transition series by applying group trends in electronic configurations, catalytic behavior, and oxidation state stabilities using E.M.F. diagrams.

CO 2: Apply Crystal Field Theory (CFT) to determine the geometries, splitting patterns, and stability (CFSE) of coordination complexes.

CO 3: Analyse the magnetic properties and electronic spectra of coordination compounds using spin-only formulas, Molecular Orbital Theory, selection rules, and qualitative Orgel diagrams.

CO 4: Differentiate between the f-block series by evaluating trends in electronic configuration, colours, magnetic profiles, and the consequences of lanthanide contraction on separation methodologies.

CO 5: Explain the structural characteristics, bonding variations, and coordination properties of nitrogen and phosphorus derivatives, including their hydrides, oxides, oxoacids, and catenated compounds.

CO 6: Synthesize specific inorganic complexes and **analyze** target by applying standardized redox, iodometric, and iodimetric titration techniques.

Knowledge Dimension	Remember L1	Understand L2	Apply L3	Analyze L4	Evaluate L5	Create L6
Factual						
Conceptual		CO1, CO5	CO2	CO3, CO4		
Procedural			CO6			
Metacognitive						

Suggested Books:

- Lee, J. D. *Concise Inorganic Chemistry*, 5th Ed., Wiley India Pvt. Ltd., 2008.
- Coordination Chemistry, Ajai Kumar, Aaryush Educations, Ghaziabad, 2014
- Atkin, P. *Shriver & Atkins' Inorganic Chemistry*, 5th Ed., Oxford University Press (2010)
- Cotton, F.A., Wilkinson, G. and Gaus, P.L., *Basic Inorganic Chemistry 3rd Ed.*; Wiley India.
- Sharpe, A.G., *Inorganic Chemistry*, 4th Ed. Indian Reprint (Pearson Education) 2005.
- Huheey, J. E.; Keiter, E.A. & Keiter, R.L. *Inorganic Chemistry*, Pearson, 2006
- Mingos, D.M.P., *Essential trends in inorganic chemistry*. Oxford University Press (1998)

- General and Inorganic Chemistry, RP Sarkar, NCBA, 2015
- SWAYAM
- N-LIST
- E-PATHSALA

Paper Title	: ORGANIC CHEMISTRY-II (THEORY)
Paper Code	: CHMMJ-042
Course No	: C- 07
Credits	: 03
No. of Classes	: 45
Total Theory Marks	: 45

Course Objectives

1. To understand the preparation and reactions of nitrogen-containing organic compounds and diazonium salts.
2. To study the structure, aromaticity, synthesis, and reactions of heterocyclic compounds.
3. To explain the chemistry and medicinal importance of alkaloids, terpenoids, and pharmaceutical compounds.
4. To develop knowledge of reaction mechanisms, structure elucidation, and polynuclear hydrocarbons.

Learning Outcomes

1. Learners will be able to explain the preparation and reactions of important organic compounds.
2. Learners will be able to analyze the structure and reactivity of heterocyclic and bioactive molecules.
3. Learners will be able to interpret basic organic reaction mechanisms and synthetic pathways.
4. Learners will be able to relate organic compounds to their medicinal and industrial applications.

Unit-I: Nitrogen Containing Functional Groups: Preparation and important reactions of nitro compounds, nitriles and isonitriles. Amines: Effect of substituent and solvent on basicity; Preparation and properties: Gabriel phthalimide synthesis, Carbylamine reaction, Mannich reaction, Lossen rearrangement, Hofmann's exhaustive methylation, Hofmann-elimination reaction; Distinction between 1°, 2° and 3° amines with Hinsberg reagent and nitrous acid.

Diazonium Salts: Preparation and their synthetic applications.

(8 Lectures; Marks: 8)

Unit-II: Heterocyclic Compounds: Classification and nomenclature, Structure, aromaticity in 5-numbered and 6-membered rings containing one heteroatom; Synthesis, reactions and mechanism of substitution reactions of: Furan, Pyrrole (Paal-Knorr synthesis, Knorr pyrrole synthesis, Hantzsch synthesis), Thiophene, Pyridine (Hantzsch synthesis), indole, Fischer indole synthesis and Madelung synthesis), Structure elucidation of quinoline and isoquinoline, Skraup synthesis, Friedlander's synthesis, Knorr quinoline synthesis, Doebner-Miller synthesis, Bischler-Napieralski reaction, Pictet-Spengler reaction.

(12 Lectures; Marks: 12)

Unit-III: Alkaloids and Terpenoids: Alkaloids: Natural occurrence, General structural features, Isolation and their physiological action Hoffmann's exhaustive methylation, Emde's modification, Structure elucidation and synthesis of Hygrine and Nicotine. Medicinal importance of Nicotine, Hygrine, Quinine, Morphine, Cocaine, and Reserpine.

Terpenoids: Occurrence, classification, isoprene rule; Elucidation of structure and synthesis of Citral, Neral and α -terpineol.

(12 Lectures; Marks: 12)

Unit-IV: Pharmaceutical Compounds: Classification, structure and therapeutic uses of antipyretics: Paracetamol (with synthesis), Analgesics: Ibuprofen (with synthesis), Antimalarials: Chloroquine (with synthesis). An elementary treatment of Antibiotics and detailed study of chloramphenicol and sulpha drugs (Preparation and mechanism of action), Medicinal values of curcumin (haldi), azadirachtin (neem), vitamin C and antacid (ranitidine).

(6 Lectures; Marks: 6)

Unit-V: Polynuclear Hydrocarbons: Structure, preparation and reactions of Reactions of naphthalene, phenanthrene and anthracene.

(5 Lectures; Marks: 5)

Paper Title	: ORGANIC CHEMISTRY-II (Practical)
Paper Code	: CHMMJ-042
Course No	: C- 07
Credits	: 01
No. of Classes	: 30
Total Theory Marks	: 15

EXPERIMENTAL WORK

- Detection of extra elements in organic compounds (up to two extra elements).
- Functional group test for nitro, amine and amide groups.
- Organic Preparations:
 - Acetylation of amines or phenols
 - Benzoylation of amines or phenols (β -naphthol, resorcinol, p-cresol) by Schotten-Baumann reaction.

(c) Preparation of Aspirin and its analysis.

MODES OF IN-SEMESTER ASSESSMENT: 40 Marks

- Two Internal Examination - 20 Marks
- Others - 20 Marks
 - Home Assignment
 - Seminar presentation on any of the relevant topics
 - Practical Notebook/Viva

Course Outcomes (COs) & Bloom's Mapping

After the completion of this course, the learner will be able to:

CO 1: Differentiate the basicity, structural properties, and reactions of amines, and utilize diazonium salts or rearrangement reactions for nitrogen-based molecular synthesis.

CO 2: Analyse the structural aromaticity, reactivity, and electrophilic/nucleophilic substitution mechanisms of five- and six-membered heterocyclic rings, indoles, and quinolines.

CO 3: Explain the occurrence, isolation, structural features, and physiological importance of natural products by applying degradation techniques like Hofmann's exhaustive methylation and the isoprene rule.

CO 4: Apply synthetic methods and mechanisms of action to prepare and evaluate therapeutic agents like paracetamol, ibuprofen, chloroquine, and sulpha drugs.

CO 5: Compare the structural configurations, resonance stabilization, and chemical reactions of fused aromatic systems like naphthalene, phenanthrene, and anthracene.

Knowledge Dimension	Remember L1	Understand L2	Apply L3	Analyze L4	Evaluate L5	Create L6
Factual						
Conceptual		CO3	CO4	CO1, CO2, CO5		
Procedural						
Metacognitive						

Text Book(s):

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

- Clayden, J.; Greeves, N.; Warren, S.; Wothers, P. *Organic Chemistry*, Oxford University Press.
- Singh, J.; Ali, S.M.; Singh, J. *Natural Product Chemistry*, Prajati Parakashan (2010).
- Graham Solomons, T.W. *Organic Chemistry*, John Wiley & Sons, Inc.
- Kalsi, P. S. *Textbook of Organic Chemistry*, 1st Ed., New Age International (P) Ltd. Pub.

Paper Title	: PHYSICAL CHEMISTRY-II (THEORY)
Paper Code	: CHMMJ-043
Course No	: C- 08
Credits	: 03
No. of Classes	: 45
Total Theory Marks	: 45

Course Objectives

- To understand crystal structures, symmetry, and properties of solids.
- To explain adsorption phenomena and colloidal systems.
- To introduce free energy functions and thermodynamic relations.
- To study thermodynamic behavior of mixtures and variable composition systems.

Learning Outcomes: After completion of the course, learners will be able to:

- Explain crystal structures, X-ray diffraction, and defects in solids.
- Interpret adsorption isotherms and properties of colloids.
- Apply free energy concepts and thermodynamic equations.
- Analyze thermodynamic properties of mixtures using chemical potential and Gibbs-Duhem equation.

Unit-I: Solid State: Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, elementary ideas of symmetry, symmetry elements, discussion of various symmetry elements of a cubical crystal, Crystallographic terms, Space lattice or crystal lattice, crystal structure and unit cell, calculation of interplanar separation for cubic systems, seven crystal systems and fourteen Bravais lattices; X-ray diffraction, Bragg's law, a simple account of rotating crystal method and powder pattern method, Density of cubic crystals, Closest packing, Packing in ionic solids, Effect of ion size on crystal structure – radius ratio, Void, Defects in crystals, conductors, semiconductors and insulators from band theory.

(13 Lectures; Marks: 13)

Unit-II: Surface Chemistry and Colloids: Physical adsorption, chemisorption, adsorption isotherms- Langmuir & Freundlich. nature of adsorbed state, BET Theory

The colloidal systems, Preparation of lyophobic colloidal solutions, Properties of colloidal systems, zeta potential, DLVO theory).

(12 Lectures; Marks: 12)

Unit III: Free Energy Functions: Gibbs and Helmholtz energy; variation of S, G, A with T, V, P; Free energy change and spontaneity. Relation between Joule-Thomson coefficient and other thermodynamic parameters; inversion temperature; Gibbs-Helmholtz equation; Maxwell relations; thermodynamic equation of state.

(12 Lectures; Marks: 12)

Unit-IV: Systems of Variable Composition: Partial molar quantities, dependence of thermodynamic parameters on composition; Gibbs-Duhem equation, chemical potential of ideal mixtures, change in thermodynamic functions in mixing of ideal gases.

(08 Lectures; Marks: 8)

Paper Title	: PHYSICAL CHEMISTRY-II (Practical)
Paper Code	: CHMMJ-043
Course No	: C- 08
Credits	: 01
No. of Classes	: 30
Total Marks	: 15

EXPERIMENTAL WORK

1. Verify the Freundlich and Langmuir isotherms for adsorption of acetic acid on activated charcoal.

2. Study the kinetics of the following reactions.

A. Initial rate method: Iodide-persulphate reaction

B. Integrated rate method:

- (i) Acid hydrolysis of methyl acetate with hydrochloric acid.
- (ii) Saponification of ethyl acetate.

MODES OF IN-SEMESTER ASSESSMENT:

40 Marks

- Two Internal Examination -

20 Marks

- Others -

20 Marks

- Home Assignment

- Seminar presentation on any of the relevant topics

- Practical Notebook/Viva

Course Outcomes (COs) & Bloom's Mapping

After the completion of this course, the learner will be able to:

CO1: Explain the fundamental concepts of crystal structure, symmetry, lattices, and X-ray diffraction in solid state chemistry.

CO2: Apply principles of crystal geometry, packing, and defects to interpret properties of solids and materials.

CO3: Describe the principles of adsorption, surface phenomena, and colloidal systems along with their theoretical models.

CO4: Apply thermodynamic free energy concepts and related equations to determine spontaneity and equilibrium behaviour of systems.

CO5: Analyze the effect of composition on thermodynamic properties of mixtures using partial molar quantities and chemical potential concepts.

Knowledge Dimension	Remember L1	Understand L2	Apply L3	Analyze L4	Evaluate L5	Create L6
Factual						
Conceptual		CO1, CO3	CO2, CO4	CO5		
Procedural			CO6			
Metacognitive						

Suggested Books:

- Atkins, P. Paula, J., et al.; *Physical Chemistry International Edition* (2018).
- West, A. R.; *Solid State Chemistry and its Applications*. Wiley (2014).
- Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.
- Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A. J., Smith, P. W. G., Textbook of Practical Organic Chemistry, 5th Edn., (Prentice-Hall, 1996).
- Jadav, J. B. Advanced Practical Physical Chemistry, (Krishna Prakashan, 2015)
- Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co. New York (2003).

Reference Books:

- Butler, J. N.; *Ionic Equilibrium: Solubility and pH Calculations*. Wiley-Interscience (1998).
- Levine, I.N. *Physical Chemistry 6th Ed.*, Tata Mc Graw Hill (2010).
- Pathania, P. S.; *Physical Chemistry. 48th Edition* (2021).
- Kapoor K. L. *A Textbook of Physical Chemistry Sixth Ed.*, Vol. 2, Macmillan, India

Paper Title : POLYMER CHEMISTRY-I (Theory)
Paper Code : CHMMJ-043

Course No	: C- 08
Credits	: 03
No. of Classes	: 45
Total Marks	: 45

Course Objectives

- Teach polymer classifications, molecular weights, and reaction mechanisms.
- Cover synthesis, structures, and applications of inorganic polymers.
- Explain coordination polymerization using Ziegler-Natta catalysis.
- Introduce commercial plastics, rubbers, and functional polymers.

Learner Outcomes:

- Calculate polymer molecular weights and PDI.
- Compare inorganic polymers with organic polymer networks.
- Differentiate radical, ionic, and coordination polymerization mechanisms.
- Classify commercial plastics, synthetic fibres, and rubbers by use.

Unit-I: Fundamentals of Polymers: Introduction and classification including di-block, tri-block and amphiphilic polymers; Number average molecular weight, Weight average molecular weight, Degree of polymerization, Polydispersity Index. Polymerisation reactions - Addition and condensation Mechanism of cationic, anionic and free radical addition polymerization.

(15 Lecture, 15 Marks)

UNIT-II: Inorganic Polymers: Types of inorganic polymers, comparison with organic polymers, synthesis, structural aspects and applications of silicones and siloxanes. Borazines, silicates and phosphazenes, and polysulphates.

(15 Lecture, 15 Marks)

UNIT-III: Organic Polymers: Metallocene-based Ziegler-Natta polymerisation of alkenes; Preparation and applications of plastics-thermosetting (phenol-formaldehyde, Polyurethanes) and thermosoftening (PVC, polythene); Fabrics-natural and synthetic (acrylic, polyamido, polyester); Rubbers-natural and synthetic: Buna-S, Chloroprene and Neoprene; Vulcanization; Polymer additives; Introduction to liquid crystal polymers; Biodegradable and conducting polymers with examples.

(15 Lectures; Marks: 15)

Paper Title	: POLYMER CHEMISTRY-I (Practical)
Paper Code	: CHMMJ-043
Course No	: C- 08

Credits	: 01
No. of Classes	: 30
Total Marks	: 15

1. Preparation of urea formaldehyde resin
2. Preparation of phenol formaldehyde resin
3. Determination of molecular weight of a polymer by viscosity method.

MODES OF IN-SEMESTER ASSESSMENT:	40 Marks
• Two Internal Examination	20 Marks
• Others	20 Marks
○ Home Assignment	
○ Seminar presentation on any of the relevant topics	
○ Practical Notebook/Viva	

Course Outcomes (COs) & Bloom's Mapping

After the completion of this course, the learner will be able to:

CO 1: Calculate the molecular weights (number-average and weight-average) and the polydispersity index of polymer systems to determine their molecular weight distributions.

CO 2: Differentiate between the mechanistic pathways of chain-growth (free radical, cationic, anionic) and step-growth polymerizations.

CO 3: Compare the synthesis, structural features, and functional applications of inorganic polymers like silicones and phosphazenes with standard organic frameworks.

CO 4: Explain the mechanism and industrial significance of coordination polymerization utilizing metallocene-based Ziegler-Natta catalysts.

CO 5: Classify major commercial materials—including thermoplastic and thermosetting plastics, synthetic rubbers, fibres, and advanced conducting polymers—based on their synthetic properties and applications.

CO 6: Synthesize thermosetting step-growth polymers and determine the molecular weight of a polymer sample utilizing dilute solution viscometry methods.

Knowledge Dimension	Remember L1	Understand L2	Apply L3	Analyze L4	Evaluate L5	Create L6
Factual			CO1	CO2		
Conceptual		CO4, CO5		CO3		
Procedural			CO6			
Metacognitive						

Suggested Books:

- Introduction to Polymer by R. J. Young and P. A. Lovell

SEMESTER-V

Paper Title	: INORGANIC CHEMISTRY-III (Theory)
Paper Code	: CHMMJ-051
Course No	: C- 10
Credits	: 03
No. of Classes	: 45
Total Theory Marks	: 45

Course Objectives

- To understand the fundamentals of organometallic compounds, bonding, and electron counting rules.
- To study important organometallic reactions and catalytic industrial processes.
- To explain the structure and properties of carbon, boron, halogen, and noble gas compounds.
- To develop knowledge of structure, bonding, reactivity, and applications of inorganic compounds.

Learning Outcomes: Learners will be able to

- Classify and explain the bonding and structure of organometallic compounds.
- Describe important organometallic reactions and catalytic mechanisms.
- Interpret the properties and applications of carbon, boron, halogen, and noble gas compounds.
- Apply concepts of bonding, reactivity, and molecular structure in inorganic chemistry.

UNIT-I: Organometallic Chemistry: Definition and classification of organometallic compounds on the basis of bond type. Concept of hapticity of organic ligands. 18-electron and 16-electron rules (pictorial MO approach). Applications of 18-electron rule to metal carbonyls, nitrosyls, cyanides. General methods of preparation of mono and binuclear carbonyls of 3d series. Structures of mononuclear and binuclear carbonyls of Cr, Mn, Fe, Co and Ni. pi-acceptor behaviour of CO, synergic effect and use of IR data to explain extent of back bonding. Zeise's salt: Preparation, structure, evidences of synergic effect. Ferrocene: Structure, preparation and reactions (acetylation, alkylation, metallation, Mannich Condensation). Structure and aromaticity. Comparison of aromaticity and reactivity with that of benzene. Schlenk equilibrium.

(15 Lectures; 15 Marks)

UNIT-II: Reactions of Organometallic Complexes and Organometallic Catalysis: Oxidative addition, reductive elimination, insertion, nucleophilic and electrophilic attack of coordinated ligands substitution, Study of the following industrial processes and their mechanism: Alkene hydrogenation (Wilkinson's Catalyst), Hydroformylation, Wacker

Process, Synthetic gasoline (Fischer Tropsch reaction), Ziegler-Natta catalysis for olefin polymerization

(10 Lectures; 10 Marks)

UNIT III: Carbon and boron family: Allotropes of carbon: fullerene, graphite and diamond; graphene, CNT, carbon quantum dot (introductory idea and applications only)

Boron: Boron hydrides, Wedge's rule; carborane and metalborane.

(07 Lectures; 07 Marks)

UNIT-IV: Halogen Family: Electronic structure and valences, preparation, interhalogen compounds, polyhalides, pseudohalogenes, oxides and oxoacids of halogens.

(06 Lectures; 06 Marks)

UNIT-V: Noble Gases: Occurrence separation and uses, rationalization of inertness of noble gases, special affinity of Xe, O & F to form compounds, Clathrates; preparation and properties of XeF₂, XeF₄ and XeF₆. Nature of bonding in noble gas compounds (Valence bond treatment for XeF₂ and XeF₄, MO treatment for XeF₂). Xenon-oxygen compounds. Molecular shapes of noble gas compounds (VSEPR theory).

(07 Lectures; 07 Marks)

Paper Title	: INORGANIC CHEMISTRY-III (Practical)
Paper Code	: CHMMJ-051
Course No	: C- 10
Credits	: 01
No. of Classes	: 30
Total Theory Marks	: 15

1. Gravimetric Analysis:

- (i) Estimation of Nickel (II) using Dimethylglyoxime (DMG)
- (ii) Estimation of iron as Fe₂O₃ by precipitating iron as Fe(OH)₃

2. Inorganic Preparations:

- (a) Tetraamminecopper (II) sulphate, [Cu(NH₃)₄]SO₄.H₂O
- (ii) *Cis* and *trans* K[Cr(C₂O₄)₂.(H₂O)₂] Potassium dioxalatodiaquachromate (III)
- (iii) Tetraamminecarbonatocobalt (III) ion [Co(NH₃)₄(CO₃)]⁺
- (iv) Potassium tris(oxalate)ferrate (III) K₃[Fe(C₂O₄)₃]

MODES OF IN-SEMESTER ASSESSMENT:

	40 Marks
• Two Internal Examination	20 Marks
• Others	20 Marks
○ Home Assignment	

- Seminar presentation on any of the relevant topics
- Practical Notebook/Viva

Course Outcomes (COs) & Bloom's Mapping

After the completion of this course, the learner will be able to:

CO1: Explain the classification, bonding concepts, electron counting rules, and structure of organometallic compounds including carbonyls and ferrocene.

CO2: Apply electron counting rules and molecular orbital concepts to predict stability and structure of organometallic complexes.

CO3: Analyze reaction mechanisms of organometallic transformations and catalytic processes such as hydrogenation, Wacker process, and Fischer–Tropsch synthesis.

CO4: Describe the structure, properties, and applications of carbon, boron, halogen, and noble gas compounds using fundamental chemical principles.

CO5: Apply bonding theories (VSEPR, VBT, MO theory) to interpret the structure and reactivity of noble gas compounds and boron hydrides.

CO6: Perform gravimetric estimations and inorganic preparations of selected metal complexes, demonstrating accurate experimental techniques, stoichiometric calculations, and understanding of coordination chemistry principles.

Knowledge Dimension	Remember L1	Understand L2	Apply L3	Analyze L4	Evaluate L5	Create L6
Factual						
Conceptual		CO1, CO4	CO2, CO5	CO3		
Procedural			CO6			
Metacognitive						

Suggested Books:

- Lee, J. D. *Concise Inorganic Chemistry*, 5th Ed., Wiley India Pvt. Ltd., 2008.
- Organometallic and Bioinorganic Chemistry, Ajai Kumar, Aaryush Educations, 2014
- Atkin, P. *Shriver & Atkins' Inorganic Chemistry*, 5th Ed., Oxford University Press (2010)
- Huheey, J. E.; Keiter, E.A. & Keiter, R.L. *Inorganic Chemistry*, Pearson, 2006
- Cotton, F.A., Wilkinson, G. and Gaus, P.L., *Basic Inorganic Chemistry 3rd Ed.*; Wiley India.
- Sharpe, A.G., *Inorganic Chemistry*, 4th Ed. Indian Reprint (Pearson Education) 2005.
- Mingos, D.M.P., *Essential trends in inorganic chemistry*. Oxford University Press (1998)
- Bioinorganic Chemistry, K Hussain Reddy, New Age International, 2003
- SWAYAM
- N-LIST
- E-PATHSALA

Paper Title : ORGANIC CHEMISTRY-III (THEORY)
Paper Code : CHMMJ-052

Course No	: C- 11
Credits	: 03
No. of Classes	: 45
Total Theory Marks	: 45

Course Objectives

- To understand structure, properties, and reactions of biomolecules.
- To study enzyme function, kinetics, and inhibition.
- To learn biological energy transfer and metabolism.
- To understand carbohydrates and lipids chemistry and transformations.

Learning Outcomes: Learners will be able to

- Describe biomolecules and their reactions.
- Explain enzyme action and inhibition.
- Outline basic metabolic pathways and energy concepts.
- Interpret structures and reactions of carbohydrates and lipids.

Unit-I: Amino Acids, Peptides and Proteins: Amino acids, Peptides and their classification. α -Amino Acids - Synthesis, ionic properties and reactions. Zwitterions, pKa values, isoelectric point and electrophoresis; Study of peptides: determination of their primary structures-end group analysis, methods of peptide synthesis. Synthesis of peptides using N-protecting, C-protecting and C-activating groups - Solid-phase synthesis.

(10 Lectures; Marks: 10)

Unit-II: Enzymes: Introduction, classification and characteristics of enzymes. Salient features of active site of enzymes. Mechanism of enzyme action (taking trypsin as example), factors affecting enzyme action, coenzymes and cofactors and their role in biological reactions, specificity of enzyme action (including stereospecificity), enzyme inhibitors and their importance, phenomenon of inhibition (competitive, uncompetitive and non-competitive inhibition including allosteric inhibition).

(8 Lectures; Marks: 8)

Unit-III: Concept of Energy in Biosystems: Cells obtain energy by the oxidation of foodstuff (organic molecules). Introduction to metabolism (catabolism, anabolism). ATP: The universal currency of cellular energy, ATP hydrolysis and free energy change. Agents for transfer of electrons in biological redox systems: NAD^+ , FAD. Conversion of food to energy: Outline of catabolic pathways of carbohydrate- glycolysis, fermentation, Krebs cycle.

(8 Lectures; Marks: 8)

Unit-IV: Carbohydrates: Monosaccharides: Constitution and absolute configuration of glucose and fructose, epimers and anomers, mutarotation, determination of ring size of glucose and fructose, Haworth projections and conformational structures; Interconversions of aldoses and ketoses; Killiani-Fischer synthesis and Ruff degradation; Disaccharides – Structure elucidation of maltose, lactose and sucrose. Polysaccharides – Elementary treatment of starch, cellulose and glycogen.

(14 Lectures; Marks: 14)

Unit-V: Lipids: Introduction to oils and fats; common fatty acids present in oils and fats, Hydrogenation of fats and oils, Saponification value, acid value, iodine number. Reversion and rancidity.

(5 Lectures; Marks: 5)

Paper Title	: ORGANIC CHEMISTRY-III (Practical)
Paper Code	: CHMMJ-052
Course No	: C- 11
Credits	: 01
No. of Classes	: 30
Total Marks	: 15

1. Estimation of glycine by Sorenson's formalin method.
2. Study of the titration curve of glycine.
3. Estimation of Glucose.
4. Saponification value of an oil or a fat.
5. Determination of Iodine number of an oil/ fat.

MODES OF IN-SEMESTER ASSESSMENT:**40 Marks**

- Two Internal Examination -
- Others -
 - Home Assignment
 - Seminar presentation on any of the relevant topics
 - Practical Notebook/Viva

20 Marks**20 Marks****Course Outcomes (COs) & Bloom's Mapping**

After the completion of this course, the learner will be able to:

CO1: Describe the structure, classification, properties, and synthesis of amino acids, peptides, carbohydrates, and lipids.

CO2: Explain enzyme structure, function, inhibition, and catalytic mechanisms in biological systems.

CO3: Apply concepts of energy metabolism including ATP, redox carriers, and major biochemical pathways.

CO4: Analyse structural features and reactions of carbohydrates, peptides, and biomolecules for elucidation and transformation.

CO5: Interpret biochemical properties and relationships of biomolecules in physiological and metabolic contexts.

CO6: Perform quantitative estimation of biomolecules and physicochemical properties of oils/fats, including amino acid titration, carbohydrate estimation, and determination of saponification and iodine values using standard analytical techniques.

Knowledge Dimension	Remember L1	Understand L2	Apply L3	Analyze L4	Evaluate L5	Create L6
Factual						
Conceptual		CO1, CO2	CO3	CO4, CO5		
Procedural			CO6			
Metacognitive						

Text Book(s):

- Bruice, P. Y. *Organic Chemistry*, Pearson, 3rd Edn., 2013.
- Warren, S. *Organic Synthesis: The disconnection approach*, Wiley, 2nd Edn., 2009.
- McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Edn. Cengage Learning India Edn., 2013.

Reference Books:

- Kalsi, P.S. *Organic Synthesis through Disconnection Approach*, MedTech Science Press, 2nd Edn., 2022.
- Nelson, D.L.; Cox, M. M. and Lehninger A.L. *Principles of Biochemistry*, 4th Edn., W.H. Freeman and Co., 2009.
- Berg, J.M.; Tymoczko, J.L. and Stryer, L. *Biochemistry*. 6th Edn., W.H. Freeman and Co. 2006.
- Billmeyer, F. W. *Textbook of Polymer Science*, John Wiley & Sons, Inc.
- Graham Solomons, T.W. *Organic Chemistry*, John Wiley & Sons, Inc.

Paper Title	: PHYSICAL CHEMISTRY-III (THEORY)
Paper Code	: CHMMJ-053
Course No	: C- 12
Credits	: 03
No. of Classes	: 45
Total Theory Marks	: 45

Course Objectives

- To understand basics of chemical kinetics, catalysis, and equilibrium.
- To study rate laws, mechanisms, and temperature effects.
- To learn enzyme and surface catalysis.
- To apply thermodynamics to chemical equilibrium.

Learning Outcomes: Learners will be able to

- Describe reaction rates and orders.

- Explain catalytic processes.
- Apply kinetic equations.
- Interpret equilibrium using thermodynamics.

Unit I: Chemical Kinetics: Order and molecularity of a reaction, rate laws in terms of the advancement of a reaction, differential and integrated form of rate expressions up to second order reactions, experimental methods of the determination of rate laws, kinetics of complex reactions (integrated rate expressions up to first order only): (i) Opposing reactions (ii) parallel reactions and (iii) consecutive reactions and their differential rate equations (steady-state approximation in reaction mechanisms) (iv) chain reactions. Temperature dependence of reaction rates; Arrhenius equation; activation energy. Collision theory of reaction rates, Lindemann mechanism, qualitative treatment of the theory of absolute reaction rates.

(20 Lectures; Marks: 20)

Unit II: Catalysis: Types of catalyst, specificity and selectivity, mechanisms of catalyzed reactions at solid surfaces; effect of particle size and efficiency of nanoparticles as catalysts. Enzyme catalysis, Michaelis-Menten mechanism, acid-base catalysis.

(8 Lectures; Marks: 8)

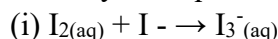
Unit III: Chemical Equilibrium: Criteria of thermodynamic equilibrium, degree of advancement of reaction, chemical equilibria in ideal gases, concept of fugacity. Thermodynamic derivation of relation between Gibbs free energy of reaction and reaction quotient. Coupling of exoergic and endoergic reactions. Equilibrium constants and their quantitative dependence on temperature, pressure and concentration. Free energy of mixing and spontaneity; thermodynamic derivation of relations between the various equilibrium constants K_p , K_c and K_x . Le Chatelier principle (quantitative treatment); equilibrium between ideal gases and a pure condensed phase.

(17 Lectures; Marks: 17)

Paper Title	: PHYSICAL CHEMISTRY-III (Practical)
Paper Code	: CHMMJ-053
Course No	: C- 12
Credits	: 01
No. of Classes	: 30
Total Theory Marks	: 15

Experimental Work

1. Determination of critical solution temperature and composition of the phenol-water system and to study the effect of impurities on it.
2. Distribution of acetic/ benzoic acid between water and cyclohexane.
3. Study the equilibrium of at least one of the following reactions by the distribution method:



**MODES OF IN-SEMESTER ASSESSMENT:**

	40 Marks
• Two Internal Examination -	20 Marks
• Others -	20 Marks
○ Home Assignment	
○ Seminar presentation on any of the relevant topics	
○ Practical Notebook/Viva	

Course Outcomes (COs) & Bloom's Mapping

After the completion of this course, the learner will be able to:

CO1: Describe fundamental concepts of chemical kinetics, catalysis, and chemical equilibrium.

CO2: Explain rate laws, reaction mechanisms, and temperature dependence of reaction rates.

CO3: Apply kinetic models and Arrhenius equation to analyse reaction rates and mechanisms.

CO4: Analyse catalytic processes including enzyme, surface, and nanoparticle catalysis.

CO5: Interpret thermodynamic principles governing chemical equilibrium and predict system behaviour.

CO6: Perform experimental determination of phase equilibrium and distribution equilibria of chemical systems, and analyze the effect of impurities and complex formation using appropriate physico-chemical methods.

Knowledge Dimension	Remember L1	Understand L2	Apply L3	Analyze L4	Evaluate L5	Create L6
Factual						
Conceptual		CO1, CO2	CO3	CO4, CO5		
Procedural			CO6			
Metacognitive						

Suggested Books:

- Pathania, P. S.; *Principles of Physical Chemistry*. 48th Edition (2021).
- Kapoor K. L. *A Textbook of Physical Chemistry Sixth Ed.*, Vol. 2, Macmillan, India.
- Mukerjee, R.C.; *Modern Approach to Physical Chemistry I*, BB Bharati Bhawan (P & D) (2022).
- Levine, I.N. *Physical Chemistry 6th Ed.*, Tata Mc Graw Hill (2010).

Paper Title	: Group theory & Spectroscopy-I (Theory)
Paper Code	: CHMMJ-054
Course No	: C- 13
Credits	: 03

No. of Classes : 45

Total Theory Marks : 45

Course Objectives

- To understand molecular symmetry and group theory concepts.
- To learn fundamentals of rotational, vibrational, Raman, and electronic spectroscopy.
- To apply group theory in molecular structure analysis.
- To interpret basic spectroscopic data for molecules.

Learning Outcomes: Learners will be able to

- Describe symmetry elements and point groups.
- Explain basic spectroscopic principles.
- Apply group theory and selection rules.
- Analyse molecular spectra for structure determination.

UNIT-I: Symmetry and Group Theory: Symmetry as a universal theme, Molecular symmetry, Symmetry elements and operations, Point groups, Matrix representation of symmetry operations, character, Definition of a mathematical group, Abelian group, Cyclic group, symmetry operations as group elements. Symmetry classification of molecules into point groups (H_2 , HCl , BCl_3 , NH_3 , H_2O , C_2H_2 , C_2H_4 , BF_3 , $[Pt(CN)_4]^{2+}$) (Schoenflies symbol). Group multiplication table. Reducible and irreducible representations, Great Orthogonality Theorem and its consequences, character tables, reduction formula, construction of character tables for C_{2v} and C_{3v} point groups.

(15 Lectures; 13 Marks)

Unit II: Introduction to Spectroscopy, Interaction of electromagnetic radiation with matter, natural line width, broadening of lines, various types of spectroscopies, .

(4 Lectures; 5 Marks)

UNIT-III: Rotational Spectroscopy: Selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution.

(4 Lectures; 5 Marks)

UNIT-IV: Vibrational & Raman Spectroscopy: Classical equation of vibration, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, Fermi resonance, degrees of freedom for polyatomic molecules, modes of vibration, concept of group frequencies.

Raman Spectroscopy: Qualitative treatment of Rotational Raman effect; Effect of nuclear spin, Stokes and anti-Stokes lines; their intensity difference, rule of mutual exclusion.

(13 Lectures; 13 Marks)

UNIT-V: Electronic Spectroscopy-I: Principle of electronic spectroscopy, Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, calculation of electronic transitions of polyenes using free electron model.

(9 Lectures; Marks: 9)

Paper Title	: Group theory & Spectroscopy-I (Practical)
Paper Code	: CHMMJ-054
Course No	: C- 13
Credits	: 01
No. of Classes	: 30
Total Theory Marks	: 15

EXPERIMENTAL WORK

1. Verify Lambert-Beer's law and determine the concentration of $\text{CuSO}_4/\text{KMnO}_4/\text{K}_2\text{Cr}_2\text{O}_7$ in a solution of unknown concentration.
2. Determine the concentrations of KMnO_4 and $\text{K}_2\text{Cr}_2\text{O}_7$ in a mixture by colorimetric method.
3. Determine the amount of iron present in a sample using 1,10-phenanthroline by spectrophotometric method.
4. Determine the dissociation constant of an indicator (phenolphthalein)

MODES OF IN-SEMESTER ASSESSMENT:

	40 Marks
• Two Internal Examination -	20 Marks
• Others -	20 Marks
○ Home Assignment	
○ Seminar presentation on any of the relevant topics	
○ Practical Notebook/Viva	

Course Outcomes (COs) & Bloom's Mapping

After the completion of this course, the learner will be able to:

CO1: Describe molecular symmetry, point groups, and basic concepts of group theory.

CO2: Explain principles of rotational, vibrational, Raman, and electronic spectroscopy.

CO3: Apply group theory concepts and character tables to molecular symmetry problems.

CO4: Analyse spectroscopic selection rules and molecular vibrational and rotational behavior.

CO5: Interpret electronic, vibrational, and rotational spectra for molecular structure determination.

CO6: Perform quantitative spectrophotometric and volumetric analysis to verify Beer–Lambert law, determine concentrations of metal ions and mixtures, and evaluate equilibrium

constants using standard analytical techniques.

Knowledge Dimension	Remember L1	Understand L2	Apply L3	Analyze L4	Evaluate L5	Create L6
Factual						
Conceptual		CO1, CO2	CO3	CO4, CO5		
Procedural			CO6			
Metacognitive						

Suggested Books:

- Banwell, C.N.; *Fundamentals of Molecular Spectroscopy*, 4th Edition. Mc-Graw Hill (1994).
- Pavia, D.L.; *Introduction to Spectroscopy*, 5th Edition Cengage India Private Limited (2015).

SEMESTER-VI

Paper Title	: INORGANIC CHEMISTRY-IV (Theory)
Paper Code	: CHMMJ-061
Course No	: C- 14
Credits	: 03
No. of Classes	: 45
Total Theory Marks	: 45

Course Objectives

1. To understand basic principles of metallurgy and metal extraction.
2. To learn statistical analysis and error treatment in data.
3. To study solvent extraction and chromatographic techniques.
4. To understand bioinorganic roles of metal ions.

Learning Outcomes: Learners will be able to

1. Describe metallurgical processes and refining methods.
2. Apply basic statistical tools in data analysis.
3. Explain separation techniques like extraction and chromatography.
4. Interpret biological functions of metal ions.

UNIT-I: General Principle of Metallurgy: Occurrence of metals based on standard electrode potential, methods of concentration of ores, reduction to free metal, electrometallurgy, hydrometallurgy and pyrometallurgy, synthesis of ultrapure elements. Refining of metals, electrolytic, ion exchange, zone refining, vapour phase refining and

oxidative refining. Thermodynamics of the oxidation of metals to metaloxides- Ellingham diagrams. Extractive metallurgy of Th, Ti. Kroll process, Parting process, van Arkel-de Boer process and Mond's process, Zone refining, Ferrous metallurgy-manufacture of steel by open hearth process.

(10 Lectures; 10 Marks)

UNIT-II: Errors and Statistics in Data Analysis: Significant figures, Accuracy, Precision, Error, Types of errors- Determinate and Indeterminate errors, Distribution of random errors, Mathematical Expression for error- Absolute and Relative error, Methods to reduce error, Statistical tools for expressing precision- Standard deviation, Relative standard deviation, Variance, Comparison of results- Students t test, f test, Criteria for rejecting a value-Q test, Confidence interval, Correlation and Regression, Linear regression analysis with experimental data.

(10 Lectures; 10 Marks)

UNIT – III: Separation Techniques: Mechanism of extraction: extraction by solvation and chelation. Technique of extraction: batch, continuous and counter current extractions. Qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and nonaqueous media.

(6 Lectures; 6 Marks)

UNIT – IV: Chromatography: Classification, principle and efficiency of the technique. Mechanism of separation: adsorption, partition & ion exchange. Development of chromatograms: frontal, elution and displacement methods. Qualitative and quantitative aspects of chromatographic methods of analysis: GLC, GPC, TLC and HPLC. Paper chromatographic separation of following metal ions: Ni (II) and Co (III).

(7 Lectures; 8 Marks)

UNIT-V: Bioinorganic Chemistry: Elements of life: essential and beneficial elements, major, trace and ultratrace elements, the role of metal ions (specially Na, K, Mg, Ca, Fe, Cu, and Zn) in biological system. Metal ion transport across biological membrane Na/ K-ion pump. Metal ions in biological systems: Heme proteins-hemoglobin, myoglobin, Non-Heme Iron Proteins: Iron storage and transfer, superoxide dismutase, cytochrome oxidase; Zinc and Cobalt enzymes-carbonic anhydrase, carboxypeptidase, Vitamin B₁₂. Toxic metal ions and their effects (Hg, Pb, Cd and As), chelation therapy (examples only).

(12 Lectures; 12 Marks)

Paper Title	: INORGANIC CHEMISTRY-IV (Practical)
Paper Code	: CHMMJ-061
Course No	: C- 14
Credits	: 01
No. of Classes	: 30
Total Theory Marks	: 15

EXPERIMENTAL WORK

1. Principles involved in chromatographic separations. Paper chromatographic separation of following metal ions:

i. Ni (II) and Co (II)

ii. Fe (III) and Al (III)

2. Determination of dissolved oxygen in water.

3. Percentage of available chlorine in bleaching powder.

4. Measurement of chloride, sulphate and salinity of water samples by simple titration method (AgNO_3 and potassium chromate).

5. Estimation of total alkalinity of water samples (CO_3^{2-} , HCO_3^-) using double titration method.

6. Separation of metal complex in different medium through solvent extraction by Batch method.

MODES OF IN-SEMESTER ASSESSMENT:

40 Marks

• Two Internal Examination -

20 Marks

• Others -

20 Marks

○ Home Assignment

○ Seminar presentation on any of the relevant topics

○ Practical Notebook/Viva

Course Outcomes (COs) & Bloom's Mapping

After the completion of this course, the learner will be able to:

CO1: Describe principles of metallurgy, ore processing, and metal extraction techniques.

CO2: Explain statistical tools for data analysis, error estimation, and result validation.

CO3: Apply solvent extraction and chromatographic methods for separation and analysis of compounds.

CO4: Analyse efficiency and mechanisms of separation techniques used in chemical analysis.

CO5: Interpret the biological roles and toxicity of metal ions in bioinorganic systems.

CO6: Perform qualitative and quantitative analysis of mixtures and water samples using chromatographic separation, titrimetric methods, and solvent extraction, demonstrating understanding of analytical principles and data interpretation.

Knowledge Dimension	Remember L1	Understand L2	Apply L3	Analyze L4	Evaluate L5	Create L6
Factual						
Conceptual		CO1, CO2	CO3	CO4, CO5		

Procedural			CO6			
Metacognitive						

Suggested Books:

- General and Inorganic Chemistry (Part-2), RP Sarkar, NBCA, 2002.
- Molecular Symmetry in Chemistry, Agarwalla, Nigam, and Karla,
- Basic Concepts of Analytical Chemistry, 4th Ed. SM Khopker, New Age International
- Metallurgical Engineering, Arvind Kumar, Khanna Publisher, 1998
- Material Science and Metallurgy, OP Khanna, Dhanpat Rai Publications
- Basic Statistics, BL Agarwal, New Age International
- SWAYAM
- N-LIST
- E-PATHSALA

Paper Title	: ORGANIC CHEMISTRY-IV (THEORY)
Paper Code	: CHMMJ-062
Course No	: C- 15
Credits	: 03
No. of Classes	: 45
Total Theory Marks	: 45

Course Objectives

- To understand classification, chemistry, and applications of dyes and their synthesis mechanisms.
- To develop knowledge of nucleic acids, organic biomolecules, and their structural features.
- To introduce principles of retrosynthesis and planning of organic synthesis.
- To learn basics of pericyclic reactions and green chemistry principles for sustainable synthesis.

Learning Outcomes: Learners will be able to

- Describe structure, classification, and synthesis of dyes and biomolecules.
- Explain structure and reactions of nucleic acid components.
- Apply basic retrosynthetic strategies in organic synthesis.
- Analyse pericyclic reaction mechanisms using orbital symmetry concepts.

Unit-I: Dyes: Classification, Colour and constitution; Mordant and Vat Dyes; Chemistry of dyeing; Synthesis and applications of: Azo dyes-Methyl Orange and Congo Red (mechanism

of Diazo Coupling); Triphenyl Methane Dyes -Malachite Green, Rosaniline and Crystal Violet; Phthalein Dyes-Phenolphthalein and Fluorescein; Natural dyes-structure elucidation and synthesis of Alizarin and Indigotin; Edible Dyes with examples.

(7 Lectures; Marks: 7)

Unit-II: Nucleic Acids: Components of nucleic acids, Nucleosides and nucleotides; Structure, synthesis and reactions of: Adenine, Guanine, Cytosine, Uracil and Thymine; Structure of polynucleotides.

(6 Lectures; Marks: 6)

Unit-III: Planning of Organic Synthesis I: Disconnection, functional group interchange (FGI), functional group addition (FGA), synthons and synthetic equivalent, simple example of reactions (Corey House, Wittig and aldol condensation), retrosynthesis of monofunctionalized compounds.

(8 Lectures; Marks: 8)

Unit-IV: Pericyclic Reactions: Definition and classification, Orbital symmetry and HOMO-LUMO approach (FMO method), Cycloaddition reactions ([2+2] and [4+2]), electro-cyclic reactions and sigma-tropic rearrangement (Cope and Claisen).

(10 Lectures; Marks: 10)

Unit-V: Introduction to Green Chemistry:

Green Chemistry and Green Technology, Need for Green Chemistry; Goals of Green Chemistry; Limitations/ Obstacles in the pursuit of the goals of Green Chemistry.

Principles of Green Chemistry and Designing a Chemical synthesis:

Twelve principles of Green Chemistry with their explanations and examples and special emphasis on the following: Designing a Green Synthesis using these principles, Prevention of Waste/ byproducts, maximum incorporation of the materials used in the process into the final products, Atom Economy: calculation of atom economy of the rearrangement, addition, substitution and elimination reactions, Prevention/ minimization of hazardous/ toxic products reducing toxicity, risk factor, Green solvents, Energy requirements for reactions, catalytic reagents, biocatalysis in Organic synthesis, inherent safer design-principle of ISD, Bhopal Gas Tragedy, Flixiborough accident.

(14 Lectures; Marks: 14)

Paper Title	: ORGANIC CHEMISTRY-IV (Practical)
Paper Code	: CHMMJ-062
Course No	: C- 15
Credits	: 01
No. of Classes	: 30
Total Theory Marks	: 15

EXPERIMENTAL WORK

1. Qualitative analysis of unknown organic compounds containing monofunctional groups (carbohydrates, aryl halides, aromatic hydrocarbons) and simple bifunctional groups, for e.g. salicylic acid, cinnamic acid, nitrophenols etc.

2. Preparation of methyl orange.

Green Synthesis

3. Preparation of biodiesel from vegetable/ waste cooking oil.

4. Calculation of atom economy of organic reaction.

5. Preparation of Manganese (III) acetylacetonate, $Mn(acac)_3$

6. Synthesis of dihydropyrimidone.

7. Synthesis of 1,1-bis(2-naphthol)

MODES OF IN-SEMESTER ASSESSMENT:

• Two Internal Examination	-	40 Marks
• Others	-	20 Marks
○ Home Assignment		
○ Seminar presentation on any of the relevant topics		
○ Practical Notebook/Viva		

Course Outcomes (COs) & Bloom's Mapping

After the completion of this course, the learner will be able to:

CO1: Describe the classification, structure, and synthesis of dyes and nucleic acid components.

CO2: Explain principles of dye chemistry, nucleic acid structure, and organic reaction mechanisms.

CO3: Apply retrosynthetic analysis and synthetic strategies for designing organic molecules.

CO4: Analyse pericyclic reaction mechanisms using orbital symmetry and FMO concepts.

CO5: Evaluate green chemistry principles for designing environmentally sustainable chemical processes.

CO6: Perform qualitative analysis of organic compounds and carry out selected organic,

green, and coordination chemistry preparations, applying fundamental laboratory techniques and principles of synthesis, identification, and atom economy.

Knowledge Dimension	Remember L1	Understand L2	Apply L3	Analyze L4	Evaluate L5	Create L6
Factual						
Conceptual		CO1, CO2	CO3	CO4, CO5		
Procedural			CO6			
Metacognitive						

Suggested Book(s):

- Banwell, C. N.; McCash, E. M. *Fundamentals of Molecular Spectroscopy* 4th Ed., Tata McGraw-Hill: New Delhi 2006.
- Bruice, P. Y. *Organic Chemistry*, Pearson, 3rd Ed., 2013.
- Ahluwalia, V. K.; Kidwai M. R. *New Trends in Green Chemistry*, Anamalaya Publishers, 2012.
- Anastas, P. T., Warner, J. K. *Green Chemistry - Theory and Practical*, Oxford University Press, 2005.
- Cann, M.C.; Connely, M. E. *Real-World cases in Green Chemistry*, American Chemical Society, Washington, 2000.
- Kemp, W. *Organic Spectroscopy*, Palgrave.
- Silverstein, *Spectrometric Identification of Organic Compounds*, 7th Ed., John Wiley & Sons, 2005.
- Chandra, S. *Molecular Spectroscopy*, Narosa, 2009.
- McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.
- Fleming, I. *Molecular Orbitals and Organic Chemical Reactions*, Oxford University Press, 2010.
- Sankararaman, S. *Pericyclic reactions—a textbook: reactions, applications and theory*, 1st Edn., Wiley VCH, 2005.
- Matlack, A. S. *Introduction to Green Chemistry*, 2nd Ed., Marcel Dekker, 2010.
- Ryan, M. A.; Tinneland, M. *Introduction to Green Chemistry*, American Chemical Society, Washington, 2002.
- Lancaster, M. *Green Chemistry: An Introductory Text*, 2nd Ed., RSC Publishing, 2010

Paper Title	: PHYSICAL CHEMISTRY-III (THEORY)
Paper Code	: CHMMJ-063
Course No	: C- 16
Credits	: 03
No. of Classes	: 45
Total Theory Marks	: 45

Course Objectives

- To understand phase equilibria, phase diagrams, and thermodynamic principles governing multicomponent systems.
- To develop knowledge of conductance, ionic transport, and electrolytic behaviour of solutions.
- To study electrochemical cells, electrode potentials, and applications of EMF measurements.
- To apply thermodynamic and electrochemical concepts in analysing chemical systems and reactions.

Learning Outcomes: Learners will be able to

- Describe phase rule, phase diagrams, and binary/ternary equilibria.
- Explain ionic conductance, mobility, and transference numbers.
- Apply electrochemical equations such as Nernst equation in cell analysis.
- Analyse conductometric and potentiometric data for chemical systems.

UNIT I: Phase Equilibria: Concept of phases, components and degrees of freedom, derivation of Gibbs Phase Rule for nonreactive and reactive systems; Clausius-Clapeyron equation and its applications to solid-liquid, liquid-vapour and solid-vapour equilibria, phase diagram for one component systems, with applications. Phase diagrams for systems of solid-liquid equilibria involving eutectic, congruent and incongruent melting points, solid solutions. Three component systems, water-chloroform-acetic acid system, triangular plots. Binary Solutions: Gibbs-Duhem-Margules equation, its derivation and applications to fractional distillation of binary miscible liquids (ideal and nonideal), azeotropes, lever rule, partial miscibility of liquids, CST, miscible pairs, steam distillation. Nernst distribution law: its derivation and applications.

(15 Lectures; Marks: 15)

UNIT II: Conductance: Arrhenius theory of electrolytic dissociation. Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Molar conductivity at infinite dilution. Kohlrausch law of independent migration of ions. Debye-Huckel-Onsager equation, Wien effect, Debye-Falkenhagen effect, Walden's rules. Ionic velocities, mobilities and their determinations, transference numbers and their relation to ionic mobilities, determination of transference numbers using Hittorf and Moving Boundary methods. Applications of conductance measurement: (i) degree of dissociation of weak electrolytes, (ii) ionic product of water (iii) solubility and solubility product of sparingly soluble salts, (iv) conductometric titrations, and (v) hydrolysis constants of salts.

(15 Lectures; Marks: 15)

UNIT III: Electrochemistry: Quantitative aspects of Faraday's laws of electrolysis, rules of oxidation/reduction of ions based on half-cell potentials, applications of electrolysis in metallurgy and industry. Chemical cells, reversible and irreversible cells with examples. Electromotive force of a cell and its measurement, Nernst equation; Standard electrode (reduction) potential and its application to different kinds of half-cells. Application of EMF

measurements in determining (i) free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) pH values, using hydrogen, quinone-hydroquinone, glass and SbO/Sb₂O₃ electrodes. Concentration cells with and without transference, liquid junction potential; determination of activity coefficients and transference numbers. Qualitative discussion of potentiometric titrations (acid-base, redox, precipitation).

(15 Lectures; Marks: 15)

Paper Title	: PHYSICAL CHEMISTRY-III (Practical)
Paper Code	: CHMMJ-063
Course No	: C- 16
Credits	: 01
No. of Classes	: 30
Total Theory Marks	: 15

EXPERIMENTAL WORK

1. Conductometric Titrations of (i) Strong acid vs. strong base; (ii) Weak acid vs. strong base; (iii) Strong acid vs. weak base
2. Potentiometric Titration of (i) Strong acid vs. strong base; (ii) Weak acid vs. strong base; (iii) Dibasic acid vs. strong base

MODES OF IN-SEMESTER ASSESSMENT:

40 Marks

- | | | |
|--|---|-----------------|
| • Two Internal Examination | - | 20 Marks |
| • Others | - | 20 Marks |
| ○ Home Assignment | | |
| ○ Seminar presentation on any of the relevant topics | | |
| ○ Practical Notebook/Viva | | |

Course Outcomes (COs) & Bloom's Mapping

After the completion of this course, the learner will be able to:

CO1: Apply the concepts of phase rule, phase equilibria, and distribution law to analyse phase behaviour in chemical systems.

CO2: Apply thermodynamic principles to interpret phase diagrams and solution behaviour in binary and ternary systems.

CO3: Apply conductometric principles to evaluate ionic mobility, conductivity, and dissociation parameters.

CO4: Analyse electrochemical cells and EMF measurements to determine thermodynamic and equilibrium properties.

CO5: Evaluate phase, conductance, and electrochemical data to predict physicochemical behaviour of systems.

CO6: Analyze conductometric and potentiometric titration curves of different acid–base systems to determine equivalence points and evaluate the strength of acids and bases using electrochemical methods.

Knowledge Dimension	Remember L1	Understand L2	Apply L3	Analyze L4	Evaluate L5	Create L6
Factual						
Conceptual			CO1, CO2, CO3	CO4, CO5		
Procedural				CO6		
Metacognitive						

Suggested Books:

- Kapoor K. L. *A Textbook of Physical Chemistry Sixth Ed.*, Vol. 2, Macmillan, India.
- Pathania, P. S.; *Principles of Physical Chemistry*. 48th Edition (2021).
- Negi, A.S., Anand S.C.; *A Textbook of Physical Chemistry*, New Age International (P) Publishers (2004).

Reference Books:

- Gurdeep, R. *Advanced Practical Inorganic Chemistry*, (Krishna Prakashan, 2013).
- Levine, I.N. *Physical Chemistry 6th Ed.*, Tata Mc Graw Hill (2010).
- Bockris, J.; *Modern Electrochemistry-Volume 1-Ionics 2nd Edition*, Springer (2018).
- Laidler, K.J.; *Chemical Kinetics 3rd Edition*, Pearson (2003).

Paper Title : SPECTROSCOPY-II (THEORY)
Paper Code : CHMMJ-064
Course No : C- 17
Credits : 03
No. of Classes : 45
Total Theory Marks : 45

Course Objectives

- To understand the principles of UV–Visible, NMR, ESR, and mass spectroscopy.
- To study electronic transitions and key spectral parameters of organic molecules.
- To develop skills in structure elucidation using spectroscopic techniques.
- To interpret spectroscopic data and basic empirical rules for analysis.

Learning Outcomes: Learners will be able to

- Describe principles of major spectroscopic techniques.

- Explain electronic transitions, chemical shifts, and fragmentation behaviour.
- Apply Woodward rules and spectral data for molecular structure prediction.
- Analyse IR, UV, NMR, and mass spectra for identification of organic compounds.

UNIT-I: Electronic Spectroscopy-II: Types of electronic transitions, λ_{\max} , Chromophores and Auxochromes, Bathochromic and Hypsochromic shifts, Intensity of absorption; Application of Woodward Rules for calculation of λ_{\max} for the following systems: α , β unsaturated aldehydes, ketones, carboxylic acids and esters; Conjugated dienes: alicyclic, homoannular and heteroannular; Extended conjugated systems (aldehydes, ketones and dienes); distinction between cis and trans isomers.

(15 Lectures; Marks: 15)

UNIT-II: Spin resonance spectroscopy Nuclear Magnetic Resonance (NMR) spectroscopy: Principles of NMR spectroscopy, Larmor precession, chemical shift and low-resolution spectra, different scales, spin-spin coupling and high-resolution spectra, interpretation of PMR spectra of organic molecules.

Electron spin resonance (ESR) spectroscopy and its principle, hyperfine structure, ESR of simple free radicals.

(15 Lectures; Marks: 15)

UNIT-III: Mass Spectrometry: Principle, molecular ion peak, base peak, metastable ion, nitrogen rule, and even electron rule; Mc Lafferty rearrangement.

Applications of IR, UV, NMR and Mass for identification of simple organic molecules.

(15 Lectures; Marks: 15)

Paper Title	: SPECTROSCOPY-II (Practical)
Paper Code	: CHMMJ-064
Course No	: C- 17
Credits	: 01
No. of Classes	: 30
Total Theory Marks	: 15

EXPERIMENTAL WORK

1. Measurement of $10 Dq$ by spectrophotometric method
2. Preparation of acetylacetonato complexes of Cu^{2+}/Fe^{3+} . Find the λ_{\max} of the complex.
3. Identification of simple organic compounds by IR spectroscopy and NMR Spectroscopy (Spectra to be provided).

MODES OF IN-SEMESTER ASSESSMENT:**40 Marks**

- Two Internal Examination - **20 Marks**
- Others - **20 Marks**
 - Home Assignment
 - Seminar presentation on any of the relevant topics
 - Practical Notebook/Viva

Course Outcomes (COs) & Bloom's Mapping**After the completion of this course, the learner will be able to:**

CO1: Describe the principles, types of electronic transitions, and UV–Visible spectral parameters including chromophores, auxochromes, and shifts.

CO2: Apply Woodward–Fieser rules to calculate λ_{max} for conjugated organic systems including enones and dienes.

CO3: Explain the principles of NMR and ESR spectroscopy, including chemical shift, spin–spin coupling, and hyperfine interactions.

CO4: Interpret mass spectrometric data including molecular ion peaks, fragmentation patterns, and characteristic rearrangements.

CO5: Analyse and integrate IR, UV, NMR, and mass spectral data for structural elucidation of simple organic molecules.

CO6: Perform spectrophotometric and spectroscopic experiments to determine ligand field parameters, synthesize coordination complexes, and identify simple organic compounds using IR and NMR spectral analysis.

Knowledge Dimension	Remember L1	Understand L2	Apply L3	Analyze L4	Evaluate L5	Create L6
Factual						
Conceptual		CO1, CO3	CO2	CO4, CO5		
Procedural			CO6			
Metacognitive						

Text Books

- Organic Spectroscopy by PS Kalsi
- Organic Spectroscopy by YR Sharma (S Chand)

Paper Title	: QUANTUM CHEMISTRY-I
Paper Code	: CHMMJ-065
Course No	: C- 18
Credits	: 02
No. of Classes	: 30
Total Theory Marks	: 30

Course Objectives:

- To understand inadequacy of classical mechanics.
- To understand postulates of quantum mechanics,
- To develop understanding of concept of wave function, Valence bond theory and Molecular orbital theory.

Learners Outcome: Learners will gain an understanding of

- Drawbacks of classical mechanics and the origin of quantum theory
- Postulates of quantum mechanics. concept of wave functions, operators and eigen value equation
- Valence bond and molecular orbital theory
- Approximation methods for the solution of the Schrodinger equation for many body systems.

Quantum Chemistry-I: Origin of the quantum theory of matter: Franck- Hertz experiment, Photoelectric effect, Compton Effect, Black body radiation, Planck's law, Wein's law, Bohr's theory and atomic spectra. Matter wave: Wave-particle duality, uncertainty principle. Operators and wave functions in quantum mechanics: Operator principles, Hamiltonian and Hermitian operators, postulates of quantum mechanics, Schrödinger equation, free particle, particle in a box (one and three dimensional). Wave mechanics of simple systems: One-dimensional harmonic oscillator, rigid rotator, the hydrogen atom, angular momentum, electron spin, spin-orbit coupling. Molecular orbital theory: Born-Oppenheimer approximation, LCAO approximation, LCAO MO of H_2 and H_2^+ , VB Theory, comparison of VB and MO. Approximate methods: Basic idea of variation and perturbation theory.

(30 Lectures; Marks: 30)**MODES OF IN-SEMESTER ASSESSMENT:**

	20 Marks
• Two Internal Examination -	10 Marks
• Others -	10 Marks
○ Home Assignment	

Course Outcomes (COs) & Bloom's Mapping

After the completion of this course, the learner will be able to:

CO1: Explain the origin and development of quantum theory based on key experiments and models.

CO2: Apply quantum mechanics postulates to solve simple model systems.

CO3: Analyze operators, wave functions, and angular momentum in quantum systems.

CO4: Compare MO and VB theories for molecular systems using basic approximations.

Knowledge Dimension	Remember L1	Understand L2	Apply L3	Analyze L4	Evaluate L5	Create L6
Factual						
Conceptual		CO1	CO2	CO3, CO4		
Procedural						
Metacognitive						

Suggested Books:

- Kapoor, K. L.; *A Textbook of Physical Chemistry Sixth Ed., Vol. 4*, Macmillan, India.
- Sen, BK; *Quantum Chemistry-Including Spectroscopy*, 4th Edition Kalyani (2011).
- Prasad, R.K.; *Quantum Chemistry, 4th Edition*, New Age (2020).
- Levine, I. N.; *Quantum Chemistry, 7th Edition*, Pearson (2014).
- McQuarrie, D. A.; *Quantum Chemistry, 2nd Edition*, Viva Books (2011).

SEMESTER VII

Paper Title	: INORGANIC CHEMISTRY-V (Theory)
Paper Code	: CHMMJ-071
Course No	: C- 19
Credits	: 03
No. of Classes	: 45
Total Theory Marks	: 45

Course Objectives

- Understand molecular structure and bonding.
- Learn acid-base and redox concepts.
- Study coordination and solid-state chemistry.
- Understand electrochemical and periodic properties.
- Explore bioinorganic chemistry and biomolecules.
- To understand synthesis and characterization of coordination compounds.

Expected Learner Outcomes: Learners will be able to

- Explain bonding and molecular geometry.
- Apply acid-base and redox principles.
- Interpret electrochemical behavior.
- Describe coordination and solid-state structures.
- Explain roles of metals in biological systems.
- Prepare and characterize coordination complexes.

Unit I: Chemical Bonding

VSEPR Theory: Structure of molecules with lone pairs, hybridization, Bent's rule. LCAO-MO methods for diatomic (homo/heteronuclear) and tri/tetraatomic molecules. Bonding in electron-deficient compounds (boranes, carboranes, S-N, Se-N, P-N). Metallic and Metal-ligand bonding: Spinel, Perovskite, Crystal Field Theory, Transition metal MO and ligand field theory, ML_6 and ML_4 structures. Chemical periodicity, hardness, electronegativity.

(15 Lectures, 15 Marks)

Unit II: Acid Base and Redox Chemistry

Acid-Base concepts, strengths, non-aqueous solvents, superacids, Hard and Soft Acids and Bases (SHAB principle).

Half-cell reactions, reduction potential, electrochemical series, corrosion, Nernst equation, Latimer and Frost diagrams, disproportionation, cyclic voltammetry.

(10 Lectures, 10 Marks)

Unit III: Bioinorganic Chemistry

Fundamentals, essential/non-essential elements, role of 3d block elements and non-metals in bio-systems.

Oxygen carriers (Hemoglobin, myoglobin, hemerythrin, hemocyanin), Electron transfer proteins (Cytochromes, Iron-Sulphur), Nitrogen fixation. Metalloenzymes, corrinoids (B₁₂), carboxypeptidases, chlorophyll, photosynthesis, Na-K pump, crown ethers, organo-transition metal complexes in bioinorganic chemistry.

(20 Lectures, 20 Marks)

Paper Title	: INORGANIC CHEMISTRY-V (Practical)
Paper Code	: CHMMJ-071
Course No	: C- 19
Credits	: 01
No. of Classes	: 30
Total Theory Marks	: 15

EXPERIMENTAL WORK

Preparation and characterization (viz. conductivity measurement, IR, UV-Vis) of the following complexes:

1. Potassium chromioxalate, $K_3[Cr(C_2O_4)_3]$
2. Reinecke's salt
3. Tris-(thiourea) copper(I) sulphate, $[Cu(tu)_3]2SO_4.2H_2O$
4. Potassium chromithiocyanate
5. Chloropentamine Cobalt (III) chloride $[Co(NH_3)_5Cl]Cl_2$
6. NitropentamineCobalt(III) chloride $[Co(NO_2)(NH_3)_5]Cl_2$

MODES OF IN-SEMESTER ASSESSMENT:

40 Marks

- Two Internal Examination - **20 Marks**
- Others - **20 Marks**
 - Home Assignment
 - Seminar presentation on any of the relevant topics
 - Practical Notebook/Viva

Course Outcomes (COs) & Bloom's Mapping:

After the completion of this course, the learner will be able to:

CO1: Explain concepts of chemical bonding and molecular structure.

CO2: Apply acid-base and redox principles in chemical systems.

CO3: Interpret bonding and properties of coordination and solid-state compounds.

CO4: Describe the role of metals and inorganic compounds in biological systems.

CO5: Prepare and characterize coordination complexes using basic spectroscopic techniques.

Knowledge Dimension	Remember L1	Understand L2	Apply L3	Analyze L4	Evaluate L5	Create L6
Factual		CO1				
Conceptual		CO2	CO2,	CO3, CO4		
Procedural			CO5			
Metacognitive						

Text Books: K. Hussain Reddy (Bioinorganic Chemistry), Gary L. Miessler & Donald A. Tarr (Inorganic Chemistry).

Recommended Books: M.N. Hughes (The Inorganic Chemistry of Biological Processes), D.E. Fenton (Bio-coordination Chemistry), C.E. Housecraft & A.G. Sharpe (Inorganic Chemistry).

Paper Title : PHYSICAL CHEMISTRY-V (THEORY)
Paper Code : CHMMJ-072
Course No : C- 20
Credits : 03
No. of Classes : 45
Total Theory Marks : 45

Course Objectives:

- To develop understanding of equilibrium thermodynamics and related thermodynamic properties.
- To introduce fundamental concepts and applications of quantum chemistry.
- To explain the principles and applications of different spectroscopic techniques.
- To develop analytical and problem-solving skills in physical chemistry.

Learner Outcomes: Learners will be able to

- Explain thermodynamic properties and equilibrium behavior of chemical systems.
- Apply quantum mechanical models to simple chemical problems.
- Interpret molecular spectra using various spectroscopic methods.
- Solve numerical and theoretical problems related to physical chemistry concepts.

Unit I: Equilibrium Thermodynamics (10 Lectures, 10 Marks)

Concept of Fugacity, ideal/non-ideal solutions, activity and activity coefficient, excess functions. Partial molar quantities (chemical potential, partial molar volume), thermodynamics of mixing.

Third law of thermodynamics, experimental verification, absolute entropy determination.

Unit II: Quantum Chemistry-II (10 Lectures, 10 Marks)

Review of Quantum Mechanics: Postulates, operators, commutation relation, theorems, Model Systems: Free particle, particle in a box (1D, 3D), degeneracy, Simple Harmonic Oscillator, two-particle rigid rotor, particle in a ring, quantum mechanical tunnelling.

Unit III: Spectroscopy-III (25 Lectures, 25 Marks)

Rotational (microwave) spectroscopy: Basic principle, Classification of molecules, rotational energy levels (HCl), selection rules, intensity, Stark effect, spectra of symmetric/asymmetric top molecules.

Vibrational spectroscopy: Fundamental frequencies, selection rules, harmonic/anharmonic oscillators, vibration-rotational spectra, P, Q, R branches, hot bands, group frequencies, normal modes, symmetry.

Quantum theory of Raman effect, selection rules, mutual exclusion principle, vibration-rotation Raman spectra, intensity.

EPR/ESR spectroscopy: Zero field splitting, Kramer degeneracy, ESR analysis of organic compounds, transition metal complexes of vanadium, copper, cobalt and iron

Mossbauer spectroscopy: Nuclear resonance absorption, recoil energy, Doppler effect, Mössbauer effect, Isomer shift, quadruple interactions, effect of magnetic field, determination of oxidation states of iron (including bioinorganic systems, ferredoxins) tin and cobalt compounds.

Paper Title	: PHYSICAL CHEMISTRY-V (Practical)
Paper Code	: CHMMJ-072
Course No	: C- 20
Credits	: 01
No. of Classes	: 30
Total Theory Marks	: 15

EXPERIMENTAL WORK

- Kinetics experiments: Rate constant and activation energy of hydrolysis of methyl acetate (acid-catalyzed); velocity constant of ethyl acetate hydrolysis by NaOH; kinetics of iodine and acetone reaction; rate constant and order of $K_2S_2O_8$ and KI reaction (influence of ionic strength).
- Study of complex formation between Cu^{2+} and ammonia by distribution method.
- Determine radius of glycerol by viscosity.
- Determine partial molar volume of ethanol.

MODES OF IN-SEMESTER ASSESSMENT: 40 Marks

- Two Internal Examination - **20 Marks**

- Others - 20 Marks
 - Home Assignment
 - Seminar presentation on any of the relevant topics
 - Practical Notebook/Viva

Course Outcomes (COs) & Bloom's Mapping:

After the completion of this course, the learner will be able to:

CO 1: Understand concepts of equilibrium thermodynamics such as fugacity, activity, partial molar quantities, and entropy.

CO 2: Apply quantum mechanical principles to model chemical systems and solve basic quantum chemistry problems.

CO 3: Interpret rotational, vibrational, Raman, electronic, ESR, and Mössbauer spectra.

CO 4: Explain molecular transitions, selection rules, and spectroscopic behavior of molecules.

CO 5: Perform physical chemistry experiments and analyze data related to kinetics, viscosity, complex formation, and partial molar properties.

Knowledge Dimension	Remember L1	Understand L2	Apply L3	Analyze L4	Evaluate L5	Create L6
Factual						
Conceptual		CO1 CO2	CO3	CO4		
Procedural			CO5			
Metacognitive						

Text Books:

- P.W. Atkins (Physical Chemistry)
- Ira N. Levine (Quantum Chemistry)
- C.N. Banwell and E.M. McCash (Fundamentals of Molecular Spectroscopy).
- N. Levine (Physical Chemistry)
- S. Glasstone (Thermodynamics for Chemist)
- A.K. Chandra (Introduction to Quantum Chemistry)
- P.W. Atkins & R.S. Friedman (Molecular Quantum Mechanics)
- D.A. McQuarrie (Quantum Chemistry)
- G.M. Barrow (Introduction to Molecular Spectroscopy).

Paper Title	: RESEARCH METHODOLOGY
Paper Code	: CHMMJ-073
Course No	: C- 21
Credits	: 04
No. of Classes	: 60
Total Theory Marks	: 60

Course Objectives

- To introduce the fundamentals of scientific research.
- To develop understanding of research design and ethics.
- To familiarize learners with literature search and citation methods.
- To provide basic knowledge of data handling and analysis.
- To develop skills in scientific report and proposal writing.

Learner Outcomes: Learners will be able to

- Identify research problems and formulate objectives.
- Apply basic research methods and ethical practices.
- Perform literature search and manage references.
- Organize, analyze, and present research data.
- Prepare scientific reports and research proposals.

Unit I: Research Fundamentals and Types

Research Basics: Concept, meaning, objective, and process of research; Research methods versus research methodology. Types of Research: Basic, Applied, Inter-disciplinary and multi-disciplinary research.

Qualitative and Quantitative approaches; Characteristics and when to use each approach. Problem Formulation: Identifying a research topic, defining the research problem and parameters, formulating objectives and hypotheses.

(13 Lectures; Marks: 13)

Unit II: Research Design and Ethics: Survey vs. Experimental designs; Introduction to basic experimental setup in STEM. Data Collection: Types of data (primary/secondary); Introduction to instrument selection and validation. Research Ethics: Integrity and misconduct; Plagiarism (detailed discussion); Informed consent.

(12 Lectures; Marks: 12)

Unit III: Literature Search, Evaluation, and Citation

Introduction to chemical abstracts; Subject Index, Substance Index, Author Index, Formula Index, and other indices. Uses of these indices with examples.

Digital Literature Search: Use of computer browsing for literature search and downloading basics of internet services; various sources of abstracts, articles, and papers of browsing and downloading. Advanced Tools: Techniques of conversion from one format to another; Structure drawing programs and their uses, searches through structure.

Journal Metrics: Knowledge of National and International Journals; Impact Factor, Citation-Index, h-Index, SCI Journals.

Academic Writing: Use of Literature; Citing sources and reference management systems.

(20 Lectures; Marks: 20)

Unit IV: Data Handling and Research Reporting

Data Organization: Introduction to data entry, cleaning, and spreadsheet organization.

Basic Data Analysis: Descriptive statistics (Mean, Median, Mode, Standard Deviation); Graphical representation of data (Histograms, Scatter plots).

Report Structure: Organizing and conducting research in an appropriate manner; Structure of a research report (Abstract, Introduction, Methodology, Results, Discussion, Conclusion).

Proposal Writing: Detailed training on preparing a good research proposal.

(15 Lectures; Marks: 15)

MODES OF IN-SEMESTER ASSESSMENT:

40 Marks

- Two Internal Examination - **20 Marks**
- Others (Any one) - **20 Marks**
 - Home Assignment
 - Seminar presentation on any of the relevant topics

Course Outcomes (COs) & Bloom's Mapping:

After the completion of this course, the learner will be able to:

CO1: Explain the fundamentals and types of research.

CO2: Apply basic research methods and ethical principles.

CO3: Demonstrate literature search and citation skills.

CO4: Analyse and organize research data using basic statistical tools.

CO5: Prepare scientific reports and research proposals.

Knowledge Dimension	Remember L1	Understand L2	Apply L3	Analyze L4	Evaluate L5	Create L6
Factual		CO1				
Conceptual		CO2 CO3	CO3	CO4		
Procedural			CO4 CO5			
Metacognitive						

Text Books

- C. R. Kothari and Gaurav Garg, Research Methodology Methods and Techniques, New Age International.
- Gopal, M. H. (1992). *An Introduction to Research Procedure in Social Science*. New Delhi: Vikas.

- O. R. Krishnaswami, (1993). *Methodology of Research in Social Sciences*. Bombay: Himalaya. Lewis - Beck, Michael S. (1995). *Data analysis: an introduction*. Thousand Oaks: Sage.

Paper Title	: ORGANIC CHEMISTRY-V (Theory)
Paper Code	: CHMMJ-074
Course No	: D- 22
Credits	: 03
No. of Classes	: 45
Total Theory Marks	: 45

Course Objectives

- Understand organic structure and reactivity.
- Learn organic reaction mechanisms.
- Study stereochemistry and organic synthesis.
- Understand retrosynthetic approaches.
- Learn spectroscopic and analytical techniques.

Learner Outcomes: Learners will be able to

- Explain organic bonding and reactivity.
- Interpret reaction mechanisms and intermediates.
- Apply stereochemical concepts in synthesis.
- Analyze simple retrosynthetic pathways.
- Perform basic organic analysis and separation techniques.

Unit I: Structure, Bonding and Reactivity

Aromaticity, antiaromaticity, homoaromaticity, metallocenes, tropolones, azulenes.

Supramolecular chemistry: weak bonds, charge transfer complexes, inclusion complexes, crown ethers, cryptands, rotaxanes.

Fullerenes, Graphenes, Phase transfer catalyst, Hammett equation, Taft equation, influence of reaction medium.

(8 Lectures, 8 Marks)

Unit II: Organic Reaction Mechanism

Transition state vs. reaction intermediate, energy profile, rate limiting step, catalyzed/uncatalyzed reactions, kinetic vs. thermodynamic control.

Kinetic and non-kinetic methods (Isotope labeling, kinetic isotope effects, cross-over experiment), Reactivity-selectivity principle (chemoselectivity, regioselectivity, stereoselectivity, stereospecificity). Neighbouring group effects, generation, stability, and reactivity of carbocations, carbanions, free radicals, carbenes, benzyne, nitrenes.

(10 Lectures, 10 Marks)

Unit III: Stereochemistry II

Prostereoisomerism, prochirality, homotopic/heterotopic ligands/faces, optical purity, enantiomeric excess. Chirality in allenes, spirans, biphenyls. Stereoselective synthesis (diastereoselective, enantioselective), Stereo-differentiating approach, Nucleophilic addition to aldehydes/ketones (Cram, Felkin-Ahn). Enantioselective synthesis (chiral reagent, catalyst, auxillary), Resolution (optical, kinetic).

(12 Lectures, 12 Marks)**Unit IV: Planning of Organic Synthesis-II**

Acceptor/donor synthons, umpolung, retrosynthesis of alcohols (Grignard, hydride transfer) and carbonyl compounds. One/two group C-X disconnections, one/two group C-C disconnections. Retrosynthesis of 1,2-, 1,3-, 1,4-, 1,5-, 1,6- difunctional compounds (O,O and N,O).

Protecting groups (hydroxyl, dihydroxy, carbonyl, carboxyl, amino).

(8 Lectures, 8 Marks)**Unit V: NMR & IR Spectroscopy**

NMR: NOE, double resonance, tickling. Proton and ^{13}C NMR of simple organic molecules, MRI, 2D NMR (NOESY, DEPT, INEPT), Instrumentation, FT NMR.

IR: Application in organic spectroscopy.

(7 Lectures, 7 Marks)

Paper Title	: ORGANIC CHEMISTRY-V (Practical)
Paper Code	: CHMMJ-074
Course No	: D- 22
Credits	: 01
No. of Classes	: 30
Total Theory Marks	: 15

EXPERIMENTAL WORK

1. Estimation of
 - (i) Glucose and sucrose in a mixture.
 - (ii) Acetone by iodoform method.
 - (iii) Hydroxyl and amino groups by acetylation method.
2. Chromatographic separation:
 - (i) Qualitative TLC separation and identification.
 - (ii) Column chromatographic separation of a mixture of compounds.

MODES OF IN-SEMESTER ASSESSMENT:

	40 Marks
• Two Internal Examination	20 Marks
• Others	20 Marks
○ Home Assignment	
○ Seminar presentation on any of the relevant topics	
○ Practical Notebook/Viva	

Course Outcomes (COs) & Bloom's Mapping:

After the completion of this course, the learner will be able to:

CO1: Explain concepts of organic structure, bonding, and reactivity.

CO2: Interpret organic reaction mechanisms and reactive intermediates.

CO3: Apply stereochemical principles in organic synthesis.

CO4: Analyze organic compounds using retrosynthetic and spectroscopic methods.

CO5: Perform basic organic estimation and chromatographic separation Techniques.

Knowledge Dimension	Remember L1	Understand L2	Apply L3	Analyze L4	Evaluate L5	Create L6
Factual		CO1				
Conceptual		CO2	CO2 CO3	CO4		
Procedural			CO4 CO5			
Metacognitive						

Suggested Books:

- L. Finar (Organic Chemistry)
- P.S. Kalsi (Stereochemistry and Mechanism)
- Donald L. Pavia (Introduction to Spectroscopy), Peter Sykes (A Guidebook to Mechanism in Organic Chemistry).
- R. T. Morrison, R. N. Boyd and S. K. Bhattacharjee (Organic Chemistry)
- Paula Yurkanis Bruice (Organic Chemistry)
- Jerry March (Advanced Organic Chemistry)
- D. Nasipuri (Stereochemistry of Organic Compounds)
- Earnest E. Eliel (Stereochemistry of Carbon Compounds)
- Subrata Sengupta (Stereochemistry of Carbon Compounds)
- S. Warren (Disconnection Approach in Organic Synthesis, Designing Organic Synthesis)
- Christine Willis and Martin Willis (Organic Reaction Mechanism)
- E.J. Corey and Xue Min Chen (The Logic of Organic Synthesis)

Paper Title	: Project-I
Paper Code	:
Course No	: P-01
Credits	: 02
No. of Classes	: 30
Total Theory Marks	: 30

Course Objectives

- To introduce scientific literature survey methods.
- To develop skills in literature search and reference management.
- To train students in scientific review writing and publication.

Learner Outcomes: Learners will be able to

- Perform literature searches using scientific databases.
- Use bibliographic management tools for citation handling.
- Prepare and communicate a review article for publication.

Description: During this project work student will have to learn Scientific Literature survey methods including literature search strategies and databases, bibliographic management tools (e.g., Mendeley/Zotero) and write a review article which have to be communicated for journal publication.

MODES OF IN-SEMESTER ASSESSMENT:

20 Marks

20 Marks

- Home Assignment
- Seminar presentation on any of the relevant topics

Course Outcomes (COs) & Bloom's Mapping:

After the completion of this course, the learner will be able to:

CO1: Demonstrate literature search and reference management skills.

CO2: Prepare and communicate a scientific review article.

Knowledge Dimension	Remember L1	Understand L2	Apply L3	Analyze L4	Evaluate L5	Create L6
Factual						
Conceptual			CO1	CO2		
Procedural			CO2			
Metacognitive						

SEMESTER VIII

Paper Title	: INORGANIC CHEMISTRY-VI (Theory)
Paper Code	: CHMMJ-081
Course No	: C- 23
Credits	: 03
No. of Classes	: 45
Total Theory Marks	: 45

Course Objectives

- To understand inorganic reaction mechanisms and stability.
- To introduce symmetry and group theory concepts.
- To explain applications of group theory in chemistry.
- To develop knowledge of coordination and reaction behavior.
- To provide practical skills in inorganic analysis and synthesis.

Expected Learner Outcomes: Learners will be able to

- Explain stability and substitution reactions of complexes.
- Apply symmetry and group theory principles to molecules.
- Interpret spectroscopic and orbital symmetry concepts.
- Perform complexometric estimations of metal ions and alloys.
- Synthesize and characterize inorganic nanoparticles.

Unit I: Inorganic Reaction Mechanism

Lability and inertness, stability constants, chelate effect, thermodynamic and kinetic stability. Factors affecting stability, determination of stability constant (Jobs, Bjerrum's methods). Mechanism of ligand replacement reactions: Substitution in octahedral [Cr(III), Co(III)] and square planar [Rh(I), Pt(II), Pd(II)] complexes. Rate of water replacement, solvolysis, hydrolysis (acid/base), factors affecting substitution rate, trans effect (theories, importance), electron transfer reactions (inner/outer sphere).

(15 Lectures, 15 Marks)

Unit II: Symmetry and Group Theory-II

Matrices and matrix representation of symmetry operations, definition of group (finite, infinite), examples. Symmetry elements as elements of group, Point groups. Orthogonality theorem, reducible and irreducible representations, construction of character tables (C_{2v} , C_{3v}). Direct product representation. Projection operator, symmetry adapted linear combination (SALC) for C_{2v} , C_{3v} , D_{4h} , T_d point group molecules.

(15 Lectures, 15 Marks)

Unit-III: Chemical Application of Group Theory

Construction of hybrid orbitals (d^2sp^3 , sp^3), IR absorption and Raman scattering spectroscopy (vibrational modes as bases, symmetry selection rules). Classification of vibrational modes and analysis. Orbital Symmetry and Chemical Reactions (Woodward-Hoffman rules for electrocyclic and cycloaddition reactions).

(15 Lectures, 15 Marks)

Paper Title	: INORGANIC CHEMISTRY-VI (Practical)
Paper Code	: CHMMJ-081
Course No	: C- 23
Credits	: 01
No. of Classes	: 30
Total Theory Marks	: 15

EXPERIMENTAL WORK

- Estimation of Mg^{2+} and Ca^{2+} by complexometric method.
- Estimation of Zn^{2+} and Cu^{2+} by complexometric method in different ores and from given solution with one / two components.
- Analysis of alloys (Brass, Cu-Ni, Bronze).
- Analysis of cement.
- Synthesis and characterization of nanoparticles by sol-gel, co-precipitation, and biogenic methods.

MODES OF IN-SEMESTER ASSESSMENT:**40 Marks**

- | | | |
|--|---|-----------------|
| • Two Internal Examination | - | 20 Marks |
| • Others | - | 20 Marks |
| ○ Home Assignment | | |
| ○ Seminar presentation on any of the relevant topics | | |
| ○ Practical Notebook/Viva | | |

Course Outcomes (COs) & Bloom's Mapping:

After the completion of this course, the learner will be able to:

CO1: Explain inorganic reaction mechanisms and stability concepts.

CO2: Apply symmetry and group theory principles to chemical systems.

CO3: Interpret spectroscopic and orbital symmetry applications.

CO4: Analyze substitution reactions and bonding behavior in complexes.

CO5: Perform inorganic estimations and nanoparticle synthesis techniques.

Knowledge Dimension	Remember L1	Understand L2	Apply L3	Analyze L4	Evaluate L5	Create L6
Factual						
Conceptual		CO1	CO2 CO3	CO4		
Procedural			CO5			
Metacognitive						

Suggested Books:

- F.A. Cotton (Chemical Applications of Group Theory),
- J.E. Huheey, E.A. Keiter, R.L. Keiter and O.K. Medhi (Inorganic Chemistry: Principles of Structure and Reactivity).
- Hargittai and M. Hargittai (Symmetry Through the Eyes of a Chemist)

Paper Title	: ORGANIC CHEMISTRY-VI (Theory)
Paper Code	: CHMMJ-082
Course No	: C- 24
Credits	: 03
No. of Classes	: 45
Total Theory Marks	: 45

Course Objectives

1. Understand natural products and biomolecules.
2. Learn heterocyclic chemistry and synthesis.
3. Study spectroscopic and mass spectrometric methods.
4. Understand molecular structure and reactions.
5. Develop skills in organic synthesis and separation.

Expected Learner Outcomes

1. Explain natural products and biomolecules.
2. Apply heterocyclic synthesis methods.
3. Interpret spectral and mass spectral data.
4. Perform chromatographic separation techniques.
5. Prepare organic compounds and green reagents.

Unit I: Chemistry of Natural Products

Terpenoids: Biosynthesis (isoprenoid rule, mevalonic acid pathway), classification, structure elucidation, synthesis of selected mono/sesqui/diterpenes.

Alkaloids: Classification, extraction, structure elucidation, synthesis of selected alkaloids.

(10 Lectures, 10 Marks)

Unit II: Chemistry of Biomolecules

Carbohydrates: Structure, reaction, conformation of disaccharides (sucrose, maltose, lactose). Polysaccharides (starch, cellulose).

Peptides and Proteins: Structure determination and synthesis of small peptides (di-, tri-, tetra-peptides). Solid phase peptide synthesis. Classification of proteins (primary, secondary, tertiary structures).

(12 Lectures, 12 Marks)

Unit-III: Heterocyclic Chemistry:

Principles of synthesis (cyclization, cycloaddition). Synthesis and properties of three-, four-, and five-membered heterocycles with one/two heteroatoms (N, O, S) like aziridine, oxirane, thiirane, azetidene, oxetane, thietane, pyrazole, isoxazole, isothiazole, imidazole, oxazole, thiazole.

(12 Lectures, 12 Marks)

Unit-IV: Mass Spectrometry:

Ion fragmentation mechanism, Base peak, molecular ion peak, metastable peak, instrumentation, ionization methods, isotopic distribution. Application in determining structure of organic/inorganic compounds.

Spectroscopic Methods in Analysis: Use of IR, electronic, ^1H , ^{13}C , ^{31}P NMR, Mass spectrometry in molecular composition/structure analysis.

(11 Lectures, 11 Marks)

Paper Title	: ORGANIC CHEMISTRY-VI (Practical)
Paper Code	: CHMMJ-082
Course No	: C- 24
Credits	: 01
No. of Classes	: 30
Total Theory Marks	: 15

EXPERIMENTAL WORK

- Separation and identification of amino acids by paper chromatography.
- Organic Preparation (One-step): Cannizzaro reaction of benzaldehyde, oxidation of p-nitrotoluene, reduction of benzophenone, phthalic anhydride to phthalimide.
- Organic Preparation (Two-step): p-nitrobenzene azo 2-naphthol, Benzanilide from benzophenone, Dibenzyl from benzoin.
- Preparation of Green reagent: TetrabutylammoniumTribromide (TBATB) and its use.

MODES OF IN-SEMESTER ASSESSMENT:

		40 Marks
• Two Internal Examination	-	20 Marks
• Others	-	20 Marks
○ Home Assignment		

- Seminar presentation on any of the relevant topics
- Practical Notebook/Viva

Course Outcomes (COs) & Bloom's Mapping:

After the completion of this course, the learner will be able to:

CO1: Explain concepts of natural products and biomolecules.

CO2: Apply methods for synthesis of heterocyclic compounds.

CO3: Interpret spectroscopic and mass spectrometric data.

CO4: Analyze molecular structures and organic reactions.

CO5: Perform organic synthesis and chromatographic separation techniques.

Knowledge Dimension	Remember L1	Understand L2	Apply L3	Analyze L4	Evaluate L5	Create L6
Factual						
Conceptual		CO1	CO2 CO3	CO4		
Procedural			CO5			
Metacognitive						

Text Books: I.L. Finar (Organic Chemistry Vol II), S. Warren (Organic Synthesis: The Disconnection Approach)

Paper Title : PHYSICAL CHEMISTRY-VI (THEORY)
Paper Code : CHMMJ-083
Course No : D- 25
Credits : 03
No. of Classes : 45
Total Theory Marks : 45

Course Objectives:

1. To introduce quantum mechanical concepts in chemistry.
2. To develop understanding of atomic and molecular structure theories.
3. To explain principles of surface chemistry and colloidal systems.
4. To impart knowledge of statistical thermodynamics and thermodynamic functions.
5. To develop experimental and analytical skills in physical chemistry.

Expected Learner Outcomes:

1. Understand quantum mechanical treatment of chemical systems.
2. Apply MO, VB, and statistical methods to chemical problems.

3. Interpret adsorption, catalysis, and colloidal behavior.
4. Calculate thermodynamic properties using partition functions and distribution laws.
5. Perform and analyze physicochemical laboratory experiments accurately.

Unit I: Quantum Chemistry III

Hydrogen atom (Schrödinger equation, radial solution, probability, radial distribution, angular solution, orbitals, degeneracy, angular momentum). Approximate methods: Variation theorem, linear variation functions. Perturbation theory. Antisymmetry Principle, Slater determinant, Term symbol, spectroscopic states. Born-Oppenheimer approximation, LCAO-MO and VB treatment of H_2 and H_2^+ . Comparison of MO and VB methods. Huckel molecular orbital theory (postulates, application to ethylene, butadiene, benzene).

(20 Lectures, 20 Marks)

Unit II: Surface Chemistry-II

Adsorption: Freundlich, Langmuir isotherms, BET theory, physisorption, chemisorption. Heterogeneous catalysis (Langmuir-Hinshelwood, Eley-Riedel model, uni/bimolecular surface reaction). Colloids: Electrokinetic phenomena, electrical double layer structure, Zeta potential, colloidal stability. Surfactants (definition, classification), micelle formation, Critical Micelle Concentration (CMC). Reverse micelle, solubilization, microemulsion.

(10 Lectures, 10 Marks)

Unit III: Statistical Thermodynamics

Probability, most probable distribution, distinguishable/indistinguishable particles. Concept of ensembles, partition functions, distributions (Boltzmann, Fermi-Dirac, Bose-Einstein). Ideal gases: Canonical partition function, translational, rotational, vibrational partition functions. Absolute thermodynamic quantities (U, H, S, A) for ideal mono/diatomic gases, heat capacity (C_v , C_p), chemical equilibrium. Monoatomic Crystals (Einstein and Debye models, T³ dependence of heat capacity). Numerical calculations.

(15 Lectures, 15 Marks)

Paper Title	: PHYSICAL CHEMISTRY-VI (PRACTICAL)
Paper Code	: CHMMJ-083
Course No	: D- 25
Credits	: 01
No. of Classes	: 30
Total Theory Marks	: 15

Experimental Work

- Determination of relative acid strength: Hydrolysis of methyl acetate in HCl and H_2SO_4

- Equivalent conductivity of acetic acid at infinite dilution (Kohlrausch).
- Determination of relative strength of acetic acid and monochloro acetic acid by conductance.
- Determination of pH of CH_3COOH and CH_3COONa mixture and dissociation constant.
- Conductometric titration of ternary mixtures (HCl , CH_3COOH , CuSO_4 ; HCl , NaCl , NH_4Cl).
- Critical Micelle Concentration (CMC) of SDS by surface tension.

MODES OF IN-SEMESTER ASSESSMENT:**40 Marks**

- Two Internal Examination -
- Others -
 - Home Assignment
 - Seminar presentation on any of the relevant topics
 - Practical Notebook/Viva

20 Marks**20 Marks****Course Outcomes (COs) & Bloom's Mapping:****After the completion of this course, the learner will be able to:****CO1: Explain** quantum mechanical models of atoms and molecules.**CO2: Interpret** electronic structure, bonding, and spectroscopic states using MO/VB and Hückel theories.**CO3: Analyse** adsorption, catalysis, colloids, and surfactant systems.**CO4: Apply** statistical thermodynamics to evaluate thermodynamic properties of gases and solids.**CO5: Perform** physicochemical experiments and determine parameters using conductometric, kinetic, pH-metric, and surface tension methods.

Knowledge Dimension	Remember L1	Understand L2	Apply L3	Analyze L4	Evaluate L5	Create L6
Factual						
Conceptual		CO1	CO2 CO3	CO4		
Procedural			CO5			
Metacognitive						

Text Books: P.W. Atkins (Physical Chemistry), I.N. Levine (Physical Chemistry), S. Glasstone (Textbook of Physical Chemistry).

Recommended Books: K.J. Laidler (Chemical Kinetics), D.A. McQuarrie (Statistical Mechanics), A.W. Adamson (Physical Chemistry of Surfaces).

Paper Title	: Project-II
Paper Code	:
Course No	: P-02
Credits	: 6
No. of Classes	: 180
Total Theory Marks	: 90

Course Objectives

- To develop skills in scientific research and methodology.
- To train students in academic writing and dissertation preparation.
- To enhance presentation and research communication skills.

Learner Outcomes: Learners will be able to

- Conduct and present original research systematically.
- Prepare a structured scientific dissertation.
- Defend research findings through viva voce presentation.

The dissertation will comprise of following components:

- **Original Research:** The core requirement of a dissertation is that it must contribute **new knowledge** to the field. This can involve new theories, new data, new experimental findings, or novel interpretations of existing information.
- **Structured Format:** It follows a strict, standardized academic structure (e.g., Abstract, Introduction, Literature Review, Methodology, Results, Discussion, Conclusion).
- **Methodology:** The research must employ **systematic and rigorous methods**, whether qualitative (interviews, textual analysis) or quantitative (laboratory experiments, statistical modelling).
- **Viva Voce:** The work concludes with an oral defense (or *viva voce*), where the student presents their findings and answers critical questions from a committee of experts.

MODES OF IN-SEMESTER ASSESSMENT:

60 Marks

- Home Assignment
- Seminar presentation on any of the relevant topics

Course Outcomes (COs) & Bloom's Mapping:

After the completion of this course, the learner will be able to:

CO1: Analyse and evaluate original research problems to develop a dissertation that contributes new knowledge or interpretations in the relevant field.

CO2: Design and organize a dissertation following standardized academic structure and scholarly writing conventions.

CO3: Apply appropriate qualitative and quantitative research methodologies for systematic data collection, analysis, and interpretation.

CO4: Defend and justify research findings effectively through seminar presentations and viva voce examinations with logical and evidence-based arguments.

Knowledge Dimension	Remember L1	Understand L2	Apply L3	Analyze L4	Evaluate L5	Create L6
Factual						
Conceptual				CO1	CO1	
Procedural			CO3		CO5	CO2
Metacognitive						