Morigaon College (Autonomous)

Morigaon: Assam

SYLLABUS

Chemistry

FYUGP

(3rd Semester)

MORIGAON COLLEGE (AUTONOMOUS)
DEPARTMENT OF CHEMISTRY
SYLLABUS
FYUGP Semester – 3

Course Type: CORE
Course Title: **Chemistry III**
Course Code: **CHE-CORE-(MJ/MN)-MC-0300104**
Credit: **(3 L - 0 T- 1 P)**

Course Description:
This core undergraduate course delivers an integrated curriculum bridging advanced concepts across inorganic, organic, and physical chemistry. The inorganic modules expand on molecular acid-base mechanics, standard redox parameters, and transition metal coordination using Valence Bond Theory. The organic chemistry component systematically classifies compounds, investigating their aromaticity, preparation pathways, and underlying reaction mechanisms-spanning halogenated hydrocarbons, alcohols, epoxides, and carbonyl groups. The physical chemistry segment dives deeply into the thermodynamics of ideal and non-ideal solutions, colligative properties, and partial molar quantities.

The accompanying laboratory course transitions students from theory to practice, refining critical quantitative benchmarks in acid-base and redox volumetric analysis and systematic organic functional group decoding.

Learning Objectives:

- Extend core concepts of acids, bases, and coordination chemistry, while introducing redox reactions, ideal solutions, and colligative properties.
- Cover the structure and properties of various organic compounds, including halogenated hydrocarbons, alcohols, phenols, thiols, epoxides, and carbonyls.
- Focus on hands-on laboratory experiments featuring volumetric analysis, chemical identification, and the preparation of organic derivatives.
- Develop students' expertise in both the qualitative (identification) and quantitative (measurement) aspects of chemical analysis.

Course Outcomes:

CO1: Gain a deep understanding of acid/base behaviour, bonding in coordination compounds, principles of redox chemistry, and the behaviour of solutions.

CO2: Master the ability to describe, classify, and predict the chemical reactivity of organic compounds based on their functional groups.

CO3: Consolidate practical analytical skills through hands-on laboratory experience with acid/base and redox titrations.

CO4: Develop the skill to identify common organic functional groups and understand their distinct chemical properties through lab testing.

Course Contents

Unit	Content	Contact Hours
Unit I: Acid and Bases	Acid-base concepts, measure of acid and base strength; proton affinity, acidity and basicity of binary hydrogen compounds; inductive effect and strength of oxyacids; acidity of aqua ions, steric effect, proton sponge, solvation and acid base strength; non-aqueous solvents and acid base strength; levelling effect; superacids and superbases; Hard and soft acids and bases (HSAB): application of HSAB principle and symbiosis.	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 indicators.	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.	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.	3
Unit V: Halogenated compounds	Methods of preparation, properties and relative reactivity of alkyl and aryl halides; Selectivity in electrophilic and nucleophilic substitution reactions (S_NAr).	4
Unit VI: Alcohols, phenols, thiols and related compounds	Preparation, properties and relative reactivity of 1°, 2°, and 3°-alcohols, ethers; reactions of epoxides with alcohols, ammonia derivatives, and $LiAlH_4$; thiols and sulfides; phenols (preparation, properties and reactivity; Reimer-Tiemann and Kolbe's-Schmidt Reactions)	4
Unit VII: Carbonyl compounds	Structure and reactivity; oxidations (Jones reagent, PCC and PDC, Oppenauer, Baeyer Villiger oxidation) and reductions (Clemmensen, Wolff-Kishner, $NaBH_4$, $LiAlH_4$, MPV),	4
Unit VIII: Solution	Vapour pressure of solution; Raoult's law & Henry's Law; ideal solutions, ideally diluted solutions and colligative properties; Thermodynamic derivation of colligative properties of solution (using chemical potentials) and their inter-relationships; Abnormal colligative properties.	7
Unit IX: Partial molar quantities	Fugacity, activity coefficients and concept of chemical potential: Gibbs Duhem equation and Duhem-Margules equation: their use and application; Enthalpy, free energy and entropy of mixing; excess thermodynamic functions.	8
Laboratory Course III	***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. d) Estimation of Fe(II) with $K_2Cr_2O_7$ using internal indicator (diphenylamine).	30

	Group B Qualitative organic analysis for N, S and halogen in a given organic compound a) Identification of functional groups in a given organic sample: Simple functional groups such as alcohols, phenols, amines, nitro, carbonyl and carboxylic acid groups. b) Prepare derivatives of a given organic sample containing single functional group (i.e. alcohols, phenols, amines, nitro, carbonyl and carboxylic acid group). (Students need to perform at least two experiments from Group A and B.)	
Text/ Reference Books:	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. Inorganic Chemistry (Principles of Structure and Reactivity), J. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, 5th edition, Pearson Education. 4. Principles of Physical Chemistry, Puri, Sharma, Pathania, 48th edition, Vishal Publishing House. 5. Atkins Physical Chemistry, Atkins, de Paula and Keeler, 11th edition, Oxford University Press. 6. March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, Michael B. Smith 7th edition (Wiley). 7. Organic Chemistry, Volume 1, I. L. Finar, 5th edition. 8. Organic Chemistry, L. G. Wade Jr., Maya Shankar Singh, 6th edition. 9. Organic Chemistry, P. Y. Bruice, 8th edition, Pearson Eduacation.	

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DEPARTMENT OF CHEMISTRY
SYLLABUS
FYUGP Semester – 3

Course Type: CORE
Course Title: **Molecular Spectroscopy I**
Course Code: **CHE-CORE(MJ)-MC-0300204**
Credit: **(4 L - 0 T- 0 P)**

Course Description:
This core undergraduate course focuses on the fundamental theories, mechanics, and physical applications of photochemistry alongside major branches of molecular spectroscopy. The curriculum acts as a conceptual bridge between quantum chemistry principles and structural identification techniques used to decode unknown chemical systems. Students will first explore photochemical reaction pathways, energy degradation, and quantum yield laws. Following this, the course systematically details interaction regimes of electromagnetic radiation with matter, moving through the rules and structural implications of rotational (microwave), vibrational (IR), electronic (UV-Vis), and Raman spectroscopy.

Learning Objectives:

- To provide a fundamental understanding of the theories and applications of photochemistry.
- To introduce various spectroscopic techniques, specifically rotational, vibrational, electronic, and Raman spectroscopy.

Course Outcomes:
CO1: Students will learn the core theories of photochemistry and spectroscopy, alongside their specific applications in the field of chemistry.
CO2: Learners will be able to apply the knowledge gained from quantum theories to identify unknown chemical compounds using modern techniques.

Course Contents

Unit	Content	Contact 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.	12
Unit II: Introduction to 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.	12

Unit III: Rotational Spectroscopy	Microwave (pure rotational) spectra of diatomic molecules; selection rules and transition dipole moment; structural information derived from rotational spectroscopy; IR Spectroscopy: selection rules, IR spectra of diatomic molecules and organic compounds having functional groups.	12
Unit IV: Vibrational Spectroscopy & Raman Spectroscopy	Structural information derived from vibrational spectra; vibrations of polyatomic molecules; group frequencies; effect of hydrogen bonding (inter and intramolecular) and substitution on vibrational frequencies. 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.	12
Unit V: Electronic Spectroscopy	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.	12
Text/ Reference Books:	Textbooks: 1. Fundamentals of Molecular Spectroscopy, C N Banwell, 4th Edition, McGraw-Hill. 2. Atkins Physical Chemistry, P Atkins, J Paula and J Keeler, 11th Edition, Oxford University Press. 2018. Reference Books: 1. Introduction to Spectroscopy, DL Pavia, GL Lampman, GS Kriz and J R Vyvyan, 5th Edition, Cengage India Private Limited, 2015. 2. Introduction to Molecular Spectroscopy: G M Barrow, McGraw Hill, 1992. 3. Basic Atomic and Molecular Spectroscopy, Vol 11, J M Hollas, Royal Society of Chemistry, 2002. 4. Symmetry and Spectroscopy: an introduction to vibrational and electronic spectroscopy, DC Harris and M D Bertolucci, 1989, Dover Publications. 5. Molecular Spectroscopy, JL McHale, 2nd Edition, CRC Press 6. Atomic and Molecular Spectroscopy: Basic Concepts and Applications. Rita Kakkar, 2nd Edition, S Chand Publishing	

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Course Type: SEC
Course Title: **Chemistry Tools for Environmental Monitoring**
Course Code: **SEC-CHE-MC-0300103**
Credit: **(2 L - 0 T- 1 P)**

Course Description:

This course introduces students to the chemistry of environmental pollution, focusing on the sources, effects, monitoring, and control of air, water, and soil pollutants. It covers key concepts such as air quality, greenhouse gases, ozone depletion, water and soil quality parameters, BOD, COD, eutrophication, biomagnification, and heavy metal contamination. The course also provides practical training in standard analytical techniques for assessing environmental quality, enabling students to understand pollution-related challenges and apply chemical methods for environmental monitoring and sustainable management.

Learning Objectives:

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

- Understand the sources, types, and chemical processes involved in air, water, and soil pollution.
- Explain the impact of environmental pollutants on ecosystems and human health, along with appropriate pollution control and mitigation strategies.
- Develop knowledge of key environmental quality parameters, including pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), and chemical oxygen demand (COD), for pollution assessment.
- Acquire practical skills in the analysis of environmental samples using standard chemical methods for monitoring water and soil quality.
- Promote environmental awareness and sustainable practices through the application of chemical principles in pollution prevention and environmental management.

Course Outcomes:

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

CO1: Explain the chemical principles underlying air, water, and soil pollution and identify their major sources and environmental impacts.

CO2: Evaluate environmental quality using key pollution indicators such as pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), and other relevant parameters.

CO3: Perform standard laboratory techniques for the qualitative and quantitative analysis of pollutants in environmental samples, including water and soil.

CO4: Analyze the effectiveness of pollution control and remediation strategies and recommend sustainable approaches for environmental protection.

CO5: Apply chemical knowledge and analytical skills to assess environmental pollution problems and promote environmentally responsible practices.

Course Contents

Unit	Content	Contact Hours
Unit I: Chemistry of Air Pollution	Parameters of air quality and their permissible limits; contaminants and pollutants; primary air pollutants and formation of secondary air pollutants, smog formation; automobile vehicles as a source of air pollution and its control using catalytic converters; increasing level of CO_2 in air and green house effect, measures (such as shifting to greener energy sources, afforestation, preventing deforestation, etc.) to control CO_2 pollution; CFCs as pollutants, ozone layer depletion and measures for its mitigation.	14
Unit II: Chemistry of Soil and Water Pollution	Parameters of water and soil, their permissible limits; soil and water pollution due to anthropogenic sources: changes in pH in both cases, reclamation of problem soil, adverse effects of petroleum exploration and processing on soil and water; concept of BOD and COD of water, increase of BOD in water, decrease of dissolved oxygen in water, effect of industrial effluents and thermal pollution on aquatic life, pesticides in soil and water, its trophic level biomagnification; groundwater pollution by pesticides and heavy metals; fertilizers, detergents and sewage as water pollutants, eutrophication of water bodies.	16
Laboratory Course	1. Determination of dissolved oxygen in a water sample. 2. Determination of COD in a water sample. 3. Indicating presence of soaps and detergents in water sample by surface tension measurements with distilled water as the reference liquid. 4. Determination of lead in ground water by complexometric titration.	30
Text/ Reference Books:	1. De, A. K. Environmental Chemistry. 8th Edition, New Age International Publishers, New Delhi. 2. Manahan, S. E. Environmental Chemistry. 10th Edition, CRC Press, Boca Raton. 3. Anastasia M. and V. K. Ahluwalia. Environmental Chemistry. Ane Books Pvt. Ltd., New Delhi.	