

Syllabus
B.Sc. Chemistry (Honors)
Four-Year UG (B.Sc. Honors) Programme
Full-Time CBCS Programme
Based on New National Education Policy-2020
(Effective from July, 2025)



DEPARTMENT OF CHEMISTRY
University of Allahabad
Prayagraj – 211002, Uttar Pradesh
India

CORE COURSE

SEM - I

PAPER I – INORGANIC CHEMISTRY

Credit: 2

Course Objectives

- To understand the atomic and nuclear structure and its implications.
- To understand ionization potential, electron affinity, electronegativity, lattice and hydration energy, and their periodic variations.
- To explain the general principles of metal extraction and purification.
- To understand the theoretical principles of volumetric analysis, including redox titrations.

Learning Outcomes

CO1: Students are expected to be able to understand the wave-particle duality, quantum numbers, and the screening effect of electrons and its consequences.

CO2: Students will be able to understand the basis of classification in the Modern Periodic Table, and will also be able to explain the properties of various elements.

CO3: Students will be able to identify the occurrence and mineral sources of lithium, beryllium, and radium.

CO4: Students will be able to perform qualitative analysis of inorganic mixtures based on characteristic chemical reactions

Syllabus

Unit	Course Content	Hours of Teaching
I	ATOMIC AND NUCLEAR STRUCTURE (a) Bohr's and Sommerfelds' Atomic Models, de Broglie equation, Heisenberg uncertainty principle. Schrodinger wave equation, Radial and angular wave function, Physical significance and characteristics of a wave function, shapes of s, p, d and f-orbitals. Aufbau principle and electronic configuration of atoms. Periodic classification of elements (IUPAC recommendation), Long form of the periodic table including translawrencium elements. (b) Structure of nucleus, fundamental particles, forces in the nucleus, nuclear stability - N/P ratio and binding energy, packing function.	[12]

II	PROPERTIES OF THE ELEMENTS Atomic, Covalent and ionic radii, Ionization potential, Electron affinity, Electronegativity, including an idea about group electronegativity and their variation in the Periodic table. Ionization Potential, Lattice energy, and hydration energy, and their relation to the solubility of ionic compounds.	[05]
III	EXTRACTION OF ELEMENTS General principles of extraction and purification of metals. Occurrence and isolation of the elements, Extraction and isolation of Li, Be, and Ra from their minerals.	[10]
IV	PRINCIPLES INVOLVED IN VOLUMETRIC ANALYSIS General principles of volumetric analysis, Redox titrations, Equivalent weight, normality, molarity, and molality. Numericals based on volumetric analysis.	[03]

PAPER II – ORGANIC CHEMISTRY

Credit: 2

Course Objectives

- Understand structure, bonding, aromaticity, and stereochemistry in organic compounds.
- Explain reaction mechanisms, reactive intermediates, and orientation effects in aromatic substitution.
- Describe the preparation and reactivity of alkanes.

Course Outcome

At the end of the course, students will be able to:

- **CO1:** Explain hybridization, resonance, aromaticity, and intermolecular interactions.
- **CO2:** Interpret mechanisms, identify reagents and reactive intermediates.
- **CO3:** Determine stereochemistry of optical and geometrical isomers.
- **CO4:** Explain preparation and reactivity of alkanes and predict halogenation patterns.
hexane.

Syllabus

Unit	Course Content	Hours of Teaching
I	STRUCTURE, BONDING : Hybridization, bond lengths and bond angles, bond energy, localized and delocalized chemical bond, resonance, hyperconjugation, inductive and field effect, hydrogen bonding. Aromaticity: The Huckel rule, aromatic ions. Structure of benzene, molecular formula, and Kekule Structure. Stability and carbon-carbon bond lengths of benzene, resonance structure, MO picture.	[08]
II	MECHANISM OF ORGANIC REACTIONS: (A) Curved arrow notation, drawing electron movements with arrow, half-headed and double-headed arrow, Homolytic and heterolytic bond breaking, Types of reagents, electrophiles and nucleophiles, Types of organic reactions, Energy consideration, Reactive intermediates: carbocations, carbanions, free radicals, carbenes, nitrenes and arynes with examples. (B) Arenium ion: Aromatic Electrophillic substitution-general pattern of the mechanism. Role of σ and Π - complexes. Mechanism of nitration, halogenation, sulphonation, mercuration, and Friedel-Crafts reaction and deactivating substituents, orientation, and ortho/para ratio.	[10]
III	STEREOCHEMISTRY OF ORGANIC COMPOUNDS 1: Concept of isomerism, types of isomerism. Optical isomerism: elements of symmetry, molecular chirality, enantiomers, stereo-genic centre, optical activity, properties of enantiomers, diastereomers, threo and erythro, diastereomers, meso-compounds, resolution of enantiomers, inversion, retention and racemization. Relative and absolute configuration, sequence rules, D & L and R & S system of nomenclature. Geometrical Isomers: Elementary idea of geometrical isomerism, determination of configuration of geometrical isomers. E&Z system of nomenclature of geometrical isomers. Geometrical isomerism in oxime and alicyclic compounds.	[08]
IV	ALKANES: Methods of formation: (with special references to Wurtz reaction, Kolbe reaction, Corey-House reaction and decarboxylation of carboxylic acids) and chemical reactions of alkanes. Mechanism of free radical halogenations of alkanes: orientation, reactivity and selectivity.	[04]

Course Objectives

- To understand the basic concepts of chemical kinetics, electrochemistry, and chemical equilibrium.
- To understand the reaction rate, order and molecularity of reaction.
- To explain the types of reactions regarding first-order reaction.
- To explain electrolytic conductance and Kohlrausch law
- To understand chemical equilibria and Le-Chatelier's principle.

Course Outcome

At the end of the course, students will be able to:

CO1. Determine reaction order and understand reaction mechanisms.

CO2. Analyze factors affecting reaction rates, including temperature and catalysts.

CO3. Understand concepts of electrolytic conductance, ion migration, electrolysis.

CO4. Apply these to real-world electrochemical systems.

CO5. Analyze chemical equilibria, apply Le-Chatelier's principle, and determine equilibrium constants in various systems.

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Unit	Course Content	Hours of Teaching
I	CHEMICAL EQUILIBRIUM: Law of mass action and its application to homogeneous and heterogeneous equilibria, Le-Chatelier principle and its application to chemical equilibrium. Degree of dissociation and abnormal molecular weights.	[10]
II	CHEMICAL KINETICS: Reaction rate, order, and molecularity of reaction: zero, first, second, and third order reactions. Methods for determining the order of a reaction. Complex reactions, opposing reactions, consecutive reactions, and side reactions regarding first-order reactions. Effect of temperature on reaction velocity. Energy of activation and collisions theory of bimolecular gaseous reactions.	[10]
III	ELECTROCHEMISTRY: Electrolytic conductance: equivalent conductance, molar conductance, variation of conductance with concentration, Kohlrausch's law of independent migration of ions, conductance ratio, effect of other factors on conductance. Qualitative treatment of the interionic attraction theory. Ionic mobilities, transport number, determination of transport number (Hittorf and moving boundary method), and some applications of conductance measurements. Hydrolysis of salts. Bronsted and Lewis acids and bases. pH and pKa, acid-base concept in non-aqueous media, Buffer solutions. Theory of acid-base indicators.	[10]

Syllabus

(A) Volumetric Analysis (i) Use of $K_2Cr_2O_7$ (Determination of Iron) (ii) Iodometry and iodimetry (Determination of Copper, dichromate. Permanganate etc.) (B) Detection of one element and one functional group in organic compounds (two compounds) (C) Record and viva-voce	[60]
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Texts/Reference Books

1. Basic Inorganic Chemistry, F. A Cotton, G. Wilkinson, and Paul L. Gaus, 3rd Edition (Indian Adaptation 2021), Wiley.
2. Concise Inorganic Chemistry, J. D. Lee, 5th Edition (1996), Chapman & Hall, London.
3. Principle of Physical Chemistry, B. R. Puri, L. R. Sharma and M. S. Pathania, Vishal Publishing Co., New Delhi.
4. Physical Chemistry, P. C. Rakshit, 5th Edition (1988), 4th Reprint (1997), Sarat Book House, Calcutta.
5. Physical Chemistry, P. W. Atkins, 8th Ed., Oxford University Press, New York.
6. Textbook of Physical Chemistry, K.L. Kapoor, vol. 1, Macmillan India Ltd, New Delhi.
7. Physical Chemistry, G. W. Castellan, 3rd Ed (1983), Addison-Wesley Publishing Company, Massachusetts.
8. Organic Chemistry, I. L. Finar, [Vol. I, 6th Edition (1973), Reprinted in 1980 & Vol. II, 5th Edition (1975), Reprinted in 1996], ELBS and Longman Ltd., New Delhi.
9. Organic Chemistry, R. T. Morrison and R. N. Boyd, 6th Edition (1992), Prentice-Hall of India (P) Ltd., New Delhi.
10. Organic Chemistry, Paula Y. Bruice, 2nd Edition, (1998) Prentice-Hall, International Edition.

SEM - II

PAPER I – INORGANIC CHEMISTRY

Credit: 2

Course Objectives

- To understand the nature of chemical bonding
- To understand Werner's theory, Sidgwick's Effective Atomic Number (EAN) concept, IUPAC nomenclature and ligands classification
- To interpret electrode potential diagrams and understand their applications in predicting feasibility of redox reactions
- To study the chemical reactivity and group trends of alkali and alkaline earth metals
- To study the structure and bonding of H_2O_2 , $\text{Be}(\text{BH}_4)_2$, BeMe_2 , anhydrous BeCl_2 , basic beryllium acetate, and polymeric $\text{Ca}(\text{C}_2\text{H}_5)_2$

Course Outcome

CO1: Students will be able to describe odd-electron bonds, hydrogen bonding, van der Waals forces, and metallic bonding and apply Fajans' rules to predict covalent character in ionic compounds.

CO2: Students will be able to explain Werner's theory and Sidgwick's Effective Atomic Number (EAN) concept

CO3: Students will be able to analyze electrode potential diagrams and apply them in electrochemical calculations

CO4: Student will be able to compare the chemical reactivity and group trends of alkali and alkaline earth metals

CO5: Student will be able to describe the structure and bonding of H_2O_2 , $\text{Be}(\text{BH}_4)_2$, BeMe_2 , anhydrous BeCl_2 , basic beryllium acetate, and polymeric $\text{Ca}(\text{C}_2\text{H}_5)_2$

Syllabus

Unit	Course Content	Hours of Teaching
I	CHEMICAL BONDING Ionic, covalent (polar and non-polar), coordinate bonds, sigma and pi-bonds, odd electron bonds, hydrogen bond, van der Waal's forces and metallic bond. Covalent character in ionic bonds (Fajans' rules), partial ionic character of a covalent bond.	[08]

II	CO-ORDINATION CHEMISTRY Double salts and co-ordination compounds. Werner's theory, Sidgwick's concept of effective atomic number (EAN), IUPAC system of nomenclature of co-ordination compounds. Types and classification of ligands. Chemical reactions in qualitative analysis of an inorganic mixture and problems based on mixture analysis. Applications of Co-ordination compounds in qualitative analysis.	[07]
III	ELECTRODE POTENTIAL Electrode potential and the importance of the electrochemical series. Electrode potential diagram and its applications.	[05]
IV	CHEMISTRY OF ZERO GROUP AND S-BLOCK ELEMENTS (a) Isolation and separation of inert gases from air and compounds of inert gases. (b) Chemical reactivity of alkali and alkaline earth metals and group trends. Uses of s-block elements and their compounds (Li, Na, and K only), Organometallic compounds of Li, Na, K, Be, and Mg. Polyether complexes (crown ether complexes) of alkali metals.	[05]
V	PREPARATIONS, PROPERTIES AND USE (a) Heavy water, lithium tetrahydroaluminate, lithium stearate, basic beryllium acetate. (b) Structure and Bonding of: H_2O_2 , $\text{Be}(\text{BH}_4)_2$, BeMe_2 , Anhydrous beryllium chloride, basic beryllium acetate, polymeric $\text{Ca}(\text{C}_2\text{H}_5)_2$.	[05]

PAPER II – ORGANIC CHEMISTRY

Credit: 2

Course Objectives

- Understand conformational analysis, cycloalkane stability, and reactivity.
- Explain preparation, properties, and reactions of alkenes, dienes, alkynes, alkyl halides, aryl halides, and aromatic derivatives.
- Apply regioselectivity and stereoselectivity principles to organic reactions.

Course Outcome

At the end of the course, students will be able to:

- **CO1:** Analyze conformations and ring strain in cycloalkanes.
- **CO2:** Explain preparation and mechanisms of addition, substitution, and elimination in unsaturated hydrocarbons.

- **CO3:** Compare reactivity of alkyl, allyl, vinyl, and aryl halides.
- **CO4:** Predict orientation and products in aromatic side-chain and substitution reactions.

Syllabus

Unit	Course Content	Hours of Teaching
I	STEREOCHEMISTRY OF ORGANIC COMPOUNDS 2: Conformational isomerism: Conformational analysis of ethane and n-butane, conformations of cyclohexane, axial and equatorial bonds, conformation of mono substituted cyclohexane derivatives, Newman projection and Fischer formulae. Difference between configuration and conformation.	[08]
II	CYCLOALKANES: Methods of formation, chemical reactions. Baeyer strain theory and its limitations. Ring strain in small rings (cyclopropane), Theory of strainless rings. The cases of cyclopropane ring: banana bond.	[04]
III	ALKENES, DIENES AND ALKYNES: Alkenes: Methods of formation, mechanisms and dehydration of alcohols and dehydrohalogenation of alkyl halides, regio selectivity in alcohol dehydration. The Saytzeff Rule, Hofmann elimination and relative stabilities of alkenes. Chemical reactions of alkenes—mechanisms involved in hydrogenation, electrophilic and free radical additions. Markownikoff's addition, hydroboration oxidation, oxymercuration reduction, Epoxidation, Ozonolysis, Hydration and hydroxylation and oxidation with KMnO_4 . Substitution at the allylic and vinylic position of alkenes. Structure of allenes and butadiene, methods of formation. Chemical reaction-1, 2 and 1, 4-addition. Diels-Alder reaction. Alkynes: methods of formation. Chemical reactions of alkynes, acidity of alkynes, mechanism of electrophilic and nucleophilic addition reaction, hydroboration oxidation and metal ammonia reductions and oxidation.	[10]
IV	ALKYL HALIDE AND ARYL HALIDES Alkyl halides: Methods of formation, chemical reactions. Mechanism of nucleophilic substitution reactions of alkyl halides, $\text{S}_\text{N}1$ and $\text{S}_\text{N}2$ reactions with energy profile diagrams. Aryl halides: The addition–elimination and the elimination-addition mechanisms of nucleophilic aromatic substitution reactions of aryl halides. Relative reactivities of alkyl halides vs allyl, vinyl and aryl halides.	[08]

	Reactions of Aromatic Derivatives: Side chain reaction of benzene derivatives, Birch reduction. Methods of formation and chemical reactions of alkyl benzene, alkynylbenzenes and biphenyl.	
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PAPER III – PHYSICAL CHEMISTRY

Credit: 2

Course Objectives

- To understand the basic concepts of physical chemistry.
- To understand the first law of thermodynamics and thermochemistry.
- To explain the Joule-Thompson effect.
- To explain various thermodynamic quantities for Van der Waals gases
- To explain the Heat of reaction, formation, combustion, and neutralisation

Course Outcome

At the end of the course, students will be able to:

CO1: Explain the fundamental principles governing gases.

CO2: Analyze thermodynamic systems.

CO3: Understand concepts such as enthalpy, internal energy, and heat capacity.

CO4: Apply the first law of thermodynamics to various processes.

CO5: Understand and calculate heats of reactions and bond energies, enabling them to predict energy changes in chemical reactions.

Syllabus

Unit	Course Content	Hours of Teaching
I	GASES: Kinetic theory of gases and gas laws, specific heat ratio C_p/C_v . Non-ideality of gas behaviour, Van der Waals equation of state, critical constants, and their determination. Reference to some other equations of state, e.g., Berthelot and Dieterici. Law of corresponding states. Maxwell Law of Distributions (Quantitative treatment).	[10]
II	THE FIRST LAW OF THERMODYNAMICS: Thermodynamic terms and statement of the first law, thermodynamic reversibility and maximum work, enthalpy of a system, heat capacity at constant volume and constant pressure. Extensive and intensive properties, state functions, exact differentials, cyclic rule, and integration factor. Variation of internal energy with temperature and volume; enthalpy as a function of temperature and pressure. Relation between C_p and C_v .	[15]

	Joule-Thomson effect: Joule and Joule-Thomson effect, Joule-Thomson coefficient. Inversion temperature. Van der Waals equation and J – T effect. Important thermodynamic quantities (W, Q, E, and H) in an isothermal expansion of an ideal gas and an adiabatic expansion of an ideal gas. Calculations of various thermodynamic quantities for Van der Waals gases undergoing various operations under different conditions.	
III	THERMO CHEMISTRY: Heat of reaction, formation, combustion and neutralisation, solvation, dilution and hydration, Hess's law and its application, Bond energy and resonance energy.	[05]

Practical Lab

Credit: 2

Syllabus

	(A) Qualitative Analysis Detection of two cations and two anions in a given inorganic salt mixture. (B) Record and viva-voce	[60]
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2. Concise Inorganic Chemistry, J. D. Lee, 5th Edition (1996), Chapman & Hall, London.
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