Madhabdev University

(A State University Established under the Assam Act. No. XXXV of 2017)

Curriculum and Syllabus

Of

Four Year Undergraduate Programme

In

Chemistry (Minor)

From Academic Session

2026-2027

Department of Chemistry
Narayanpur, P.O.: Dikrong (784164), Dist.: Lakhimpur, Assam

Course Distribution

Sem	Paper	Paper Name	Paper Code	Marks Distribution		Credit Distribution		Total credit
				In-Sem	End-Sem	Theory	Practical	
I	*Minor I*	*General Chemistry- I*	CHMN-101	30	70	4	0	4
II	*Minor II*	*General Chemistry-II*	CHMN-201	30	70	4	0	4
III	*Minor III*	*General Chemistry-III*	CHMN-301	30	70	4	0	4
IV	*Minor IV*	*General Chemistry- IV (Practical)*	CHMN-401	30	70	0	4	4
V	*Minor V*	*General Chemistry- V*	CHMN-501	30	70	4	0	
VI	*Minor VI*	*General Chemistry-VI*	CHMN-601	30	70	4	0	4
VII	*Minor VII*	*General Chemistry-VII (Practical)*	CHMN-701	30	70	0	4	4
VIII	*Minor VIII*	*General Chemistry-VIII*	CHMN-801	30	70	4	0	4
					Total	24	8	32

Introduction

Chemistry is a central science that bridges the physical, biological, environmental, and material sciences. It provides fundamental knowledge of the composition, structure, properties, and transformations of matter and forms the basis for understanding numerous natural phenomena and technological innovations. The study of chemistry contributes significantly to advancements in healthcare, agriculture, energy, environmental sustainability, pharmaceuticals, nanotechnology, and advanced materials.

The Minor Programme in Chemistry has been designed in accordance with the National Education Policy (NEP) 2020 and the UGC Curriculum and Credit Framework (CCF) for undergraduate education. The programme provides students from diverse academic backgrounds with a systematic understanding of the fundamental principles of Inorganic, Organic, and Physical Chemistry while emphasizing experimental skills, scientific reasoning, and interdisciplinary applications.

The curriculum adopts a progressive approach, beginning with the fundamentals of atomic structure, chemical bonding, states of matter, thermodynamics, stereochemistry, and basic laboratory techniques during the initial semesters. Advanced semesters introduce students to coordination chemistry, organometallic chemistry, bioinorganic chemistry, industrial inorganic materials, biomolecules, pharmaceutical chemistry, electrochemistry, polymers, surface chemistry, colloids, environmental analysis, and modern analytical techniques. The practical courses are carefully designed to develop laboratory competence through qualitative and quantitative analysis, organic synthesis, instrumental methods, polymer preparation, environmental chemistry, and project-based learning.

The programme promotes experiential learning, critical thinking, problem-solving ability, and scientific communication through laboratory work, mini-projects, and application-oriented experiments. It also incorporates concepts of green chemistry, sustainability, environmental stewardship, and ethical laboratory practices, thereby preparing students to contribute responsibly to society.

Upon completion of the programme, students will possess a sound understanding of chemical principles, practical laboratory skills, and the ability to apply chemical knowledge to interdisciplinary problems. The programme also provides a strong academic foundation for higher studies, research, entrepreneurship, and careers in education, healthcare, environmental management, quality control, chemical industries, pharmaceuticals, and allied scientific fields.

Semester I

NCrF level	*4.5*
Title of the Course	*General Chemistry- I*
Course code	*CHMN-101*
Paper credit	*04* ((L 4 – T 0 - P 0)
Total Contact Hours	*Theory 70*
Distribution of Marks	*Theory 100 (End semester examination 70 + internal assessment 30)*

Course Objectives

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

- Understand the historical development of atomic structure from classical mechanics to quantum mechanics and explain the quantum mechanical description of atoms and electronic configurations.
- Explain periodic trends in the physical and chemical properties of elements and relate these trends to electronic structure and effective nuclear charge.
- Understand the electronic effects governing the structure, stability, and reactivity of organic molecules and explain the formation, stability, and behaviour of reactive intermediates and apply thermodynamic and kinetic principles to interpret organic reaction mechanisms.
- Develop a sound understanding of stereochemistry, including molecular chirality, stereochemical nomenclature, and conformational analysis of organic molecules.
- Apply the kinetic theory of gases and equations of state to explain the behaviour of ideal and real gases under different physical conditions.
- Develop scientific reasoning, quantitative problem-solving ability, and analytical skills by integrating concepts from inorganic, organic, and physical chemistry.

Course Outcomes (COs)

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

CO1. Explain the evolution of atomic theory from classical to quantum mechanics, Schrödinger wave equation, quantum numbers, and electronic configuration of atoms.

CO2. Interpret periodic trends in atomic and ionic properties based on electronic structure.

CO3. Analyse the influence of electronic effects on the stability, acidity/basicity, and reactivity of organic molecules and distinguish between electrophiles and nucleophiles.

CO4. Explain the formation, stability, and reactivity of organic reaction intermediates and analyse reaction pathways

CO5. Apply stereochemical principles to represent, identify, and classify stereoisomers using various projection formulae and evaluate conformational stability of organic compounds.

CO6. Apply the kinetic molecular theory, Maxwell–Boltzmann distribution, van der Waals equation, virial equation, and related gas laws to solve problems involving ideal and real gases.

Unit I: Atomic Structure *Lecture/Marks: 20*

Classical mechanics: Newtonian mechanics, wave concept and electromagnetic theory of radiation, inadequacy of classical mechanics: Black body radiation and laws associated, photoelectric effect, Compton Effect, discrete energy levels, Bohr's theory of structure of atom, hydrogen atom spectrum, wave particle duality and its experimental confirmation, uncertainty principle and its basis

Mathematical description of waves, Schrodinger time independent wave equation, concept of wave function, properties of wave function, normalised and orthogonal wave functions, Eigen function, Significance of Ψ and Ψ^2

Schrodinger equation of hydrogen atom (no derivation), radial and angular wave functions probability distribution functions, representation of orbitals, the quantum numbers

Many electron atoms: Effective nuclear charge, Slater's Rule, Sequence of energy levels, electronic configuration, Aufbau's principle, Pauli's Exclusion Principle, Hund's rule, stability of half-filled and fully filled subshells (exchange energy).

Unit II: Periodicity in Properties of atoms and ions *Lecture/Marks: 05*

General trends of the following properties across the period and down the group: electronic configurations and types of elements, Melting and boiling points, Density, atomic radius, van der walls radius, metallic radius, covalent and ionic radius, thermochemical radii, ionization energies, electron affinities, electronegativity (various scales), group electronegativity , Secondary periodicity, Relativistic Effect, Inert pair effect.

Unit III: Basic Organic Chemistry *Lecture/Marks: 10*

Concept of Inductive, Electrometric, Resonance, mesomeric effects and hyperconjugation and their applications, Concept of electrophiles and nucleophiles, nucleophilicity and basicity

Basic ideas about different types of reactions: addition, substitution, elimination, rearrangement, and condensation reactions, rate constant and free energy of activation, energy profile diagrams for one-step and multi-step reactions, curly arrow rules, formal charges.

Concepts of aromatic, anti-aromatic and non-aromatic compounds, Hückel's rules for aromaticity up to [8] annulene (including mononuclear heterocyclic compounds up to 6-membered ring); concept of antiaromaticity and homoaromaticity; non-aromatic molecules.

Unit IV: Stereochemistry-I *Lecture Marks 15*

Representation of organic molecules: Fischer, saw-horse, Newman, and flying-wedge, projection formulae and their interconversion.

Concept of chirality and symmetry: Symmetry elements, molecular chirality, optical activity, optical purity, meso-compounds, racemic mixture, resolution, enantiomers, diastereomers, epimers, anomers.

Basic concepts of stereochemical nomenclatures: threo/erythro, syn/anti, R/S, cis/trans and E/Z, α/β and endo/exo epimers, anomers.

Conformation: conformational nomenclature: eclipsed, staggered, gauche, syn and anti; dihedral angle, torsion angle; Klyne-Prelog terminology; energy barrier of rotation, concept of torsional and steric strains; relative stability of conformers on the basis of steric effect, dipole-dipole interaction and H-bonding; butane gauche interaction; conformational analysis of ethane, propane, n-butane, 2-methylbutane and 2,3-dimethylbutane; haloalkane, 1,2-dihaloalkanes; conformation of conjugated systems (s-cis ands-trans).

Unit V: States of Matter-I (Gaseous State) ***Lecture Marks 20***

Kinetic Theory of Gases: 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, the relation between mean free path and coefficient of viscosity, calculation of σ from η; variation of viscosity with temperature and pressure.

Real Gas behaviour and Its Deviations: 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, introduction of equations of state; 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, and law of corresponding states

Molecular Motion and Energy Distribution in Gases: Maxwell–Boltzmann Distribution of Molecular Speeds and Its Applications in Determining Average, Root Mean Square, and Most Probable Velocities; Average Kinetic Energy; Law of Equipartition of Energy; Degrees of Freedom; and Molecular Interpretation of Heat Capacities.

Suggested reading

- *Quantum Chemistry including Spectroscopy, B.K.Sen, 4th* edition, Kalyani Publishers
- *Fundamentals of Quantum Chemistry, P.K. Bhattacharyya, Global Publishing House (India)*
- *General and Inorganic Chemistry*, R.P. Sarkar (part 1) 3rd edition, NCBA
- *Concise Inorganic Chemistry, J. D. Lee, 5th Edition, Pearson Education*
- *Morrison, R. N. & Boyd, R. N. Organic Chemistry, 6th Edition, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).*
- *H. Pine. Organic Chemistry, 5th Edition, McGraw-Hill Bool (1987)*
- *P. S. Kalsi. Stereochemistry, Conformation and Mechanism 3rd Edition, John Wiley (1995).*
- *D. Nasipuri, Stereochemistry of Organic Compounds. Principles and Applications, Second Edition, Wiley Eastern Limited, New Delhi, 1994.*
- *Atkins, P. W.; de Paula, J.; Keeler, J., Physical Chemistry, 11th Edition, Oxford University Press India (2018). (ISBN: 978-0198814740).*
- *Puri, B. R.; Sharma, L. R.; Pathania, M. S., Principles of Physical Chemistry, 47th Edition, Vishal Publishing (2020). (ISBN: 978-9382956013).*
- *Kapoor, K. L., A Textbook of Physical Chemistry: States of Matter and Ions in Solution, Vol. I, 6th Edition, McGraw Hill Education India (2019). (ISBN: 978-9353165185).*
- *Bahl, A.; Bahl, B. S.; Tuli, G. D., Essentials of Physical Chemistry, 28th Ed., S. Chand and Company (2020). (ISBN: 978-9352836093)*

Semester II

NCrF level	*4.5*
Title of the Course	*General Chemistry- II*
Course code	*CHMN-201*
Paper credit	*04* ((L 4 – T 0 - P 0)
Total Contact Hours	*Theory 70*
Distribution of Marks	*Theory 100 (End semester examination 70 + internal assessment 30)*

Course Objectives

Upon successful completion of this course, students will be able to:

- Understand the fundamental principles of chemical bonding and explain molecular structure using various theories and models.
- Correlate the nature of chemical bonding and intermolecular interactions with the physical and chemical properties of molecules and solids.
- Develop a comprehensive understanding of coordination chemistry, including coordination compounds, nomenclature, bonding, and stereoisomerism.
- Understand the mechanisms, kinetics, stereochemistry, and selectivity of important organic reactions, including substitution, elimination, and aromatic substitution reactions.
- Explain the structure and properties of crystalline solids, liquids, liquid crystals, and colloidal systems using modern concepts of physical chemistry.
- Apply theoretical concepts from inorganic, organic, and physical chemistry to analyse chemical phenomena and solve qualitative and quantitative problems.

Course Outcomes (COs)

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

CO1. Explain chemical bonding using Lewis theory, VSEPR theory, Valence Bond Theory, Molecular Orbital Theory, and lattice energy models, and correlate bonding with molecular geometry, polarity, aromaticity, and intermolecular forces.

CO2. Analyse the bonding, nomenclature, stereochemistry, and isomerism of coordination compounds based on Werner's theory and modern coordination chemistry concepts.

CO3. Analyse the structure, stability, and reactivity of organic reaction intermediates and explain reaction mechanisms involving substitution, elimination, addition, rearrangement, electrophilic aromatic substitution, and nucleophilic aromatic substitution using thermodynamic and kinetic principles.

CO4. Explain the structure and properties of crystalline solids, crystal defects, band theory, and packing arrangements, and relate these concepts to the physical properties of materials.

CO5. Describe the physical properties of liquids, liquid crystals, and colloidal systems, explain their stability and behaviour, and apply the principles governing colloidal phenomena to chemical and industrial processes.

Unit I Bonding Theories *Lecture/Marks: 20*

Electronic theory of Valency: octet rule, Lewis electron dot formula, formal charge, electronutrality principle.

Shapes of molecules: Valence shell electron pair repulsion (VSEPR) theory (steric number, merits and demerits).

The chemical bond: Bond length, bond strength, bond angle, bond energy, polarity of bonds.

Valence Bond theory (VBT): The basic approach, some useful concept of VBT, Energetics of hybridization, equivalent and non-equivalent hybrid orbitals, Bent's rule, calculation of formal charges and double bond equivalent (DBE); orbital pictures of bonding (sp^3, sp^2, sp: C-C, C-N & C-O systems)

Molecular orbital theory (MOT): Introduction, linear combination of orbitals, types of molecular orbitals, MO diagrams of homonuclear (Li-Ne) and heteronuclear diatomic (HF, CO, NO, CN^-), and HCl (idea of s-p mixing and orbital interaction), idea about σ, σ*, π, π *, n – MOs; concept of HOMO, LUMO and SOMO; sketch and energy levels of π MOs of acyclic p orbital system (C=C, conjugated diene, triene, allyl and pentadienyl systems)

Covalent character in ionic compounds: polarising power and polarizability, Fajan's rules and consequences of polarisation.

Ionic character in covalent compounds: influence of hybridization on bond properties: bond dissociation energy (BDE) and bond energy; bond distances, bond angles; concept of bond angle strain, Bond dipole, dipole moment, and molecular polarizabilities, percentage ionic character.

Bonding models in ionic compounds: Properties of ionic substances, lattice and solvation energy; Born Lande equation; Kapustinski equation, Madelung constant, Born Haber Cycle for lattice energy calculation.

Weak Chemical Forces: van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interactions, instantaneous dipole-induced dipole interactions and hydrogen bonding; melting point/boiling point and solubility of common organic compounds in terms of covalent & non-covalent intermolecular forces

Unit II: Introduction to Coordination Chemistry *Lecture/Marks: 05*

Coordinate bonding; double and complex salts. Werner's theory of coordination complexes, Classification of ligands, 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

Unit IV: Organic Reaction intermediate *Lecture/Marks: 10*

Reaction thermodynamics: Free energy and equilibrium, enthalpy and entropy factor, calculation of enthalpy change via BDE, intermolecular & intramolecular reactions.

Reaction kinetics: Rate constant and free energy of activation; free energy profiles for one-step, and two-step reactions; catalyzed reactions.

Generation, structure and reactivity, classical and non-classical carbocations, neighboring group participation and rearrangements in acyclic, monocyclic systems, carbanions, carbon radicals: generation and stability, structure and electrophilic/nucleophilic behaviour of reactive intermediates like carbenes, nitrenes, Enolates (Themodynamic versus kinetic enolates, enolate equivalent and enamines), Ylides (Chemistry of phosphorous and sulfur ylides, stabilized and non-stabilised ylides), Arynes (Generation, structure and stability, rearrangement reactions)

Unit IV: Organic Reaction mechanism — *Lecture/Marks: 10*

Nucleophilic Substitution at sp3 carbon centre mechanism: substitution at sp3 centre (systems: alkyl halides, allyl halides, benzyl halides, alcohols, ethers, epoxides, α-halocarbonyls), mechanisms (with evidence), relative rates & stereochemical features: SN1, SN2, SN2', SN1' (allylic rearrangement) and SNi; effects of solvent, substrate structure, leaving group and nucleophiles.

Elimination Reaction: E1, E2, E1cB and Ei (pyrolytic syn eliminations); formation of alkenes and alkynes; mechanisms (with evidence), reactivity, regioselectivity (Saytzeff/Hofmann) and stereoselectivity; comparison between substitution and elimination.

Electrophilic aromatic substitution Mechanisms: π- and ς-complex, ipso substitution, activating and deactivating groups, orienting influence. Reactions: Friedel-Crafts alkylation/acylation, nitration, sulfonation, halogenation, formylation.

Nucleophilic Aromatic Substitution Mechanisms, orientation, and reactivity

Unit VI: States of Matter-II (Solid state) — *Lecture/Marks: 15*

General characteristics of solid state, amorphous and crystalline solids, classification of crystalline solids, crystal lattices and unit cells, number of atoms in unit cell, closed packed structures, radius ratio rule, voids, packing efficiency and calculations, imperfections in solids, electrical and magnetic properties. Examples of crystal structures: NaCl, CsCl, ZnS, CaF_2, TiO_2

Band theory of solids

Law of constancy of interfacial angles, crystal planes, law of rational indices, Miller indices, space lattice and unit cell, packing in crystals, crystal defects

Unit VII: States of Matter-III (Liquid State) — *Lecture/Marks 10*

Qualitative description of the structure of liquids, Physical properties of liquids - vapour pressure, surface tension, viscosity, refractive index (definitions and descriptions), Liquid crystals- elementary discussion on structure and types of liquid crystals

Suggested Readings

- General and Inorganic Chemistry, R.P. Sarkar (part 1) 3rd edition, NCBA
- Inorganic Chemistry (Principles of Structure and Reactivity), J. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, 5^{th} edition, Pearson Education
- March, J., Smith, M. B. March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, 6th Edn., (Wiley, 2007).
- P. S. Kalsi. Stereochemistry, Conformation and Mechanism (3rd edn.), John Wiley (1995).
- D. Nasipuri, Stereochemistry of Organic Compounds. Principles and Applications, Second Edition, Wiley Eastern Limited, New Delhi, 1994. Ch.2-6 and 9-12.
- Atkins, P. W.; de Paula, J.; Keeler, J., Physical Chemistry, 11th Ed., Oxford University Press India (2018). (ISBN: 978-0198814740).
- Puri, B. R.; Sharma, L. R.; Pathania, M. S., Principles of Physical Chemistry, 47th Ed., Vishal Publishing (2020). (ISBN: 978-9382956013).
- Kapoor, K. L., A Textbook of Physical Chemistry: States of Matter and Ions in Solution, Vol. I, 6th Ed., McGraw Hill Education India (2019). (ISBN: 978-9353165185).
- Bahl, A.; Bahl, B. S.; Tuli, G. D., Essentials of Physical Chemistry, 28th Ed., S. Chand and Company (2020). (ISBN: 978-9352836093)

Semester III

NCrF level	*5.0*
Title of the Course	*General Chemistry- III*
Course code	*CHMN-301*
Paper credit	*04* ((L 4 – T 0 - P 0)
Total Contact Hours	*Theory 70*
Distribution of Marks	*Theory 100 (End semester examination 70 + internal assessment 30)*

Course Objectives

Upon successful completion of this course, students will be able to:

- Develop a comprehensive understanding of acid–base theories, aqueous acid–base equilibria, buffer systems, and factors governing the strength of acids and bases.
- Explain the principles of redox chemistry, electrochemical potentials, and their applications in redox reactions, electrochemical processes, and analytical chemistry.
- Understand the fundamental principles of extractive metallurgy and relate thermodynamic concepts to the extraction, purification, and refining of metals.
- Interpret the mechanisms, regioselectivity, stereoselectivity, and synthetic applications of addition and substitution reactions involving alkenes, alkynes, and aromatic compounds.
- Apply the laws of thermodynamics and thermochemistry to analyse energy changes, spontaneity, and equilibrium in physical and chemical processes.
- Understand the thermodynamic basis of chemical equilibrium and predict the effects of changes in temperature, pressure, and concentration on equilibrium systems.
- Develop competency in statistical analysis of experimental data, including estimation of errors, accuracy, precision, and confidence limits, for reliable interpretation of chemical measurements.
- Integrate concepts from inorganic, organic, analytical, and physical chemistry to solve qualitative and quantitative chemical problems using scientific reasoning.

Course Outcomes (COs)

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

CO1: Explain various acid–base theories, calculate pH and buffer composition, interpret acid–base equilibria, and correlate molecular structure with the strength of organic and inorganic acids and bases.

CO2: Analyse oxidation–reduction reactions using electrochemical principles, balance redox equations, apply the Nernst equation.

CO3: Explain the thermodynamic and electrochemical principles involved in metallurgy, including ore processing, metal extraction, refining techniques, and the application of Ellingham diagrams.

CO4: Analyse the mechanisms, regioselectivity, stereoselectivity, and synthetic applications of addition reactions of alkenes and alkynes, and electrophilic and nucleophilic aromatic substitution reactions.

CO5: Explain the mechanisms, orientation and reactivity of electrophilic and nucleophilic aromatic substitution reactions and predict the products of aromatic substitution reactions.

CO5: Apply the First Law of Thermodynamics, thermochemical principles, and energy relationships to calculate thermodynamic quantities, interpret energy changes, and analyse reversible and irreversible processes.

CO6: Explain thermochemical concepts, calculate various thermodynamic quantities using Hess's law and Kirchhoff's equations, and interpret the energetics of chemical reactions.

Unit I: Acid-base Chemistry — *Lecture/Marks: 10*

Acid-base concepts (various theories and application to different molecules), Measure of acid and base strength, gas phase proton affinity, Acid-base equilibria in aqueous solution (Proton transfer equilibria in water), pH, buffer, acid-base neutralisation curves; indicator, choice of indicators, Inductive effect and strength of oxyacids, acidity of aqua ions, steric effect, proton sponge, superacids and superbases Hard and Soft Acids and Bases (HSAB), Application of HSAB principle, symbiosis,

The definition of pKa, organic acids and bases (factors affecting relative strength), substituents affect the pKa (carbon acid)

Unit II Redox reactions — *Lecture/Marks: 07*

Ion-electron method of balancing equation of redox reaction, Elementary idea on standard redox potentials with sign conventions, Redox half-reactions, standard potentials and spontaneity, trends in standard potentials, the electrochemical series, Nernst equation, (without derivation), disproportionation and comproportionation, redox indicators

Unit III d-block Chemistry — *Lecture/Marks:08*

Electronic configuration, General Properties of d-block elements (melting points, atomic and ionic size, ionization enthalpies, oxidation states) trends in standard reduction potentials, magnetic properties, formation of colour compounds, catalytic properties, alloy formation, formation of interestial compounds, Some important compounds of transition metals: $KMnO_4$, $K_2Cr_2O_7$ etc, application of some important compounds

Unit IV: Organic Reaction of alkene and alkyne — *Lecture/Marks: 10*

Addition to C=C: mechanism (with evidence wherever applicable), reactivity, regioselectivity (Markovnikov and anti-Markovnikov additions) and stereoselectivity; reactions: hydrogenation, halogenation, oxymercuration demercuration, hydroboration-oxidation, ozonolysis, radical addition: HBr addition; mechanism of allylic and benzylic bromination in competition with brominations across C=C; use of NBS.

Addition to C≡C (in comparison to C=C): mechanism, reactivity, regioselectivity (Markovnikov and anti-Markovnikov addition) and stereoselectivity; reactions: hydrogenation, halogenations, oxymercuration demercuration, hydroboration-oxidation, dissolving metal reduction of alkynes; reactions of terminal alkynes.

Unit V: Organic Reactions: Aromatic substitution — *Lecture/Marks: 10*

Aromatic Substitution Electrophilic aromatic substitution: mechanisms and evidences in favour of it; orientation and reactivity; reactions: nitration, sulfonation, halogenation, Friedel-Crafts reaction; one-carbon electrophiles (reactions: chloromethylation, Gatterman-Koch, Vilsmeier-Haack, Reimer-Tiemann); Ipso substitituion.

Nucleophilic aromatic substitution: addition-elimination mechanism and evidences in favour of it; SN1 mechanism; cine substitution (benzyne mechanism), structure of benzyne

Unit VI: Thermodynamics and Thermochemistry *Lecture/Marks: 15*

Basic Concepts: System and surroundings; open, closed and isolated systems; state and path functions; intensive and extensive properties; work, heat and internal energy.

First Law of Thermodynamics: Statement and applications; internal energy and enthalpy; heat capacities (Cp and Cv); relationship between Cp and Cv (ideal gases); calculation of work and heat for simple processes (qualitative treatment).

Second Law of Thermodynamics: Concept of spontaneous and non-spontaneous processes; entropy and entropy change (qualitative treatment); Carnot cycle, Carnot engine and refrigerator; efficiency of heat engines; Gibbs free energy and criteria for spontaneity and equilibrium.

Thermochemistry: Enthalpy of reaction, standard enthalpy of formation and combustion; Hess's law and its applications; bond enthalpy and bond dissociation energy; Kirchhoff's equation (statement only); applications of thermochemistry in chemical and industrial processes.

Unit VII: Chemical Kinetics *Lecture Marks 10*

Rate of a chemical reaction; rate law and rate equation; factors affecting reaction rate; order and molecularity of reactions; integrated rate equations for zero-, first- and second-order reactions (without detailed derivation); half-life of reactions; determination of reaction order; temperature dependence of reaction rates; Arrhenius equation and activation energy; collision theory (basic concepts); effect of catalysts on reaction rate.

Suggested Readings

- Lee, J. D. Concise Inorganic Chemistry,5th Ed., Wiley India Pvt. Ltd., 2008.
- Atkin, P. Shriver & Atkins' Inorganic Chemistry, 5th Ed., Oxford University Press (2010).
- Huheey, J. E.; Keiter, E.A. & Keiter, R.L. Inorganic Chemistry, Principles of Structure and Reactivity 4th Ed., Harper Collins 1993, Pearson,2006.
- Atkins, P.W. & Paula, J. Physical Chemistry, Oxford Press, 2006.
- Winter, M. J., The Orbitron, http://winter.group.shef.ac.uk/orbitron/ (2002). An illustrated gallery of atomic and molecular orbitals.
- Bruice, P. Y. (2016). *Organic Chemistry* (8th ed.). Pearson.
- Solomons, T. W. G., Fryhle, C. B., & Snyder, S. A. (2023). *Organic chemistry* (13th ed.). John Wiley & Sons, Inc.
- March, J., Smith, M. B. March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, 6th Edn., (Wiley, 2007).

Semester IV

NCrF level	*5.0*
Title of the Course	*General Chemistry- IV*
Course code	*CHMN- 401 (P)*
Paper credit	*04* ((L 0 – T 0 - P 4)
Total Contact Hours	*Practical 120*
Distribution of Marks	*Practical 100 (End semester examination 70 + internal assessment 30)*

Course Objectives

The objectives of this practical course are to:

- Develop proficiency in basic laboratory techniques, safe handling of chemicals, and maintenance of laboratory records following good laboratory practices.
- Train students in the qualitative analysis of inorganic salts and organic compounds using systematic analytical methods.
- Familiarize students with the synthesis, purification, and characterization of selected inorganic compounds and coordination complexes.
- Develop practical skills in the separation, purification, and identification of organic compounds using conventional laboratory techniques.
- Introduce the operation, calibration, and applications of common laboratory instruments such as pH meters, conductivity meters, viscometers, and stalagmometers.
- Enable students to perform physicochemical measurements related to pH, conductivity, surface tension, viscosity, and thermochemistry, and interpret the experimental data.
- Develop scientific observation, experimental design, data analysis, graphical representation, and report-writing skills essential for higher studies and professional careers.

Course Outcomes (COs)

After successful completion of this practical course, students will be able to:

CO1: Perform systematic qualitative analysis of simple inorganic salts, identify common cations and anions, and interpret experimental observations using standard analytical procedures.

CO2: Synthesize selected inorganic compounds and coordination complexes, purify the products by recrystallization, and verify their composition using qualitative analytical techniques.

CO3: Separate and purify components of binary organic mixtures based on their chemical properties and determine the purity of isolated compounds using melting point measurements.

CO4: Identify common functional groups and hetero elements in organic compounds through qualitative tests and correlate the results with the structure of the compounds.

CO5: Operate and calibrate pH and conductivity meters, measure physicochemical properties of solutions, and apply these techniques for the analysis of environmental water samples.

CO6: Determine surface tension, viscosity, and thermochemical parameters using standard laboratory methods, analyse experimental data, prepare graphs where appropriate, and draw scientifically valid conclusions.

CO7: Demonstrate competence in laboratory safety, experimental planning, accurate observation, data recording, interpretation of results, and scientific communication through practical reports and viva voce.

Part A

i) Qualitative analysis of inorganic salt **30 hrs**

Analysis of a simple water soluble salt containing one or two cations and anions

Marks distribution: Physical properties and solubility-01, Preliminary Dry tests for acid radicals-02, special confirmatory test for acid radicals – 02, Wet test for acid radicals-02, Group analysis -04 Conclusion and remarks-01, total =12 marks)

ii) Inorganic Preparation **10** hours

Preparation of the following (at least two compounds one from double salt and another from complex ions should be prepared and make them understand the difference between double salt and coordination complex):

- Mohr's salt
- Chrome alum
- Potash alum
- Tetramminecopper(II) sulphate
- Cu(glycinate)$_2$
- Hexamminenickel(II) chloride
- Potassium trioxalato chromate(III)
- [Ni(DMG)$_2$]

Students should recrystallize the product and verify presence of anions and cations by qualitative analysis.
(Distribution of Marks: Experimentation–02, quality and quantity – 01+03=04, Result and conclusion – 2; total=08)

Part B

i) Separation of solid organic compound **10hrs**

Separation based upon solubility, by using common laboratory reagents like water (cold, hot), dil. HCl, dil. NaOH, dil. $NaHCO_3$, *etc*., of components of a binary solid mixture; purification of **any one** of the separated components by crystallization and determination of its melting point. The composition of the mixture should be of the following types **[minimum three]**:

- *p*-Nitrobenzoic acid/*p*-Aminobenzoic acid;
- *p*-Nitrotolune/*p*-Anisidine;
- benzoic acid/naphthalene;
- urea/phenyl benzoate;
- *p*-toluidine/benzophenone;
- *p*-chlorobenzoic acid/ benzophenone,

Use of pH paper is recommended.

(Distribution of Marks: solubility separation-02, crystallization and quality =03, Result and conclusion – 03; total=08)

ii) Qualitative analysis of an organic compound **30 hrs**

- Detection of N, S, Halogens
- Test for functional groups

(Distribution of Marks: Detection of elements –02, Test for functional group – 04, solubility, aromaticity, unsaturation test, mp/bp – 02, Result and conclusion – 2; total=12)

Part C

i) pH and conductivity measurement 10 hours

- Calibration of pH meter
- Determination of pH of different acid and basic solution prepared with various normality and molarity
- Determination of pH, acidity, and alkalinity of water samples collected from different water body/supply sources like river water, supply water, Groundwater, water samples collected from water sewage treatment plants in nearby areas
- Calibration of conductivity meter
- Measurement of cell constant
- Measurement of various solution and determination of ionic composition

ii) Surface tension and viscosity 20 hours

- Determine the surface tension of a given liquid at room temperature using stalagmometer by drop number method
- Determine the surface tension of a given liquid by means of stalagmometer using drop weight method
- Determine the composition of a given mixture by surface tension method.
- Study the variation of surface tension of detergent solutions with concentration
- Determine the viscosity of a liquid at a given concentration at laboratory temperature, by viscometer
- Determine the composition of a given liquid mixture by viscosity method
- Study the variation of viscosity of sucrose solution with the concentration of the solute

iii) Thermochemistry 10 hours

- Determination of heat capacity of a calorimeter and enthalpy of neutralisation (eg. hydrochloric acid with sodium hydroxide)
- Determine the enthalpy of solution of oxalic acid from solubility measurements
- Determination of heat capacity of a calorimeter for different volumes using change of enthalpy data of a known system (method of back calculation of heat capacity of calorimeter from known enthalpy of solution or enthalpy of neutralization)

(Distribution of Marks: Writing theory: 03, experimentation –02, Graphical representation of data/ tabulation - 03, Result and conclusion – 2; total=10)

Total marks: 70 (end semester examination) + 30 (internal)
Marks distribution: Part A: Inorganic (any two) experiment: 20, Part B: Organic (any two) experiment(s): 20, Part C: Physical (any two) experiment(s): 20, Viva: 10

Suggested readings

- Vogel, A. I., Tatchell, A. R., Furnis, B. S., Hannaford, A. J. & Smith, P. W. G. Vogel's Textbook of Practical Organic Chemistry, 5th Edition, Pearson Education.
- Mendham, J., Denney, R. C., Barnes, J. D. & Thomas, M. J. K. Vogel's Textbook of Quantitative Chemical Analysis, 6th Edition, Pearson Education.
- Svehla, G. Vogel's Qualitative Inorganic Analysis, 7th Edition, Pearson Education.
- Ahluwalia, V. K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, Universities Press.
- Ahluwalia, V. K. & Dhingra, S. Comprehensive Practical Organic Chemistry: Qualitative Analysis, Universities Press.
- Das, R. C. & Behera, B. Experimental Physical Chemistry, Tata McGraw-Hill Education.
- Khosla, B. D., Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Company.
- Gurdeep Raj. Advanced Practical Chemistry, Goel Publishing House.

Semester V

NCrF level	5.5
Title of the Course	General Chemistry- V
Course code	CHMN-501
Paper credit	04 (L 4 – T 0 - P 0)
Total Contact Hours	Theory 70 hours
Distribution of Marks	100 (End semester examination 70 + internal assessment 30)

Course Objectives

The objectives of this course are to:

- Develop a comprehensive understanding of the chemistry of main group, transition, inner transition, organometallic, nuclear, and bioinorganic compounds.
- Explain the structure, bonding, reactivity, and properties of important inorganic compounds using modern theories of chemical bonding.
- Introduce the fundamental concepts of coordination chemistry, including bonding theories, stability, reaction mechanisms, and applications of coordination compounds.
- Familiarize students with the chemistry of lanthanides and actinides, organometallic compounds, and their significance in catalysis and industrial processes.
- Provide knowledge of nuclear chemistry, radioactivity, radiation safety, and the peaceful applications of radioactive isotopes.
- Explain the biological importance of metal ions, metalloproteins, metallodrugs, and the role of inorganic chemistry in living systems.
- Introduce industrially important inorganic materials such as glass, ceramics, cement, and alloys, along with emerging functional materials and their applications.
- Develop analytical thinking and problem-solving skills by correlating theoretical concepts with industrial, biological, environmental, and technological applications of inorganic chemistry.

Course Outcomes (COs)

Upon successful completion of this course, the students will be able to:

CO1: Explain the periodic trends, oxidation states, anomalous behaviour, hydrides, and the structure, bonding, properties, and applications of important compounds of the s- and p-block elements.

CO2: Interpret the bonding, geometry, magnetic behaviour, and stability of coordination compounds using Valence Bond Theory and Crystal Field Theory, and calculate Crystal Field Stabilization Energy (CFSE).

CO3: Describe the electronic configuration, oxidation states, magnetic properties, coordination chemistry, and technological importance of lanthanides and actinides.

CO4: Differentiate between thermodynamic and kinetic stability of coordination compounds, explain substitution reactions in coordination chemistry, and apply concepts such as the chelate effect and trans effect.

CO5: Apply the principles of organometallic chemistry, including electron counting, the 18-electron rule, metal–carbon bonding, and homogeneous catalysis, to understand the structure and reactivity of organometallic compounds.

CO6: Explain the principles of nuclear chemistry, radioactivity, nuclear reactions, radiation safety, and the applications of radioactive isotopes in medicine, agriculture, industry, and scientific research.

CO7: Illustrate the biological role of essential and trace metal ions, metalloproteins, metallodrugs, and metal ion transport systems, and evaluate the beneficial and toxic effects of metals in biological systems.

CO8: Describe the preparation, properties, processing, and applications of industrially important inorganic materials such as glass, ceramics, cement, alloys, and advanced functional materials used in modern technology.

Unit I Main Group Chemistry ***Lecture/Marks: 20***

Relative stability of different oxidation states, diagonal relationship and anomalous behaviour of first member of each group, Complex formation tendency of *s- and p block* elements. Allotropy and catenation

Hydrides and their classification: ionic, covalent and interstitial; basic beryllium acetate and nitrate

Preparation and properties of oxides, superoxides, peroxides, hydrides, hydroxides, halides and carbonates of alkali and alkaline earth metals

Study of the following compounds with emphasis on structure, bonding, preparation, properties and uses: borane (bonding in diborane), ammonia, phosphine and hydrogen sulphide, oxides of nitrogen, phosphorus pentoxide; nitric acid, phosphoric acid, sulphuric acid, borazine, phosphazene, boric acid, borax, S_4N_4; Interhalogen compounds, triiodide, cyanide, thiocyanide

Preparation, properties and molecular shapes of XeF_2, XeF_4 and XeF_6

Unit II Coordination Chemistry II: Bonding Theories ***Lecture/Marks:10***

Valence bond theory, inner and outer orbital complexes, magnetic properties of complexes, drawback of VBT
Crystal Field Theory (CFT) (qualitative treatment): d-orbital splitting in tetrahedral, and octahedral geometries, Calculation of CFSE, Thermodynamic and structural aspect of orbital splitting, pairing energies (contribution of exchange and coulomb energy), factors affecting the magnitude of 10 Dq (Δ_o, Δ_t), spectrochemical series, Applications of CFT in explaining colour and magnetic behaviour, demerits of CFT.

Unit III Inner Transition Elements ***Lecture/Marks: 05***

Lanthanoids: Electronic configuration, oxidation states, colour, spectral and magnetic properties, lanthanide contraction, separation of lanthanides (ion-exchange method only), coordination chemistry of lanthanides
Actinoids: electronic configuration, oxidation states, magnetic properties, Comparison with lanthanides

Unit IV Reaction Mechanism in Coordination Chemistry ***Lecture/Marks: 08***

Thermodynamic stability of complexes, stepwise and overall formation constants, factors effecting on stability, Irving-Williams series, kinetic stability, lability and inertness, chelate effect, applications in analytical chemistry and biology

Introduction to inorganic reaction mechanisms, Substitution reactions in octahedral complexes, factors affecting the substitution reactions

Substitution reaction of square planar complexes, basic concept of trans-effect with examples

Unit V Organometallic Chemistry ***Lecture/Marks: 07***

Definition, classification, hapticity, 18-electron rule, Electron counting in organometallic complexes, nature of metal-carbon bond, nomenclature,

Metal carbonyls: classifications, bonding, synergistic effect, synthesis and reactions of metal carbonyls

Metal–alkene complexes: Structure and Bonding

Brief introduction to homogeneous catalysis, Homogeneous hydrogenation (Wilkinson catalyst) and hydroformylation reactions

Unit VI Nuclear Chemistry ***Lecture/Marks: 05***

Composition of nucleus, Elementary Particles, Composite Particles, Mass defect and binding energy, nuclear stability, packing fractions, fundamentals of radioactive decay, nuclear models, nuclear reactions, nuclear Fusion and Fission, applications of radioactive isotopes, Nuclear waste management (brief introduction), Radiation safety

Unit VII Bioinorganic Chemistry ***Lecture/Marks: 05***

Essential and trace elements and their biological role, Effect of deficiency of some metal ions, Toxic effect of metal ions (Fe, Cu, Hg, Pb, Cd and As), metals in medicine, Chelate therapy, Cisplatin as anticancer drug

Structure-function relationship of haemoglobin and myoglobin, active transport of ions (Sodium - potassium pump), Vitamin B_{12} (Cobalt), Chlorophyll (Magnesium)

Unit VIII Inorganic Materials of Industrial Importance ***Lecture/Marks: 10***

Glass: Glassy state and its properties, classification (silicate and non-silicate glasses), manufacture and processing of glass, Composition and properties of the following types of glasses: Soda lime glass, lead glass, armoured glass, safety glass, borosilicate glass, fluorosilicate, coloured glass, photosensitive glass, smart glass, Optical fibres and their applications

Ceramics: Important clays and feldspar, ceramic, their types and manufacture, high technology ceramics and their applications, superconducting and semiconducting oxides, nanoceramics, Piezoelectric materials and their applications

Cements: Classification of cement, ingredients and their role, Manufacture of cement and the setting process, quick setting cements.

Alloys: Classification of alloys, ferrous and nonferrous alloys, specific properties of elements in alloys.

Suggested reading

- J. D. Lee, Concise Inorganic Chemistry, 5th Edition, Wiley India.
- Catherine E. Housecroft and Alan G. Sharpe, Inorganic Chemistry, 5th Edition, Pearson Education.
- Shriver, D. F., Weller, M., Overton, T., Rourke, J., and Armstrong, F., Shriver & Atkins' Inorganic Chemistry, Oxford University Press.
- F. A. Cotton, G. Wilkinson, C. A. Murillo and M. Bochmann, Advanced Inorganic Chemistry, 6th Edition, Wiley.
- Huheey, J. E., Keiter, E. A., and Keiter, R. L., Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Education.
- Satya Prakash, G. D. Tuli, S. K. Basu and R. D. Madan, Advanced Inorganic Chemistry, S. Chand Publishing.
- R. L. Madan, Modern Inorganic Chemistry, S. Chand Publishing.
- P. L. Soni and Mohan Katyal, Textbook of Inorganic Chemistry, Sultan Chand & Sons.
- B. R. Puri, L. R. Sharma and K. C. Kalia, Principles of Inorganic Chemistry, Vishal Publishing Co.
- Gurdeep Raj, Advanced Inorganic Chemistry, Goel Publishing House.
- K. De, Environmental Chemistry, New Age International Publishers.
- Miessler, G. L., Fischer, P. J., and Tarr, D. A., Inorganic Chemistry, Pearson.
- Greenwood, N. N. and Earnshaw, A., Chemistry of the Elements, 2nd Edition, Butterworth-Heinemann.
- Douglas, D. McDaniel and J. Alexander, Concepts and Models of Inorganic Chemistry, Wiley.
- Keith F. Purcell and John C. Kotz, Inorganic Chemistry, Cengage Learning.

Additional Learning Resources

- SWAYAM–NPTEL: Inorganic Chemistry, Coordination Chemistry, and Organometallic Chemistry courses offered by IITs.
- UGC e-PG Pathshala modules in Inorganic Chemistry.
- Virtual Labs (Ministry of Education, Government of India) for demonstrations in coordination chemistry and inorganic materials.

Semester VI

NCrF level	*5.5*
Title of the Course	*General Chemistry - VI*
Course code	*CHMN-601*
Paper credit	*04* (L 4 – T 0 - P 0)
Total Contact Hours	*Theory 70 hours*
Distribution of Marks	*100 (End semester examination 70 + internal assessment 30)*

Course Objectives

Upon completion of this course, students will be able to:

- Understand the structure, nomenclature, preparation, properties, and reactions of important classes of organic compounds.
- Explain reaction mechanisms of organic transformations using concepts of electronic effects, stereochemistry, and reaction intermediates.
- Describe the chemistry of carbonyl compounds, carboxylic acids, carbohydrates, amino acids, and nitrogen-containing compounds.
- Understand the structure and biological significance of biomolecules including amino acids, peptides, nucleic acids, and carbohydrates.
- Explain the synthesis and reactions of pharmaceutically important organic compounds and appreciate their therapeutic applications.
- Correlate organic chemistry concepts with applications in medicinal chemistry, biotechnology, and the pharmaceutical industry.
- Develop analytical and problem-solving skills for predicting reaction pathways and designing simple organic syntheses.

Course Outcomes (COs)

Upon successful completion of the course, students will be able to:

CO1: Explain the preparation, properties, reactivity, and reaction mechanisms of alkyl and aryl halides and compare their substitution and elimination reactions.

CO2: Describe the synthesis, properties, and biological importance of amino acids, peptides, and nucleic acids, and explain their structural features and analytical characterization.

CO3: Interpret the preparation, reactions, and mechanisms of carboxylic acids and their derivatives, including esterification and hydrolysis reactions.

CO4: Analyze the structure, reactivity, and reaction mechanisms of aldehydes and ketones, including carbonyl addition, condensation, oxidation–reduction, and α-substitution reactions.

CO5: Explain the structural features, stereochemistry, reactions, and biological significance of carbohydrates and relate their chemistry to biological systems.

CO6: Describe the preparation, properties, and reactions of alcohols, phenols, and ethers, and explain their industrial and synthetic importance.

CO7: Explain the chemistry of amines and diazonium salts, including their preparation, properties, synthetic applications, and analytical identification.

CO8: Describe the synthesis, structure, therapeutic importance, and mechanism of action of selected pharmaceutical compounds and appreciate the role of organic chemistry in drug development.

Unit I Alkyl and Aryl halides — *Lecture Marks 10*

Alkyl halides: Preparation from alkenes and alcohols, Reactions: Hydrolysis, nitrite and nitro formation, Williamson's Synthesis: elimination vs Substitution

Aryl halides: Preparation (chloro, bromo, iodo benzene only) from phenol, Sandmeyer & Gattermann reaction, Reactions (chlorobenzene): Aromatic nucleophilic substitution (replacement by –OH) and effect of nitro substituent. Reactivity and relative carbon–halogen bond strength in alkyl, allyl, benzyl, vinyl, and aryl halides

Unit-II Amino acids — *Lecture/Marks: 07*

Amino acids: Synthesis with mechanistic details: Strecker, Gabriel; isoelectric point, zwitterions; electrophoresis, reaction: ninhydrin reaction.

Peptides: peptide linkage and its geometry; syntheses of peptides using N-protection & C-protection

Nucleic acids: pyrimidine and purine bases (only structure & nomenclature); nucleosides and nucleotides corresponding to DNA and RNA

Biological importance of amino acids and peptides

Unit III Carboxylic Acids and their Derivatives — *Lecture Marks: 08*

Preparation, physical properties and reactions of monocarboxylic acids, typical reactions of dicarboxylic acids, hydroxy acids and unsaturated acids: succinic/phthalic, lactic acid. Preparation and reactions of sulphonic acids.

Preparation and reactions of acid chlorides, anhydrides, esters, and amides; mechanisms of acidic and alkaline hydrolysis of esters

Unit IV Carbonyl and Related Compounds — *Lecture/Marks: 15*

Addition to C=O: structure, reactivity and preparation of carbonyl compounds; reactions: Cannizzaro reactions, reactions with ylides: Wittig reaction; oxidations and reductions: Clemmensen, Wolff-Kishner, $LiAlH_4$, $NaBH_4$, oxidation of alcohols with PDC and PCC.

Exploitation of acidity of α-H of C=O: formation of enols and enolates; kinetic and thermodynamic enolates; reactions (mechanism with evidence): halogenation of carbonyl compounds under acidic and basic conditions, Hell-Volhard-Zelinsky (HVZ) reaction, condensations (mechanism with evidence): Aldol , Knoevenagel, Claisen-Schmidt.

Nucleophilic addition to α,β-unsaturated carbonyl system: general principle and mechanism (with evidence); direct and conjugate addition, addition of enolates (Michael reaction).

Unit V Carbohydrates — *Lecture Marks 10*

Occurrence and classification

Monosaccharides: Aldoses up to 6 carbons; structure of D-glucose & D-fructose (configuration & conformation); ring structure of monosaccharides (furanose and pyranose forms): Haworth representations and non-planar conformations; anomeric effect (including stereoelectronic explanation); mutarotation, Disaccharides: Glycosidic linkages

Applications of carbohydrates in food, medicine, and biotechnology

Unit VI Alcohol, phenols and ethers *Lecture/Marks: 10*

Alcohols: preparation, properties, and relative reactivity of 1°, 2°, and 3° alcohols; oxidation by periodic acid and lead tetraacetate; Pinacol-Pinacolone rearrangement. Lucas test or distinguishing tests for alcohols

Phenols: Preparation and properties; acidity and factors affecting it; ring substitution reactions; reactions of phenols: Reimer-Tiemann reaction, nitration, sulphonation, halogenation, oxidation, coupling with diazonium salts.

Ethers: Preparation and reactions with acids. Dialkyl, aryl alkyl and diaryl ethers; cyclic ethers: epoxides. Synthesis: Williamson ether synthesis, dehydration of alcohols, diaryl- and aryl alkyl ethers by SNAr.

Unit-VII Nitrogen containing compounds *Lecture/Marks: 05*

Amines: Effect of substituent and solvent on basicity; Preparation and properties: Gabriel phthalimide synthesis, Hoffmann'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.

Unit VIII Pharmaceutical Compounds *Lecture/Marks: 05*

Classification, structure, therapeutic uses, and representative synthesis of selected pharmaceutical compounds: Paracetamol, Ibuprofen, Chloroquine, Suphanilamides

An elementary treatment of antibiotics and study of chloramphenicol

Suggested reading

- Morrison, R. T. and Boyd, R. N., Organic Chemistry, 7th Edition, Pearson.
- Clayden, J., Greeves, N., and Warren, S., Organic Chemistry, Oxford University Press.
- Solomons, T. W. G., Fryhle, C. B., and Snyder, S. A., Organic Chemistry, Wiley.
- McMurry, J., Organic Chemistry, Cengage Learning.
- Finar, I. L., Organic Chemistry, Volume I & II, Pearson Education.
- Arun Bahl and B. S. Bahl, Advanced Organic Chemistry, S. Chand Publishing.
- P. S. Kalsi, Organic Reactions and Their Mechanisms, New Age International.
- O. P. Agarwal, Organic Chemistry: Reactions and Reagents, Goel Publishing.
- M. K. Jain and S. C. Sharma, Modern Organic Chemistry, Vishal Publishing.
- B. S. Furniss (Indian Edition), Vogel's Textbook of Practical Organic Chemistry (for supplementary reading).
- Gurdeep Raj, Organic Chemistry, Goel Publishing House.
- Carey, F. A. and Giuliano, R. M., Organic Chemistry, McGraw-Hill.
- March, J., Advanced Organic Chemistry: Reactions, Mechanisms and Structure, Wiley.
- Loudon, G. M., Organic Chemistry, Oxford University Press.
- Peter Sykes, A Guidebook to Mechanism in Organic Chemistry, Pearson.

Semester VII

NCrF level	*6.0*
Title of the Course	*General Chemistry VII (Practical)*
Course code	*CHMN-601 (P)*
Paper credit	*04* (L 4 – T 0 - P 0)
Total Contact Hours	*Theory 70 hours*
Distribution of Marks	*100 (End semester examination 70 + internal assessment 30)*

Course Objectives

The objectives of this practical course are to:

- Develop proficiency in advanced laboratory techniques involving volumetric analysis, organic synthesis, instrumental analysis, and physicochemical measurements.
- Train students in quantitative chemical analysis using acid–base, redox, and complexometric titrations for the estimation of chemically and environmentally important analytes.
- Familiarize students with the synthesis, purification, and characterization of selected organic compounds while emphasizing reaction monitoring, product isolation, and yield calculations.
- Develop competence in the use of modern analytical instruments such as pH meters and conductivity meters for chemical and environmental analysis.
- Introduce students to the principles and applications of chemical kinetics, adsorption, polymer synthesis, and environmental analytical techniques.
- Promote interdisciplinary learning through experiments involving polymer science, water quality assessment, environmental chemistry, and sustainable materials.
- Develop scientific reasoning, experimental design, data analysis, report writing, teamwork, and problem-solving skills through project-based laboratory investigations.

Course Outcomes (COs)

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

CO1: Perform quantitative chemical analyses using acid–base, redox, and complexometric titrations and interpret the analytical results with appropriate calculations.

CO2: Synthesize selected organic compounds, purify the products using suitable techniques, determine percentage yield, monitor reaction progress, and evaluate product purity using melting point determination.

CO3: Operate pH meters and conductivity meters, perform conductometric and potentiometric titrations, determine dissociation constants, and analyze physicochemical properties of solutions.

CO4: Investigate reaction kinetics, adsorption phenomena, and physicochemical processes through laboratory experiments and analyze experimental data using appropriate graphical and mathematical methods.

CO5: Prepare polymeric materials and environmentally relevant products, and explain the relationship between synthesis, structure, properties, and applications of polymers.

CO6: Analyze environmental samples for important water quality parameters such as chloride, dissolved oxygen, residual chlorine, total dissolved solids, conductivity, and pH using standard analytical procedures.

CO7; Design and execute a mini-project by integrating chemical concepts, laboratory techniques, data interpretation, and scientific communication to address practical problems related to chemistry and the environment.

Part A: Inorganic Practical

i) Simple volumetric analysis **10** hours

Following estimations have to be performed

(a) Acid base titration: Estimation of carbonate, bicarbonate and hydroxide.
(b) Redox titration:
- Estimation of oxalic acid by using standardised $KMnO_4$ solution
- Estimation of oxalic acid by Fe(II) using standardised KMnO4 solution
- Determination of water of crystallisation of Mohr Salt using standardised $KMnO_4$ solution
- Estimation of Fe(II) with $K_2Cr_2O_7$ using internal indicator

(c) Complexometric Titration
- To determine the hardness of water by EDTA titration

Part B: Organic Practical

ii) Preparation of organic compound and purification by recrystallization **10hrs**

The following reactions are to be performed, noting the yield of the crude product: (student must perform at least three experiments)

- Cannizaro reaction of benzaldehyde (separation of benzyl alcohol and benzoic acid by solvent extraction)
- Reduction of benzophenone to benzihydrol
- Nitration of salicylic acid with ceric ammonium nitrate under greener method.
- Diazo-coupling reaction
- Preparation of aspirin
- Preparation of paracetamol
- Preparation of acetanilide

Students are asked to monitor the reaction progress with

Students must also calculate percentage yield, based upon isolated yield (crude) and theoretical yield. Purification of the crude product is to be made by crystallisation from water/alcohol, Crystallization after charcoal treatment, or sublimation, whichever is applicable. Melting point of the purified product is to be noted.

Part C: Physical Practical

At least 04 experiments are to be performed from the list of experiments given below:

- To conduct conductometric titrations across targeted systems: (a) strong acid vs. strong base, and (b) weak acid vs. strong base
- To determine the baseline cell constant of a physical conductivity cell to calculate the specific conductance of an electrolyte solution
- To conduct pH-metric titrations across varied systems: (a) strong acid vs. strong base, (b) weak acid vs. strong base, and (c) strong acid vs. weak base
- Determination of dissociation constant of a weak acid.
- Determine the rate constant of the acid catalyzed hydrolysis of methyl acetate.
- Determine the rate constant of saponification of ethyl acetate.
- Determine the activation energy of the hydrolysis of methyl acetate catalyzed by hydrochloric acid.
- Verify the Freundlich isotherm for the adsorption of oxalic acid on activated charcoal.

Part D: Interdisciplinary Practical

- Preparation of nylon-6,6
- Preparation of phenol-formaldehyde resin
- Preparation of urea-formaldehyde resin
- Preparation of biodegradable starch-based polymer film
- Determination of chloride in water
- Estimation of dissolved oxygen (Winkler method)
- Estimation of residual chlorine
- Measurement of TDS and conductivity of water

Part E: Mini Project / Skill Component

Each student performs one mini-project, compulsorily

- Comparative analysis of drinking water
- Analysis of commercial detergents
- Preparation of biodegradable plastic
- Comparative adsorption efficiency of charcoal
- Conductivity of beverages
- Comparative pH study of household products

NB: Faculty member can introduce some new practical time to time in line with NEP 2020.

Suggested Readings

- Vogel, Vogel's Textbook of Quantitative Chemical Analysis, Pearson.
- V. V. Ramanujam, Inorganic Semi-micro Qualitative Analysis, National Publishing House.
- O. P. Agarwal, Advanced Practical Chemistry, Goel Publishing House.
- S. Furniss, A. J. Hannaford, P. W. G. Smith and A. R. Tatchell, Vogel's Textbook of Practical Organic Chemistry, Pearson.
- F. G. Mann and B. C. Saunders, Practical Organic Chemistry, Pearson.
- O. P. Agarwal, Practical Organic Chemistry, Goel Publishing House.
- Raj K. Bansal, Laboratory Manual of Organic Chemistry, Wiley Eastern.
- V. R. Gowariker, N. V. Viswanathan and J. Sreedhar, Polymer Science, New Age International.
- Malcolm P. Stevens, Polymer Chemistry: An Introduction, Oxford University Press.
- S. M. Khopkar, Environmental Pollution Analysis, New Age International.
- A. Skoog, F. J. Holler and S. R. Crouch, Principles of Instrumental Analysis, Cengage Learning.
- H. H. Willard, L. L. Merritt, J. A. Dean and F. A. Settle, Instrumental Methods of Analysis, CBS Publishers.
- S. M. Khopkar, Basic Concepts of Analytical Chemistry, New Age International.

Suggested Assessment Scheme

Internal (30)		External (70)	
Component	**Marks**	**Component**	**Marks**
Laboratory Record	3	Inorganic Practical	15
Continuous Assessment	7	Organic Practical	15
Laboratory Performance	5	Physical Practical	15
Mini Project Report	5	Interdisciplinary Practical	15
Mini Project Presentation	10	Comprehensive Viva Voce	10
Total	**30**	**Total**	**70**

Semester VIII

NCrF level	*6.0*
Title of the Course	*General Chemistry – VIII*
Course code	*CHMN-801*
Paper credit	*04* (L 4 – T 0 - P 0)
Total Contact Hours	*Theory 70 hours*
Distribution of Marks	*100 (End semester examination 70 + internal assessment 30)*

Course Objectives

The objectives of this course are to:

- Develop a fundamental understanding of the physical principles governing the behaviour of solutions, colloids, electrolytes, surfaces, polymers, and chemical equilibria.
- Introduce the concepts of conductance, electrochemical cells, ionic equilibrium, phase equilibria, and colligative properties, and their applications in chemistry and allied sciences.
- Explain the principles of adsorption, catalysis, and polymerization, highlighting their importance in industrial, environmental, and technological processes.
- Familiarize students with modern materials such as biodegradable and conducting polymers and their emerging applications.
- Develop the ability to interpret physicochemical phenomena using thermodynamic and electrochemical principles.
- Correlate theoretical concepts of physical chemistry with practical applications in analytical chemistry, environmental science, medicine, materials science, and industry.
- Foster analytical thinking and problem-solving skills through the study of physicochemical properties and their applications in real-life systems.

Course Outcomes (COs)

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

CO1: Explain the properties of ideal and non-ideal solutions, apply Raoult's and Henry's laws, interpret phase diagrams, and describe the preparation, properties, stability, and applications of colloidal systems.

CO2: Describe the principles of electrolytic conductance, electrochemical cells, electrode potentials, and electrochemical measurements, and apply these concepts to conductometric and potentiometric analyses

CO3: Interpret chemical and ionic equilibrium using equilibrium constants and Le Chatelier's principle, and solve problems involving pH, buffer solutions, salt hydrolysis, and solubility equilibria.

CO4: Explain phase equilibria using Gibbs phase rule and Clausius–Clapeyron equation, and describe the significance of phase diagrams of one-component systems.

CO5: Apply the principles of colligative properties to determine molar masses of solutes and explain the behaviour of associated and dissociated solutions.

CO6: Describe adsorption phenomena, adsorption isotherms, and heterogeneous catalysis, and evaluate their applications in industrial catalysis, environmental remediation, and surface chemistry.

CO7: Explain the classification, synthesis, structure, properties, and applications of polymers, and recognize the importance of biodegradable and conducting polymers in modern materials science and sustainable technologies.

CO8: Integrate the principles of physical chemistry to interpret physicochemical processes occurring in chemical industries, biological systems, environmental technologies, and advanced functional materials.

Unit I Solutions and colloids — *Lecture Marks 12*

Types of solutions; concentration units; solubility of gases in liquids (Henry's law); ideal and non-ideal solutions; Raoult's law; positive and negative deviations; vapour pressure–composition and temperature–composition diagrams; azeotropes and fractional distillation; lever rule (basic applications).

Classification, preparation and purification of colloids; properties of colloids (Tyndall effect, Brownian motion, electrophoresis, electro-osmosis); electrical double layer and zeta potential (basic concepts); stability and coagulation of colloids; protective colloids and gold number; emulsions, micelles and critical micelle concentration (CMC); applications of colloids in medicines, food industry, paints, wastewater treatment

Unit II Conductance and Electrochemistry — *Lecture Marks 12*

Arrhenius theory of electrolytic dissociation; conductors and electrolytes; specific, equivalent and molar conductance; variation of conductance with dilution; Kohlrausch's law and its applications; ionic mobility and transference number (introductory concepts); conductometric titrations.

Electrochemical cells; reversible and irreversible cells; EMF of a cell; Nernst equation; standard electrode potential; electrochemical series and its applications, reference electrodes (SHE, Calomel and Ag/AgCl electrodes); glass electrode and pH measurement; basic principles and applications of potentiometric titrations.

Unit III: Chemical and Ionic Equilibrium — *Lecture/Marks: 10*

Concept of chemical equilibrium; Gibbs free energy and equilibrium constant; equilibrium constants (K_c, K_p); relationship among equilibrium constants; Le Chatelier's principle and its applications; effect of temperature, pressure and concentration on equilibrium

Strong and weak electrolytes; degree of ionization; ionization constant; ionic product of water; pH; common ion effect; weak acids and weak bases; buffer solutions and Henderson–Hasselbalch equation

Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts, Buffer solutions; derivation of Henderson equation and its applications, buffer range, buffer action and applications of buffers in analytical chemistry and biochemical processes in the human body.

Solubility and solubility product of sparingly soluble salts – applications of solubility product principle

Unit IV Phase Equilibria — *Lecture Marks 06*

Concept of phase, component and degrees of freedom; Gibbs phase rule (statement and applications); phase diagrams of one-component systems (water and sulphur); Clausius–Clapeyron equation (statement) and applications

Unit V Colligative Properties — *Lecture/ Marks 06*

Colligative properties: Relative lowering of vapour pressure, elevation of boiling point, depression of freezing point and osmotic pressure; determination of molar masses of normal, associated and dissociated solutes; applications of colligative properties.

Unit VI Surface Chemistry and Catalysis — *Lecture Marks 12*

Adsorption; physisorption and chemisorption; factors affecting adsorption; adsorption isotherms (Freundlich and Langmuir); BET adsorption isotherm (qualitative treatment) and determination of surface area (basic principle),

Catalysis; homogeneous and heterogeneous catalysis; adsorption theory of catalysis; surface catalysis and catalytic activity; Langmuir–Hinshelwood and Eley–Rideal mechanisms (introductory treatment); applications of catalysis in industry and environmental chemistry

Applications of adsorption in environmental remediation and catalysis

Unit VII Polymer Chemistry — *Lecture/Marks: 12*

Introduction and classification of polymers; addition and condensation polymerization; free-radical, cationic and anionic addition polymerization (basic concepts); Ziegler–Natta polymerization; preparation, characteristics and applications of thermoplastics (PVC, polyethylene) and thermosetting polymers (phenol-formaldehyde, polyurethanes); natural and synthetic fibres; natural and synthetic rubbers; vulcanization; polymer additives; biodegradable polymers and environmental aspects, conducting polymers (introductory concept and applications)

Suggested reading

- P. W. Atkins and Julio de Paula, Atkins' Physical Chemistry, 11th Edition, Oxford University Press.
- Peter Atkins and Julio de Paula, Elements of Physical Chemistry, Oxford University Press.
- Ira N. Levine, Physical Chemistry, 6th Edition, McGraw-Hill Education.
- G. M. Barrow, Physical Chemistry, Tata McGraw-Hill.
- B. R. Puri, L. R. Sharma and M. S. Pathania, Principles of Physical Chemistry, Vishal Publishing Co.
- K. L. Kapoor, A Textbook of Physical Chemistry, Macmillan India.
- P. C. Rakshit, Physical Chemistry, Sarat Book House.
- S. Glasstone and D. Lewis (Indian Edition), Elements of Physical Chemistry, Macmillan India.
- Gurdeep Raj, Advanced Physical Chemistry, Goel Publishing House.
- Keith J. Laidler, John H. Meiser and Bryan C. Sanctuary, Physical Chemistry, Houghton Mifflin.
- D. A. McQuarrie and J. D. Simon, Physical Chemistry: A Molecular Approach, Viva Books.
- G. W. Castellan, Physical Chemistry, Narosa Publishing House.