



Darrang College (Autonomous), Tezpur-784001

Syllabus for FYUGP B.Sc. Chemistry (Major)

Approved by:

Board of Studies meeting held on 18-12-2025 &
&
Academic Council vide Resolution no. 2, dated 29-12-2025

Prerequisites:

- For Major in Chemistry a student must pass in Chemistry and Mathematics at XII level.

Major Syllabus of FYUGP in Chemistry
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FOUR-YEAR UNDERGRADUATE PROGRAMME (FYUGP)
IN CHEMISTRY,
Darrang College (Autonomous)

Introduction:

The Chemistry syllabus at Darrang College (Autonomous) has been designed in alignment with the transformative vision of the **National Education Policy (NEP) 2020**, which emphasizes a holistic, multidisciplinary, and flexible education system rooted in Indian values and committed to nurturing globally competent individuals.

This syllabus aims to provide students with a strong foundation in the principles and applications of Chemistry, while also fostering scientific temper, critical thinking, creativity, and problem-solving abilities. It embraces the spirit of NEP 2020 by offering **multiple entry and exit options, skill-based learning, interdisciplinary integration, and continuous formative assessment.**

The curriculum is structured to support a learner-centric approach that balances core concepts, laboratory experience, environmental and ethical awareness, and the development of communication and research skills. Through this, students will not only gain knowledge in the chemical sciences but also be empowered to apply it responsibly in real-world contexts, contributing to sustainable development and societal progress.

Darrang College (Autonomous) reaffirms its commitment to academic excellence, innovation, and nation-building, preparing graduates to meet the scientific and technological challenges of the 21st century.

The Four-Year Undergraduate Programme (FYUGP) in Chemistry is designed to nurture a deep and holistic understanding of the chemical sciences, while promoting interdisciplinary learning, research aptitude, and employability. The programme aspires to prepare students for academic, industrial, and societal roles by fostering foundational knowledge, technical skills, and ethical awareness.

Aims of Four Year Under-Graduate Programme (FYUGP) in Chemistry:

The primary aims of the FYUGP in Chemistry are:

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1. **To provide a strong foundation in chemical principles and their applications** in diverse areas such as organic, inorganic, physical, analytical, and environmental chemistry.
2. **To develop critical thinking, scientific reasoning, and analytical skills** that enable students to approach scientific problems methodically and creatively.
3. **To promote experiential learning through practical laboratory work, fieldwork, and research projects**, encouraging innovation, curiosity, and hands-on skills.
4. **To foster interdisciplinary learning and flexibility**, in accordance with NEP 2020, allowing students to explore connections between chemistry and fields such as biology, physics, environmental science, materials science, and computational studies.
5. **To enhance communication skills and ethical understanding**, ensuring that students can effectively disseminate scientific knowledge and apply it responsibly for societal and environmental well-being.
6. **To prepare students for diverse career paths**, including higher studies, research, teaching, industry, entrepreneurship, and public service, by integrating skill development and value-added courses.
7. **To cultivate a lifelong learning mindset and a spirit of inquiry**, aligned with the vision of building competent, compassionate, and self-reliant individuals for national and global development.

By fulfilling these aims, the FYUGP in Chemistry at Darrang College seeks to create graduates who are not only knowledgeable chemists but also responsible citizens and capable contributors to sustainable and inclusive growth.

Programme Outcome (PO) of (FYUGP) in Chemistry:

- **PO1: Fundamental Knowledge:** Demonstrate a solid understanding of the core areas of chemistry-organic, inorganic, physical, analytical, and interdisciplinary branches integrated with emerging fields like environmental chemistry, green chemistry, and materials science.

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- **PO2: Scientific Thinking and Problem Solving:** Apply chemical knowledge and scientific methods to analyse, interpret, and solve real-world problems in laboratory and practical settings.
- **PO3: Laboratory and Technical Skills:** Acquire hands-on experience with classical and modern laboratory techniques, instrumentation, safety protocols, and data analysis relevant to chemical research and industry.
- **PO4: Research and Innovation:** Develop the ability to design and carry out experiments or research projects independently or collaboratively, fostering innovation, creativity, and inquiry-based learning.
- **PO5: Communication and Teamwork:** Communicate scientific ideas and research findings effectively through oral, written, and digital media, and work collaboratively in diverse teams.
- **PO6: Ethical and Environmental Responsibility:** Understand and practice ethical behaviour in scientific research and industry, while being sensitive to the environmental and societal impact of chemical substances and processes.
- **PO7: Interdisciplinary and Multidisciplinary Learning:** Integrate chemical knowledge with other disciplines such as physics, biology, mathematics, environmental science, and computational tools to address complex scientific questions.
- **PO8: Career Readiness and Lifelong Learning:** Be prepared for higher education, competitive examinations, professional roles in industry and research, or entrepreneurship, with an aptitude for continuous learning and upskilling.
- **PO9: Digital and Technological Proficiency:** Utilize information and communication technologies (ICT), computational tools, and digital resources for data handling, simulations, presentations, and scientific communication.
- **PO10: National Development and Global Citizenship:** Act as responsible citizens contributing to national development goals, sustainability, and global scientific progress, in alignment with the values promoted by NEP 2020.

Teaching Learning Process:

The programme allows using of varied pedagogical methods and techniques both within the classroom and in laboratories.

- Lecture
- Tutorial

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- PowerPoint presentation
- Project Work/Dissertation
- Seminars/workshops/conferences
- Industry Visits/Field Visits

Teaching Learning Tools:

- White/Green/Black Board
- LCD projectors/Monitor
- Smart Board
- Model Demonstration
- Learning through lab experiments
- Industry and field visits

Assessment:

- Home assignment
- Project/Industry/Field Visit Report
- Seminar Presentation
- In semester/Sessional examinations (Theory and Practical)
- End Semester examinations (Theory and Practical)

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NEP-FYUGP Course Distribution
Department of Chemistry, Darrang College (Autonomous)

Year	Semester	Course Title	Paper Code	Credit
Year 01	1st Semester	Chemistry-I	CHE-MJ-01014	4
	2nd Semester	Chemistry-II	CHE-MJ-02014	4
Year 02	3rd Semester	Chemistry -III	CHE-MJ-03014	4
		Molecular Spectroscopy	CHE-MJ-03024	4
	4th Semester	Inorganic Chemistry-I	CHE-MJ-04014	4
		Organic Chemistry-I	CHE-MJ-04024	4
		Physical Chemistry-I	CHE-MJ-04034	4
		Advanced Spectroscopy and Analytical Techniques	CHE-MJ-04044	4
Year 03	5th Semester	Inorganic Chemistry-II	CHE-MJ-05014	4
		Organic Chemistry -II	CHE-MJ-05024	4
		Physical Chemistry -II	CHE-MJ-05034	4
	6th Semester	Inorganic Chemistry-III	CHE-MJ-06014	4
		Organic Chemistry -III	CHE-MJ-06024	4
		Advanced Quantum Theory & Molecular Properties	CHE-MJ-06034	4
		Industrial Chemistry	CHE-MJ-06044	4

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FYUGP in Chemistry
Detailed Syllabus of 1st Semester

Semester	I
Title of the Course	Chemistry -I
Paper Code	CHE-MJ-01014
Total Credits	4 (Theory: 03, Practical: 01)
Distribution of Marks	45 (End Semester Theory) + 25 (End Semester Practical) + 30 (Internal) [Sessional Exam: 15 marks, Home Assignment: 6 marks, Class Test: 5 marks, Attendance: 4 marks]
Course Outcomes	<p>By the end of this course/module, students will be able to:</p> <ul style="list-style-type: none">• CO 1: Explain the principles of atomic structure and electronic configuration, and relate them to the placement of elements in the periodic table.• CO 2: Analyse periodic trends (e.g., atomic and ionic radii, ionization energy, electronegativity) to predict and explain the chemical behaviour of elements.• CO 3: Describe the nature and energetics of ionic bonding, including factors such as lattice energy, ion size, and charge, and use this to predict compound stability.• CO 4: Identify and classify stereoisomers in organic molecules, including chirality, enantiomers, and diastereomers, and explain their relevance in chemical and biological systems.• CO 5: Evaluate the impact of electronic effects such as inductive, resonance, and hyperconjugation on the stability, reactivity, and acidity/basicity of organic compounds.• CO 6: Apply the gas laws and intermolecular force concepts to explain the physical behaviour of substances in the gaseous and liquid states under various conditions.
No. of Required Classes	45 (Theory) + 30 (Practical)
Details of Course Designer	<ol style="list-style-type: none">1. Dr. Pankaj Hazarika, HoD, Department of Chemistry2. Tumpa Paul, Assistant Professor, Department of Chemistry3. Dr. Manash Protim Hazarika, Assistant Professor, Department of Chemistry

Major Syllabus of FYUGP in Chemistry
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Textbook	<ol style="list-style-type: none"> 1. Puri, B. R., Sharma, L. R., & Kalia, K. C. <i>Inorganic Chemistry</i>. 2. Prakash, S., Tuli, G.D., Basu, S.K. & Madan, R. D. <i>Advanced Inorganic Chemistry (Vol. 1)</i>, S. Chand. 3. Prasad, R. K. <i>Quantum Chemistry</i>. 4. Sen, B. K. <i>Quantum Chemistry</i>. 5. Kalsi, P. S. (2005). <i>Stereochemistry: Conformation and Mechanism</i>. New Age International. 6. Singh, S., Mukherjee, S. P., & Kapoor, R. P. <i>Organic Chemistry (Vol. I & II)</i>. 7. Clayden, J., Greeves, N., Warren, S., & Wothers, P. <i>Organic Chemistry</i>. Oxford University Press. 8. Puri, B. R., Sharma, L. R., & Pathania, M. S. (48th ed.). <i>Principles of Physical Chemistry</i>. Vishal Publishing Co. 9. Kapoor, K. L. <i>A Textbook of Physical Chemistry (Vol. 1)</i>.
Reference Book	<ol style="list-style-type: none"> 1. Cotton, F. A., & Wilkinson, G. <i>Basic Inorganic Chemistry</i>. 2. Ghosh, S. C. <i>Advanced General Organic Chemistry (Part I & II)</i>. 3. Huheey, J. E., Keiter, E. A., Keiter, R. L., & Medhi, O. K. (5th ed.). <i>Inorganic Chemistry: Principles of Structure and Reactivity</i>. Pearson Education. 4. Lee, J. D. (5th ed.). <i>Concise Inorganic Chemistry</i>. Pearson Education. 5. March, J. <i>Advanced Organic Chemistry: Reactions, Mechanisms, and Structure</i>, Wiley. 6. Finar, I. L. <i>Organic Chemistry (Vol. 1)</i>. Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). 7. Atkins, P., de Paula, J., & Keeler, J. (11th ed.). <i>Atkins' Physical Chemistry</i>. Oxford University Press. 8. Negi, A. S., & Anand, S. C. <i>A Textbook of Physical Chemistry</i>. Wiley Eastern. 9. Ball, D. W. (2007). <i>Physical Chemistry</i>. Thomson Press India.

Semester-I (Theory Credit: 03)
Paper Code: CHE-MJ-01014

Unit	Content	L	T	P	Total Hours
Unit I: Atomic structure	<p><i>Review of: Bohr's theory and its limitations, dual behaviour of matter and radiation, de-Broglie's relation, Heisenberg Uncertainty principle. Hydrogen atom spectra. Need of a new approach to Atomic structure.</i></p> <p>Time independent Schrodinger equation and meaning of various terms in it(including mathematical treatment), Significance of ψ and ψ^2, Schrödinger equation for hydrogen atom. , normalized and orthogonal wave functions ; Operators; Particle in one- dimension box, radial and angular wave functions for hydrogen atom, radial probability distribution;</p>	5	3	-	8

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	Finding maxima of distribution functions (idea of maxima and minima), Significance of quantum numbers, orbital angular momentum and quantum numbers m_l and m_s . Discovery of spin, spin quantum number (s) and magnetic spin quantum number (m_s). Shapes of s, p, d and f orbitals, nodal planes. Pauli's Exclusion Principle; Hund's rule of maximum multiplicity. Rules for filling electrons in various orbitals, Electronic configurations of the atoms. Stability of half-filled and completely filled orbitals, concept of exchange energy. Relative energies of atomic orbitals, Anomalous electronic configurations.				
Unit II: Periodicity and chemical behaviour	Periodic classification of elements, periodicity; Effective nuclear charge; Slater's Rule; covalent and ionic radii, ionization energies, electronegativity (various scales), electron affinities, electronic configuration of diatomic molecules (first and second row elements).	2	1	-	3
Unit III: Chemical bonding I (ionic interaction)	General characteristics of ionic compounds; lattice and solvation energy and their importance in the context of stability and solubility of ionic compounds.; Born Lande equation; Kapustinski equation, Madelung constant, Born Haber cycle for lattice energy calculation	3	1	-	4
Unit IV: Structure of organic molecules	Nature of bonding: hybridisation of atomic orbitals (qualitative VB and MO approach); effect of hybridization on bond properties.	3	1	-	4
Unit V: Basic Organic Chemistry	Inductive effects and its application in the acidity and basicity of organic acids and bases; resonance, mesomeric effects, conjugation and delocalization and their application. Free energy of activation, energy profile diagrams for one-step and multi-step reactions, basic ideas about different types of reactions: addition, substitution, elimination, rearrangement, condensation and Polymerisation reactions	3	0	-	3
Unit VI: Stereochemistry of organic molecules	Representation of organic molecules in 2D and 3D (Fischer, Newman and Sawhorse projection formulae and their interconversions); Optical isomerism: Concepts of asymmetry, dissymmetry, optical activity, Specific rotation, Chirality, enantiomers, Diastereomers, racemic mixture, racemization and Resolution, Threo and Erythro forms, Meso structures & Epimers. Relative and absolute configuration: D/L and R/S designations. Walden inversion. Geometrical isomerism (cis-trans, syn-anti, E/Z notations); configuration	5	3	-	8

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	and conformation, barriers to rotation, conformational analysis (ethane, butane, cyclohexane).				
Unit VII: Gaseous State	Derivation of kinetic gas equation, Maxwell distribution of molecular speed, different types of speeds, collision properties, mean free path, determination of collision diameter, transport phenomenon in gases Causes of deviation from ideal gas behaviour, compressibility factor, Z, and its variation with pressure and temperature for different gases. State variables and equation of states for real gases; van der Waals equation of state, its derivation and application in explaining real gas behaviour. Reasons and examples of failure of van der Waal equation of state and interpretation of van der Waals pressure-volume isotherm. Critical state and phenomena, mathematical definition and interpretation of critical point, relation between critical constants and van der Waals constants: along with their thermodynamic interpretation. Introduction to virial equation and virial coefficients, derivation of Boyle temperature.	5	3	-	8
Unit VIII: Liquid State	Qualitative treatment of the structure of the liquid state. Physical properties of liquids: vapour pressure, surface tension coefficient of viscosity, and their determination. Temperature variation of viscosity of liquids and comparison with that of gases. Effect of addition of various solutes on surface tension and viscosity. Explanation of cleansing action of detergents (micelle formation and critical micelle concentration), Newtonian and non-Newtonian liquid, liquid crystals.	5	2	-	7
Semester-I (Practical Credit: 01)					
Unit	Content	L	T	P	Total Hours
Laboratory Course	1. Introduction to laboratory apparatus and safety measures in laboratory, 2. Calibration of apparatus (volumetric flask, thermometer, melting point apparatus etc.) Group A a) Preparation of normal and molar solution, for example KCl, Na ₂ C ₂ O ₄ , HCl, H ₂ SO ₄ etc. (Verification by conductometric measurement). b) Determination of solubility of a given salt at different temperature and plot solubility curve. c) Determination of water of crystallisation of hydrated	-	-	30	30

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	<p style="text-align: center;">salt by ignition and weighing.</p> <p style="text-align: center;">Group-B ((Minimum two experiments from Group-B)</p> <ul style="list-style-type: none">a) Purification of organic compounds by crystallization using water, alcohol and alcohol-water mixture.b) Determination of the melting points of organic compounds.c) Effect of impurities on the melting point – mixed melting point of two unknown organic compounds. <p style="text-align: center;">Group-C (Minimum two experiments from Group-C)</p> <ul style="list-style-type: none">a) Evaluating the compressibility factor using standard packages such as Excel/Origin/Python/Fortran.b) Simulating an ideal/real gas using programming.c) To determine the partial molar volume of ethanol-water mixture at a given composition.d) Determine the surface tension of a given liquid at room temperature using stalagmometer by drop number method.e) Determine the surface tension of a given liquid by means of stalagmometer using drop weight method.f) Determine the composition of a given mixture by surface tension method.g) Study the variation of surface tension of detergent solutions with concentration.				
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FYUGP in Chemistry
Detailed Syllabus of 2nd Semester

Semester	II
Title of the Course	Chemistry -II
Paper Code	CHE-MJ-02014
Total Credits	4 (Theory: 03, Practical: 01)
Distribution of Marks	45 (End Semester Theory) + 25 (End Semester Practical) + 30 (Internal) [Sessional Exam: 15 marks, Home Assignment: 6 marks, Class Test: 5 marks, Attendance: 4 marks]
Course Outcomes	<p>By the end of this course/module, students will be able to:</p> <ul style="list-style-type: none">• CO1: Explain the nature, formation, and characteristics of covalent bonds and various intermolecular forces such as hydrogen bonding, van der Waals forces, and dipole interactions.• CO2: Analyse and predict molecular geometries, hybridization, and bond parameters in covalently bonded compounds.• CO3: Describe the basic structure and bonding theories of coordination compounds, including the application of VBT and CFT.• CO4: Identify and differentiate between types of isomerism (structural and stereoisomerism) in coordination complexes.• CO5: Understand the formation and stability of reactive intermediates such as carbocations, carbanions, free radicals, and carbenes in organic reactions.• CO6: Compare acidity and basicity of organic and inorganic compounds using concepts like resonance, inductive effect, and hybridization.• CO7: Determine and interpret pK_a values to evaluate the strength of acids and bases in different chemical environments.• CO8: Apply the fundamental laws of thermodynamics to chemical systems and calculate thermodynamic quantities like enthalpy, entropy, and Gibbs free energy.
No. of Required Classes	45 (Theory) + 30 (Practical)
Details of Course Designer	<ol style="list-style-type: none">1. Dr. Pankaj Hazarika, HoD, Department of Chemistry2. Tumpa Paul, Assistant Professor, Department of Chemistry3. Dr. Manash Protim Hazarika, Assistant Professor, Department of Chemistry

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Textbook	<ol style="list-style-type: none"> Sarkar, R. P. (3rd ed., Part 1). <i>General and Inorganic Chemistry</i>. NCBA. Gopalan, R., & Ramalingam, V. (1st ed.). <i>Concise Coordination Chemistry</i>. Vikas Publishing House. Clayden, J., Greeves, N., Warren, S., & Wothers, P. <i>Organic Chemistry</i>. Oxford University Press. Kalsi, P. S. <i>Reaction Mechanism in Organic Chemistry</i>. Singh, S., Mukherjee, S. P., & Kapoor, R. P. <i>Organic Chemistry (Vol. I & II)</i>. Puri, B. R., Sharma, L. R., & Pathania, M. S. (48th ed.). <i>Principles of Physical Chemistry</i>. Vishal Publishing Co. McQuarrie, D. A., & Simon, J. D. (2004). <i>Molecular Thermodynamics</i>. Viva Books Pvt. Ltd., New Delhi.
Reference Book	<ol style="list-style-type: none"> Huheey, J. E., Keiter, E. A., Keiter, R. L., & Medhi, O. K. (5th ed.). <i>Inorganic Chemistry: Principles of Structure and Reactivity</i>. Pearson Education. Puri, B. R., Sharma, L. R., & Kalia, K. C. <i>Inorganic Chemistry</i>. Cotton, F. A., & Wilkinson, G. <i>Basic Inorganic Chemistry</i>. Sykes, P. <i>A Guide Book to Mechanism in Organic Chemistry</i>. Longman. Ghosh, S. K. <i>Mechanism and Theory in Organic Chemistry</i>. New Central Book Agency. Atkins, P., de Paula, J., & Keeler, J. (11th ed.). <i>Atkins' Physical Chemistry</i>. Oxford University Press. Levine, I. N. (2010). <i>Physical Chemistry</i> (6th ed.). Tata McGraw-Hill.

Semester-II (Theory Credit: 03)
Paper Code: CHE-MJ-02014

Unit	Content	L	T	P	Total Hours
Unit I: Chemical bonding II (covalent bond and chemical forces)	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 (MOT). Molecular orbital diagrams of homonuclear (N ₂ , O ₂) and heteronuclear diatomic (CO, NO, CN ⁻), bonding in BeF ₂ and HCl (idea of s-p mixing and orbital interaction). Valence shell electron pair repulsion theory (VSEPR). Covalent character in ionic compounds, polarising power and polarizability. Fajan's rules and consequences of polarisation. Ionic character in covalent compounds: Bond moment and dipole moment. Percentage ionic character from dipole moment and electronegativity difference.	7	3	-	10

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	Weak chemical forces (van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interactions, instantaneous dipole-induced dipole interactions and hydrogen bonding) and their effects on melting and boiling points, solubility and hydration energy				
Unit II: Coordination chemistry I (structure and isomerism)	Werner's theory, EAN rule, piano-stool compounds, IUPAC nomenclature of coordination compounds, isomerism in coordination compounds. Stereochemistry of complexes with the coordination number 4 and 6, Chelate effect,	3	2	-	5
Unit III: Organic Reagents and Reactive intermediates in organic reactions	Cleavage of Bonds- Homolysis and Heterolysis. Concept of Electrophiles and Nucleophiles; Reactive intermediates: Carbocations, carbanions, free radicals. carbenes, nitrenes and benzyne (Chichibabin reaction). Types, Shape and their relative Stability. Mechanism of Wurtz Reaction, Wurtz-Fittig reaction, Simmons-Smith reaction; Free radical substitutions	6	2	-	8
Unit IV: Electrophilic addition reaction of alkenes & alkynes	Addition of hydrogen halide (Markovnikov's / Anti-Markovnikov's addition), addition of halides (X_2), hydroboration-oxidation and ozonolysis of alkene with mechanism and stereochemical aspects. Electrophilic additions of alkynes and their mechanisms – addition of hydrogen halide, addition of halides (X_2) and hydration.	6	1	-	7
Unit V: Thermodynamics	Mathematical treatment: exact and inexact differentials, partial derivatives, Euler's reciprocity, cyclic rules, Intensive and extensive variables. Isolated, closed and open systems. Cyclic, reversible and irreversible processes. Zeroth law of thermodynamics. First law of thermodynamics, concept of heat (q) and work (w), internal energy(U) and enthalpy (H) in differential forms: their molecular interpretation. Calculation of w, q, ΔU and ΔH for expansion of ideal gas under isothermal and adiabatic conditions for reversible and irreversible processes. Derivation of Joule-Thomson coefficient and inversion temperature. Application of first law of thermodynamics: standard state, standard enthalpy changes of physical and chemical transformations: fusion, sublimation, vaporization, solution, dilution, neutralization, ionization. Bond-dissociation energy Kirchhoff's equation, relation between ΔH and ΔU of a reaction. Difference between enthalpy and standard enthalpy. Second law of thermodynamics, entropy (S) as a state function, molecular interpretation of entropy. Residual Entropy. Free energy:	12	3	-	15

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	Gibb's function (G) and Helmholtz function (A) and their molecular interpretation. Difference between free energy and standard free energy. Gibbs-Helmholtz equation, criteria for thermodynamic equilibrium and spontaneity of a process. Maxwell's Relations and their physical significance.				
Semester-II (Practical Credit: 01)					
Unit	Content	L	T	P	Total Hours
Laboratory Course	<p>Preparation of buffer solution and measurement of pH using pH meter (acetic acid-sodium acetate buffer)</p> <p>Group A:</p> <ol style="list-style-type: none"> a) Determination of total hardness of water by titration against standardised EDTA solution. b) Synthesis of coordination compounds: <ol style="list-style-type: none"> i) Potassium tris(oxalato)chromate(III) ii) Nickel(II) dimethylglyoxime <p>Group B:</p> <ol style="list-style-type: none"> a) Detection of presence of unsaturation and aromaticity in an organic sample. b) Qualitative organic analysis for N, S and halogen in a given organic compound. c) Identify acidic functional groups of a given organic sample (Acetic acid, Lactic acid, Tartaric acid and Phthalic acid) and determine the pKa by titrimetric methods. <p>Group C:</p> <ol style="list-style-type: none"> a) Determination of heat capacity of a calorimeter and enthalpy of neutralisation (e.g., hydrochloric acid with sodium hydroxide). b) Determine the enthalpy of solution of oxalic acid from solubility measurements. c) 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). d) Calculation of ionization enthalpy of ethanoic acid. e) Determination of enthalpy of hydration of copper sulphate. <p><i>(Students are required to perform Exp. 1 and minimum of two from each group)</i></p>	-	-	30	30

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FYUGP in Chemistry
Detailed Syllabus of 3rd Semester

Semester	III
Title of the Course	Chemistry -III
Paper Code	CHE-MJ-03014
Total Credits	4 (Theory: 03, Practical: 01)
Distribution of Marks	45 (End Semester Theory) + 25 (End Semester Practical) + 30 (Internal) [Sessional Exam: 15 marks, Home Assignment: 6 marks, Class Test: 5 marks, Attendance: 4 marks]
Course Outcomes	<p>By the end of this course/module, students will be able to:</p> <ul style="list-style-type: none">• CO 1: Explain the principles of atomic structure and electronic configuration, and relate them to the placement of elements in the periodic table.• CO 2: Analyse periodic trends (e.g., atomic and ionic radii, ionization energy, electronegativity) to predict and explain the chemical behaviour of elements.• CO 3: Describe the nature and energetics of ionic bonding, including factors such as lattice energy, ion size, and charge, and use this to predict compound stability.• CO 4: Identify and classify stereoisomers in organic molecules, including chirality, enantiomers, and diastereomers, and explain their relevance in chemical and biological systems.• CO 5: Explain the behaviour of dilute and ideal solutions using Raoult's and Henry's laws, and apply thermodynamic relations derived from chemical potential to determine colligative properties and calculate molar masses of normal, associated, and dissociated solutes.• CO 6: Analyse composition-dependent thermodynamic properties of mixtures by evaluating partial molar quantities, applying the Gibbs–Duhem equation, and interpreting changes in enthalpy, entropy, and free energy during mixing, including excess thermodynamic functions.
No. of Required Classes	45 (Theory) + 30 (Practical)
Details of Course Designer	<ol style="list-style-type: none">1. Dr. Pankaj Hazarika, HoD, Department of Chemistry2. Tumpa Paul, Assistant Professor, Department of Chemistry

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	<ol style="list-style-type: none"> 3. Dr. Manash Protim Hazarika, Assistant Professor, Department of Chemistry 4. Dr. Pinky Gogoi, Assistant Professor, Department of Chemistry
Textbook	<ol style="list-style-type: none"> 1. General and Inorganic Chemistry, R.P. Sarkar (part 1), 3rd edition, NCBA. 2. Concise Coordination Chemistry, R. Gopalan, V. Ramalingam, 1st edition, Vikash Publishing House. 3. Principles of Physical Chemistry, Puri, Sharma, Pathania, 48th edition, Vishal Publishing House. 4. Organic Chemistry, Volume 1, I. L. Finar, 5th edition. 5. Organic Chemistry, L. G. Wade Jr., Maya Shankar Singh, 6th edition. 6. Puri, B. R., Sharma, L. R., & Kalia, K. C. <i>Inorganic Chemistry</i>. 7. Prakash, S., Tuli, G.D., Basu, S.K. & Madan, R. D. <i>Advanced Inorganic Chemistry (Vol. 1)</i>, S. Chand. 8. Prasad, R. K. <i>Quantum Chemistry</i>. 9. Sen, B. K. <i>Quantum Chemistry</i>. 10. Kalsi, P. S. (2005). <i>Stereochemistry: Conformation and Mechanism</i>. New Age International. 11. Singh, S., Mukherjee, S. P., & Kapoor, R. P. <i>Organic Chemistry (Vol. I & II)</i>. 12. Clayden, J., Greeves, N., Warren, S., & Wothers, P. <i>Organic Chemistry</i>. Oxford University Press. 13. Puri, B. R., Sharma, L. R., & Pathania, M. S. (48th ed.). <i>Principles of Physical Chemistry</i>. Vishal Publishing Co. 14. Kapoor, K. L. <i>A Textbook of Physical Chemistry (Vol. 3)</i>. 15. Rakshit, P.C., <i>Physical Chemistry (7th Ed.)</i>
Reference Book	<ol style="list-style-type: none"> 1. Atkins Physical Chemistry, Atkins, de Paula and Keeler, 11th edition, Oxford University Press. 2. March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, Michael B. Smith 7th edition (Wiley). 3. Organic Chemistry, P. Y. Bruice, 8th edition, Pearson Education 4. Inorganic Chemistry (Principles of Structure and Reactivity), J. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, 5th edition, Pearson Education. 5. Cotton, F. A., & Wilkinson, G. <i>Basic Inorganic Chemistry</i>. 6. Ghosh, S. C. <i>Advanced General Organic Chemistry (Part I & II)</i>. 7. Huheey, J. E., Keiter, E. A., Keiter, R. L., & Medhi, O. K. (5th ed.). <i>Inorganic Chemistry: Principles of Structure and Reactivity</i>. Pearson Education.

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	<p>8. Lee, J. D. (5th ed.). <i>Concise Inorganic Chemistry</i>. Pearson Education.</p> <p>9. March, J. <i>Advanced Organic Chemistry: Reactions, Mechanisms, and Structure</i>, Wiley.</p> <p>10. Finar, I. L. <i>Organic Chemistry (Vol. 1)</i>. Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).</p> <p>11. Atkins, P., de Paula, J., & Keeler, J. (11th ed.). <i>Atkins' Physical Chemistry</i>. Oxford University Press.</p> <p>12. Negi, A. S., & Anand, S. C. <i>A Textbook of Physical Chemistry</i>. Wiley Eastern.</p> <p>13. Ball, D. W. (2007). <i>Physical Chemistry</i>. Thomson Press India.</p>
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Semester-III (Theory Credit: 03)

Paper Code: CHE-MJ-03014

Unit	Content	L	T	P	Total Hours
Unit I: Acid and Bases	Acid-base concepts, measure of acid and base strength, proton affinity, inductive effect and strength of oxyacid's (P, S and Cl), acidity of aqua ions, steric effect, proton sponge, solvation and acid base strength, non-aqueous solvents and acid base strength, levelling effect, super acids and superbases. Hard and soft acids and bases (HSAB), application of HSAB principle.	5	2	-	7
Unit II: Oxidation and reduction -I	Reduction potentials: Redox half-reactions, standard potentials and spontaneity, trends in standard potentials, the electrochemical series, Nernst equation (Influence of pH and concentration on electrode potential). Principles of redox titration and choice of redox indicator	3	1	-	4
Unit: III Coordination chemistry-II	Valence bond theory (VBT), inner and outer orbital complexes, electroneutrality principle and back bonding, effects of hybridization in metal ligand bond strength and stability of complexes, choice of metal d-orbital(s) in hybridization in different coordination geometries, magnetic properties of complexes, drawback of VBT	2	2	-	4
Unit IV: Aromaticity	Concepts of aromatic, anti-aromatic and non-aromatic compounds (including examples of cyclic carbocations, carbanions and heterocyclic compounds); Hückel's rule.	2	0	-	2
Unit V: Electrophilic aromatic substitutions	General mechanism (benzene as substrate) with evidences, formation of π -complex and σ -complex, Ortho-para ratio. Ipso substitution.	2	1	-	3

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Unit VI: Hydrocarbons and halogenated compounds	Methods of preparation, properties and relative reactivity of alkyl and aryl halides; Nucleophilic substitution reactions: SN1, SN2, and SNi Mechanisms with stereochemical aspects and effect of solvent. Nucleophilic Aromatic Substitution SNAr and electrophilic substitution reaction. Nucleophilic substitution vs elimination. (SNAr), Preparation and reactions of diazonium salts;	4	1	-	5
Unit VII: Alcohols, phenols, ethers and thiols	Preparation, properties and relative reactivity of 1°, 2°, and 3°-alcohols, diols-Pinacol pinacolone rearrangement; ethers, epoxides (preparation and reactions with alcohols, ammonia derivatives and LiAlH ₄). Thiols; phenols (preparation, properties and reactivity; Reimer-Tiemann and Kolbe's-Schmidt Reactions). Oxidation by periodic acid and lead tetraacetate.	5	0	-	5
VIII: Solution	Dilute solutions: lowering of vapour pressure, Ideal solutions, ideally diluted Solutions, 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.	6	3	-	9
Unit IX: Partial molar quantities	Partial molar quantities, dependence of thermodynamic parameters on composition; Gibbs Duhem equation, chemical potential of ideal mixtures, change in thermodynamic functions (Enthalpy, free energy and entropy) in mixing of ideal gases, excess thermodynamic functions.	4	2	-	6
Semester-III (Practical Credit: 01)					
Unit	Content	L	T	P	Total Hours
Laboratory Course	Group A (a) Acid-base titration: estimation of carbonate, bicarbonate and hydroxide. (b) Redox titration: estimation of Fe(II) using standardised KMnO ₄ solution. (c) Determination of water of crystallisation of Mohr Salt using standardised KMnO ₄ solution.	-	-	30	30

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	<p>(d) Estimation of Fe(II) with $K_2Cr_2O_7$ using internal indicator (diphenylamine).</p> <p>Group B</p> <p>(a) Qualitative analysis of solid organic compounds containing one functional group, preparation of suitable derivatives and determination of m.p.</p> <p>Group C</p> <p>(a) Determine the surface tension of a given solution at room temperature using a stalagmometer.</p> <p>(b) Determine the viscosity of a liquid at a given concentration at laboratory temperature, by viscometer.</p> <p>(c) Determine the composition of a given liquid mixture by viscosity method.</p> <p>(d) Study the variation of viscosity of sucrose solution with the concentration of the solute.</p> <p>(e) Compare the strengths of HCl and H_2SO_4 by studying kinetics of hydrolysis of methylacetate.</p> <p><i>(Students need to perform at least three experiments from Group A and C. Group B is compulsory.)</i></p>				
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Semester	III
Title of the Course	Molecular Spectroscopy
Paper Code	CHE-MJ-03024
Total Credits	4 (Theory: 03, Practical: 01)
Distribution of Marks	45 (End Semester Theory) + 25 (End Semester Practical) + 30 (Internal) [Sessional Exam: 15 marks, Home Assignment: 6 marks, Class Test: 5 marks, Attendance: 4 marks]
Course Outcomes	<p>By the end of this course/module, students will be able to:</p> <ul style="list-style-type: none"> • CO1: Explain fundamental photochemical laws, Beer–Lambert law (with limitations), and key concepts such as quantum yield, actinometry, photostationary state, and photosensitized reactions.

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	<ul style="list-style-type: none"> • CO2: Interpret Jablonski diagrams and describe fluorescence, phosphorescence, internal conversion, intersystem crossing, and the Franck–Condon principle along with primary and secondary photochemical processes. • CO3: Understand the interaction of electromagnetic radiation with matter, wave–particle duality, types of spectroscopies, and related concepts such as absorption cross section and Einstein coefficients. • CO4: Differentiate atomic and molecular spectra using the Born–Oppenheimer approximation and explain how energy separations and various physical factors influence spectral intensities and linewidths. • CO5: Apply selection rules to analyze rotational spectra of diatomic molecules and derive molecular structural parameters such as bond lengths. • CO6: Interpret IR spectra using selection rules and group frequencies while explaining the effects of hydrogen bonding, substitution, and molecular structure on vibrational transitions. • CO7: Explain electronic transitions, chromophores, auxochromes, spectral shifts, vibronic/spin–orbit coupling, and apply Woodward–Fieser rules to conjugated systems. • CO8: Describe the Raman effect, Stokes and anti-Stokes lines, mutual exclusion principle, and interpret basic rotational and vibrational Raman spectra. • CO9: Integrate UV–Vis, IR, Raman, and microwave spectroscopic data to derive meaningful structural and mechanistic information about chemical systems.
No. of Required Classes	45 (Theory) + 30 (Practical)
Details of Course Designer	<ol style="list-style-type: none"> 1. Dr. Pinky Gogoi, Assistant Professor, Department of Chemistry 2. Dr. Manash Protim Hazarika, Assistant Professor, Department of Chemistry
Textbook	<ol style="list-style-type: none"> 1. Atkins and Friedman. (5th ed.). <i>Molecular Quantum Mechanics</i>. Oxford University Press. 2. McQuarrie. <i>Quantum Chemistry</i>. Viva Student Edition, Viva Press. 3. Banwell, C. N. (4th Ed.) <i>Fundamentals of Molecular Spectroscopy</i>. McGraw-Hill.

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	4. Atkins, P., Paula, J. & Keeler, J. (11 th Ed.). (2018). <i>Atkins Physical Chemistry</i> . Oxford University Press.
Reference Book	<ol style="list-style-type: none"> 1. Chandra, A. K. (2017). <i>Introductory Quantum Chemistry</i>. McGraw Hill Education. 2. Griffiths, D. J. & Schroeter, D. F. (3rd Ed.). (2018). <i>Introduction to Quantum Mechanics</i>. Cambridge University Press. 3. Szabo, A. & Ostlund, N. S. (1996). <i>Modern Quantum Chemistry</i>. Dover Publications. 4. Pavia, D. L., Lampman, G. L., Kriz, G. S. & Vyvyan, J. R. (5th Ed.). 2015. <i>Introduction to Spectroscopy</i>. Cengage India Private Limited. 5. Barrow, G. M (1992). <i>Introduction to Molecular Spectroscopy</i>. McGraw Hill.

Semester-III (Theory Credit: 03)

Paper Code: CHE-MJ-03024

Unit	Content	L	T	P	Total Hours
Unit I: Photochemistry	Laws of photochemistry: Grotthus-Draper law, Stark-Einstein law of photochemical equivalence. Beer-Lambert law (for solids and liquids) and limitations. Quantum yield and its measurement for photochemical processes. Actinometry. Photostationary state. Photosensitized reactions (with examples). Jablonski diagrams: internal conversion, intersystem crossing, fluorescence and phosphorescence. Frank Condon principle. Primary and secondary processes in photochemical reactions.	9	1	-	10
Unit II: Fundamentals of Spectroscopy	Spectroscopy and its importance in chemistry. Wave-particle duality. Link between spectroscopy and quantum chemistry. Electromagnetic radiation and its interaction with matter. Types of spectroscopy. Absorption cross section and Einstein's coefficients. Difference between atomic and molecular spectra. Born- Oppenheimer approximation. Separation of molecular energies into translational, rotational, vibrational and electronic degrees of freedom. Factors affecting intensities and width of spectral lines.	6	2	-	8
Unit III: Molecular Spectroscopy	Microwave (pure rotational) spectra of diatomic molecules. Selection rules and transition dipole moment. Structural information derived from rotational spectroscopy. IR	22	5	-	27

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	<p>Spectroscopy: Selection rules, IR spectra of diatomic molecules and organic compounds having functional groups. Structural information derived from vibrational spectra. Vibrations of polyatomic molecules. Group frequencies. Effect of hydrogen bonding (inter and intramolecular) and substitution on vibrational frequencies. Electronic Spectroscopy: electronic excited states and selection rules. Free electron model and its application to electronic spectra of polyenes. Vibronic and spin orbit coupling. Colour and constitution, chromophores, auxochromes, bathochromic and hypsochromic shifts. Woodward-Fieser rules. Qualitative treatment of Raman effect. Elements of rotational Raman spectra Vibrational Raman spectra, Stokes and anti-Stokes lines; their intensity difference. Rule of mutual exclusion.</p>				
Semester-III (Practical Credit: 01)					
Unit	Content	L	T	P	Total Hours
Laboratory Course	<ol style="list-style-type: none"> 1. Verify Beer-Lamberts's Law and determine the concentration of CuSO₄/KMnO₄/K₂Cr₂O₇ in a solution of unknown concentration. 2. Determine the concentrations of KMnO₄ and K₂Cr₂O₇ in a mixture. 3. Verify the linear relationship between absorbance and concentration for a coloured dye and determine the concentration of an unknown sample. 4. Record the UV spectrum of an organic/inorganic species, identify λ_{\max}, and calculate the molar absorptivity. 5. Study of Effect of pH on UV Spectrum (Acid-base indicators) 6. Spectrophotometric Estimation of an Organic Dye (e.g., Methylene Blue / Rhodamine / Congo Red) 7. Determine the pKa of weak acids (e.g., p-nitrophenol or phenol red) from UV spectra using p-nitroaniline as the basic indicator 8. Kinetics of a Simple Chemical Reaction Monitored by UV 	-	-	30	30

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FYUGP in Chemistry
Detailed Syllabus of 4th Semester

Semester	IV
Title of the Course	Inorganic Chemistry-I
Paper Code	CHE-MJ-04014
Total Credits	4 (Theory: 03, Practical: 01)
Distribution of Marks	45 (End Semester Theory) + 25 (End Semester Practical) + 30 (Internal) [Sessional Exam: 15 marks, Home Assignment: 6 marks, Class Test: 5 marks, Attendance: 4 marks]
Course Outcomes	<p>CO 1: Analyze molecular geometry to identify symmetry elements and operations; assign a molecule to its correct point group and interpret the basic information contained within a Character Table and the meaning of Mulliken symbols.</p> <p>CO 2: Compare the variable oxidation states and chemical properties of the first-row transition elements (Ti-Cu) in their halide and oxide forms, and contrast the general trends across the first, second, and third transition series.</p> <p>CO 3: Illustrate the d-orbital splitting patterns for complexes in octahedral, tetrahedral, square planar, and other geometries, and calculate the Crystal Field Stabilization Energy (CFSE) for a given configuration.</p> <p>CO 4: Evaluate the factors (e.g., ligand type, metal oxidation state) that influence the magnitude of the splitting energy and utilize the spectrochemical series to predict high-spin vs. low-spin complexes.</p> <p>CO 5: Explain the limitations of CFT (e.g., nephelauxetic effect) and qualitatively describe the principles of Ligand Field Theory (LFT) and Molecular Orbital Theory (MOT) for bonding in octahedral and tetrahedral complexes.</p> <p>CO 6: Apply the concept of standard electrode potentials to determine the chief modes of occurrence of metals and interpret Ellingham diagrams to select appropriate reducing agents (C or CO) and minimum temperatures for metal oxide reduction.</p> <p>CO 7: Describe and differentiate between major methods of metal purification (e.g., Mond's process, van Arkel-de Boer, Zone refining, Kroll process, Parting) based on their underlying chemical principles.</p> <p>CO 8: Analyze the redox stability of species by predicting tendencies for reactions with water, oxidation, disproportionation, and comproportionation, and interpret the stability and reactivity of species using Latimer, Frost, and Pourbaix diagrams.</p>

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	<p>CO 9: Relate the electronic configuration of Lanthanides and Actinides to their characteristic oxidation states, colour, spectral, and magnetic properties; explain the Lanthanide contraction; and outline the separation of lanthanides using the ion-exchange method.</p> <p>CO 10: Explain the concepts of mass defect and nuclear stability; describe various types of radioactive decay processes and nuclear reactions; and apply the principles of half-lives and radioisotopes for age determination.</p>
No. of Required Classes	45 (Theory) + 30 (Practical)
Details of Course Designer	1. Dr. Pankaj Hazarika, HoD, Department of Chemistry
Textbook	<ol style="list-style-type: none"> Inorganic Chemistry, G.L. Meissler and D. A. Tarr, 5th edition, Pearson. Inorganic Chemistry, P. Atkins, Overtone Rourke, Weller and Armstrong 5th edition, Oxford. Principles of Inorganic Chemistry, 7th edition, Puri, Sharma, Kalia, Vishal Publishing Co.
Reference Book	<ol style="list-style-type: none"> Inorganic Chemistry (Principles of Structure and Reactivity), J. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, 5th edition, Pearson Education. Advanced Inorganic Chemistry, F. Albert Cotton, Geoffrey Wilkinson, Carlos A. Murillo, Manfred Bochmann, Wiley. Vogel's Qualitative Inorganic Analysis, 7th Edition, G. Svehla, B Sivasankar, Pearson.

Semester-IV (Theory Credit: 03)

Paper Code: CHE-MJ-04014

Unit	Content	L	T	P	Total Hours
Unit I: Introduction to molecular symmetry	Symmetry elements and operations, molecular point groups, symmetry elements present in C_{2v} , C_{3v} , T_d and O_h point group (pictorial representation), introductory idea of character tables, Mulliken symbols.	4	2	-	6
Unit II: d-block Chemistry	Chemistry of first row transition elements (Ti-Cu) in various oxidation states as halides and oxides, comparison of the first, second and third transition series elements.	6	2	-	8
Unit III Coordination chemistry III	Crystal Field Theory (CFT) (qualitative treatment): d-orbital splitting in tetrahedral, square planar, trigonal bipyramidal, square pyramidal 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,	9	1	-	10

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	tetragonal distortions from octahedral geometry and Jahn-Teller theorem. Limitations of CFT (nephelauxetic effect and EPR evidences), Elementary idea on ligand field theory, molecular orbital theory (MOT) with special reference to sigma bonded octahedral and tetrahedral complexes (qualitative treatment only), pi bonding in octahedral complexes. Metal-metal quadruple bond in $[\text{Re}_2\text{C}_{18}]^{2-}$.				
Unit IV: Metallurgy	Chief modes of occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon and carbon monoxide as reducing agents. Electrolytic reduction, methods of purification of metals: electrolytic Kroll process, Parting process, van Arkel-de Boer process and Mond's process, Zone refining.	3	2	-	5
Unit V: Oxidation and reduction -II	Redox stability: reaction with water, oxidation by atmospheric oxygen, disproportionation and comproportionation, the influence of complexation, relation between solubility and standard potential. Diagrammatic representation of potential data (Latimer diagram, Frost diagram, Pourbaix diagram).	5	1	-	6
Unit VI: Lanthanoids and Actinoids	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.	4	2	-	6
Unit VII: Nuclear Chemistry	Stability of nucleus and radioactive decay processes, Fermi theory, half-lives, auger effect, Mass defect, nuclear reactions – notations, comparison with chemical reaction: Types of nuclear reactions. Applications of radioisotopes in age determination.	4	0	-	4
Semester-IV (Practical Credit: 01)					
Unit	Content	L	T	P	Total Hours
Laboratory Course	Qualitative analysis of mixtures containing four cations and anions. Emphasis should be given to the understanding of reactions. 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+} ,	-	-	30	30

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	<p>Fe^{3+}, Al^{3+}, Cr^{3+}, Zn^{2+}, Mn^{2+}, Co^{2+}, Ni^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, Mg^{2+}.</p> <p>Mixtures should preferably contain one interfering anion, or insoluble component (BaSO_4, SrSO_4, PbSO_4, CaF_2 or Al_2O_3) or combination of anions such as CO_3^{2-} and SO_3^{2-}, NO_2^- and NO_3^-, Cl^- and Br^-, Cl^- and I^-, Br^- and I^-, NO_3^- and Br^-, NO_3^- and I^-. Spot tests should be done whenever possible.</p>				
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Semester	IV
Title of the Course	Organic Chemistry-I
Paper Code	CHE-MJ-04024
Total Credits	4 (Theory: 03, Practical: 01)
Distribution of Marks	45 (End Semester Theory) + 25 (End Semester Practical) + 30 (Internal) [Sessional Exam: 15 marks, Home Assignment: 6 marks, Class Test: 5 marks, Attendance: 4 marks]
Course Outcomes	<p>CO 1: Determine the symmetry elements and point groups of molecules, and apply the basic concepts of character tables and Mulliken symbols to predict molecular properties.</p> <p>CO 2: Analyse the varied oxidation states and chemical reactivity of the first-row transition elements (Ti-Cu), and compare the general chemical trends across the three-transition series.</p> <p>CO 3: Apply Crystal Field Theory (CFT) to calculate CFSE and predict the d-orbital splitting patterns and magnetic properties for complexes in various geometries; and qualitatively describe bonding using Ligand Field Theory (LFT) and Molecular Orbital Theory (MOT).</p> <p>CO 4: Interpret Ellingham diagrams to select effective reducing agents and reaction conditions for metal oxide reduction, and explain the chemical principles behind major metal purification methods (e.g., Mond's, van Arkel-de Boer, Zone refining).</p> <p>CO 5: Utilize Latimer, Frost, and Pourbaix diagrams to predict the thermodynamic stability of chemical species towards redox reactions, including disproportionation and comproportionation.</p> <p>CO 6: Correlate the electronic configurations of Lanthanides and Actinides with their characteristic spectral and magnetic properties; explain the Lanthanide contraction; and describe the principles of radioactive decay and nuclear reactions used in applications like age determination.</p>

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No. of Required Classes	45 (Theory) + 30 (Practical)
Details of Course Designer	1. Tumpa Paul, Associate Professor, Department of Chemistry
Textbook	<ol style="list-style-type: none"> 1. March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, Michael B. Smith 7th Edition. 2. Organic Chemistry, Jonathan Clayden, Nick Greeves, Stuart Warren, 2nd Edition. 3. Principles of Organic Synthesis, R. O. C. Norman, J. M. Coxon, 3rd Edition. 4. Organic Chemistry, P. Y. Bruice, 8th Edition. 5. Organic Chemistry, Volume 2, I. L. Finar, 5th Edition. 6. Organic Chemistry, P. Y. Bruice, 8th Edition. 7. Organic Spectroscopy, 3rd Edition, William Kemp.
Reference Book	<ol style="list-style-type: none"> 1. Introduction to Spectroscopy, D. L. Pavia, G. M. Lampman, G. S. Kriz, 4th Edition. 2. B. S. Furniss, A. J. Hannaford, P. W. G. Smith, Vogel's Textbook of Practical Organic Chemistry, Pearson, 2012. 3. V. K. Ahluwalia, S. Dhingra, Comprehensive Practical Organic Chemistry, University Press. 4. F. G. Mann, B. C. Saunders, Practical Organic Chemistry, 3rd Edition Longman, 1978.

Semester-IV (Theory Credit: 03)					
Paper Code: CHE-MJ-04024					
Unit	Content	L	T	P	Total Hours
Unit I: Carbonyl compounds	Structure, reactivity and preparation; Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanism; Haloform reaction and, oxidation-reduction reactions (Jones reagent, PCC and PDC, Oppenauer and Bayer-Villiger oxidation, Clemmensen, Wolff-Kishner, Merwein-Pondorff-Verley reduction), Addition reactions of unsaturated carbonyl compounds - Michael addition. Nucleophilic attack at the carbonyl group (geometrical aspects); concept of prochirality; stereoselective additions to carbonyl groups: Cram's rule, Felkin-Anh model.	8	3	-	11
Unit II: Carboxylic acids and their derivatives	Preparation, properties and reactions of carboxylic acids: reactions of dicarboxylic acids, hydroxy acids and unsaturated acids: succinic/phthalic, lactic, malic, tartaric, citric, maleic and fumaric acids.	6	4	-	10

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	Preparation and reactions of acid chlorides, anhydrides, esters and amides; comparison of nucleophilic substitution at acyl group: mechanism of acidic and alkaline hydrolysis of esters; Claisen condensation, Dieckmann and Reformatsky reactions.				
Unit III: Nitrogen containing functional groups	Preparation and properties of amines: effect of substituent and solvent on basicity; Gabriel phthalimide synthesis, Carbylamine reaction, Mannich reaction, Hofmann-elimination reaction; distinction between 1°, 2° and 3° amines with Hinsberg reagent and nitrous acid. Diazonium Salts: preparation and their synthetic applications. General methods for preparation and reactions of nitro compounds.	5	2	-	7
Unit IV: Amino acids, peptides and proteins	α -Amino acids (synthesis and reactions); zwitterions, pK _a values, isoelectric point and electrophoresis; structure of the peptide bond; primary, secondary and tertiary structures of proteins; intramolecular interactions in protein binding site; mechanism of enzyme action (acid–base catalysis); enzyme inhibitors; determination of peptide sequence.	3	2	-	5
Unit V: Alkaloids	Natural occurrence, general structural features, isolation and their physiological action; Hoffmann's exhaustive methylation, Emde's modification, structure elucidation of nicotine; medicinal importance of nicotine, hygrine, quinine, morphine and cocaine.	5	0	-	5
Unit VI: Organic spectroscopy	Introduction to UV-visible and infrared spectroscopy in structure elucidation of organic compounds; relation between absorption spectroscopy and molecules containing conjugated C=C and C=O groups; analysis of compounds containing alkenes, alkynes and carbonyl compounds using infrared spectroscopy (conceptual aspects).	4	3	-	7
Semester-IV (Practical Credit: 01)					
Unit	Content	L	T	P	Total Hours
Laboratory Course	1. Organic preparations (any two from each): benzoylation of organic compounds: amines (aniline, toluidines, anisidine) and phenols (phenol, β -naphthol, salicylic acid) by the following methods: a. Using conventional method. b. Using green chemical approach. 2. Organic preparations (any three): a. Bromination of acetanilide by conventional methods. b. Nitration of salicylic acid using ceric ammonium (green	-	-	30	30

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	<p>chemistry approach).</p> <p>c. Selective reduction of <i>m</i>-dinitrobenzene to <i>m</i>-nitroaniline</p> <p>d. Oxidation of ethanol/ isopropanol (iodoform reaction).</p> <p>e. Aldol condensation using either conventional or green method.</p> <p>f. Benzil-Benzilic acid rearrangement.</p> <p>3. Chromatography: (a) Separation of a mixture of two amino acids by ascending paper chromatography; (b) Separation of a mixture of <i>o</i>- and <i>p</i>-nitrophenol or <i>o</i>- and <i>p</i>-nitroaniline by thin layer chromatography (TLC).</p>				
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Semester	IV
Title of the Course	Physical Chemistry-I
Paper Code	CHE-MJ-04034
Total Credits	4 (Theory: 03, Practical: 01)
Distribution of Marks	45 (End Semester Theory) + 25 (End Semester Practical) + 30 (Internal) [Sessional Exam: 15 marks, Home Assignment: 6 marks, Class Test: 5 marks, Attendance: 4 marks]
Course Outcomes	<p>By the end of this course/module, students will be able to:</p> <ul style="list-style-type: none"> • CO1: Explain the concepts of order and molecularity, derive rate laws using reaction advancement, and apply integrated and differential rate equations to first, second, fractional-order, and pseudo-unimolecular reactions. • CO2: Analyse the kinetics of complex reactions—opposing, parallel, consecutive, and chain reactions—using steady-state approximation and interpret their rate expressions. • CO3: Evaluate the temperature dependence of reaction rates using the Arrhenius equation, calculate activation energy, and interpret collision theory and Lindemann mechanism for unimolecular reactions. • CO4: Describe the Arrhenius theory of electrolytic dissociation, and compare the variation of conductivity, equivalent and molar conductivity for weak and strong electrolytes using Kohlrausch's law and Debye-Hückel-Onsager theory. • CO5: Determine ionic properties such as ionic mobilities, velocities, transference numbers, and apply Hittorf and Moving Boundary methods for their experimental evaluation. • CO6: Apply conductometric techniques to determine degree of dissociation, ionic product of water, solubility product, hydrolysis constants, and to perform conductometric titrations.

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	<ul style="list-style-type: none"> • CO7: Use Faraday's laws, oxidation–reduction rules, and electrolysis principles to explain industrial and metallurgical applications and analyze chemical cells, EMF, and Nernst equation. • CO8: Utilize EMF measurements to calculate thermodynamic parameters (ΔG, ΔH, ΔS), equilibrium constants, pH, activity coefficients, and interpret potentiometric titrations and concentration cells (with/without transference).
No. of Required Classes	45 (Theory) + 30 (Practical)
Details of Course Designer	<ol style="list-style-type: none"> 1. Dr. Pinky Gogoi, Assistant Professor, Department of Chemistry 2. Dr. Manash Protim Hazarika, Assistant Professor, Department of Chemistry
Textbook	<ol style="list-style-type: none"> 1. Houston, P. L. <i>Chemical Kinetics and Reaction Dynamics</i>. 2. Puri, B. R., Sharma, L. R., & Pathania, M. S. (48th ed.). <i>Principles of Physical Chemistry</i>. Vishal Publishing Co. 3. Kapoor, K. L. <i>A Textbook of Physical Chemistry (Vol. 5)</i>. 4. Banwell, C. N. (4th Ed.). <i>Fundamentals of Molecular Spectroscopy</i>. 5. Atkins, P., Paula, J. & Keeler, J. (11th Ed.). (2018). <i>Atkins Physical Chemistry</i>. Oxford University Press.
Reference Book	<ol style="list-style-type: none"> 1. Berry, R. S., Rice, S. A. & Ross, J. (2nd Ed.), <i>Physical Chemistry</i>. Oxford University Press. 2. Bockris, J. & Reddy, A. K. N. <i>Modern Electrochemistry. (Vol. 1)</i>. Ionics, Second Edition, Springer. 3. Laidler, K. J. <i>Chemical Kinetics</i>. McGraw-Hill. 4. Rakshit, P. C. (Enlarged 7th Ed.). <i>Physical Chemistry</i>. Sarat Book House.

Semester-IV (Theory Credit: 03)

Paper Code: CHE-MJ-04034

Unit	Content	L	T	P	Total Hours
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	17	3	-	20

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	reaction rates, Lindemann mechanism, qualitative treatment of the theory of absolute reaction rates.				
Unit II: Catalysis	Types of catalyst, specificity and selectivity, mechanisms of catalysed reactions at solid surfaces; effect of particle size and efficiency of nanoparticles as catalysts. Enzyme catalysis, Michaelis-Menten mechanism, acid-base catalysis.	5	1	-	6
Unit III: Surface Chemistry and Colloids	Physical adsorption, chemisorption, adsorption isotherms (Freundlich, Temkin, Derivation of Langmuir adsorption isotherms, surface area determination), BET theory of multilayer adsorption (no derivation), Adsorption in solution, surface films on liquids. The colloidal systems, Preparation of lyophobic colloidal solutions, Properties of colloidal systems, zeta potential, DLVO theory, Micelles, Critical Micelle Concentration (CMC)	8	2	-	10
Unit IV 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.	7	2	-	9
Semester-IV (Practical Credit: 01)					
Unit	Content	L	T	P	Total Hours
Laboratory Course	<ol style="list-style-type: none"> Study the kinetics of the following reactions: <ul style="list-style-type: none"> Initial rate method: Iodide-persulphate reaction. Iodine-Clock reaction Integrated rate method: Acid hydrolysis of methyl acetate with hydrochloric acid. Saponification of ethyl acetate. To determine the rate of decomposition of H_2O_2 by ferric ion (Fe^{3+}). Verify the Freundlich isotherm for the adsorption of oxalic acid on activated charcoal. 	-	-	30	30

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	6. Verify the Langmuir isotherm for the adsorption of acetic acid on activated charcoal.				
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Semester	IV
Title of the Course	Advanced Spectroscopy and Analytical Techniques
Paper Code	CHE-MJ-04044
Total Credits	4 (Theory: 03, Practical: 01)
Distribution of Marks	45 (End Semester Theory) + 25 (End Semester Practical) + 30 (Internal) [Sessional Exam: 15 marks, Home Assignment: 6 marks, Class Test: 5 marks, Attendance: 4 marks]
Course Outcomes	<p>By the end of this course/module, students will be able to:</p> <ul style="list-style-type: none"> • CO1: Explain the principles of nuclear spin, Zeeman effect, Larmor precession, and the basic theory behind NMR spectroscopy. • CO2: Interpret NMR chemical shifts, splitting patterns, peak integrations, and apply them to identify simple organic molecules. • CO3: Analyse EPR spectra, including g-values, hyperfine splitting, and electron Zeeman effects with simple systems such as H-atom and organic radicals. • CO4: Describe and apply ionization methods and mass analysis techniques, interpret mass spectra, and deduce molecular formulae using fragmentation patterns and isotopic distributions. • CO5: Apply mathematical tools of error analysis, statistics, and probability in quantitative chemical measurements. • CO6: Perform and evaluate classical qualitative and quantitative analyses, including acid–base, redox, complexometric, and precipitation titrations using appropriate indicators and reagents. • CO7: Explain and apply crystal packing concepts, Bragg’s law, Miller indices, reciprocal lattice ideas, and the fundamentals of powder and single-crystal X-ray diffraction. • CO8: Integrate spectroscopic (NMR, EPR, MS) and analytical (titrimetric, XRD) techniques to solve structural and chemical analysis problems in inorganic and organic systems.
No. of Required Classes	45 (Theory) + 30 (Practical)
Details of Course Designer	<ol style="list-style-type: none"> 1. Dr. Pinky Gogoi, Assistant Professor, Department of Chemistry 2. Dr. Manash Protim Hazarika, Assistant Professor, Department of Chemistry
Textbook	<ol style="list-style-type: none"> 1. Kemp, W. (3rd Ed.). <i>Organic Spectroscopy</i>. 2. Pavia, D. L., Lampman, G. M. & Kriz, G. S. (4th Ed.). <i>Introduction to Spectroscopy</i>.

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	3. Atkins, P., Paula, J. & Keeler, J. (11 th Ed.). (2018). <i>Atkins Physical Chemistry</i> . Oxford University Press.
Reference Book	1. Günther, H. (2 nd Ed.). <i>NMR Spectroscopy</i> . 2. Drago, R. S. <i>Physical Methods in Inorganic Chemistry</i> .

Semester-IV (Theory Credit: 03)

Paper Code: CHE-MJ-04014

Unit	Content	L	T	P	Total Hours
Unit I: NMR Spectroscopy	Radio waves and principles of NMR spectroscopy. Nuclear spin quantum number, effect of magnetic field on the nuclear spin, Zeeman effect and nuclear magneton, and Larmor precession. Chemical shift and factors affecting it. Factors affecting intensity and spectral width. NMR peak area integration relative peak positions of organic functional groups eg. alkyl halides, olefins, alkynes, aldehyde, substituted benzenes (toluene, anisole, nitrobenzene, halobenzene, chloronitrobenzene), first order coupling (splitting of the signals: ordinary ethanol, bromoethane, dibromoethanes), Spin-spin coupling and high-resolution spectra, interpretation of PMR spectra of simple organic molecules such as methanol, ethanol, acetaldehyde, acetic acid and aromatic protons, Proton decoupling, Correlation data for ¹³ C NMR data, interpretation of ¹³ C NMR spectra of ethanol, acetone, acetic acid, toluene, ethylbenzene.	11	3	-	14
Unit II: ESR spectroscopy	Electron spin resonance and hyperfine splitting, g value and hyperfine constant, Bohr magneton, electron Zeeman splitting, electron nuclear hyperfine splitting, illustration using simple examples like H atom, methyl radical etc.	5	2	-	7
Unit III: Mass Spectrometry	Ionization techniques (electron impact, chemical ionization), making liquids and solids into ions (electrospray, electrical discharge, laser desorption, fast atom bombardment), separation of ions on basis of mass to charge ratio, interpretation of the mass spectrum, base peak and molecular ion peak. Fragmentation patterns of common organic molecules along with McLafferty rearrangement. Determination of empirical chemical formula from molecular ion peak and isotopic distribution.	9	1	-	10

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Unit IV: Error Analysis and Classical Quantitative Analysis	Mathematical treatment in error analysis, accuracy and precision, statistical test of data; F, Q and t test, Principles of quantitative analysis; Acid-base, oxidation- reduction and complexometric titrations using EDTA; Precipitation reactions; Use and types of indicators; Use of organic reagents in inorganic analysis	5	1	-	6
Unit V: Crystallography	Unit Cells, Miller indices, crystal systems and Bravais Lattices, elementary applications of vectors to crystal systems; Bragg's Law, Miller indices and reciprocal lattices. Laws of crystallography. Basics of X-ray diffraction (powder and single crystal). Structure of NaCl, CsCl, and KCl, diamond, and graphite; Close packing in metals and metal compounds, semiconductors, insulators; Defects in crystals, lattice energy; isomorphism; heat capacity of solids.	5	3	-	8
Semester-4 (Practical Credit: 01)					
Unit	Content	L	T	P	Total Hours
Laboratory Course	<ol style="list-style-type: none"> 1. Structure elucidation from simple proton NMR spectrum, MS. 2. Determination of total hardness of water by EDTA 3. Estimation of Fe(II) with Potassium Permanganate (KMnO₄) 4. Determination of Chloride by Mohr's Method (AgNO₃) 5. Gravimetric Determination of Sulfate as BaSO₄ 6. Indexing of Powder Diffraction Pattern of Cubic Crystal (Data Provided) 7. Determination of Percentage Crystallinity from Powder X-Ray Diffraction (PXRD) Data (Data Provided) 	-	-	30	30

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FYUGP in Chemistry
Detailed Syllabus of 5th Semester

Semester	V
Title of the Course	Inorganic Chemistry-II
Paper Code	CHE-MJ-05014
Total Credits	4 (Theory: 03, Practical: 01)
Distribution of Marks	45 (End Semester Theory) + 25 (End Semester Practical) + 30 (Internal) [Sessional Exam: 15 marks, Home Assignment: 6 marks, Class Test: 5 marks, Attendance: 4 marks]
Course Outcomes	<ul style="list-style-type: none"> • CO1: Students will be able to apply ligand field theory to interpret the electronic spectra of coordination compounds, specifically by deriving free ion term symbols, using Orgel diagrams to predict transitions, and explaining the influence of the Jahn-Teller effect and selection rules. • CO2: Students will be able to calculate the spin-only and orbital contribution to the magnetic moments of complexes, and explain phenomena like spin crossover and the nature and significance of charge transfer spectra. • CO3: Students will be able to explain periodic trends like the inert pair effect and anomalous behaviour of the first member of a group, and describe the structure, bonding, and synthesis of important s- and p-block compounds, including diborane, carboranes, and various oxides and oxoacids. • CO4: Students will be able to rationalize the inertness of noble gases, describe the preparation and structure of noble gas compounds using VSEPR theory, and discuss the bonding using both valence bond and MO treatments. • CO5: Students will be able to classify organometallic compounds based on bond type, determine the electron count (18-electron rule) and hapticity of ligands, and explain the preparation of metal carbonyls of 3d-series elements. • CO6: Students will be able to analyse the bonding in metal carbonyls and Zeise's salt by interpreting the synergic effect (back bonding) and its influence on IR spectral data, and correlate this with the stability and structure of these complexes.
No. of Required Classes	45 (Theory) + 30 (Practical)
Details of Course Designer	1. Dr. Pankaj Hazarika, HoD, Department of Chemistry
Textbook	<ol style="list-style-type: none"> 1. Inorganic Chemistry (Principles of Structure and Reactivity), J. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, 5th edition, Pearson Education. 2. Principles of Inorganic Chemistry, 7th edition, Puri, Sharma, Kalia, Vishal Publishing Co.

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Reference Book	<ol style="list-style-type: none"> 1. Concepts and Models of Inorganic Chemistry, 3rd edition, Bodie Douglas, Darl Mcdaniel, John Alexander, Wiley. 2. Advanced Inorganic Chemistry, F. Albert Cotton, Geoffrey Wilkinson, Carlos A. Murillo, Manfred Bochmann, Wiley. 3. Vogel's Quantitative Chemical Analysis 6th edition, J. Mendham, R. C. Denney, J. D. Barnes, M. Thomas, B. Sivsankar, Pearson.
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Semester-V (Theory Credit: 03)

Paper Code: CHE-MJ-05014

Unit	Content	L	T	P	Total Hours
Unit I: Coordination Chemistry IV	Electronic spectra and magnetism of coordination compounds: microstates, free ion term symbols and their splitting in tetrahedral and octahedral fields, Racah parameters, selection rules and relaxation mechanisms (vibronic coupling and spin orbit coupling), Orgel diagrams and prediction of spectral transitions, Jahn-Teller effect on electronic spectra, charge transfer spectra, calculation of spin only and orbital contribution to magnetic moments. Spin crossover.	10	2	-	12
Unit II: Main Group elements	Inert pair effect, Relative stability of different oxidation states, diagonal relationship between B and Si and anomalous behaviour of first member of each group. Allotropy and catenation. Complex formation tendency of s and p block elements. Hydrides and their classification ionic, covalent and interstitial. Basic beryllium acetate and nitrate. Structure, bonding, preparation, properties and uses. boron nitrides, borohydrides (diborane) carboranes and graphitic compounds, silanes. Oxides and oxoacids of nitrogen, Phosphorus and chlorine. Per-oxo acids of Sulphur. Inter-halogen compounds, polyhalide ions, pseudo-halogens, properties of halogens.	11	4	-	15
Unit III: Noble Gases	Occurrence and uses, rationalization of inertness of noble gases, Clathrates; preparation and properties of XeF ₂ , XeF ₄ and XeF ₆ . Bonding in noble gas compounds (Valence bond and MO treatment for XeF ₂), Shapes of noble gas compounds (VSEPR theory).	5	1	-	6
Unit IV: Organometallics I	Definition and classification of organometallic compounds on the basis of bond type. Concept of hapticity of organic ligands, 18 electron rule. Metal carbonyls: electron count of mononuclear, polynuclear and substituted metal carbonyls of 3d series. General methods	10	2	-	12

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	<p>of preparation (direct combination, reductive carbonylation, thermal and photochemical decomposition) of mono and binuclear carbonyls of 3d series.</p> <p>Structures of mononuclear and binuclear carbonyls of Cr, Mn, Fe, Co and Ni. Pi -acceptor behaviour of CO (MO diagram of CO to be discussed), synergic bonding effect and use of IR data to explain the extent of back bonding.</p> <p>Zeise's salt: preparation and structure, evidence of synergic effect and comparison of synergic effect with that in carbonyls.</p>				
Semester-V (Practical Credit: 01)					
Unit	Content	L	T	P	Total Hours
Laboratory: Inorganic quantitative analysis	<p>1. Estimation by volumetric method of any two of the following:</p> <p style="margin-left: 20px;">a. Fe(III)- By standard KMnO₄ solution</p> <p style="margin-left: 20px;">b. Fe(III) – By standard K₂Cr₂O₇ solution</p> <p style="margin-left: 20px;">c. Cu(II) – By Iodometric method.</p> <p>2. Estimation of Ni(II) by gravimetric method.</p> <p>3. Separation and estimation of individual ions in two component systems of:</p> <p style="margin-left: 20px;">a. Cu and Fe</p> <p style="margin-left: 20px;">b. Fe and Ca</p> <p style="margin-left: 20px;">c. Ca and Mg</p> <p style="margin-left: 20px;">d. Cu and Ni and</p> <p style="margin-left: 20px;">e. Cl⁻ and SO₄²⁻.</p>	-	-	30	30

Semester	V
Title of the Course	Organic Chemistry-II
Paper Code	CHE-MJ-05024
Total Credits	4 (Theory: 03, Practical: 01)
Distribution of Marks	45 (End Semester Theory) + 25 (End Semester Practical) + 30 (Internal) [Sessional Exam: 15 marks, Home Assignment: 6 marks, Class Test: 5 marks, Attendance: 4 marks]
Course Outcomes	<ul style="list-style-type: none"> CO1: Students will be able to classify, name, and illustrate the synthesis and reactions of common five- and six-membered heterocyclic compounds, including furan, pyrrole, thiophene, pyridine, and indoles, and apply selected name reactions such as Paal-Knorr, Fischer Indole, and Hantzsch syntheses.

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	<ul style="list-style-type: none"> • CO2: Students will be able to explain the concept of keto-enol tautomerism in active methylene compounds and apply the synthetic utility of diethyl malonate and ethyl acetoacetate in organic synthesis. • CO3: Students will be able to elucidate and predict the products based on the detailed reaction mechanisms of various significant organic transformations, including Aldol, Cannizzaro, Wittig, Michael addition, Beckmann rearrangement, and Hofmann/Curtius/Lossen rearrangements. • CO4: Students will be able to identify the components of nucleic acids and relate the structure, synthesis, and reactions of the major bases (adenine, guanine, cytosine, uracil, thymine) to the overall structure of DNA (Watson & Crick model) and RNA, and describe their fundamental biological roles (replication, transcription, translation). • CO5: Students will be able to classify monosaccharides, determine their absolute configurations, epimers, and anomers, explain mutarotation, and elucidate the structures of common di- and polysaccharides (e.g., maltose, lactose, sucrose, starch, cellulose). • CO6: Students will be able to classify and apply the isoprene rule to determine the structure of terpenes, and outline the synthesis of important monoterpenoids and the biosynthesis of selected terpenes via the isopentenyl pyrophosphate pathway.
No. of Required Classes	45 (Theory) + 30 (Practical)
Details of Course Designer	1. Tumpa Paul, Associate Professor, Department of Chemistry
Textbook	<ol style="list-style-type: none"> 1. Organic Chemistry, Jonathan Clayden, Nick Greeves, Stuart Warren, 2nd Edition. 2. Principles of Organic Synthesis, R. O. C. Norman, J. M. Coxon, 3rd Edition. 3. Organic Chemistry, R. T. Morrison, R. N. Boyd, S. K. Bhattacharjee, 7th Edition. 4. Organic Chemistry, Volume 2, I. L. Finar, 5th Edition. 5. Organic Chemistry, Volume 3, Singh, Mukherjee, Kapoor. 6. V. K. Ahluwalia, S. Dhingra, Comprehensive Practical Organic Chemistry, University Press.
Reference Book	<ol style="list-style-type: none"> 1. Advanced Organic Chemistry, R. Bruckner. 2. Organic Chemistry, G. M. Loudon, 4th Edition 3. B. S. Furniss, A. J. Hannaford, P. W. G. Smith, Vogel's Textbook of Practical Organic Chemistry, Pearson, 2012. 4. F. G. Mann, B. C. Saunders, Practical Organic Chemistry, 3rd Edition Longman, 1978.

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Semester-V (Theory Credit: 03)					
Paper Code: CHE-MJ-05024					
Unit	Content	L	T	P	Total Hours
Unit I: Heterocyclic compounds	Classification and nomenclature (5-numbered and 6-membered rings with one heteroatom); synthesis and reactions of furan, pyrrole, thiophene, pyridine and indoles: selected name reactions (Paal-Knorr synthesis, Knorr synthesis, Hantzsch synthesis, Fischer indole synthesis, Madelung synthesis)	5	2	-	7
Unit II: Reactions of active methylene compounds	Active methylene compounds (keto-enol tautomerism): preparation and synthetic applications of diethyl malonate and ethyl acetoacetate.	4	2	-	6
Unit III: Reactions of enolates and enamines	Mechanisms of Aldol and Benzoin condensation, Knoevenagel condensation, Claisen-Schmidt, Perkin, Darzen, Cannizzaro and Wittig reaction, Favorskii reaction, Beckmann rearrangement, Benzil-Benzilic acid rearrangement; addition reactions of unsaturated carbonyl compounds; Michael addition, Wolff rearrangement, Hofmann-Curtius- Lossen rearrangement.	6	3	-	9
Unit IV: Nucleic acids	Components of nucleic acids, nucleosides and nucleotides; structure, synthesis and reactions of: adenine, guanine, cytosine, uracil and thymine; structure of polynucleotides. structure of DNA (Watson &Crick model) and RNA, genetic code biological role of DNA and RNA, replication, transcription and translation (elementary idea only)	5	0	-	5
Unit V: Carbohydrate chemistry	Classification of monosaccharides; absolute configuration of glucose and fructose, epimers and anomers; mutarotation; determination of ring size of glucose and fructose; conformations of glucose (Fischer, Haworth and stereoscopic projections); interconversions of aldoses and ketoses; Killiani Fischer synthesis and Ruff degradation; disaccharides: structure elucidation of maltose, lactose and sucrose. Polysaccharides -structures of starch, cellulose and glycogen.	7	2	-	9
Unit VI: Terpenes	Occurrence of terpenes; structure and classification of terpenes, isoprene rule; synthesis of citral, neral and α -terpineol;	3	2	-	5

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	biosynthesis of limonene, pinene, carvone (<i>via</i> isopentenyl pyrophosphate).				
Semester-V (Practical Credit: 01)					
Unit	Content	L	T	P	Total Hours
Laboratory: Organic qualitative analysis	<p>1. Qualitative analysis of carbohydrates: aldoses and ketoses, reducing and non-reducing sugars.</p> <p>2. (a) Qualitative analysis of unknown organic compounds containing simple functional groups (alcohols, phenols, amines, nitro, carboxylic acids and carbonyl compounds). (b) Interpretation of infrared (IR) spectra of simple organic compounds.</p> <p><i>The student is required to learn about identification of functional groups of simple organic compounds by interpreting the IR spectra. The spectra may be recorded and/or provided to the students from literature</i></p>		-	30	30

Title of the Course	Physical Chemistry -II
Paper Code	CHE-MJ-05034
Total Credits	4 (Theory: 03, Practical: 01)
Distribution of Marks	45 (End Semester Theory) + 25 (End Semester Practical) + 30 (Internal) [Sessional Exam: 15 marks, Home Assignment: 6 marks, Class Test: 5 marks, Attendance: 4 marks]
Course Outcomes	<p>By the end of this course/module, students will be able to:</p> <ul style="list-style-type: none"> • CO1: Analyse complex reactions—opposing, parallel, consecutive, and chain processes—using first order integrated and differential rate laws and steady-state or rate-determining step approximations. • CO2: Explain the temperature dependence of reaction rates using the Arrhenius equation, activation energy, collision theory, Lindemann mechanism, and transition state theory, and compare their predictive abilities. • CO3: Apply principles of chemical equilibrium, including the law of mass action, equilibrium constants (K_p, K_c, K_x, K_n), Le-Chatelier principle, ionic equilibria, pH,

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	<p>buffer action, hydrolysis, and solubility product to solve numerical and conceptual problems.</p> <ul style="list-style-type: none"> • CO4: Interpret phase behaviour using Gibbs phase rule, Clausius-Clapeyron equation, and phase diagrams of one-component and binary systems, including eutectics, congruent/incongruent melting, and partial miscibility. • CO5: Evaluate thermodynamic relations in liquid mixtures using the Gibbs–Duhem–Margules equation, apply concepts of azeotrope, CST, steam distillation, and Nernst distribution law to separation and extraction processes. • CO6: Describe the fundamental principles of catalysis, including specificity, selectivity, surface catalytic mechanisms, nanoparticle effects, enzyme kinetics (Michaelis–Menten), and acid-base catalysis. • CO7: Explain and apply theories of adsorption, including physical and chemical adsorption, Freundlich, Temkin and Langmuir isotherms, BET multilayer adsorption, and determination of surface area. • CO8: Integrate kinetic, equilibrium, phase, catalytic, and adsorption concepts to interpret real chemical systems and predict their behaviour under varying physical and chemical conditions.
No. of Required Classes	45 (Theory) + 30 (Practical)
Details of Course Designer	<ol style="list-style-type: none"> 1. Dr. Pinky Gogoi, Assistant Professor, Department of Chemistry 2. Dr. Manash Protim Hazarika, Assistant Professor, Department of Chemistry
Textbook	<ol style="list-style-type: none"> 1. Kapoor, K. L. <i>A Textbook of Physical Chemistry. (Vol. 5).</i> 2. Houston, P. L. <i>Chemical Kinetics and Reaction Dynamics.</i> 3. Puri, B. R., Sharma, L. R., & Pathania, M. S. (48th ed.). <i>Principles of Physical Chemistry.</i> Vishal Publishing Co. 4. Atkins, P., Paula, J. & Keeler, J. (11th Ed.). (2018). <i>Atkins Physical Chemistry.</i> Oxford University Press.
Reference Book	<ol style="list-style-type: none"> 1. Rakshit, P. C. <i>Physical Chemistry.</i> 2. Berry, R. S., Rice, S. A. & Ross, J. (2nd Ed.), <i>Physical Chemistry.</i> Oxford University Press.

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Semester-V (Theory Credit: 03)					
Paper Code: CHE-MJ-05034					
Unit	Content	L	T	P	Total Hours
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.	10	2	-	12
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-Hückel-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.	11	4	-	15
Unit III: Electrochemistry	Quantitative aspects of Faraday's laws of electrolysis, rules of oxidation/reduction of ions based on half-cell potentials. 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)	15	3	-	18

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	pH values, using hydrogen, quinone-hydroquinone, glass and SbO/Sb ₂ O ₃ 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). Applications of electrolysis in metallurgy and industry.				
Semester-V (Practical Credit: 01)					
Unit	Content	L	T	P	Total Hours
Laboratory Course	<p>Group A:</p> <ol style="list-style-type: none"> 1. Determination of critical solution temperature and composition of the phenol-water system and to study the effect of impurities on it. 2. Determine the transition temperature of a salt hydrate. 3. Study of the solubility of benzoic acid in water and determination of ΔH 4. Study the distribution of iodine between water and carbon tetrachloride <p>Group B:</p> <ol style="list-style-type: none"> 1. Determination of cell constant 2. Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid. 3. Perform the following conductometric titrations: <ol style="list-style-type: none"> a. Strong acid vs. strong base b. Weak acid vs. strong base c. Mixture of strong acid and weak acid vs. strong base d. Strong acid vs. weak base <p>Group C:</p> <ol style="list-style-type: none"> 1. Perform the following potentiometric titrations: <ol style="list-style-type: none"> a. Strong acid vs. strong base b. Weak acid vs. strong base c. Dibasic acid vs. strong base d. Potassium dichromate vs. Mohr's salt 		-	30	30

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FYUGP in Chemistry
Detailed Syllabus of 6th Semester

Semester	VI
Title of the Course	Inorganic Chemistry-III
Paper Code	CHE-MJ-06014
Total Credits	4 (Theory: 03, Practical: 01)
Distribution of Marks	45 (End Semester Theory) + 25 (End Semester Practical) + 30 (Internal) [Sessional Exam: 15 marks, Home Assignment: 6 marks, Class Test: 5 marks, Attendance: 4 marks]
Course Outcomes	<ul style="list-style-type: none">• CO1: Students will be able to analyse and explain the key thermodynamic and kinetic factors influencing metal complex stability, including stepwise/overall formation constants and the chelate effect, and apply these principles to analytical and biological systems.• CO2: Students will be able to compare and contrast the mechanisms of substitution reactions in both octahedral and square planar complexes, specifically detailing the effect of acids/bases and utilizing the trans effect for the directed synthesis of square planar complexes.• CO3: Students will be able to describe the synthesis, structure, and bonding in various organometallic compounds such as metal alkenes, alkynes, allyls, and carbenes, and explain the aromaticity and reactivity of ferrocene.• CO4: Students will be able to identify and illustrate the fundamental mechanisms of core organometallic reactions that form the basis of transition metal catalysis.• CO5: Students will be able to explain the function and mechanism of key industrial catalytic processes involving transition metals, such as alkene hydrogenation (Wilkinson's Catalyst), the Wacker Process, and the Monsanto acetic acid process.• CO6: Students will be able to describe the biological roles of essential and trace metals and explain the active site structure and function of critical metalloenzymes and proteins, including haemoglobin (cooperativity and Bohr effect), myoglobin, superoxide dismutase, and cytochrome P450.
No. of Required Classes	45 (Theory) + 30 (Practical)
Details of Course Designer	1. Dr. Pankaj Hazarika, HoD, Department of Chemistry
Textbook	1. Inorganic Chemistry (Principles of Structure and Reactivity), J. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, 5th edition, Pearson Education.

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	2. Principles of Inorganic Chemistry, 7th edition, Puri, Sharma, Kalia, Vishal Publishing Co.
Reference Book	1. Concepts and Models of Inorganic Chemistry, 3rd edition, Bodie Douglas, Darl Mcdaniel, John Alexander, Wiley. 2. Advanced Inorganic Chemistry, F. Albert Cotton, Geoffrey Wilkinson, Carlos A. Murillo, Manfred Bochmann, Wiley. Vogel's Quantitative Chemical Analysis 6th edition, J. Mendham, R. C. Denney, J. D. Barnes, M. Thomas, B. Sivsankar, Pearson.

Semester-VI (Theory Credit: 03)

Paper Code: CHE-MJ-06014

Unit	Content	L	T	P	Total Hours
Unit I: Coordination Chemistry-V	Introduction to inorganic reaction mechanisms. Stepwise and overall formation constants, the chelate effect, thermodynamic and kinetic stability of complexes, chelate effect and its applications in analytical chemistry and biology. Substitution reactions in octahedral complexes, factors affecting the substitution reaction, effect of acid and bases on substitution reaction of octahedral complexes. Substitution reaction of square planar complexes, trans effect, theories of trans effect, trans effect in synthesis of square planar complexes. Electron transfer reactions (elementary ideas only)	10	5	-	15
Unit II Organometallics II	Metal alkenes, alkynes and allyls: synthesis, structure, bonding and reactivity. Metal carbene: synthesis, structure, bonding and reactivity Ferrocene: preparation and reactions (acetylation, alkylation, metallation, Mannich condensation). Structure and aromaticity. Comparison of aromaticity and reactivity with that of benzene Fundamentals of organometallic reactions: oxidative addition, reductive elimination, insertion and β -hydride elimination reaction. Transition metals in catalysis. Study of the industrial processes and their mechanism: alkene hydrogenation (Wilkinson's Catalyst), hydroformylation (Co catalysts), Wacker Process, synthetic gasoline (Fischer Tropsch reaction), Monsanto acetic acid process.	13	2	-	15
Unit III Bioinorganic Chemistry	Essential and trace metals in biology. Effect of deficiency of essential metal ions. Toxic effect of metal ions (Fe, Cu, Hg, Pb, Cd and As), chelate therapy, cisplatin as anticancer drug. Storage and transport of iron, active transport of ions (sodium	10	5	-	15

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	-potassium pump) Active site structure and function of haemoglobin (cooperativity and Bohr effect), myoglobin, hemocyanin, hemerythrin, rubredoxin, ferredoxin (Fe ₂ S ₂ , Fe ₄ S ₄), cytochrome P450, superoxide dismutase, carbonic anhydrase and carboxypeptidase, nitrogenase enzyme, vitamin B ₁₂				
Semester-VI (Practical Credit: 01)					
Unit	Content	L	T	P	Total Hours
Laboratory: Inorganic Preparation	<p>Following compounds should be prepared and tested for the presence of ions qualitatively. IR and UV-Visible spectra of these complexes should be recorded, interpreted and discussed.</p> <ol style="list-style-type: none"> 1. Preparation of Mohr's Salt, chrome alum and potash alum 2. Cis and trans K[Cr(C₂O₄)₂·(H₂O)₂] Potassium dioxalatodiaquachromate (III) 3. Potassium tris(oxalato)ferrate(III) 4. Vanadyl bis(acetylacetonate) 5. Cu-thiourea complex 6. Acetylation of ferrocene and purification of mono and bis derivatives by column chromatography. 		-	30	30

Semester	VI
Title of the Course	Organic Chemistry-III
Paper Code	CHE-MJ-06024
Total Credits	4 (Theory: 03, Practical: 01)
Distribution of Marks	45 (End Semester Theory) + 25 (End Semester Practical) + 30 (Internal) [Sessional Exam: 15 marks, Home Assignment: 6 marks, Class Test: 5 marks, Attendance: 4 marks]
Course Outcomes	<ul style="list-style-type: none"> • CO1: Analyze the principles of electron excitation in organic molecules (e.g., alkenes and carbonyl compounds) and predict the subsequent fate of the excited species, differentiating between singlet and triplet states. • CO2: Explain and illustrate the mechanisms of key photochemical reactions, including the Paterno-Büchi reaction and the Norrish Type I and Type II fragmentations, and apply these principles to predict product formation. • CO3: Apply the Woodward-Hoffmann rules and frontier molecular orbital (FMO) theory to rationalize the stereoselectivity and feasibility of thermal and

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	<p>photochemical pericyclic reactions, specifically cycloadditions (like the Diels-Alder reaction) and electrocyclic reactions.</p> <ul style="list-style-type: none"> • CO4: Determine the required conditions and predict the products of sigmatropic rearrangements, such as the Cope rearrangement, by analyzing the orbital symmetry constraints. • CO5: Describe the structure, general methods of preparation, and characteristic reactions of polycyclic aromatic hydrocarbons like naphthalene, phenanthrene, and anthracene. • CO6: Differentiate between the various types of organometallic reagents (organolithium, organomagnesium, organocopper, organozinc, etc.) based on their structure and general methods of preparation (e.g., metal-halogen exchange, transmetallation). • CO7: Illustrate and explain the significance of the Schlenk equilibrium in organomagnesium chemistry and the principles governing directed metallation in synthetic routes. • CO8: Propose synthetic strategies utilizing the reactivity of a variety of organometallic reagents (Li, Mg, Cu, Zn, Al, B) to form new carbon-carbon bonds and execute functional group transformations.
No. of Required Classes	45 (Theory) + 30 (Practical)
Details of Course Designer	1. Tumpa Paul, Associate Professor. Department of Chemistry
Textbook	<ol style="list-style-type: none"> 1. Foundations of Photochemistry, K. K. Rohatgi-Mukherjee, 3rd Edition. 2. Principles of Organic Synthesis, R. O. C. Norman, J. M. Coxon, 3rd Edition. 3. Pericyclic Reactions, Vinod Kumar, S. P. Singh. 4. Organic Chemistry, Volume 1, I. L. Finar, 5th Edition. 5. B. S. Furniss, A. J. Hannaford, P. W. G. Smith, Vogel's Textbook of Practical Organic Chemistry, Pearson, 2012.
Reference Book	<ol style="list-style-type: none"> 1. Mechanism and Theory in Organic Chemistry, T. H. Lowry, K. S. Richardson. 2. Modern Methods of Organic Synthesis, W. Carruthers, I. Coldham, 4th Edition. 3. V. K. Ahluwalia, S. Dhingra, Comprehensive Practical Organic Chemistry, University Press. 4. F. G. Mann, B. C. Saunders, Practical Organic Chemistry, 3rd Edition Longman, 1978.

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Organic Chemistry, Jonathan Clayden, Nick Greeves, Stuart Warren, 2nd Edition.

Semester-VI (Theory Credit: 03)

Paper Code: CHE-MJ-06024

Unit	Content	L	T	P	Total Hours
Unit I: Photochemistry	Electron excitation in organic molecules (alkenes and carbonyl compounds); fate of electronically excited molecules; singlet and triplet states; photoreduction of carbonyl compounds; photoaddition of alkenes to carbonyl compounds (Paterno-Buchi reaction); photoaddition of alkenes to aromatic compounds; photorearrangement (cis-trans isomerization, intramolecular cyclization of dienes); photochemical fragmentation (photolysis of carbonyl compounds: Norrish type I and type II reactions).	8	2	-	10
Unit II: Pericyclic reactions	Cycloadditions: general description of the Diels-Alder reaction; frontier orbital description of [4+2] cycloadditions; regioselectivity in Diels-Alder reactions; Woodward-Hoffmann description of the Diels-Alder reaction; photochemical [2+2] cycloadditions; thermal[2+2] cycloadditions. Sigmatropic reactions: conditions for sigmatropic reactions, orbital descriptions of[3,3]-sigmatropic rearrangements; Cope rearrangement. Electrocyclic reactions: conditions for [4 π +2] and [4 π] electrocyclic reactions; conrotatory and disrotatory reactions.	12	3	-	15
Unit III: Polynuclear hydrocarbons	Preparation, structure and reactions of naphthalene, phenanthrene and anthracene.	5	0	-	5
Unit IV: Organometallic chemistry	General introduction to preparation, structure and reactivity of organolithium, organomagnesium (Schlenk equilibrium), organocopper, organozinc, organoaluminum, and organoboron reagents; general methods of preparation: deprotonation, metal-halogen exchange, transmetallation; directed metallation.	12	3	-	15

Semester-6 (Practical Credit: 01)

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Unit	Content	L	T	P	Total Hours
Laboratory: Organic Practical	<ol style="list-style-type: none"> 1. Extraction of D-limonene from orange peel by the conventional method/ using liquid CO₂ prepared form dry ice. 2. Extraction of caffeine from commercially available tea leaves. 3. Photoreduction of benzophenone to benzopinacol in the presence Organic estimations (any three): <ol style="list-style-type: none"> (a) Estimation of glycine by Sorenson's formalin method. (b) Study of the titration curve of glycine (by pH metric methods). (c) Determination of Iodine number of vegetable oil or a fat. (d) Saponification value of vegetable oil or a fat. 4. Estimation of glucose by titrimetric methods.of sunlight/UV irradiation. 		-	30	30

Semester	VI
Title of the Course	Advanced Quantum Theory & Molecular Properties
Paper Code	CHE-MJ-06034
Total Credits	4 (Theory: 03, Practical: 01)
Distribution of Marks	45 (End Semester Theory) + 25 (End Semester Practical) + 30 (Internal) [Sessional Exam: 15 marks, Home Assignment: 6 marks, Class Test: 5 marks, Attendance: 4 marks]
Course Outcomes	<p>By the end of this course/module, students will be able to:</p> <ul style="list-style-type: none"> • CO1: Solve the Schrödinger equation for a particle in a 1-D box, perform orthonormalization of wavefunctions, and relate the model to conjugated polyenes and the origin of quantized energies. • CO2: Apply the Heisenberg Uncertainty Principle using expectation values for 1-, 2-, and 3-D box systems and interpret quantum tunnelling qualitatively. • CO3: Explain the quantum mechanical treatment of rotation and vibration by using the rigid rotator and harmonic oscillator models and describe the quantization of rotational/vibrational energy levels and zero-point energy.

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	<ul style="list-style-type: none"> • CO4: Interpret the Hamiltonian and wavefunctions of the hydrogen atom, construct radial and angular distribution curves, and correlate them with atomic orbitals and electron probability densities. • CO5: Discuss the formation of chemical bonds using Heitler–London valence bond theory and apply atomic units, quantum numbers, and atomic term symbols to multi-electron systems including LS and j–j coupling schemes. • CO6: Set up the Schrödinger equation for hydrogen-like ions and simple many-electron atoms (He, Li), justify the need for approximation methods, and apply the variation theorem to simple quantum systems. • CO7: Compare VB and MO approaches in describing H₂ and H₂⁺, analyze bonding and antibonding orbitals, and extend MO concepts qualitatively to homo- and heteronuclear diatomics (HF, LiH) and triatomic molecules (BeH₂, H₂O, AH₂). • CO8: Describe intermolecular forces, polarizability, and dielectric properties, and derive and apply the Clausius–Mosotti equation and Debye equations to polar and non-polar molecular systems.
No. of Required Classes	45 (Theory) + 30 (Practical)
Details of Course Designer	<ol style="list-style-type: none"> 1. Dr. Pinky Gogoi, Assistant Professor, Department of Chemistry 2. Dr. Manash Protim Hazarika, Assistant Professor, Department of Chemistry
Textbook	<ol style="list-style-type: none"> 1. Atkins and Friedman. (5th ed.). <i>Molecular Quantum Mechanics</i>. Oxford University Press. 2. McQuarrie. <i>Quantum Chemistry</i>. Viva Student Edition, Viva Press
Reference Book	<ol style="list-style-type: none"> 1. Chandra, A. K. (2017). <i>Introductory Quantum Chemistry</i>. McGraw Hill Education. 2. Griffiths, D. J. & Schroeter, D. F. (3rd Ed.). (2018). <i>Introduction to Quantum Mechanics</i>. Cambridge University Press. 3. Szabo, A. & Ostlund, N. S. (1996). <i>Modern Quantum Chemistry</i>, Dover Publications.

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Semester-VI (Theory Credit: 03)					
Paper Code: CHE-MJ-06034					
Unit	Content	L	T	P	Total Hours
Unit I: Quantum theory-I	Planck's Quantization of energy and Hydrogen Line spectrum. Postulates of quantum mechanics and their physical interpretation, wavefunctions and quantum mechanical operators. Born interpretation. Well behaved wavefunctions and commutation relations. Orthonormality and physical meaning of expanding a wavefunction in orthonormal basis. Hermitian Operators and Real Eigenvalues, Eigenvectors: their physical significance.	5	2	-	7
Unit II: Quantum theory-II	Particle in a 1-D box (complete solution with orthonormalization) and relation to conjugated polyenes. Heisenberg Uncertainty Principle from expectation values of 1 D box, extension to two and three-dimensional boxes. Qualitative idea of tunnelling. Rotational Motion and Energy: Schrodinger equation of a rigid rotator and brief discussion of its results (solution not required). Quantization of rotational energy levels. Vibrational Motion: Schrodinger equation of a linear harmonic oscillator and brief discussion of its results (solution not required). Quantization of vibrational energy levels. Interpretation of zero-point energy. Hamiltonian for 1 electron H-atom, its wavefunctions (only explanation, no derivation) and its relation to atomic orbitals. Constructing Radial and Angular Distribution Curves from H-like wave functions. Quantum mechanical idea of chemical bond formation: Heitler-London's Valence bond theory. Atomic Units. Good quantum numbers for multi-electron systems and Atomic Term Symbols. LS and j-j coupling schemes.	11	4	-	15
Unit III: Quantum Approach to Bonding	Qualitative treatment of hydrogen atom and hydrogen-like ions: setting up of Schrödinger equation in spherical polar coordinates, radial part, quantization of energy (only final energy expression). Average and most probable distances of electron from nucleus. Setting up of Schrödinger equation for many-electron atoms (He, Li). Need for approximation methods. Statement of variation theorem and application to simple systems (particle-in-a-box, harmonic oscillator, hydrogen atom). Chemical bonding: Covalent bonding, valence bond and molecular orbital approaches, LCAO-MO treatment of H_2^+ . Bonding and antibonding orbitals. Qualitative extension to H_2 . Comparison of LCAO-MO and VB treatments of H_2 (only wavefunctions, detailed solution not required) and their limitations. Refinements of the two approaches	14	4	-	18

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	(Configuration Interaction for MO, ionic terms in VB). Qualitative description of LCAO-MO treatment of homonuclear and heteronuclear diatomic molecules (HF, LiH). Localised and non-localised molecular orbitals treatment of triatomic (BeH ₂ , H ₂ O) molecules. Qualitative MO theory and its application to AH ₂ type molecules.				
Unit IV: Molecular Properties	Intermolecular forces and potentials. Polarizability of atoms and molecules, dielectric constant and polarisation, molar polarisation for polar and non-polar molecules. Clausius- Mosotti equation (with derivation) and Debye equations: their applications.	3	2	-	5
Semester-VI (Practical Credit: 01)					
Unit	Content	L	T	P	Total Hours
Laboratory Course	<ol style="list-style-type: none"> 1. Writing and plotting basic expressions and corresponding graphs (e.g. Maxwell-Boltzmann distribution law, radial and angular distribution functions for H-atom etc.) using any spreadsheet software such as MS Excel/LibreOffice etc or simple programming language (GWBasic, FORTRAN, python etc) 2. Plotting the wavefunction and the energy expressions for particle in a box for $n = 1, 2$ and 3 using any spreadsheet software such as MS Excel/LibreOffice etc or simple programming language (GWBasic, FORTRAN, python etc). 3. Numerical evaluation of the the expectation values of position and square of momentum for particle in a 1 D box using the definition of the wavefunction and expectation value using any spreadsheet software such as MS Excel/LibreOffice etc or simple programming language (GWBasic, FORTRAN, python etc). 4. Plotting simple one-dimensional intermolecular potential energies (eg. harmonic, anharmonic, Lennard-Jones potential etc) using any spreadsheet software such as MS Excel/LibreOffice etc or simple programming language (GWBasic, FORTRAN, python etc) and interpreting the potentials. 5. Numerical solution of the 1D Schrodinger equation for particle in a box using any spreadsheet software such as MS Excel/LibreOffice etc or simple programming language (GWBasic, FORTRAN, python etc). 		-	30	30

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Semester	VI
Title of the Course	Industrial Chemistry
Paper Code	CHE-MJ-06044
Total Credits	4 (Theory: 03, Practical: 01)
Distribution of Marks	45 (End Semester Theory) + 25 (End Semester Practical) + 30 (Internal) [Sessional Exam: 15 marks, Home Assignment: 6 marks, Class Test: 5 marks, Attendance: 4 marks]
Course Outcomes	<p>By the end of this course/module, students will be able to:</p> <ul style="list-style-type: none">• CO1: Explain the large-scale production methods, applications, storage requirements, and safety hazards of major industrial gases such as H₂, O₂, N₂, Cl₂, Ar, He, acetylene, and phosgene.• CO2: Describe the manufacturing processes, industrial uses, and safe handling practices of key inorganic chemicals including HCl, HNO₃, H₂SO₄, NaOH, bleaching powder, H₂O₂, potash alum, and KMnO₄.• CO3: Differentiate between various types of glasses (silicate, non-silicate) and correlate their composition with properties such as thermal resistance, optical behavior, and mechanical strength.• CO4: Summarize the manufacture and processing steps of soda-lime, lead, borosilicate, armoured, coloured, and photosensitive glasses and justify their industrial applications.• CO5: Discuss the types of ceramics, raw materials (clays, feldspars), manufacturing processes, and applications of traditional and high-technology ceramics including semiconducting oxides.• CO6: Explain the composition, classification, manufacturing process, and setting mechanism of cements, including quick-setting cements.• CO7: Illustrate the production methods and nutrient functions of common fertilizers such as urea, ammonium nitrate, CAN, phosphates, superphosphate, and potash fertilizers; and distinguish between compound and mixed fertilizers.

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	<ul style="list-style-type: none"> • CO8: Classify different types of surface coatings, paints, pigments, toners, fillers, and special paints, and interpret their formulation, composition, and functional properties including metallic coatings and anodizing. • CO9: Describe the classification, composition, and applications of common alloys (ferrous and non-ferrous), and correlate the properties of steels, brass, bronze, and Cu-Ni alloys with their elemental makeup. • CO10: Analyze the principles and industrial importance of catalysts, including deactivation and regeneration, and evaluate applications of phase-transfer catalysts, zeolites, firecracker chemistry, fire extinguishers, car airbags, and rocket propellants.
No. of Required Classes	45 (Theory) + 30 (Practical)
Details of Course Designer	<ol style="list-style-type: none"> 1. Dr. Pinky Gogoi, Assistant Professor, Department of Chemistry 2. Dr. Manash Protim Hazarika, Assistant Professor, Department of Chemistry
Textbook	<ol style="list-style-type: none"> 1. Stocchi, E. <i>Industrial Chemistry. (Vol.1)</i>. Ellis Horwood Ltd. UK. 2. Sharma, B. K. <i>Industrial Chemistry-I & Industrial Chemistry-II</i>. Krishna's Educational Publishers. 3. Kent, J. A. <i>Riegel's Handbook of Industrial Chemistry</i>. CBS Publishers.
Reference Book	<ol style="list-style-type: none"> 1. Gopalan, R., Venkappayya, D. & Nagarajan, S. <i>Engineering Chemistry</i>. Vikas Publications. 2. Sharma, B. K. <i>Engineering Chemistry</i>. Goel Publishing House.

Semester-VI (Theory Credit: 03)

Paper Code: CHE-MJ-06044

Unit	Content	L	T	P	Total Hours
Unit I: Industrial Gases and Common Inorganic Chemicals	<p>Industrial Gases: large scale production, uses, storage and hazards in handling of the following gases: hydrogen, oxygen, nitrogen, chlorine, argon, helium, acetylene, phosgene.</p> <p>Inorganic Chemicals: manufacture, application and hazards in handling the following chemicals: hydrochloric acid, nitric acid, sulphuric acid, caustic soda, bleaching powder, hydrogen peroxide, potash alum, and potassium permanganate.</p>	6	3	-	9

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Unit II: Silicate Industries	<p>Glass: Glassy state and its properties, classification (silicate and non-silicate glasses).</p> <p>Manufacture and processing of glass: Composition and properties of the following types of glasses: Soda lime glass, lead glass, borosilicate glass, armoured glass, coloured glass, photosensitive glass.</p> <p>Ceramics: important clays and feldspar, ceramic, their types and manufacture. High technology ceramics and their applications, semiconducting oxides.</p> <p>Cements: classification of cement, ingredients and their role, Manufacture of cement and the setting process, quick setting cements.</p>	5	3	-	8
Unit III: Fertilizers	Different types of fertilizers. Manufacture of the following fertilizers: urea, ammonium nitrate, calcium ammonium nitrate, ammonium phosphates; polyphosphate, superphosphate. Compound and mixed fertilizers, potassium chloride, potassium sulphate.	4	2	-	6
Unit IV: Surface Coatings	classification of surface coatings. Paints and pigments- formulation, composition and related properties. Pigments, toners and lake pigments, fillers, thinners, enamels, emulsifying agents. Special paints (heat retardant, fire retardant, eco-friendly and plastic paint), dyes, wax polishing, water and oil paints, additives, metallic coatings (electrolytic and electroless), metal spraying and anodizing.	7	1	-	8
Unit V: Alloys	Classification of alloys, ferrous and non-ferrous alloys, specific properties of elements in alloys. Manufacture composition and properties of different types of steels (stainless steel, Ni-steel, Cr-steel). Brass, bronze and Cu-Ni alloy	5	1	-	6
Unit VI: Catalysis	Catalysts and their industrial applications, deactivation or regeneration of catalysts. Phase transfer catalysts, application of zeolites as catalysts.	2	2	-	4
Unit VII: Pyrotechnics and Propellants	Firecrackers- composition and effect. Fire extinguishers-types and use. Car airbag chemistry. Introduction to rocket propellants.	3	1	-	4

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Semester-6 (Practical Credit: 01)					
Unit	Content	L	T	P	Total Hours
Laboratory Course	<ol style="list-style-type: none">1. Estimation of calcium in calcium ammonium nitrate fertilizer.2. Estimation of phosphoric acid in superphosphate fertilizer.3. Electroless metallic coatings on ceramic and plastic material.4. Determination of composition of dolomite (by complexometric titration).5. Analysis of (Cu, Ni); (Cu, Zn) in alloy or synthetic samples.6. Analysis of Cement.7. Preparation of pigment (zinc oxide).		-	30	30