Home

Savitribai Phule Pune University, Pune
(Formerly University of Pune)

Under-Graduate Program in Chemistry

(Faculty of Science and Technology)

New Syllabus of T.Y.B.Sc. Chemistry

(As Per National Education Policy-2020)

For Colleges Affiliated to Savitribai Phule Pune University

(To be implemented with effect from Academic Year 2026-2027)

Board of Studies in Chemistry

Savitribai Phule Pune University, Pune

Contents

1. Introduction to T.Y.B.Sc. Chemistry

The Third Year B.Sc. Chemistry programme is designed in accordance with the National Education Policy (NEP) framework and the guidelines of Savitribai Phule Pune University, Pune. The curriculum aims to provide strong theoretical foundations, advanced practical laboratory training, skill enhancement, research orientation, and experiential learning opportunities to students. The programme consists of Major Core Courses, Major Elective Courses, Vocational Skill Courses (VSC), Field Project (FP), and On-the-Job Training (OJT). The curriculum is designed to enhance analytical thinking, laboratory competency, communication skills, scientific temperament, employability, and entrepreneurship abilities among students.

The T.Y.B.Sc. Chemistry programme also emphasizes:

- Practical laboratory skills,
- Green chemistry approaches,
- Instrumentation techniques,
- Research-based learning,
- Field-based applications,
- Industrial exposure,
- Professional ethics and safety practices.

The programme prepares students for:

- Higher education,
- Research,
- Chemical and pharmaceutical industries,
- Quality control laboratories,
- Environmental analysis,
- Entrepreneurship,
- Competitive examinations,
- Teaching and allied scientific careers.

2. Credits for Third Year

The Third Year B.Sc. Chemistry programme consists of two semesters:

Semester	Credits
Semester V	22
Semester VI	22
Total Credits	**44**

3. Credit Structure of T.Y.B.Sc. Chemistry

Level	Sem	Major Core	Major Elective	VSC	FP/OJT/ CEP	Minor	Total
5.5	V	8(T) + 4(P)	2(T) + 2(P)	2(T/P)	2(FP/CEP)	2(T)	22
	VI	8(T) + 4(P)	2(T) + 2(P)	2(T/P)	4(OJT)	--	22
						Total	**44**

4. Methods of Assessment

The primary objective of assessment is to evaluate the attainment of learning outcomes of the course in tune with strengthening theoretical knowledge, laboratory competency, analytical ability, research aptitude, and skill development.

Assessment shall be based on:

- Continuous Internal Evaluation (CIE)
- End Semester Examination (ESE)

The assessment system is designed according to the guidelines of Savitribai Phule Pune University, Pune.

A) Continuous Internal Evaluation (CIE)

During the semester, students' performance shall be assessed through various academic activities such as:

- Short answer tests
- Class tests
- Assignments
- Tutorials
- Seminars
- Presentations
- Group discussions
- Quiz competitions
- MCQ-based tests
- Practical performance
- Project work
- Field work

- Viva-voce
- Report writing
- Attendance and participation

Internal Marks Distribution

Course Type	Internal Marks
2 Credit Course	15 Marks
4 Credit Course	30 Marks

Internal assessment shall be conducted by the concerned college/department.

B) End Semester Examination (ESE)

The End Semester Examination shall be conducted by Savitribai Phule Pune University, Pune for both theory and practical courses.

The examination pattern includes:

- Written examination
- Practical examination
- Viva-voce
- Presentation
- Report evaluation (wherever applicable)

External Marks Distribution

Course Type	External Marks
2 Credit Course	35 Marks
4 Credit Course	70 Marks

C) Scheme of Examination

Course Type	Internal	External	Total
2 Credit Course	15	35	50
4 Credit Course	30	70	100

Internal examinations shall be conducted by the college, while external examinations shall be conducted by Savitribai Phule Pune University, Pune at the end of each semester.

5. Important Guidelines for Practical Courses

a. It is mandatory for students to produce a certified practical journal during the practical examination.

b. Use of molar concentrations is recommended for volumetric analysis, estimations, and synthesis experiments.

c. Optimum concentrations and minimum chemical quantities should be used wherever possible.
d. Two-burette methods should be followed for volumetric analysis of homogeneous mixtures.
e. Use of microscale techniques and green chemistry practices is recommended wherever applicable.
f. Proper laboratory safety practices must be followed during practical sessions.
g. Students should maintain neat, systematic, and updated laboratory records.
h. Scientific calculations, observations, and results must be properly recorded and verified by the teacher.
i. Students must follow ethical laboratory practices and proper chemical waste disposal methods.
j. Attendance during practical sessions is compulsory.

6. T.Y.B.Sc. Chemistry Course Structure

Year	Level	Sem	Course Type	Course Code	Course Title	Remark	Credit
3	5.5	V	MAJOR CORE	CHE-301-MJ-T	PHYSICAL CHEMISTRY-II	THEORY	2
			MAJOR CORE	CHE-302-MJ-T	INORGANIC CHEMISTRY-II	THEORY	2
			MAJOR CORE	CHE-303-MJ-T	ORGANIC CHEMISTRY-II	THEORY	2
			MAJOR CORE	CHE-304-MJ-T	ANALYTICAL CHEMISTRY-II	THEORY	2
			MAJOR CORE	CHE-305-MJP	PHYSICAL CHEMISTRY PRACTICAL-I	PRACTICAL	2
			MAJOR CORE	CHE-306-MJP	INORGANIC CHEMISTRY PRACTICAL-I	PRACTICAL	2
			MAJOR ELECTIVE	CHE-310-MJ-T	POLYMER CHEMISTRY	THEORY	2
				CHE-311-MJ-T	ENVIRONMENTAL CHEMISTRY	THEORY	
				CHE-312-MJ-T	BIOCHEMISTRY	THEORY	
			MAJOR ELECTIVE	CHE-313-MJP	ORGANIC CHEMISTRY PRACTICAL-I	PRACTICAL	2
			VOCATIONAL SKILL COURSE	CHE-321-VSC-T	PHARMACEUTICAL ANALYTICAL CHEMISTRY	THEORY	2
			FIELD PROJECT	CHE-331 FP	FIELD PROJECT	FP	2
			MINOR	CHE-341-MN-T	INTERDISCIPLINARY CHEMISTRY	THEORY	2
		VI	MAJOR CORE	CHE-351-MJ-T	PHYSICAL CHEMISTRY-III	THEORY	2
			MAJOR CORE	CHE-352-MJ-T	INORGANIC CHEMISTRY-III	THEORY	2

			MAJOR CORE	CHE-353-MJ-T	ORGANIC CHEMISTRY-III	THEORY	2
			MAJOR CORE	CHE-354-MJ-T	ANALYTICAL CHEMISTRY-III	THEORY	2
			MAJOR CORE	CHE-355-MJP	PHYSICAL CHEMISTRY PRACTICAL-II	PRACTICAL	2
			MAJOR CORE	CHE-356-MJP	ORGANIC CHEMISTRY PRACTICAL-II	PRACTICAL	2
			MAJOR ELECTIVE	CHE-360-MJ-T	MATERIAL CHEMISTRY	THEORY	2
				CHE-361-MJ-T	FORENSIC CHEMISTRY	THEORY	
				CHE-362-MJ-T	MEDICINAL CHEMISTRY	THEORY	
			MAJOR ELECTIVE	CHE-363 MJP	INORGANIC CHEMISTRY PRACTICAL-II	PRACTICAL	2
			VOCATIONAL SKILL COURSE	CHE 371-VSC-P	APPLIED ANALYTICAL CHEMISTRY	Practical	2
			ON JOB TRAINING	CHE-381 OJT	OJT	OJT	4

SEMESTER V

CHE-301-MJ-T: PHYSICAL CHEMISTRY II

Course Type: Major Theory **Credits: 2**

A. Course Objectives:

1. To provide fundamental knowledge of electrochemistry, nuclear chemistry, and quantum chemistry.
2. To develop conceptual understanding of energy transformations and atomic-level phenomena.
3. To familiarize students with electrode potentials, radioactivity, and quantum models.
4. To build a strong foundation in theoretical approaches of physical chemistry.
5. To promote insight into modern chemical and energy-related systems.

B. Course Outcomes (COs):

CO No.	Course Outcome Statement (COs) *After learning the course, the students are able to -*
CO-1	Recall basic concepts of electrochemistry, nuclear chemistry, and quantum chemistry.
CO-2	Explain principles of electrochemical cells, radioactive decay, and quantum models.
CO-3	Apply Nernst equation, decay laws, and quantum models to solve problems.
CO-4	Analyze electrochemical systems, nuclear processes, and quantum models.
CO-5	Evaluate applications of batteries, radioisotopes, and quantum concepts.
CO-6	Formulate solutions using electrochemical, nuclear, and quantum principles.

C. Contents:

Prerequisites	
Students should have a basic understanding of physical chemistry concepts such as thermodynamics, chemical equilibrium, and atomic structure from undergraduate level. Familiarity with elementary mathematics (logarithmic and exponential relations) and basic theoretical concepts of chemistry is required.	
Chapter 1: Electrochemical Cells	**10 Hours**
Electrochemical cells: concept, construction, working. Reversible and irreversible cells. Electromotive force (e.m.f.) and its measurement. Reference electrodes: Standard Hydrogen Electrode (SHE), Calomel, Ag/AgCl electrode. Weston standard cell (historical mention).	

Nernst equation for electrode potential and cell e.m.f. Sign convention, cell representation. Thermodynamics of reversible cells: Relationship between E, ΔG, and K. Electrochemical series and applications. Concentration cells, liquid junction potential, salt bridge. Applications: pH determination (Hydrogen & Glass electrode). Potentiometric titrations (Acid-base & Redox). Batteries: Primary and Secondary types, applications. Fuel cells: Types, principle, advantages, limitations. Comparison of batteries and fuel cells.

Chapter 2: Nuclear Chemistry	**10 Hours**

Radioactivity: Types (α, β, γ) and properties of radiations. Detection & Measurement: Geiger-Muller Counter, Scintillation Counter, Ionization Chamber, Film Badges. Nuclear structure. Classification of nuclides (Isotopes, Isobars, Isotones, Isomers). Radioactive decay processes, Group Displacement Law. Kinetics of decay: Decay constant, half-life, average life. Nuclear energy: Mass defect, Binding energy. Applications of radioisotopes as tracers: Chemical investigation (Esterification, Friedel-Crafts), Structural determination (PCl_5), Age determination (Tritium, C-14 dating).

Chapter 3: Quantum Chemistry	**10 Hours**

Introduction: Need for quantum mechanics. Recapitulation: de Broglie hypothesis, Heisenberg's uncertainty principle. Postulates of quantum mechanics, operators, and observables. Time-independent Schrödinger wave equation, conditions for a well-behaved wave function. Particle in a 1-D box (derivation), 2-D and 3-D box (concept). Physical interpretation of ψ and ψ^2, sketching for 1-D box. Degeneracy. Applications to conjugated systems. Vibrating particle: vibrational energy levels, zero-point energy, concept of quantum tunneling. Numerical.

References:

1. Principles of Physical Chemistry, B. R. Puri, L. R. Sharma, M. S. Pathania, Vishal Publishing Co., 50th Edition, 2025
2. Essentials of Physical Chemistry, B. S. Bahl, G. D. Tuli, Arun Bahl, S. Chand & Company Ltd., 28th Edition, 2022
3. Elements of Nuclear Chemistry, H. J. Arnikar, S. Chand & Company Ltd., 4th Edition, 2009
4. Modern Electrochemistry, Volume 2, J. O'M. Bockris, A. K. N. Reddy, Plenum Press (Springer), 2nd Edition, 2000
5. Physical Chemistry, Peter Atkins, Julio de Paula, Oxford University Press, 11th Edition, 2018

CHE-302-MJ-T: INORGANIC CHEMISTRY II

Course Type: Major Theory **Credits: 2**

A. Course Objectives:

1. To provide fundamental knowledge of molecular orbital theory for covalent and coordination compounds.
2. To familiarize students with bonding concepts and electronic structure of inorganic systems.
3. To develop understanding of properties and chemistry of d- and f-block elements.
4. To introduce concepts of organometallic chemistry and homogeneous catalysis.
5. To promote insight into structure–property relationships and catalytic processes in inorganic chemistry.

B. Course Outcomes (COs):

CO No.	Course Outcome Statement (COs) *After learning the course, the students are able to -*
CO-1	Recall concepts of MOT, coordination complexes, d- and f-block elements, and organometallic chemistry.
CO-2	Explain bonding, structure, and properties of inorganic systems.
CO-3	Apply concepts to determine bond order, stability, and reactivity.
CO-4	Analyze trends in coordination complexes and d- and f-block elements.
CO-5	Evaluate catalytic behavior and applications of organometallic systems.
CO-6	Illustrate bonding models and structure–property relationships.

C. Contents:

Prerequisites	
Students should have basic knowledge of atomic structure, periodic table, and chemical bonding (VBT and CFT). Familiarity with electronic configuration, basic inorganic reactions, and elementary coordination chemistry is required.	
Chapter 1: Molecular Orbital Theory of Covalent Compounds	**05 Hours**
Limitations of Valence Bond Theory(VBT), Concept of molecular orbitals, Linear Combination of Atomic Orbitals (LCAO) principle and rules, Bonding combinations of AOs: s-s, s-p, p-p and d-d, Types of molecular orbitals: Bonding, antibonding, non-bonding. MO Energy level diagrams for homonuclear diatomic molecules, Bond order, existence, energy (β) and magnetic behaviour of molecules or ions: H_2, H^{2+}, He^{2+}, Li_2, Be_2, B_2, C_2, N_2, O_2, O_2^+,	

O_2^-, O_2^{2-}, F_2 and Ne_2. MO energy level diagrams for heteronuclear diatomic molecules: CO and HF. **[Ref-1 to 3:** Relevant Pages**]**
Chapter 2: Molecular Orbital Theory for Coordination Complexes **05 Hours**
Electroneutrality principle, Nephelauxetic effect and need of MOT over VBT and CFT for explaining M-L bonding, Assumptions of MOT for coordination complexes and formation of MOs w.r.t. bonding, antibonding, and non-bonding MOs, MO energy level diagrams for octahedral complexes with σ-bond: $[Ti(H_2O)_6]^3$, $[Co(NH_3)_6]^3$, $[Fe(H_2O)_6]^2$, $[CoF_6]^{4-}$ & $[Co(CN)_6]^{4-}$ and $[Fe(F)_6]^{3-}$ & $[Fe(CN)_6]^3$, H.S. and L.S. complexes, and effect of π bonding on MO diagram and charge transfer transitions. **[Ref-1 to 4:** Relevant Pages**]**
Chapter 3: Chemistry of d and f-block Elements **10 Hours**
d-Block elements: [03 Hours] Position in periodic table, occurrence, electronic configuration. Trends in properties w.r.t.(a) size of atoms and ions (b) reactivity (c) catalytic activity (d) oxidation state (e) complex formation ability (f) colour (g) magnetic property (h) non-stoichiometry (i) density, melting & boiling points. **f-Block elements:** Introduction on the basis of electronic configurations, occurrence and reactivity, f-block elements as Lanthanide and Actinide series **I. Lanthanides: [04 Hours]** Position in periodic table, Name and electronic configuration of lanthanides and Oxidation States. Atomic and ionic radii, Lanthanide contraction: its causes and consequences. Occurrence and separation: Bulk separation, Individual separation by modern methods *viz.,* Ion exchange method and solvent extraction method, and applications of lanthanides. **II. Actinides: [03 Hours]** Position in periodic table, names and their electronic configurations. Oxidation States, Occurrence and general methods of preparation of transuranic elements *viz.,* Neutron Bombardment, Accelerated projectile bombardment and Heavy ion bombardment. Nuclear Fuels-Nuclear fission and fusion fuels in brief, comparison between Lanthanides and Actinides. [**Ref-1:** Pages: 859-863, 865-866; **Ref-5:** Pages: 639-685]
Chapter-4: Organometallic Chemistry and Homogeneous Catalysis **10 Hours**
Definition of Organometallic compounds and Organometallic chemistry, CO as a *π*-acid donor ligand, binary metal carbonyls, synthesis of metal carbonyls; (a) Direct reaction (b)

Reductive carbonylation (c) Photolysis and thermolysis. Hepticity, Molecular and electronic structures of binary metal carbonyls, Electron count in complexes (18 electron rule). Chemistry of ferrocene; Introduction, synthesis and physical properties of ferrocene. Reactions of ferrocene such as Friedel-Craft Acylation, Friedel-Craft Alkylation, Mannich reaction, Nitration and Halogenation

Applications of organometallic compounds in industrial catalysis (list of examples). Introduction to Catalysis, basic principles, activity and selectivity in catalysis, Types of catalysis, Homogeneous catalysis: importance of catalysis in the synthesis of high value chemicals. Catalytic cycles for: a) Hydrogenation of olefins using Wilkinson's complex, b) Hydroformylation of olefins using Co and Rh complexes, c) Carbonylation of methanol - Monsanto processes and d) C-C coupling reaction: Heck reaction.

[Ref-1: Pages: 534-542,553-564, 690-721; **Ref-2:** Pages: 534-542,553-564, 690-721; **Ref-7**; Pages: 13-23, 55-61,85-102, 161-16**]**

References:

1. Concise Inorganic Chemistry, J. D. Lee, Blackwell Science, 5th Edition, 1996.
2. Inorganic Chemistry, D. F. Shriver, P. W. Atkins, C. H. Langford, ELBS, 2nd Edition, 1994.
3. Concepts and Models of Inorganic Chemistry, B. E. Douglas, D. H. McDaniel, J. J. Alexander, Wiley, 3rd Edition, 1994.
4. Inorganic Chemistry, G. L. Miessler, D. A. Tarr, Pearson, 3rd Edition, 2010.
5. Principles of Inorganic Chemistry, B. R. Puri, L. R. Sharma, K. C. Kalia, Milestone Publications.
6. Homogeneous Catalysis: The Applications and Chemistry of Catalysis by Soluble Transition Metal Complexes, G. W. Parshall, S. D. Ittel, Wiley, 1992.
7. Homogeneous Catalysis: Mechanisms and Industrial Applications, S. Bhaduri, D. Mukesh, Wiley, 2000.

CHE-303-MJ-T: ORGANIC CHEMISTRY II

Course Type: Major Theory **Credits: 2**

A. Course Objectives:

1. To provide knowledge of electrophilic aromatic substitution and aromatic reactivity.
2. To familiarize students with heterocyclic compounds and their chemical behavior.
3. To introduce important named reactions and molecular rearrangements.
4. To develop understanding of stereochemical concepts and molecular chirality.
5. To build insight into retrosynthetic analysis and synthetic planning.

B. Course Outcomes (COs):

CO No.	Course Outcome Statement (COs) *After learning the course, the students are able to -*
CO-1	Recall concepts of aromatic substitution, heterocyclic chemistry, named reactions, stereochemistry, and retrosynthesis.
CO-2	Explain mechanisms, reactivity, and stereochemical aspects of organic compounds.
CO-3	Apply principles to predict products and plan synthetic routes.
CO-4	Analyze reaction pathways, stereochemical outcomes, and synthetic strategies.
CO-5	Evaluate reaction efficiency, selectivity, and applicability in organic synthesis.
CO-6	Illustrate mechanisms, stereochemical relationships, and retrosynthetic disconnections.

C. Contents:

Prerequisites	
Students should have basic knowledge of organic reaction mechanisms, functional groups, and chemical bonding. Familiarity with electronic effects (inductive, resonance), stereochemistry basics, and reaction intermediates is required.	
Chapter 1: Electrophilic Aromatic Substitution Reactions	**06 Hours**
Introduction to aromaticity and stability of aromatic systems, General mechanism of electrophilic aromatic substitution (formation of σ-complex/arenium ion). Nitration, sulfonation, halogenation, Friedel-Crafts alkylation and acylation reactions. Orientation and reactivity in monosubstituted benzenes: activating and deactivating groups, ortho/para and meta directing effects, Multiple substitutions, steric and electronic effects, Electrophilic substitution in polycyclic aromatic hydrocarbons (naphthalene: α and β orientation)	

Chapter 2: Heterocyclic Chemistry	06 Hours
Introduction and classification of heterocyclic compounds. Aromaticity in heterocycles. Structure, aromatic character and reactivity of five-membered heterocycles: pyrrole, furan and thiophene. Paal–Knorr synthesis. Electrophilic substitution reactions of pyrrole, furan and thiophene: reactivity and orientation, Structure of pyridine: basicity, effect of nitrogen on reactivity, Electrophilic and nucleophilic substitution reactions of pyridine.	
Chapter 3: Named Reactions and Rearrangements	**08 Hours**
Aldol condensation, Cannizzaro reaction, Perkin reaction, Reformatsky reaction, Diels-Alder reaction, Wittig reaction, Pinacol-pinacolone rearrangement, Beckmann rearrangement, Hofmann rearrangement, Baeyer-Villiger oxidation, Benzil-Benzillic acid rearrangement, Curtius and Schmidt rearrangements	
Chapter 4: Stereochemistry	**05 Hours**
Optical isomerism in compounds with and without stereocenters; optical isomerism without a classical stereogenic center; axial chirality and its origin; optical isomerism in allenes; optical isomerism in substituted biphenyls; restricted rotation and atropisomerism; helical and planar chirality (introductory). Polycyclic systems: structural features of fused ring systems; conformation of cis-decalin and trans-decalin	
Chapter 5: Retrosynthetic Analysis	**05 Hours**
Introduction to retrosynthesis and synthetic planning. Concepts and terminology: target molecule (TM), retrosynthetic analysis, disconnection approach, functional group interconversion (FGI), functional group addition (FGA), synthon and synthetic equivalent, One-group and two-group disconnections. Retrosynthetic analysis of acetophenone, ethyl acetoacetate, 1,3-diphenyl-2-propen-1-one, cinnamic acid, 1-(4-methoxy-3-nitrophenyl)ethan-1-one	

References:

1. Organic Chemistry, Jonathan Clayden, Nick Greeves, Stuart Warren, Oxford University Press, 2nd Edition, 2012.
2. Organic Chemistry, R. T. Morrison, R. N. Boyd, Pearson Education, 7th Edition, 2010.
3. Organic Chemistry, T. W. G. Solomons, Craig B. Fryhle, Scott A. Snyder, Wiley, 12th Edition, 2016.
4. Organic Chemistry, Paula Yurkanis Bruice, Pearson Education, 8th Edition, 2016.
5. Heterocyclic Chemistry, J. A. Joule, K. Mills, Wiley-Blackwell, 5th Edition, 2010.
6. A Textbook of Heterocyclic Chemistry, V. K. Ahluwalia, Renu Aggarwal, CRC Press,

2nd Edition, 2016.
7. Advanced Organic Chemistry, I. L. Finar, Volume I, Pearson Education, 6th Edition, 2009.
8. Strategic Applications of Named Reactions in Organic Synthesis, László Kürti, Barbara Czakó, Elsevier, 1st Edition, 2005.
9. Stereochemistry of Organic Compounds, Ernest L. Eliel, Samuel H. Wilen, Wiley, 1st Edition, 1994.
10. Organic Chemistry, Francis A. Carey, Richard J. Sundberg, Springer, 5th Edition, 2007.
11. Organic Synthesis, Michael B. Smith, Wiley, 3rd Edition, 2010.
12. Designing Organic Syntheses, Stuart Warren, Paul Wyatt, Wiley, 2nd Edition, 2008.

CHE-304-MJ-T: ANALYTICAL CHEMISTRY II

Course Type: Major Theory **Credits: 2**

A. Course Objectives:

1. To provide fundamental knowledge of gravimetric and thermal analytical techniques.
2. To familiarize students with chromatographic methods for separation and analysis.
3. To introduce principles of instrumental techniques such as HPLC and GC.
4. To develop understanding of analytical procedures and quantitative estimations.
5. To promote insight into modern analytical methods and their applications

B. Course Outcomes (COs):

CO No.	Course Outcome Statement (COs) *After learning the course, the students are able to -*
CO-1	Recall concepts of gravimetric analysis, thermal methods, and chromatographic techniques.
CO-2	Explain principles and instrumentation of analytical methods.
CO-3	Apply analytical techniques for quantitative determination and separation.
CO-4	Analyze data from gravimetric, thermal, and chromatographic methods.
CO-5	Evaluate accuracy, efficiency, and applications of analytical techniques.
CO-6	Illustrate working principles and methodologies of instrumental analysis.

C. Contents:

Prerequisites	
Students should have basic knowledge of analytical chemistry, chemical equilibrium, and solution chemistry. Familiarity with basic laboratory techniques, stoichiometry, and elementary instrumentation concepts is required.	
Chapter 1: Gravimetric Analysis	**06 Hours**
Introduction to gravimetric analysis; Precipitation methods; The colloidal state; Super saturation and precipitate formation; The purity of the precipitate: Co-precipitation; Conditions of precipitation; Precipitation from homogeneous solution; Washing the precipitate; Ignition of the precipitate: quantitative separations based upon precipitation methods: Fractional precipitation; Organic precipitants (8-hydroxyquinoline, DMG, Cupferron, Nitron, and Benzoin-alfa oxime, Anthranilic acid), Gravimetric Calculations-How Much Analyte is there (Ref-3) Applications of Gravimetry: Determination of Al(III) by 8-hydroxyquoline, Determination of calcium as oxalate, Numericals, Key Ref.-1: 417-428,	

433-444, 446, 451, 464, 485; [Supplementary Ref-2: Pp-342 to 362]	
Chapter 2: Thermal Methods of Analysis	**06 Hours**
General discussion, Thermogravimetry, Experimental factors affecting TG analysis, Instruments for thermogravimetry, Applications: Thermogravimetric analysis of CaC_2O_4 H_2O, $CuSO_4$ $5H_2O$, Differential Thermal Analysis: Introduction, instrumentation for DTA and DSC, experimental and instrumental factors, applications: DTA of copper sulphate pentahydrate, Purity of Pharmaceutical by DSC. Key Reference-2: 503-522, [Supplementary reference, Ref-4: 884-890, Ref-1: 428-433].	
Chapter 3: Column Chromatography	**07 Hours**
Introduction, HETP, Match Box Model, Principle of Column Chromatography, **Ion Exchange Chromatography**: Ion exchange resins, action of ion exchange resin (Ion exchange equilibria, Ion exchange capacity), Experimental technique, **Application**: i) Separation Metal ions / non-metal ions on Ion Exchange Chromatography (Zn(II) and Mg(II), Cl- and Br-), ii) Purification of water, (Ref-5: 186-192, 205-209) **Adsorption Chromatography Liquid solid chromatography**: Introduction, the technique of conventional chromatography, column packing materials, Selection of solvent for adsorption chromatography, Adsorption column preparation and loading, **Application:** Purification of anthracene (Ref-6: 209-215, 221).	
Chapter 4: High Performance Liquid Chromatography	**07 Hours**
Introduction, Types of liquid chromatography (liquid-solid, liquid-liquid), Choice of mode of separation, Equipment for HPLC: mobile phase, sample injection and column design (mobile phase, optimization of mobile phase, gradient elution, solvent delivery and sample injection, sample injection system, the column (effect of column length and column diameter), Choosing the Detector, Ultraviolet detector, Luminescence detector, electrochemical detector, Column efficiency, HPLC chromatogram and its characteristics (retention time, peak height, peak area), Method of quantitative analysis by HPLC, Example: Determination of aspirin, phenacetin and caffeine in a mixture, Numericals, Key Ref-2: 289-315, [Supplementary reference - Ref-3: 649-724, Ref-3: 1-325 -relevant part, Ref-7].	
Chapter 5: Gas Chromatography	**04 Hours**
Gas Chromatography:- Introduction, Apparatus: A supply of carrier gas from a high-pressure cylinder, Sample injection system and derivatization, The column (Packed columns, Open tubular columns), Detectors (TCD, FID, ECD), Quantitative analysis by GC (Area normalization method and internal standard addition method), Elemental analysis, numerical	

Key. Ref. 2. And Ref. 8

References:

1. Vogel's Textbook of Inorganic Quantitative Analysis, G. H. Jeffery, J. Bassett, J. Mendham, R. C. Denney, Longman Scientific & Technical, 5th Edition, 1989.
2. Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R. C. Denney, J. D. Barnes, M. J. K. Thomas, Pearson Education, 6th Edition, 2000.
3. Analytical Chemistry, G. D. Christian, Wiley, 6th Edition, 2004.
4. Principles of Instrumental Analysis, D. A. Skoog, F. J. Holler, S. R. Crouch, Thomson Brooks/Cole, 6th Edition, 2007.
5. Vogel's Textbook of Quantitative Chemical Analysis, G. H. Jeffery et al., Longman Scientific & Technical, 5th Edition, 1989.
6. Vogel's Textbook of Practical Organic Chemistry, A. I. Vogel, Longman Scientific & Technical, 5th Edition, 2004.
7. Principles of Instrumental Analysis, D. A. Skoog, F. J. Holler, S. R. Crouch, Thomson Publication, 6th Edition, 2007.
8. Instrumental Methods of Chemical Analysis, Gurdeep Chatwal, Sham Anand, Himalaya Publishing House, Latest Edition.

CHE-305-MJP: PHYSICAL CHEMISTRY PRACTICAL I

Course Type: Major Practical **Credits: 2**

A. Course Objectives:

1. To perform quantitative analysis and interpret experimental data.
2. To introduce basic computational chemistry tools.
3. To provide training in potentiometry and pH metry techniques.
4. To familiarize students with experimental methods in radioactivity and colligative properties.
5. To develop understanding of quantitative experimental procedures in physical chemistry.
6. To introduce the use of basic computational chemistry tools.
7. To inculcate skills in accurate observation, data recording, and scientific reporting.

B. Course Outcomes (COs):

CO No.	Course Outcome Statement (COs) *After learning the course, the students are able to -*
CO-1	Recall principles of potentiometry, pH metry, radioactivity, and colligative properties.
CO-2	Explain experimental techniques and underlying concepts
CO-3	Perform experiments to determine pKa, EMF, Ksp, and molecular weight.
CO-4	Analyze experimental data, graphs, and results from electrochemical and physicochemical methods.
CO-5	Evaluate accuracy, errors, and reliability of experimental observations and results.
CO-6	Prepare systematic laboratory reports.

C. Contents:

Prerequisites
Students should have basic knowledge of physical chemistry concepts such as electrochemistry, chemical equilibrium, and solutions. Familiarity with basic laboratory practices, handling of instruments (pH meter, burette, etc.), and simple calculations is required. Basic understanding of data recording and safety procedures is expected.
A minimum of 12 experiments are to be completed.
A. Potentiometry (any five)

1. To determine the pKa value of a given monobasic weak acid by potentiometric titration.To determine the formal redox potential of the Fe^{2+}/ Fe^{3+} system
2. potentiometrically.
3. To determine the amount of NaCl in the given solution by potentiometric titration against silver nitrate.
4. To determine the solubility product and solubility of AgCl potentiometrically using a chemical cell.
5. Estimate the amount of Cl^-, Br^- and I^- in given unknown halide mixture by titrating it against standard $AgNO_3$ solution (mixture of any two ions).
6. To prepare standard 0.2 M Na_2HPO_4 and 0.1 M Citric acid solution, hence prepare four different buffer solutions using them. Determine the pH value of these and unknown solution.
7. To determine the composition of Zinc ferrocyanide complex potentiometrically
8. To determine the standard electrode potentials of Cu and Ag electrodes and to determine the EMF of a concentration cell.

B. pH metry (any three)

1. To determine the degree of hydrolysis of aniline hydrochloride.
2. To determine the dissociation constant of oxalic acid by pH-metric titration with strong base.
3. Determination of Pka of given weak acid by pH metry titration with strong base.
4. To determine the acid and base dissociation constant of an amino acid and hence the isoelectric point of an acid.
5. pH metric titration of strong acid against strong base by pH measurement and hence determine the concentration and strength of strong acid.

C. Radioactivity (any one)

1. To determine plateau voltage of the given G M counter. To determine the resolving time of GM counter.
2. To determine E_{max} of beta particle

D. Colligative properties (any one)

1. To determine the molecular weight of solute by depression in freezing point depression method.
2. To study the association of Benzoic acid in benzene by the Beckmann Method.
3. Determine the molecular weight of the given electrolyte and non-electrolyte by

Landsberger's method and to study the abnormal molecular weight of the electrolyte.

4. Determination of Transition Temperature of hydrated salt and Study of Impurity Effect.

E. Turbidometry: (any one)

1. Determination of SO_4^{2-} and Cl^- by turbidimetric method (turbidimetric titration or calibration curve method)
2. To determine the molecular weight of a given polymer by turbidometry

F. Chemistry with computers (Any one)

1. Geometry Optimization and SCF Energy Calculation of Simple Molecules Using Semi-Empirical Methods (ArgusLab or Avogadro + xtb)
2. Potential Energy Surface Scan of Butane Using Computational Methods. (ArgusLab / Avogadro + ORCA)
3. Calculation of the energy gap between HOMO and LUMO in simple molecules and visualization of molecular orbitals.

References:

1. Practical Physical Chemistry, A. Findlay, T. A. Kitchener, Longmans, Green and Co.
2. Experiments in Physical Chemistry, J. M. Wilson, K. J. Newcombe, A. R. Denko, R. M. W. Richett, Pergamon Press.
3. Senior Practical Physical Chemistry, B. D. Khosla, V. S. Garg, R. Chand & Company, 2019.
4. Experimental Physical Chemistry, D. P. Shoemaker, McGraw-Hill, 7th Edition.
5. Computational Chemistry: A Practical Guide for Applying Techniques to Real World Problems, D. C. Young, John Wiley & Sons, 2001.
6. Computational Chemistry Using the PC, D. Rogers, John Wiley & Sons, 3rd Edition, 2003.
7. Molecular Modelling: Principles and Applications, A. R. Leach, Longman, 2nd Edition, 2001.

CHE-306-MJP: INORGANIC CHEMISTRY PRACTICAL I

Course Type: Major Practical **Credits: 2**

A. Course Objectives:

1. To provide training in gravimetric analysis and inorganic estimations.
2. To familiarize students with preparation of inorganic complexes and compounds.
3. To develop understanding of qualitative analysis and identification of ions.
4. To introduce analytical methods used in pharmaceutical and industrial samples.
5. To inculcate skills in laboratory techniques, safety, and scientific reporting.

B. Course Outcomes (COs):

CO No.	Course Outcome Statement (COs) *After learning the course, the students are able to -*
CO-1	Recall principles of gravimetric estimation, inorganic preparations, and qualitative analysis.
CO-2	Explain experimental procedures and chemical reactions involved in analysis and synthesis.
CO-3	Apply techniques for estimation, preparation, and identification of inorganic compounds.
CO-4	Analyze experimental data and observations from gravimetric and qualitative methods.
CO-5	Evaluate accuracy, errors, and results of analytical experiments.
CO-6	Prepare systematic laboratory reports and industrial visit documentation.

C. Contents:

Prerequisites
Students should have basic knowledge of inorganic chemistry, chemical reactions, and stoichiometry. Familiarity with laboratory practices, handling of glassware, and safety procedures is required.
A minimum of 12 experiments are to be completed.
A. Gravimetric Estimations (Any 3) 1. Estimation of Fe as Fe_2O_3. [Ref-1: Page 457] 2. Estimation of Calcium as Calcium Oxalate. 3. Estimation of Barium as Barium chromate. 4. Estimation of Mg as Oxinate.

5. Estimation of Lead as Lead Chromate.
6. Estimation of Ba as $BaSO_4$ using homogeneous precipitation method. [Ref-1: Page 448]
7. Estimation of Nickel as Ni – DMG. [Ref-1: Page 462]
8. Analysis of sodium bicarbonate from mixture by thermal decomposition method.[Ref.-6]
9. Determination of water of crystallization by thermal decomposition. [Ref.-5]
10. Analysis of Food/Pharmaceutical sample for ash and sulphated ash: Aspirin. [Ref. -2]

B. Inorganic Preparations (Any 3) (Ref-7, 8, 9)

Preparation of following inorganic complexes and spot tests for metal ions and ligands:

1. Preparation of Trsi(acetylacetonato)iron(III) : $[Fe(acac)_3]$
2. Preparation of Hexaminecobalt(III) chloride : $[Co(NH_3)_6]Cl_3$
3. Preparation of Sodium Hexanitritocobaltate(III) : $Na_3[Co(NO_2)_6]$
4. Preparation of Potassium trioxalatoferrate(III) : $K_3[Fe(C_2O_4)_3]$
5. Preparation of Trsi(acetylacetonato)manganese(III) : $[Mn(acac)_3]$
6. Preparation of Tris(glycinato)nickelate(II) : $[Ni(gly)_3]^-$
7. Preparation of Potassium dioxalatocuprate(II): : $[Cu(C_2O_4)_2]^{2-}$
8. Preparation of Prussian Blue : $KFe[Fe(CN)_6]$

C. Inorganic Qualitative Analysis (6 Experiments)

1. Inorganic Qualitative analysis (5 mixtures)

   [1 simple water soluble mixture, 2 mixtures containing borates and 2 mixtures containing phosphates] (*Procedure from DST Manual 'Green Chemistry' Monograph must be followed strictly*) [Ref.-4]

2. Limit test for iron, chloride and sulphate from pharmaceutical raw materials.[Ref.-2; pp – 220]

OR

2. Qualitative and confirmatory tests of inorganic toxicants of any four ions (Borate, copper, hypochlorite or nitrate or nitrite, Sb or Bi, Iodate, H_2O_2). [Ref.-3]

D. Industrial Visit:

Visit to any one of the Chemical / Pharmaceutical / Polymer / Research Institutes / Sugar Factories / waste water treatment plant, etc. is essential and a systematic report is to be submitted by the student to the Department of Chemistry.

References:

1. Vogel's Textbook of Inorganic Quantitative Analysis, G. H. Jeffery, J. Bassett, J. Mendham, R. C. Denney, Longman Scientific & Technical, 5th Edition, 1989.
2. Indian Pharmacopoeia, Government of India, Vol. 2, 2007.
3. Basic Analytical Toxicology, World Health Organization, Edition not specified.
4. Green Chemistry Monograph, Department of Science & Technology (DST), Government of India, Edition not specified.
5. The Gravimetric Analysis of Barium Chloride Hydrate, Online Resource, https://www.studocu.com/ec/document/universidad-de-investigacion-de-tecnologia-experimental-yachay/fisica-matematica/otros/the-gravimetric-analysis-of-barium-chloride-hydrate/8364963/view
6. Experimental Inorganic Chemistry, Mounir A. Malati, Horwood Publishing, 1999.
7. Experiments in Chemistry, D. V. Jahagirdar, Himalaya Publishing House, Edition not specified.
8. Synthesis of Cis-[$Cu(gly)_2$], Trans-[$Cu(gly)_2$] and Cis-[$Ni(gly)_2$]·H_2O, Journal of Chemical Education, ACS Publications, 97(3), 2020, 801–805.

CHE-310-MJ-T: POLYMER CHEMISTRY

Course Type: Major Elective Theory **Credits: 2**

A. Course Objectives:

1. To provide fundamental knowledge of polymer chemistry and classification of polymers.
2. To familiarize students with polymerization mechanisms and techniques.
3. To develop understanding of polymer processing and degradation processes.
4. To introduce concepts of industrial polymers and their applications.
5. To promote awareness of environmental aspects and polymer waste management.

B. Course Outcomes (COs):

CO No.	Course Outcome Statement (COs) *After learning the course, the students are able to -*
CO-1	Recall concepts of polymer classification, polymerization, processing, and industrial polymers.
CO-2	Explain polymerization mechanisms, techniques, and properties of polymers.
CO-3	Apply principles to relate structure, properties, and processing of polymers.
CO-4	Analyze polymerization methods, degradation processes, and material behavior.
CO-5	Evaluate applications and environmental impact of polymers.
CO-6	Illustrate polymer structures, mechanisms, and processing techniques.

C. Contents:

Prerequisites	
Students should have basic knowledge of organic chemistry, chemical bonding, and reaction mechanisms. Familiarity with basic concepts of macromolecules and material properties is required.	
Chapter 1: Introduction to Polymers	**02 Hours**
1.1 Brief history 1.2 Basic terms: polymer, monomer, oligomers, polymerisation, degree of polymerisation, functionality Chemical composition of the environment 1.3 Characteristics of polymers 1.4 Classification of polymers: Natural and synthetic polymers, linear, branched, cross linked and network polymers, organic and inorganic polymers, Plastics, elastomers, fibers	

and liquid resins, Homopolymers and Co-polymers. Role of chemistry in environmental protection, Applications of polymers 1.5 Molecular forces and chemical bonding in polymers: Primary and secondary bond forces in polymers, cohesive energy. 1.6 Glass transition temperature of polymer. 1.7 Molecular weight of polymers: Number Average molecular mass (Mn) and weight average molecular mass (Mw) of polymers 1.8 polydispersity index	
Chapter 2: Chemistry of Polymerization	**06 Hours**
2.1 Introduction 2.2 Chain Polymerization: Free radical Polymerization, Ionic polymerization, Co-ordination, polymerization- Ziegler-Natta catalyst Photochemical smog: formation and effects Step Polymerization: Polycondensation, Polyaddition- polymerisation, Ring opening polymerisation.	
Chapter 3: Polymerization Techniques	**04 Hours**
3.1 Bulk polymerisation 3.2 Solution polymerisation 3.3 Suspension polymerisation 3.4 Emulsion polymerization 3.5 Melt polycondensation 3.6 Solution polycondensation 3.7 Interfacial condensation Salient features of different polymerisation techniques.	
Chapter 4: Polymer Processing and Degradation	**08 Hours**
4.1 **Polymer Processing** 4.1.1 Compounding 4.1.2 Processing Techniques 4.1.3 Plastic Technology: Calendering, Die Casting, Film Casting, compression molding, Injection molding, Blow molding, thermoforming, Foaming 4.1.4Fibre Technology: Fibre Spinning- Melt spinning, Dry spinning , Wet spinning, Fibre after treatments : Scouring, Lubrications, Sizing, Dyeing, Finishing, Texture yarns, Nonwoven fabrics.	

4.2 Polymer degradation:

4.2.1 Process of degradation. Random and chain end degradation.

4.2.2 Methods of degradation: thermal degradation – factors affecting thermal stability; mechanical degradation – milling and mastication; photodegradation – photostabilisers; oxidative degradation – oxidants and antioxidants; hydrolytic degradation; degradation by high energy radiation, chemical degradation.

4.2.3 Polymer waste management.

Chapter 5: Industrial Polymers	**04 Hours**

5.1 Thermoplastics: Polyethylene, Polypropylene, polystyrene, Polyacrylonitrile, Poly Vinyl Chloride, nylon and polyester. Persistent organic pollutants (POPs)

5.2 Thermosetting Plastics: Phenol formaldehyde and epoxide resin.

5.3 Elastomers: Natural rubber and synthetic rubber - Buna - N, Buna-S and neoprene.

Conducting Polymers: poly phenylene, poly pyrrole and poly acetylene

References:

1. Polymer Science, V. R. Gowarikar, N. V. Viswanathan, Jayadev Sreedhar, New Age International Publishers, 1996.
2. Textbook of Polymer Science, F. W. Billmeyer Jr., John Wiley & Sons, 3rd Edition, 1984 (Reprint 2008).
3. Introductory Polymer Chemistry, G. S. Misra, New Age International Publishers, 1996.
4. Polymer Chemistry, Charles E. Carraher Jr., CRC Press, 6th Edition, 2005.
5. Polymer Science: A Textbook, V. K. Ahluwalia, Anuradha Mishra, Ane Books, Edition not specified.
6. Principles of Polymer Science, P. Bahadur, N. V. Sastry, Narosa Publishing House, 2nd Edition, 2002.

CHE-311-MJ-T: ENVIRONMENTAL CHEMISTRY

Course Type: Major Elective Theory **Credits: 2**

A. Course Objectives:

1. To provide fundamental knowledge of environmental chemistry and ecosystem components.
2. To familiarize students with atmospheric, water, and soil chemistry.
3. To develop understanding of pollution sources, effects, and control methods.
4. To introduce concepts of green chemistry and sustainable practices.
5. To promote awareness of environmental protection, ethics, and regulations

B. Course Outcomes (COs):

CO No.	Course Outcome Statement (COs) *After learning the course, the students are able to -*
CO-1	Recall concepts of environmental chemistry, pollution, and sustainability.
CO-2	Explain chemical processes in atmosphere, water, soil, and ecosystems.
CO-3	Apply principles to assess environmental quality and pollution control methods.
CO-4	Analyze sources, effects, and mechanisms of environmental pollution.
CO-5	Evaluate remediation strategies, green chemistry approaches, and regulations.
CO-6	Illustrate environmental processes, treatment methods, and sustainable practices.

C. Contents:

Prerequisites	
Students should have basic knowledge of general chemistry, chemical reactions, and environmental science concepts. Familiarity with basic analytical parameters (pH, concentration, etc.) and ecological concepts is required.	
Chapter 1: Fundamentals of Environmental Chemistry	**04 Hours**
1.1 Scope, relevance, and interdisciplinary nature of environmental chemistry 1.2 Environmental segments: atmosphere, hydrosphere, lithosphere, biosphere 1.3 Chemical composition of the environment 1.4 Biogeochemical cycles: carbon, nitrogen, sulfur, and phosphorus 1.5 Energy flow in ecosystems 1.6 Role of chemistry in environmental protection	

1.7 Case study: Urban air pollution due to vehicular emissions.	
Chapter 2: Atmospheric Chemistry and Air pollution	**06 Hours**
2.1 Structure and chemical composition of the atmosphere 2.2 Air pollutants: classification, sources, and effects 2.3 Photochemical smog: formation and effects 2.4 Greenhouse gases, global warming, and climate change 2.5 Ozone layer depletion and control strategies 2.6 Case study: Bhopal Gas Tragedy	
Chapter 3: Water Chemistry and Water Pollution	**06 Hours**
3.8 Sources of water pollution: domestic, industrial, agricultural 3.9 Water quality parameters: pH, DO, BOD, COD, TDS, hardness 3.10 Eutrophication: causes, chemical mechanism and control 3.11 Water treatment methods: Physical processes, Chemical processes, biological processes 3.12 Drinking water standards (WHO/BIS) 3.13 Case study: River pollution and Sewage Treatment Plant (STP).	
Chapter 4: Soil Chemistry & Solid Waste Management	**06 Hours**
4.1 Soil Composition and Soil Chemistry 4.2 Soil pollution: fertilizers, pesticides, and heavy metals 4.3 Chemistry of pesticides and their degradation 4.3 Solid Waste: classification and chemical composition 4.4 Hazardous waste and e-waste 4.5 Waste minimization and recycling strategies	
Chapter 5: Toxic Chemicals & Green Sustainable Chemistry	**08 Hours**
5.1 Heavy metals: sources, toxicity, and remediation 5.2 Persistent organic pollutants (POPs) 5.3 Principles of green chemistry 5.4 Green solvents: Water, Supercritical Carbon Dioxide ($scCO_2$), Ionic Liquids, Bio-Based Solvents, Glycerol, 2-Methyltetrahydrofuran (2-MeTHF), etc. 5.5 Sustainable development and ethics *Green solvents*: Water, Supercritical Carbon Dioxide ($scCO_2$), Ionic Liquids, Bio-Based Solvents, Glycerol, 2-Methyltetrahydrofuran (2-MeTHF), etc, *Green Catalysis* (**Titanium Dioxide, Metal–Organic Frameworks (MOFs))** *Energy-efficient chemical processes*: heat integration, advanced catalysis (e.g., enzymes, nanocatalysts), process intensification	

(combining steps), using efficient equipment (pumps, motors), and implementing smart controls, all reducing costs and environmental impact (GHG emissions)

5.6 Environmental laws and regulations (India): Environment (Protection) Act, Water (Prevention and Control of Pollution) Act, Air (Prevention and Control of Pollution) Act, Hazardous and Solid Waste Management Rules; role of regulatory bodies in environmental protection.

References:

1. Environmental Chemistry, S. E. Manahan, CRC Press, 9th Edition, 2017.
2. Environmental Chemistry, A. K. De, New Age International Publishers, 7th Edition, 2018.
3. Environmental Chemistry, Colin Baird, W. H. Freeman & Company, 5th Edition, 2012.
4. Environmental Chemistry, A. K. Singh, Blue Duck Publications, 1st Edition, 2025.
5. Green Chemistry: An Introduction, M. Lancaster, Royal Society of Chemistry, 3rd Edition, 2025.
6. Environmental Chemistry Fundamentals, Stanley E. Manahan, Springer, 1st Edition, 2007.
7. Environmental Engineering, H. S. Peavy, D. R. Row, McGraw-Hill Education, 1st Edition, 2017.
8. Chemistry for Environmental Engineering and Science, C. N. Sawyer, P. L. McCarty, G. F. Parkin, McGraw-Hill Education, 5th Edition, 2003.
9. Introduction to Environmental Engineering and Science, G. M. Masters, Pearson Education, 3rd Edition, 2008.
10. Principles of Environmental Chemistry, R. M. Harrison, Royal Society of Chemistry, 2nd Edition, 2007.
11. Basic Concepts of Environmental Chemistry, D. W. Connell, CRC Press, 2nd Edition, 2005.
12. Air Pollution: Its Origin and Control, K. Wark, C. F. Warner, Addison-Wesley, 3rd Edition, 1998.
13. Environmental Pollution and Control, P. A. Vesilind, Butterworth-Heinemann, 4th Edition, 1998.
14. Environmental Chemistry, Y. N. Sharma, IGNOU, New Delhi, 1st Edition, 2021.

CHE-312-MJ-T: BIOCHEMISTRY

Course Type: Major Elective Theory **Credits: 2**

A. Course Objectives:

1. To provide fundamental knowledge of biomolecules and cellular organization.
2. To familiarize students with structure and functions of carbohydrates, lipids, proteins, and nucleic acids.
3. To develop understanding of enzyme structure, function, and mechanisms.
4. To introduce concepts of vitamins and their biological significance.
5. To promote insight into biochemical processes and molecular functions in living systems.

B. Course Outcomes (COs):

CO No.	Course Outcome Statement (COs) *After learning the course, the students are able to -*
CO-1	Recall concepts of biomolecules, enzymes, and nucleic acids.
CO-2	Explain structure and functions of carbohydrates, lipids, proteins, and vitamins.
CO-3	Apply biochemical principles to understand reactions and metabolic functions.
CO-4	Analyze properties and behavior of biomolecules and enzyme activity.
CO-5	Evaluate biological roles and significance of biomolecules and enzymes.
CO-6	Illustrate structures, mechanisms, and functions of biomolecules.

C. Contents:

Prerequisites	
Students should have basic knowledge of organic chemistry, functional groups, and biomolecules. Familiarity with basic biological concepts and chemical bonding is required.	
Chapter 1: Carbohydrates	**08 Hours**
Chemical molecules of life, the structure of prokaryotic and eukaryotic cells, and the functions of eukaryotic cell organelles. Definition: Classification of Carbohydrates: Classification: Monosaccharides, Disaccharides, Polysaccharides, Biological significance of carbohydrates, Monosaccharides: Structure of aldoses and ketoses, D- and L-isomers, Ring structures of sugars: hemiacetals and hemiketals, Conformations of sugars, Anomers and epimers, Mutarotation, Reaction with phenyl hydrazine (Osazone formation), Disaccharides: Sucrose, lactose, and maltose, Glycosidic bond, Reducing and non-reducing disaccharides, Polysaccharides:	

Homopolysaccharides and heteropolysaccharides.	
Chapter 2: Lipids and Vitamins	**07 Hours**
Classification and biological significance of lipids. Fatty acids, Triacylglycerols, Properties of Triacylglycerols (Saponification, Rancidity), Tests to check purity of fats and oils (Iodine number, Saponification number, , Acid number), Lipoproteins, steroids (Cholesterol, Ergosterol). Definition, Classification of Vitamins- Fat-soluble and Water-soluble. Individual Vitamin: Vitamin A, D, E, K, C, B1, B2, B6, B12, Biotin, Niacin, Folic acid, Pantothenic acid, (Chemistry, Functions, Sources, Deficiency symptoms).	
Chapter 3: Amino Acids and Proteins	**06 Hours**
Amino Acids: Classification based on R-group, Structures of amino acids, Physicochemical Properties; Amphoteric nature, and zwitterions, pKa values, Isoelectric point (pI), Concept of ampholytes, Reactions of Amino Acids: Ninhydrin reaction, Transamination, Oxidative deamination. Significance of these reactions, Amino acids as useful drugs (D-Penicillamine, N-Acetylcysteine, Gabapentin) Proteins: Classification based on: Function, Structural Hierarchy of proteins: Primary structure**,** Secondary structure**,** Tertiary structure**,** Quaternary structure**.**	
Chapter 4: Introduction to Enzymes	**06 Hours**
Classification of Enzymes: Enzyme classes with examples, Chemical Nature and Properties of Enzymes: Isoenzymes, Active site: concept and features, Enzyme–substrate (ES) complex formation, Enzyme Specificity, Factors Affecting Enzyme Activity: Substrate concentration, enzyme concentration, pH, temperature, and mechanism of enzyme action: substrate strain theory. Enzyme Inhibition: Concept of enzyme inhibition, Allosteric enzymes, Conjugated Enzymes: Holoenzyme and Apoenzyme, Prosthetic groups, Industrial Applications of Enzymes	
Chapter 5: Nucleotides and Nucleic Acids	**03 Hours**
Introduction to Nucleic Acids, Functions of nucleic acids, Chemistry of Nitrogenous Bases: Purines and pyrimidines, General Composition of Nucleic Acids: Nucleosides and nucleotides, Structure of DNA: Watson–Crick model, Chargaff's rule of DNA composition, RNA: Structure and function of major RNA species.	
References: 1. Lehninger Principles of Biochemistry, David L. Nelson, Michael M. Cox, Macmillan Publishers, 4th Edition, 2005.	

2. Biochemistry, U. Satyanarayana, U. Chakrapani, Books and Allied (P) Ltd., 5th Edition, 2020.
3. Principles of Biochemistry, Donald Voet, Judith G. Voet, Charlotte W. Pratt, John Wiley & Sons, 3rd Edition, 2008.
4. Harper's Illustrated Biochemistry, Robert K. Murray et al., McGraw-Hill, 27th Edition, 2006.
5. Biochemistry, Jeremy M. Berg, John L. Tymoczko, Lubert Stryer, W. H. Freeman & Company, 7th Edition, 2012.
6. Fundamentals of Biochemistry, J. L. Jain, S. Jain, Nitin Jain, S. Chand Publishing, 7th Edition, 2016.
7. Organic Chemistry, R. T. Morrison, R. N. Boyd, Pearson Education, 7th Edition, 2010.

CHE-313-MJP: ORGANIC CHEMISTRY PRACTICAL I

Course Type: Major Elective Practical **Credits: 2**

A. Course Objectives:

1. To provide training in separation and qualitative analysis of organic compounds.
2. To familiarize students with organic synthesis and green chemistry techniques.
3. To develop understanding of reaction mechanisms and laboratory procedures.
4. To introduce methods for derivative preparation and compound identification.
5. To inculcate skills in safe laboratory practices and scientific reporting.

B. Course Outcomes (COs):

CO No.	Course Outcome Statement (COs) *After learning the course, the students are able to -*
CO-1	Recall principles of separation, organic reactions, and derivative formation.
CO-2	Explain experimental procedures, mechanisms, and qualitative analysis methods.
CO-3	Apply techniques for separation, synthesis, and identification of organic compounds.
CO-4	Analyze observations, reaction outcomes, and purity of products.
CO-5	Evaluate efficiency, yield, and environmental aspects of organic reactions.
CO-6	Prepare laboratory reports with mechanisms and results.

C. Contents:

Prerequisites
Students should have basic knowledge of organic chemistry, functional groups, and reaction mechanisms. Familiarity with laboratory techniques, purification methods, and safety procedures is required.
A minimum of 12 experiments are to be completed.
A. Separation of Binary Mixtures and Qualitative Analysis (Any Six) a) Solid–Solid Mixtures (Any Two) b) Solid–Liquid Mixtures (Any Two) c) Liquid–Liquid Mixtures (Any Two) At least one mixture from each of the following categories should be included: • Acid–Base • Acid–Phenol

- Acid–Neutral
- Phenol–Base
- Phenol–Neutral
- Base–Neutral
- Neutral–Neutral

Note: Solid–solid mixtures must be insoluble in water.

For Separation of Binary Mixtures and Qualitative Analysis, students should clearly describe the principle of separation based on solubility and acid–base behavior. A systematic separation scheme with proper flow chart should be included, along with observations for each test performed. Confirmatory tests, derivative preparation (if required), and melting point determination must be reported for identification of each component. A brief explanation of the chemical basis of each step and necessary safety precautions should also be included.

B. Organic Preparations

a) Green Chemistry Preparations (Any Two)

1. Solvent-free aldol reaction between acetophenone and *p*-tolualdehyde.
2. Preparation of benzilic acid under solvent-free (solid-state) conditions.
3. Preparation of *p*-bromoacetanilide from acetanilide using potassium bromide and ceric ammonium nitrate.
4. Preparation of 5-nitrosalicylic acid from salicylic acid using calcium nitrate.

Note: For Green Chemistry preparations, students should include a brief note on the green principles involved (such as solvent-free conditions, reduced waste, safer reagents, and energy efficiency), along with a short comparison to the conventional method. Where applicable, they may calculate atom economy and comment on environmental impact and safety. In addition to yield and melting point, a concise mechanistic explanation and product confirmation should also be included.

b) Organic Preparations (Any Three)

1. Preparation of *p*-iodonitrobenzene from *p*-nitroaniline by the Sandmeyer reaction.
2. Preparation of methyl orange by diazotization of sulfanilic acid followed by azo coupling with N,N-Dimethylaniline.
3. Preparation of *p*-chlorobenzoic acid and *p*-chlorobenzyl alcohol from *p*-chlorobenzaldehyde.
4. Preparation of anthracene–maleic anhydride adduct via the Diels–Alder reaction.

5. Preparation of acetylsalicylic acid (aspirin) from salicylic acid by acetylation using acetic anhydride.
6. Preparation of 2-amino-4-(4-chlorophenyl)thiazole from 4-chlorophenacyl bromide and thiourea
7. Preparation of 1,4-dihydropyrimidinone from ethyl acetoacetate, benzaldehyde, and urea using oxalic acid as a catalyst.

Note: For Organic Preparations, students should include the balanced reaction, reaction mechanism, and the role of reagents or catalysts. Percentage yield, purification method, and melting point for product confirmation must be reported. A brief note on the reaction type and its significance, along with necessary safety precautions, should also be included.

C) Preparation of Organic Derivatives (Any Two)

1. Oxime derivative of benzophenone
2. Acid derivative of benzamide
3. Hydrazone derivative of acetophenone and phenylhydrazine
4. 2,4-Dinitrophenylhydrazone (2,4-DNP) derivative of benzaldehyde

Note: Select any one experiment from (1) and (2), and any one from (3) and (4).

For Preparation of Organic Derivatives, students should include the balanced reaction and a brief reaction mechanism explaining derivative formation. They must report the purpose of derivative preparation (confirmation of functional group and characterization), along with observations, percentage yield, recrystallization method, and melting point determination for identification. A short note on the significance of derivative formation in qualitative analysis and necessary safety precautions should also be included.

Important Note

At the time of the practical examination, the candidate shall perform:

- Complete analysis of one binary mixture,

OR

- One organic preparation and one preparation of an organic derivative.

References:

1. Comprehensive Practical Organic Chemistry: Preparations and Quantitative Analysis, V. K. Ahluwalia, Renu Aggarwal, Universities Press / Orient Blackswan Pvt. Ltd., Illustrated Edition, 2000.
2. Green Chemistry Experiments: A Monograph, R. K. Sharma, Indu Tucker Sidhwani, M. K. Chaudhuri, I. K. International Pvt. Ltd., 1st Edition, 2009.

3. Green Chemistry Experiments in Undergraduate Laboratories, Jodie T. Fahey, Lynn E. Maelia, American Chemical Society / Oxford University Press, 1st Edition, 2013.
4. A Textbook of Practical Organic Chemistry, A. I. Vogel, Pearson / Longman, 5th Edition, 1989.
5. Practical Organic Chemistry: Qualitative Analysis Manual, Various Authors, S. Chand / New Age International Publishers, Latest Edition.
6. Advanced Practical Organic Chemistry, O. P. Agarwal, S. Chand / New Age International Publishers, Latest Edition.

CHE-321-VSC-T: PHARMACEUTICAL ANALYTICAL CHEMISTRY

Course Type: VSC **Credits: 2**

A. Course Objectives:

1. To introduce fundamental concepts of pharmaceuticals and analytical chemistry.
2. To develop understanding of drug composition, dosage forms, and pharmacopoeial standards.
3. To impart knowledge of physicochemical properties of drugs such as pH, solubility, and stereochemistry.
4. To familiarize students with impurity testing and quality control methods.
5. To provide basic understanding of instrumental techniques (UV, IR, HPLC, optical rotation) in pharmaceutical analysis.
6. To develop skills for analysis and quality evaluation of pharmaceutical formulations.

B. Course Outcomes (COs):

CO No.	Course Outcome Statement (COs) *After learning the course, the students are able to -*
CO-1	Recall basic concepts of pharmaceuticals, dosage forms, and analytical terms.
CO-2	Explain physicochemical properties and impurity testing methods of drugs.
CO-3	Apply analytical techniques for identification and assay of pharmaceuticals.
CO-4	Analyze data obtained from UV, IR, HPLC, and optical rotation methods.
CO-5	Evaluate quality and purity of pharmaceutical formulations using standards.
CO-6	Design suitable analytical approaches for drug analysis and quality control.

C. Contents:

Prerequisites	
Students should have basic knowledge of organic and physical chemistry, including acids, bases, pH, and chemical bonding. Familiarity with basic analytical techniques and laboratory practices is desirable. An introductory understanding of spectroscopic and chromatographic methods will help in better comprehension of pharmaceutical analysis.	
Chapter 1: Introduction to Pharmaceuticals and its Analytical Chemistry	**10 Hours**
Part-A: Some definitions: Pharmaceuticals Active Pharmaceutical ingredients (API), Excipients, Solvents. **Pharmaceutical dosage forms (definitions):** Tablets, Capsules, powders, syrup, suspensions, solutions, injections, sprays / aerosols, pests, creams, gels. **(Ref-**	

2) **Part-B:** Introduction, Pharmaceutical Analysis -A brief definition, Manufacture of pharmaceuticals, Development of new drugs, Use of pharmaceuticals; Marketing Authorization and Industrial Production, Pharmacopoeias, Life Time of Pharmaceutical Preparations and Ingredients. **Ref 1: Chapter 1 and 2, p 1-15** **Part-C:** Pharmaceutical Ingredients Production and Control, Pharmacopoeia Monographs, Impurities in Pharmaceutical Ingredients. **Ref 1: Chapter 18 (305-321)**	
Chapter 2: Part-A: Fundamentals of bases, Acids, solubility, Polarity, Partition and stereochemistry	**10 Hours**
Acids, Bases, pH and pKa, Buffers, Acid and base properties of drug substances , Distribution Between phases, Stereoisomers, Active Pharmaceutical Ingredient (API) - Fluoxetine, Atenolol, Morphine, Ibuprofen, Paracetamol, Hydrocortisone, Stability of drugs. **Ref -1, Chapter 3, 17-34** **Part-B**: **Methods of common impurity testing** a) Definition of Limit Test and b) Limit test for heavy metals (IP methd-A only), iron, lead, chloride, sulphate, water, ash and sulphated ash. Ref-2, Indian Pharmacopeia- volume-1)	
Chapter 3: Application of UV, IR optical rotation and HPLC in Quality Control of Pharmaceuticals	**10 Hours**
UV Visible spectroscopy: Recapitulation: Beers law, molar absorbance, specific absorbance, principle of spectrophotometry, method for quantitative analysis (absolute, relative method and calibration curve method), Test of Spectrophotometers (calibration of UV-Visible spectrophotometer): control over wavelength, Control over absorbance (tef-1: pp 116 to 118), Identification of Diazepam in Diazepam Tablets (Solid Preparation) by UV Spectrophotometry, Identification of Flupentixol Decanoate in Flupentixol Decanoate Injection (Liquid Preparation) by UV Spectrophotometry, Identification of Miconazole in Miconazole Nitrate Cream (Semi-Solid Preparation) by UV Spectrophotometry 9Ref-1 pp: 406 -410); Assay of Paracetamol in Paracetamol Tablets (Solid Preparation) by UV Spectrophotometry, Assay of Doxapram in Doxapram Hydrochloride Injection (Liquid Preparation) by UV Spectrophotometry (Ref-1: pp: 419-423) **IR Spectroscopy:** Basic principle of IR spectroscopy, functional group and IR absorption, Identification of aspirin (acetylsalicylic acid) in aspirin tablets (solid preparation) by IR spectrophotometry, Identification of fluoxetine in fluoxetine hydrochloride oral solution (liquid preparation) by IR spectrophotometry, Identification of mupirocin in mupirocin	

calcium nasal ointment (semi-solid preparation) by IR-spectrophotometry (Ref-1: pp 396 to 400).

HPLC: Principle of HPLC, Chromatogram and its characteristics, method of qualitative analysis by HPLC, method of quantitative analysis by HPLC (relative method and calibration curve method) Identification of fluoxetine in fluoxetine hydrochloride capsules (solid preparation) by LC, Identification of droperidol in droperidol injection by LC, (Ref-1: 401-406) Assay of Omeprazole in Gastro-Resistant Omeprazole Tablets (Solid Preparation) by LC, Assay of Fentanyl in Fentanyl Citrate Injection (Liquid Preparation) by LC, Assay of Hydrocortisone in Hydrocortisone Ointment (Semi-Solid Preparation) by LC (Ref-1: pp 411-419).

Optical Rotation: Definition of Optical and specific rotation. method of optical and specific rotation determination, Optical rotation for simvastatin according to Ph. Eur., (Ref-1: pp 335-339) specific rotation for glucose, sugar; Ref-2: Indian pharmacopeia 7 Ed. Vol-1 (137-138 and Vol-2 (397-398).

References:

1. Introduction to Pharmaceutical Analytical Chemistry, Stig Pedersen-Bjergaard et al., Wiley Publication, 2nd Edition, 2019.
2. Indian Pharmacopoeia, Indian Pharmacopoeia Commission, 7th Edition, Vol. 1, 2 & 3, 2014.

CHE-331 FP: FIELD PROJECT

Course Type: FP **Credits: 2**

A. Course Objectives:

1. To apply fundamental chemistry concepts to environmental and real-life problems.
2. To develop understanding of field-based chemical investigation methodologies and sampling techniques.
3. To impart practical knowledge of scientific experimentation, sample collection, and data recording.
4. To develop analytical skills for interpretation of experimental and survey data.
5. To encourage scientific evaluation of local environmental and chemical problems and suggest chemistry-based solutions.
6. To develop scientific report writing, presentation, and communication skills.
7. To inculcate ethical practices, safety awareness, and professional conduct during fieldwork and research activities.

B. Course Outcomes (COs):

CO No.	Course Outcome Statement (COs) *After learning the course, the students are able to -*
CO-1	Recall basic chemistry concepts related to environmental and field-based studies.
CO-2	Explain methodologies, sampling techniques, and procedures used in field-based chemical investigations.
CO-3	Apply standard laboratory and field techniques for sampling, experimentation, and data collection.
CO-4	Analyze experimental and survey data to interpret chemical and environmental conditions scientifically.
CO-5	Evaluate local environmental or chemical problems and suggest suitable chemistry-based solutions.
CO-6	Design and prepare scientific reports, presentations, and project documentation based on field/research findings.

C. Contents:

1. Introduction

The Field (FP) is an integral component of the T.YB.Sc. Chemistry curriculum designed to promote experiential learning, scientific inquiry, and independent thinking among students. The project work transforms the teaching-learning process into a purposeful and application-oriented activity.

The project may be:

- Field-based,
- Experimental,
- Survey-based,
- Community-oriented,
- Industry-oriented, or
- Research-oriented,

provided that chemistry remains the core discipline.

The project enables students to apply theoretical chemistry concepts to real-life environmental, industrial, agricultural, medicinal, and societal problems. It also develops analytical, experimental, organizational, communication, and scientific writing skills.

Students are expected to devote a minimum of 60 hours toward:

- Planning,
- Literature survey,
- Field visits,
- Sample collection,
- Laboratory work,
- Data analysis,
- Report writing, and
- Presentation.

2. Objectives of the Field

The major objectives of the project course are:

1. To apply chemistry principles to real-world problems and local environmental conditions.
2. To develop practical laboratory and field investigation skills.
3. To enhance research aptitude and scientific temper.
4. To train students in:

- Sampling techniques,
- Data collection,
- Analytical methodologies,
- Statistical interpretation, and
- Scientific reporting.

5. To encourage independent learning and critical thinking.
6. To improve problem-solving abilities using chemistry-based approaches.
7. To understand ethical research practices and avoid plagiarism.
8. To strengthen communication and presentation skills.
9. To develop awareness regarding green chemistry and sustainable practices.
10. To encourage creativity and innovation in chemistry applications.

3. Nature of the Project

The project may involve:

- Experimental studies,
- Field investigations,
- Community surveys,
- Industrial visits,
- Product analysis,
- Environmental monitoring,
- Awareness campaigns,
- Comparative studies,
- Mini research projects.

Projects should preferably include:

- At least one field visit,
- Data collection,
- Experimental/laboratory work,
- Interpretation of findings,
- Scientific discussion.

4. Suggested Project Themes (Chemistry-Oriented)

Students may select any chemistry-related topic approved by the department.

A. Environmental Chemistry

- Water quality analysis of local sources
- Drinking water contamination studies
- Soil pH and nutrient analysis

- Heavy metal analysis
- Air quality monitoring
- Plastic pollution studies
- E-waste management survey
- Rainwater quality assessment

B. Industrial Chemistry

- Study of local chemical industries
- Effluent analysis
- Industrial wastewater treatment
- Chemical safety practices
- Sugar, dairy, fertilizer, soap, or paint industry studies

C. Food and Consumer Chemistry

- Food adulteration analysis
- Comparative analysis of edible oils
- Testing of soaps, detergents, shampoos
- Cosmetic product analysis
- Household chemical hazard studies

D. Agricultural Chemistry

- Fertilizer and pesticide usage survey
- Soil fertility studies
- Organic farming awareness
- Biofertilizer studies

E. Herbal and Medicinal Chemistry

- Phytochemical screening
- Herbal medicine survey
- Preparation of herbal formulations
- Traditional chemical practices

F. Green Chemistry and Sustainability

- Eco-friendly products
- Natural indicators and dyes
- Green synthesis approaches
- Biodegradable materials

G. Community Chemistry

- Chemistry awareness campaigns

- Water purification awareness
- Safe handling of household chemicals
- Public awareness regarding environmental pollution

H. Any Other Chemistry-Oriented Topic

Interdisciplinary projects are permitted provided chemistry is the central component.

5. Orientation Programme

At the beginning of the semester, the department shall organize an orientation programme covering:

- Nature of projects,
- Types of projects,
- Report writing,
- Evaluation methods,
- Ethical practices,
- Safety guidelines,
- Timeline and submission procedures.

6. Selection and Approval of Topic

Topic Selection Criteria

The topic should:

- Be chemistry-based,
- Be scientifically relevant,
- Address a practical/local issue,
- Be feasible within available facilities,
- Encourage analytical thinking and creativity.

Proposal Submission

Students should submit:

- Title of project,
- Objectives,
- Proposed methodology,
- Expected outcomes,
- Tentative work plan.

Approval Procedure

- Faculty mentor approval,
- Final approval by HOD/Project Coordinator.

7. Implementation Strategy

Responsibilities of Head of Department (HOD)

The HOD shall:

- Confirm student registrations,
- Monitor project progress,
- Maintain departmental records,
- Appoint examiners for presentations/viva.

Responsibilities of Project Coordinator

The coordinator shall:

- Assign supervisors,
- Monitor schedules,
- Ensure timely completion,
- Coordinate presentations and evaluations.

Responsibilities of Faculty Mentor

The mentor shall:

- Guide students throughout the project,
- Monitor attendance and participation,
- Verify field visits and experimental work,
- Maintain records of discussions and progress,
- Assist in data interpretation and report writing,
- Conduct pre-submission review.

Responsibilities of Students

Students shall:

- Conduct work sincerely and ethically,
- Maintain regular interaction with mentor,
- Follow safety procedures,
- Submit reports on time,
- Participate in viva/presentation.

8. Project Workflow

Step 1: Topic Finalization

- Identification of research/problem area.

Step 2: Literature Review

- Study books, journals, research articles, websites.

Step 3: Planning and Methodology

- Design sampling methods,

- Prepare questionnaires/survey forms,
- Identify instruments and chemicals required.

Step 4: Field Visit and Data Collection

- Minimum one field visit is mandatory.
- Collect samples/data systematically.
- Maintain field diary.
- Take photographic/video evidence.

Step 5: Experimental/Laboratory Work

- Conduct chemical analysis,
- Record observations carefully,
- Follow standard procedures.

Step 6: Data Analysis and Interpretation

- Use tables, graphs, charts,
- Compare findings with standards/literature.

Step 7: Report Writing

- Prepare report in prescribed format.

Step 8: Presentation and Viva

- Oral or poster presentation,
- Viva voce examination.

9. Ethical and Safety Guidelines

Students must:

- Follow laboratory safety norms,
- Wear PPE during field/laboratory work,
- Respect community and environmental ethics,
- Obtain permissions where necessary,
- Avoid data fabrication,
- Strictly avoid plagiarism.

10. Fieldwork Documentation

Students should maintain:

- Attendance records,
- Field diary,
- Observation notebook,
- Raw data sheets,
- Sample labels,

- Laboratory notebook,
- Photographs/videos with captions.

11. Style and Format of Project Report

General Formatting

- Paper Size: A4
- Font: Times New Roman
- Font Size: 12 pt
- Line Spacing: 1.5
- Margins: 1 inch on all sides
- Typing: One side only
- Language: English

Submission Copies

- Two hard copies
- One soft copy (PDF)

12. Structure of the Project Report

Preliminary Pages

1. Title Page
2. Certificate by Institute
3. Certificate by Mentor
4. Student Declaration
5. Acknowledgement
6. Abstract (200–300 words)
7. Table of Contents
8. List of Figures and Tables

13. Chapter Scheme

Chapter 1: Introduction (5–6 Pages)

Include:

- Background,
- Problem statement,
- Need and significance,
- Aim and objectives,
- Scope of study.

Chapter 2: Review of Literature (5–6 Pages)

Include:

- Previous research work,
- Related scientific studies,
- Comparative analysis.

Chapter 3: Materials and Methods / Methodology (5–7 Pages)

Include:

- Study area,
- Chemicals and instruments,
- Sampling methods,
- Experimental procedures,
- Survey methods,
- Statistical tools.

Chapter 4: Results and Discussion (8–10 Pages)

Include:

- Tables,
- Graphs,
- Charts,
- Observations,
- Data interpretation,
- Comparative discussion.

Chapter 5: Conclusion (1–2 Pages)

Include:

- Summary of findings,
- Outcomes,
- Recommendations,
- Future scope.

References/Bibliography

Use standard referencing styles:

- ACS Style (Preferred),
- APA,
- Vancouver.

Minimum 10 references recommended.

Appendices (Optional)

May include:

- Raw data,

- Survey forms,
- Permissions,
- Additional calculations,
- Photographs.

14. Minimum Length of Report

The report should contain:

- Minimum 15 typed pages (excluding title page, certificates, index, acknowledgement, etc.)

15. Evaluation Pattern

Total Marks: 50

A. Internal Evaluation by Guide – 15 Marks

Criteria	**Marks**
Field Visit Completion, Attendance & Interaction	07
Presentation in poster/project competitions/workshops/conferences, etc	08
Total	**15**

B. External Evaluation – 35 Marks

Criteria	**Marks**
Objectives, Literature Review, Methodology, Data Analysis	10
Conclusion and Recommendations	05
Overall Report Structure and Style	10
Presentation Skills & Communication	10
Total	35

16. Viva Voce Guidelines

Students should be able to explain:

- Project objectives,
- Methodology,
- Chemistry concepts involved,
- Experimental procedures,
- Data interpretation,
- Conclusions and recommendations.

All group members must appear for viva separately.

17. Important Instructions

- Plagiarism is strictly prohibited.
- Proper citations and references are mandatory.
- Fabrication or manipulation of data is not allowed.
- Safety measures must be followed throughout the project.
- Students are encouraged to present their work in seminars, exhibitions, and conferences.

CHE-341-MN-T: INTERDISCIPLINARY CHEMISTRY

Course Type: Minor Theory **Credits: 2**

A. Course Objectives:

1. To introduce the interdisciplinary role of chemistry in analytical science, healthcare, environment, agriculture, and industry.
2. To develop understanding of basic analytical and spectroscopic techniques used in modern science and technology.
3. To familiarize students with concepts of quality assurance, calibration, data handling, and analytical measurements.
4. To provide knowledge of modern materials such as polymers and nanomaterials and their real-life applications.
5. To create awareness about electrochemical systems, renewable energy resources, and sustainable technologies.
6. To promote scientific thinking and problem-solving skills through application-oriented chemistry concepts.

B. Course Outcomes (COs):

CO No.	Course Outcome Statement (COs) *After learning the course, the students are able to -*
CO-1	Recall basic concepts of analytical chemistry, sampling, and quality assurance.
CO-2	Explain principles and applications of spectroscopic and analytical techniques.
CO-3	Apply statistical and calibration methods in analytical chemistry.
CO-4	Analyze applications of spectroscopy, polymers, nanomaterials, and batteries.
CO-5	Evaluate renewable energy resources and sustainable technologies.
CO-6	Develop interdisciplinary understanding for practical chemical applications.

C. Contents:

Prerequisites	
Students should have a basic understanding of chemistry including fundamental concepts of atoms, molecules, chemical reactions, and states of matter. They should also possess awareness of basic laboratory safety practices, scientific measurements, and elementary mathematical skills related to percentage, mean, and simple numerical calculations.	
Chapter 1: Chemistry in Analysis, Quality and Everyday Applications	**10 Hours**
1. Recapitulation: Introduction to Analytical Chemistry: Meaning, scope, and	

importance of analytical chemistry, Role of chemistry in medicine, food, agriculture, environment, and industries, Classical and instrumental methods, Qualitative and quantitative analysis, Steps in chemical analysis

2. **Sampling and Quality Assurance:** Sampling of solids, liquids, and gases, Sampling errors, Good Laboratory Practices (GLP), Laboratory safety, Quality control (QC)
3. **Errors and Data Handling:** Error and its types, Accuracy and precision, Mean, median, and standard deviation, Confidence limits and reliability of results, related problems
4. **Calibration and Analytical Concepts:** External and internal calibration, Standard addition method, Sensitivity of analytical instruments, Limit of Detection (LOD), Limit of Quantification (LOQ), Applications in water testing, food analysis, and pharmaceuticals

Chapter 2: Spectroscopic Methods	**10 Hours**

1. **Introduction to Spectroscopic Methods:** Interaction of light with matter, Importance of spectroscopy, Applications in medicine, environmental monitoring, and forensic science
2. **UV–Visible Spectroscopy:** Principle of UV–Visible spectroscopyBeer–Lambert law, Electronic transitions, Instrumentation: source, monochromator, detector, Applications in pharmaceutical analysis, food color analysis, and pollution monitoring
3. **Atomic Spectroscopy:** Principle of Atomic Absorption Spectroscopy (AAS), Flame and graphite furnace methods, Basic concept of ICP–OES, Applications in trace metal analysis of water, soil, food, and biological samples

Chapter 3: Materials and Energy	**10 Hours**

1. **Polymers and Plastics:** Introduction to polymers and plastics, Types and properties of polymers, Structure–property relationship, Applications in packaging, healthcare, electronics, and textiles, Biodegradable plastics and environmental concerns
2. **Nanomaterials:** Introduction to nanotechnology and nanomaterials, Properties of nanomaterials, Applications in medicine, cosmetics, sensors, electronics, and water purification
3. **Batteries and Electrochemistry:** Basic redox reactions and electrochemistry, Working principles of common batteries, Lithium-ion batteries and applications, Applications in electric vehicles and renewable energy storage
4. **Solar Energy and Photochemical Conversion:** Solar energy as a renewable resource, Photochemical conversion, Working principle of solar cells, Green and sustainable energy technologies

References:

1. Skoog, D. A., Holler, F. J., and Crouch, S. R., Principles of Instrumental Analysis, 7th Edition, Cengage Learning, 2017.
2. Christian, G. D., Analytical Chemistry, 7th Edition, Wiley India, 2013.
3. Khopkar, S. M., Basic Concepts of Analytical Chemistry, 3rd Edition, New Age International Publishers, 2008.
4. Sharma, B. K., Instrumental Methods of Chemical Analysis, 24th Edition, Goel Publishing House, 2005.
5. Callister, W. D., and Rethwisch, D. G., Materials Science and Engineering: An Introduction, 9th Edition, Wiley, 2014.
6. Poole, C. P., and Owens, F. J., Introduction to Nanotechnology, 1st Edition, Wiley India, 2007.
7. Gowariker, V. R., Viswanathan, N. V., and Sreedhar, J., Polymer Science, 1st Edition, New Age International Publishers, 1986.
8. Twidell, J., and Weir, T., Renewable Energy Resources, 3rd Edition, Routledge, 2015.

SEMESTER VI

CHE-351-MJ-T: PHYSICAL CHEMISTRY III

Course Type: Major Theory **Credits: 2**

D. Course Objectives:

1. To provide foundational knowledge of molecular spectroscopy for understanding molecular structure.
2. To familiarize students with microwave, IR, and Raman spectroscopic techniques and their significance.
3. To introduce concepts of crystal structure and X-ray diffraction methods.
4. To develop insight into kinetics of solid-state reactions and their mechanisms.
5. To build conceptual clarity in spectral interpretation and structural analysis.

E. Course Outcomes (COs):

CO No.	Course Outcome Statement (COs) *After learning the course, the students are able to -*
CO-1	Recall fundamental concepts of molecular spectroscopy, crystal structure, and solid-state kinetics.
CO-2	Explain principles of microwave, IR, Raman spectroscopy, and crystallographic methods.
CO-3	Apply spectroscopic relations and crystallographic equations to solve numerical problems.
CO-4	Analyze spectral data, crystal parameters, and solid-state reaction kinetics.
CO-5	Evaluate applications of spectroscopy and X-ray methods in structure determination.
CO-6	Develop approaches to interpret molecular structure and reaction mechanisms using theoretical concepts.

F. Contents:

Prerequisites	
Students should have a basic understanding of atomic structure, chemical bonding, and thermodynamics from undergraduate physical chemistry. Familiarity with basic mathematics (algebra, logarithms) and fundamental concepts of waves and energy.	
Chapter 1: Investigation of Molecular structure	**14 Hours**
Introduction: Molar refraction and molecular structure, Dipole moment and molecular	

structure, electromagnetic spectrum, energy of molecules, Types of molecular spectra

Microwave Spectroscopy: Introduction, Classification of molecules on the basis of moment of Inertia, Rotational spectra of rigid diatomic molecules, relative intensities of spectral lines, effect of isotopic substitution on the rotational spectra, Determination of bond length and moment of inertia from rotational spectra, Problems

Infrared Spectroscopy: Introduction, Simple Harmonic oscillator, Modes of vibration, force constant, Vibrational spectrum of a diatomic molecule: Vibrational Energy expression, Allowed vibrational energies, zero-point energy, Selection rule, Vibrational energy level diagram with transitions, spectrum depiction, Vibration-rotation Spectra: Born-Oppenheimer approximation, Energy expression for vibrational rotor, Selection rules, Vibrational-rotational energy level diagram with transitions, Nature of vibrational spectra, P, Q and R branches of lines of the IR spectra, Problems.

Raman Spectroscopy: Introduction, Classical and Quantum theory of Raman effect, Rayleigh, Stokes and anti-stokes lines, Pure rotational Raman spectra of linear diatomic molecules.

Chapter 2: Crystal structure	**09 Hours**

Types of Solids: Isotropy and Anisotropy, Isomorphism and polymorphism, Laws of crystallography: Law of constancy of interfacial angles, Law of rational indices, Law of crystal symmetry, Weiss indices and Miller indices, Crystal Structure: Parameters of the Unit Cells, Cubic Unit Cells: Three Types of Cubic Unit Cells, Calculation of Mass of the Unit Cell, Methods of Crystal structure analysis: The Laue method and Braggs method: Derivation of Bragg's equation, Determination of crystal structure of NaCl by Bragg's method, X ray analysis of NaCl crystal system, Calculation of d and λ for a crystal system, Numerical.

Chapter 3: Kinetics of Reactions in the Solid State	**07 Hours**

Some General Considerations, Factors affecting reactions in Solids, Rate Laws for Reactions in Solids , The Parabolic Rate Law, The First-Order Rate Law, The Contracting Sphere Rate Law, The Contracting Area Rate Law, The Prout–Tompkins Equation, Rate Laws Based on Nucleation, Applying Rate Laws, Results of Some Kinetic Studies, The Deaquation-Anation of $[Co(NH_3)_5H_2O]Cl_3$, Two Reacting Solids.

References:

1. Fundamentals of Molecular Spectroscopy, C. N. Banwell, E. M. McCash, McGraw-Hill Education, 4th Edition, 1994.
2. Physical Chemistry, Volume 2, N. B. Singh et al., New Age International Publishers,

3. Essentials of Physical Chemistry, B. S. Bahl, G. D. Tuli, S. Chand & Company Ltd.,
4. Principles of Physical Chemistry, B. R. Puri, L. R. Sharma, M. S. Pathania, Vishal Publishing Co., 50th Edition, 2025.
5. Principles of Chemical Kinetics, J. E. House, Academic Press, 2nd Edition, 2007.
6. Physical Chemistry, G. M. Barrow, McGraw-Hill, 6th Edition, 1996.
7. University General Chemistry, C. N. R. Rao, Macmillan, 3rd Edition, 1998.
8. Physical Chemistry, R. A. Alberty, Wiley Eastern Ltd.,
9. The Elements of Physical Chemistry, P. W. Atkins, Oxford University Press, 6th Edition, 2013.
10. Principles of Physical Chemistry, S. H. Maron, C. H. Prutton, Macmillan, 4th Edition, 1965.
11. Quantum Chemistry, D. A. McQuarrie, Viva Books Pvt. Ltd., Student Edition, 2008.
12. Quantum Chemistry, I. N. Levine, Pearson Education, 7th Edition, 2013.
13. Quantum Chemistry, R. K. Prasad, New Age International Publishers, 6th Edition, 2023.
14. Source Book of Atomic Energy, S. Glasstone, Van Nostrand Company, 3rd Edition, 1967.
15. Modern Electrochemistry, J. O'M. Bockris, Plenum Press (Springer), 2nd Edition, 2000.
16. Chemical Applications of Radioisotopes, H. J. M. Brown, Academic Press, Latest Edition.

CHE-352-MJ-T: INORGANIC CHEMISTRY III

Course Type: Major Theory **Credits: 2**

A. Course Objectives:

1. To develop a comprehensive understanding of reaction mechanisms and catalytic processes in inorganic chemistry.
2. To explore the significance of metal ions in biological and environmental systems.
3. To introduce the principles governing electrical, structural, and functional properties of solid-state materials.
4. To provide exposure to emerging areas such as nanomaterials and metal–organic frameworks.
5. To cultivate problem-solving skills related to modern inorganic chemistry concepts.

B. Course Outcomes (COs):

CO No.	Course Outcome Statement (COs) *After learning the course, the students are able to -*
CO-1	Define mechanisms, catalysis, bioinorganic systems, solids, nanomaterials, and MOFs.
CO-2	Explain reactions, catalysis, biological metals, electronic properties, and materials.
CO-3	Solve problems on mechanisms, catalysis, bioinorganic systems, and solids.
CO-4	Analyze reactions, catalytic processes, biological roles, and material behavior.
CO-5	Justify properties and applications of inorganic systems and materials.
CO-6	Derive theoretical explanations of inorganic processes.

C. Contents:

Prerequisites	
Basic understanding of coordination chemistry, chemical bonding, and periodic properties is required. Knowledge of thermodynamics, electronic structure, and introductory solid-state chemistry will support comprehension of reaction mechanisms, catalysis, and advanced inorganic topics.	
Chapter 1: Inorganic Reaction Mechanism	**04 Hours**
Introduction of stability and lability, stability or formation constant, factors affecting lability, chelate effect. Types of inorganic reactions, ligand substitution reactions and mechanisms in brief, Substitution Reactions in square planar complexes: Trans effect, Trans effect series and	

its applications. [**Ref. 1:** Pages 537-576; **Ref. 2:** Relevant Pages; **Ref. 3:** Pages 507-517; **Ref. 4:** Pages 412-420, 434-440]	
Chapter 2: Heterogeneous catalysis	**05 Hours**
Introduction, Classification of heterogeneous catalysts, supported metal catalyst, Role of support, Promoters and Poisons. Catalytic processes *viz.,* a) Hydrogenation of Olefins using Raney Nickel catalyst, b) Zeolites in catalysis: Catalytic Cracking, c) Biodiesel Synthesis using Heteropolyacids(HPAs) and d) Automotive Exhaust Catalysts: The catalytic converters. [**Ref. 5:** Pages 1-16, 87-112, 203-205, 222-224; **Ref. 6:** Relevant Pages]	
Chapter 3: Bioinorganic Chemistry	**06 Hours**
Introduction, definition, scope and importance of metal ions in biological systems. Classification of biological metals: a) Enzymatic and non-enzymatic metals and b) Redox-active and non-redox-active metals. Role of non-enzymatic metals with one example (Na, K, Ca, and Mg). Metals in enzymatic processes in brief: a) Enzymatic redox metals (Cu in superoxide dismutase), b) Enzymatic non-redox metals (Zn in hydrolases), and c) Redox-active transition-metal enzymes (catalase, peroxidase, nitrogenase). Metalloproteins: a) Iron–Sulphur proteins and electron-transfer systems, b) Iron transport and storage proteins: transferrin and ferritin. c) Bioinorganic chemistry of iron: hemoglobin and myoglobin and d) Bioinorganic chemistry of cobalt: Vitamin B_{12} (cobalamin). [**Ref. 3:** Relevant Pages; **Ref. 7:** Pages 353,775,779,796-797; **Ref. 8:** Pages 1-13,24,285-290]	
Chapter 4: Metals, Semiconductors and Superconductors	**08 Hours**
Metals: Introduction, Metallic bonding, Band theory in metals with respect to Na along with n(E) and N(E) curves/diagrams, Electrical conductivity of metals (Na, Mg, Al), Valence electrons and conductivity of metals, Effect of temperature and impurity on electrical conductivity of metals and insulators. **Semiconductors:** Types of Semiconductors: a) Intrinsic and Extrinsic, b) n and p type semiconductors and c) Non-stoichiometry and semiconductivity w.r.t. ZnO and NiO/FeO. **Superconductivity:** Discovery, property, models, structure and superconductivity, low and high temperature superconductors, applications of superconductors. [**Ref. 9 :** Pages 359-391; **Ref. 10:** Pages 394-411; **Ref. 11:** Relevant Pages; **Ref. 12:** Pages 394-411]	
Chapter 5: Introduction to Advanced topics in Inorganic Chemistry	**07 Hours**
A. Introduction to Nanomaterials [4 Hours]	

Definition and concept of nanomaterials, Difference between bulk and nanomaterials, Size scale and surface-to-volume ratio.

Classification of Nanomaterials: A) Based on dimensions: 1) 0D: nanoparticles and quantum dots, 2) 1D: nanowires and nanotubes, 3) 2D: graphene and thin films, and 4) 3D: nanocomposites and B) Based on composition: 1) Metals, 2) Metal oxides, 3) Semiconductors and 4) Carbon-based nanomaterials.

Methods for Synthesis of Nanomaterials: a) Top-Down Methods, b) Bottom-Up Methods, c) Sol–gel method, d) Chemical vapor deposition (CVD), e) Hydrothermal and f) Solvothermal methods. Properties and Applications of Nanomaterials.

[**Ref. 13 :** Pages 1-30; **Ref. 14:** Relevant Pages]

B. Introduction to Metal–Organic Frameworks [3 Hours]

Definition and basic concept of MOFs, Comparison of MOFs with coordination polymers, zeolites, and porous materials, Building Blocks of MOFs, Synthesis of MOFs: Solvothermal and hydrothermal methods, Advantages and significance of MOFs, Applications of MOFs in Gas storage (H_2, CO_2, CH_4), Gas separation and capture (CO_2 capture, air purification), MOFs in catalysis (heterogeneous catalysis concept).

[**Ref. 15 :** Pages 1-35; **Ref. 16:** Relevant Pages]

References:

1. Inorganic Chemistry – Principles of Structure and Reactivity, J. E. Huheey, E. A. Keiter & R. L. Keiter, 4th Edn. Harper Collins College Publ. New York, 1993.
2. Martin L. Tobe and John Burgess, Inorganic Reaction Mechanisms, Addison Wesley Longman Inc., 1999.
3. Inorganic Chemistry, D.F. Shriver, P.W. Atkins, C.H. Lamgford, Oxoford, 5th Edn., 1994.
4. Inorganic Chemistry - Messler and Tarr - Pearson Publishers.
5. Heterogeneous catalysis in industrial practice, Chaerls N. Shatterfield, second edition, Krieger Publishing Company, Florida USA.
6. Heterogeneous catalysis by B. Vishwanathan and D. K. Chakrabarty , New Age International Private Limited, 2007.
7. Concise Inorganic Chemistry by J.D. Lee - 5th Edn.
8. Principles of Bioinorganic Chemistry by S. J. Lippard and J. M. Berg, Panima Publishing Corporation, 1st Edn.
9. Solid State Chemistry and its Applications, Anthony R. West, Second Edition, Wiley

2014.

10. Solid State Chemistry: An Introduction, Lesley E. Smart, Elaine A. Moore, 3rd Edn.
11. Chemistry by Raymond Chang - 5th Edn.
12. New Guide to Modern Valence Theory by G.I. Brown - 3rd Edn.
13. The Chemistry of Nanomaterials, C. N. R. Rao, A. Müller, A. K. Cheetham, Wiley-VCH.
14. Nanotechnology: Principles and Practices by Sulabha K. Kulkarni, Springer Publisher
15. Introduction to Reticular Chemistry: Metal–Organic Frameworks and Covalent Organic Frameworks by Omar M. Yaghi, Markus J. Kalmutzki, and Christian S. Diercks, Wiley-VCH, 2019.
16. Review Article: a) H. Furukawa Kyle E. Cordova, Michael O'Keeffe, Omar M. Yaghi, "The Chemistry and Applications of Metal–Organic Frameworks," Science, 2013, 341, 1230444, b) G. Férey, "Hybrid porous solids: past, present, future," Chemical Society Reviews, 2008, 37, 191-214.

CHE-353-MJ-T: ORGANIC CHEMISTRY III

Course Type: Major Theory **Credits: 2**

A. Course Objectives:

1. To introduce fundamental principles and techniques of organic spectroscopy.
2. To develop understanding of UV, IR, and NMR spectroscopy for structural analysis.
3. To enable interpretation of spectral data for identification of organic compounds.
4. To study structure, synthesis, and significance of natural products.
5. To enhance analytical and problem-solving skills in organic chemistry

B. Course Outcomes (COs):

CO No.	Course Outcome Statement (COs) *After learning the course, the students are able to -*
CO-1	Recall the basic concepts of UV, IR, NMR spectroscopy and natural products.
CO-2	Explain principles of UV, IR, NMR spectroscopy and natural products.
CO-3	Solve problems based on UV, IR, and NMR spectral data.
CO-4	Analyze spectral data for structure determination of organic compounds.
CO-5	Justify structures of organic molecules using combined spectral evidence.
CO-6	Derive structures of organic compounds from spectral data.

C. Contents:

Prerequisites	
Basic knowledge of organic chemistry, functional groups, and chemical bonding is required. Familiarity with molecular structure will aid in understanding spectroscopy and natural products.	
Chapter 1: Introduction to Spectroscopy	**02 Hours**
Introduction and meaning of spectroscopy; types of spectroscopy; nature of electromagnetic radiation and regions of the electromagnetic spectrum; basic terms used in spectroscopy: wavelength, frequency, amplitude, wavenumber and energy; relationship between these terms and numerical conversions.	
Chapter 2: Ultraviolet and Visible Spectroscopy	**04 Hours**
Introduction; electromagnetic radiation; electronic transitions; λmax and εmax; chromophores and auxochromes; bathochromic and hypsochromic shifts; applications of UV–Visible spectroscopy in organic molecules; Woodward–Fieser rules for calculation of λmax of conjugated dienes and α,β-unsaturated compounds.	

Chapter 3: Infrared Spectroscopy	05 Hours
Introduction; types of molecular vibrations; functional group region and fingerprint region; application of IR spectroscopy in organic molecules; IR spectra of alkanes, alkenes and alcohols (intermolecular and intramolecular hydrogen bonding); aldehydes, ketones, carboxylic acids and their derivatives; factors affecting IR stretching frequencies, basic structural problems based on IR.	
Chapter 4: Proton Magnetic Resonance Spectroscopy	**08 Hours**
Introduction; principle of NMR; magnetic and non-magnetic nuclei; nuclear magnetic resonance; chemical shift; TMS as reference and its advantages; shielding and deshielding effects; peak area and integration; spin–spin coupling; coupling constant and J-value; basic structural problems based on PMR.	
Chapter 5: Combined Problems Based on UV, IR and PMR Spectroscopy	**05 Hours**
Interpretation of combined spectral data; structural elucidation of organic compounds using UV, IR and ^{1}H NMR spectra; practice problems.	
Chapter 6: Natural Products	**06 Hours**
Terpenoids: Isolation, Classification. Citral - structure determination using chemical and spectral methods, Synthesis of Citral by Barbier and Bouveault Synthesis. Alkaloids: Extraction, Purification, Some examples of alkaloids and their natural resources. Ephedrine - structure determination using chemical methods. Synthesis of Ephedrine by Nagai Synthesis	

References:

1. Spectroscopic Methods in Organic Chemistry – D. H. Williams & Ian Fleming, McGraw-Hill Education, 6th Edition, 2013.
2. Introduction to Spectroscopy – Donald L. Pavia, Gary M. Lampman, George S. Kriz & James R. Vyvyan, Cengage Learning, 5th Edition, 2015.
3. Organic Chemistry Through Spectroscopy – P. S. Kalsi, New Age International Publishers, 2nd Edition, 2007.
4. Organic Chemistry – R. T. Morrison & R. N. Boyd, Pearson Education, 7th Edition, 2010.
5. Organic Chemistry – T. W. Graham Solomons, Craig B. Fryhle & Scott A. Snyder, John Wiley & Sons, 12th Edition, 2016.
6. A Textbook of Organic Chemistry (Vol. I) – I. L. Finar, Pearson Education, 6th Edition, 2002.

7. Natural Products: Their Chemistry and Biological Significance – J. Mann, R. S. Davidson, J. B. Hobbs, D. V. Banthorpe & J. B. Harborne, Longman Scientific & Technical, 2nd Edition, 1994.
8. Organic Chemistry of Natural Products – Gurdeep R. Chatwal, Himalaya Publishing House, Revised Edition, 2011.
9. Natural Products – O. P. Verma & Ashok Kumar, Vishal Publishing, Revised Edition, 2010.

CHE-354-MJ-T: ANALYTICAL CHEMISTRY III

Course Type: Major Theory **Credits: 2**

A. Course Objectives:

1. To introduce principles of spectroscopic and electrochemical analytical techniques.
2. To develop understanding of instrumentation and working of analytical methods.
3. To enable quantitative analysis using spectrophotometric and electrochemical techniques.
4. To familiarize students with sample preparation and interference handling.
5. To enhance analytical and problem-solving skills in chemical analysis

B. Course Outcomes (COs):

CO No.	Course Outcome Statement (COs) *After learning the course, the students are able to -*
CO-1	Define spectrophotometry, AAS, flame photometry, and electrochemical methods.
CO-2	Explain principles, instrumentation, and interferences in analytical techniques.
CO-3	Solve numerical and analytical problems in spectroscopic and electrochemical methods.
CO-4	Analyze spectral and electrochemical data for quantitative estimation.
CO-5	Justify selection of analytical methods based on accuracy and limitations.
CO-6	Derive relationships and interpretations in analytical measurements.

C. Contents:

Prerequisites	
Basic knowledge of physical chemistry, chemical equilibrium, and solutions is required. Familiarity with fundamental concepts of optics and electrochemistry will aid in understanding analytical techniques.	
Chapter 1: Spectrophotometry	**06 Hours**
Introduction, Wave properties of electromagnetic radiation, Relation between frequency, velocity and wave number, particle properties of electromagnetic radiation, relation between wavelength and particle properties of electromagnetic radiation, electromagnetic spectrum, interaction of electromagnetic radiation with matter, atomic spectroscopy and molecular spectroscopy, types of molecular spectra, Advantages of spectroscopy. Instrumentation, Applications of spectrophotometry, Molar composition of complexes, Spectrophotometric	

Titrations. Ref-1: 351 -357, Ref-2: S-1 to S-21, Ref-3: 2.107-2.148	
Chapter 2: Atomic Absorption Spectroscopy	**06 Hours**
Introduction, Elementary theory, Instrumentation, flames, the nebulizer-burner system, non flame techniques, (graphite furnace, cold vapour technique), resonance line sources, monochromator, detectors, interferences, chemical interferences, background correction methods, Atomic absorption spectrophotometers, Experimental preliminaries (calibration curve methods, standard addition method) Preparation of sample (wet ashing, fusion, Dry ashing, microwave dissolution, concentration procedures), Detection limits, Estimation of Ca and Mg in water. Key Ref-4: 612- 643	
Chapter 3: Flame Emission Spectroscopy	**06 Hours**
Introduction, emission spectra, flame emission spectroscopy, flame photometers. Evaluation methods, calibration curve procedure, the standard addition technique, Applications: determination of alkali metals by flame photometry, determination of trace elements in contaminated soil. Numerical, Key Reference-4: 645-649, 655-656.	
Chapter 4: Electrochemical Methods- Polarography and Voltammetry	**12 Hours**
Polarography: Introduction, Principles, Electrodes, Instrumentations, Dropping Mercury Electrodes, Factors affecting polarographic current, Oxygen removal, Polarographic analysis, AC Polarography, Pulse Polarography, Differential Pulse Polarography, Square Wave Polarography, Numericals. Ref-5: 761-820, Ref-3: 2.523-2.533. **Voltammetry**: Principles, Voltammetry at solid electrodes, Hydrodynamic Voltammetry, Triangular Wave Voltammetry, Amperometry, Stripping Voltammetry.	

References:

1. A Textbook of Analytical Chemistry – Y. Anjaneyulu, K. Chandrasekhar & Valli Manickam, Pharma Med Press, 2006.
2. Instrumental Methods of Chemical Analysis – B. K. Sharma, Goel Publishing House, 27th Edition, 2011.
3. Instrumental Methods of Chemical Analysis – Gurdeep R. Chatwal & Sham K. Anand, Himalaya Publishing House, 2010.
4. Vogel's Textbook of Inorganic Quantitative Analysis – J. Mendham, R. C. Denney, J. D. Barnes & M. Thomas, Pearson Education, 6th Edition, 2000.
5. Introduction to Instrumental Analysis – R. D. Braun, Pharma Med Press, 2006.

CHE-355-MJP: PHYSICAL CHEMISTRY PRACTICAL II

Course Type: Major Practical **Credits: 2**

A. Course Objectives:

1. To provide hands-on exposure to physicochemical measurement techniques.
2. To familiarize students with the use of analytical instruments and experimental setups.
3. To develop understanding of experimental design and methodology in physical chemistry.
4. To inculcate skills in systematic data recording and scientific observation.

B. Course Outcomes (COs):

CO No.	Course Outcome Statement (COs) *After learning the course, the students are able to -*
CO-1	Recall principles of refractometry, spectrophotometry, conductometry, and viscosity.
CO-2	Explain experimental techniques and physicochemical concepts.
CO-3	Apply calculations to determine physical parameters.
CO-4	Analyze experimental data and observations.
CO-5	Evaluate accuracy and errors in results.
CO-6	Prepare laboratory reports.

C. Contents:

Prerequisites
Students should have basic knowledge of physical chemistry concepts such as solutions, kinetics, and equilibrium. Familiarity with laboratory techniques, handling of instruments and basic calculations is required.
A minimum of 12 experiments are to be completed.
A. Refractometry (any two) 1. To determine the specific refractivity's of the given liquids A and B and their mixture and hence determine the percentage composition their mixture C. 2. To determine the molecular refractivity of the given liquids A, B, C and D. 3. To determine the molar refraction of homologues methyl, ethyl and propyl alcohol and show the constancy contribution to the molar refraction by -CH_2 group. 4. Determine the refractive index of a series of salt solutions and determine the concentration of a salt of unknown solution.

B. Spectrophotometry and Colorimetry (any three)

1. To determine the indicator constant of methyl red indicator
2. To estimate the Fe^{3+} ions by the thiocyanate method.
3. Cobalt by using the R-nitroso salt method.
4. To determine the order of reaction for the oxidation of alcohol by potassium dichromate and potassium permanganate in an acidic medium calorimetrically.
5. Simultaneous determination of Cu^{2+} and Ni^{2+} ions by colorimetry/spectrophotometry method

C. Conductometry (any four)

1. To determine the velocity constant of hydrolysis of ethyl acetate by NaOH solution by conduct metric method.
2. To determine the normality of citric acid in given fruit by titrating it against standard NaOH solution by conductometric method.
3. To determine $\lambda\infty$ of strong electrolyte (NaCl or KCl) and to verify Onsager equation.
4. To estimate the amount of lead present in given solution of lead nitrate by conductometric titration with sodium sulphate.
5. To determine the relative strength of monochloro acetic acid and acetic acid conductometrically

D. Viscosity: (any one)

1. To determine the molecular weight of a high polymer by using solutions of different concentrations.
2. Determine the radius of the glycerol molecule from the viscosity measurement.

E. Solid State Chemistry (Any one)

1. Experimental Determination of Atomic Radii of Metal Atoms Using Bulk Density
2. Measurements of Metallic lumps.
3. Analysis of crystal structure from X-ray diffraction spectra of any two compounds (Calculation d, lattice constant, crystal volume and density, and assigning planes to peaks using JCPDS data).
4. Analysis of Intermolecular Interactions in Molecular Crystals using CrystalExplorer Software

F. Table work (Any one)

1. Analysis of the given vibration-rotation spectrum of HCl(g)
2. Analysis of crystal structure from X-ray diffraction spectra of any two compounds

(Calculation d, lattice constant, crystal volume and density, and assigning planes to peaks using JCPDS data)

References:

1. Practical Physical Chemistry, A. Findlay, T. A. Kitchener, Longmans, Green and Co., 9th Edition, 1973.
2. Experiments in Physical Chemistry, J. M. Wilson, K. J. Newcombe, A. R. Denko, R. M. W. Richett, Pergamon Press, Edition not specified.
3. Senior Practical Physical Chemistry, B. D. Khosla, V. S. Garg, R. Chand & Company, Delhi, 2019 Edition.
4. Experimental Physical Chemistry, D. P. Shoemaker, McGraw-Hill, 7th Edition, 2003.
5. Physical Chemistry, W. J. Moore, Prentice Hall, 5th Edition, 2001.
6. Advanced Physical Chemistry Experiments, R. C. Gurtu, S. Gurtu, Pragati Prakashan, Meerut, Edition not specified.
7. Experiments in Chemistry, D. V. Jahagirdar, Himalaya Publishing House, Edition not specified.
8. Practical Physical Chemistry, B. Vishwanathan, P. S. Raghavan, Viva Books Pvt. Ltd., 2014 Edition.
9. Vogel's Qualitative Inorganic Analysis, G. Svehla, Longman, 5th Edition, 1979.
10. Vogel's Textbook of Quantitative Inorganic Analysis, A. I. Vogel, ELBS, 5th Edition, 1989.
11. Experimental Physical Chemistry, A. M. Halpern, G. C. McBane, W. H. Freeman & Co., 3rd Edition, 2003.
12. Exploring Chemistry with Electronic Structure Methods, J. B. Foresman, A. Frisch, Gaussian Inc., 2000 Edition.
13. Computational Chemistry: A Practical Guide for Applying Techniques to Real World Problems, D. C. Young, John Wiley & Sons, 2001 Edition.
14. Computational Chemistry Using the PC, D. Rogers, John Wiley & Sons, 3rd Edition, 2003.
15. Molecular Modelling: Principles and Applications, A. R. Leach, Longman, 2nd Edition, 2001.
16. CrystalExplorer Software, CrystalExplorer Team, Official Website, Latest Version.
17. Cambridge Structural Database (CSD Teaching Subset), Cambridge Crystallographic Data Centre (CCDC), Latest Version.

CHE-356-MJP: ORGANIC CHEMISTRY PRACTICAL II

Course Type: Major Practical **Credits: 2**

A. Course Objectives:

1. To introduce students to the principles and techniques of organic chemistry practical work.
2. To provide understanding of spectroscopic methods for structural analysis.
3. To familiarize students with quantitative estimation methods in organic chemistry.
4. To impart knowledge of isolation and extraction techniques of natural products.
5. To develop awareness of chromatographic separation methods.
6. To inculcate laboratory discipline, safety, and scientific approach.

B. Course Outcomes (COs):

CO No.	Course Outcome Statement (COs) *After learning the course, the students are able to -*
CO-1	Recall laboratory techniques, safety rules, and instrumentation.
CO-2	Explain principles of spectroscopy, estimation, extraction, and chromatography.
CO-3	Perform experiments for spectral interpretation, estimation, and separation.
CO-4	Analyze spectral data and experimental observations.
CO-5	Evaluate accuracy of results and justify procedures used.
CO-6	Design and execute experiments following proper methodology and safety.

C. Contents:

Prerequisites
Students should have a basic understanding of organic chemistry, including functional groups and molecular structure, along with fundamental knowledge of chemical bonding. They should be familiar with basic laboratory techniques, safety practices, and simple titration methods. An introductory understanding of spectroscopic techniques is also desirable to effectively perform and interpret practical experiments.
A minimum of 12 experiments are to be completed.
A) Spectral Interpretation **a) IR Spectral Interpretation (Any Two)** 1. Identification of functional groups in unknown organic compounds using IR spectra. 2. Comparative IR spectral study of aldehydes and ketones.

3. Comparative IR spectral study of carboxylic acids and esters.
4. Comparative IR spectral study of aliphatic and aromatic compounds containing the same functional group.

Note: In each experiment, two IR spectra should be provided.

b) ^{1}H NMR Spectral Interpretation (Any Two)

1. Interpretation of ^{1}H NMR spectra of simple aliphatic organic compounds.
2. Interpretation of ^{1}H NMR spectra of simple aromatic organic compounds.
3. Analysis of spin–spin splitting patterns using the (n + 1) rule in ^{1}H NMR spectra of simple aliphatic compounds.
4. Structural elucidation of simple straight-chain aliphatic compounds (containing 3–4 carbon atoms) using IR and ^{1}H NMR spectra.

Note: Provide the spectra of two compounds for each of the first three experiments and the spectrum of one compound for the fourth experiment.

Note: For Spectral Interpretation experiments, students should identify and assign characteristic peaks in IR spectra and interpret chemical shift, integration, multiplicity, and coupling patterns in ^{1}H NMR spectra. Proper peak assignments with justification must be provided in tabular form. In comparative studies, key differences between functional groups should be clearly discussed. For structural elucidation, students should correlate IR and ^{1}H NMR data logically to deduce the structure with proper reasoning. A brief note on the principles involved and clear presentation of spectral interpretation steps should be included.

B) Organic Estimations (Any Three)

1. Estimation of ascorbic acid (Vitamin C).
2. Estimation of glucose.
3. Estimation of glycine.
4. Determination of the saponification value of oil.
5. Estimation of alkali content in an antacid using standard HCl solution.

Note: For Organic Estimations, students should clearly state the principle of the method (titrimetric or volumetric analysis), write the balanced reaction involved, and standardize the solution where required. Proper observations and titration readings must be recorded systematically, followed by calculations with formulae and units. The final result should be expressed with appropriate significant figures.

C) Natural Product Extractions (Any Four)

1. Extraction of anthocyanin from flower petals of *Hibiscus (Hibiscus rosa-sinensis)*.

2. Isolation of casein from milk.
3. Extraction of essential oil from orange peel by solvent extraction.
4. Isolation of trimyristin from nutmeg.
5. Extraction of caffeine from tea leaves.
6. Extraction of eugenol from cloves.
7. Isolation of cinnamic acid from cinnamon.

Note: For Natural Product Extractions, students should state the principle of extraction (such as solvent extraction, acid–base extraction, or precipitation) and justify the choice of solvent based on solubility and polarity. Observations during extraction, separation, and purification should be recorded carefully. Percentage yield must be calculated, and product identification may be supported by melting point or characteristic tests where applicable. A brief note on the chemical nature, source, and applications of the isolated compound, along with safety precautions, should also be included.

D) Chromatography (Any One)

1. Qualitative identification of functional groups by TLC using suitable chemical staining reagents (acids, amino acids, aldehydes, ketones, phenols, etc.).
2. Separation of naphthalene and acetanilide by column chromatography.

Note: TLC (Functional Group Identification)

State the principle of adsorption chromatography and justify the solvent system and staining reagent based on polarity and functional group. Record Rf values, spot colors, and observations clearly. Include brief interpretation, applications, and safety precautions.

Note: Column Chromatography (Separation)

State the principle of differential adsorption and justify the choice of adsorbent and eluent based on polarity. Record order of elution, TLC monitoring, and solvent volume. Calculate percentage recovery and confirm identity where possible. Include brief notes and safety precautions.

Important Note: At the time of the practical examination, the candidate shall perform:

- Spectral interpretation and one experiment from extraction/chromatography

OR

- Any one experiments from estimation

Reference Books

1. Spectrometric Identification of Organic Compounds, Robert M. Silverstein, Francis X. Webster, David J. Kiemle, John Wiley & Sons, 7th Edition, 2005.

2. Introduction to Spectroscopy, Donald L. Pavia, Gary M. Lampman, George S. Kriz, James R. Vyvyan, Cengage Learning, 5th Edition, 2015.
3. Comprehensive Practical Organic Chemistry: Preparations and Quantitative Analysis, V. K. Ahluwalia, Renu Agarwal, Universities Press / Orient Blackswan Pvt. Ltd., Illustrated Edition, 2000.
4. A Text-Book of Practical Organic Chemistry, A. I. Vogel, Pearson Education / Longman, 5th Edition, 1989.
5. Practical Organic Chemistry, F. G. Mann, B. C. Saunders, Pearson Education, 4th Edition, 2009.

CHE-360-MJ-T: MATERIAL CHEMISTRY

Course Type: Major Elective Theory **Credits: 2**

A. Course Objectives:

1. To introduce the fundamentals and classification of materials.
2. To explain the properties and behavior of different classes of materials.
3. To impart knowledge of nanomaterial synthesis techniques.
4. To familiarize students with basic material characterization methods.
5. To illustrate applications of nanomaterials in various fields.
6. To develop the ability to correlate structure, properties, and applications of materials.

B. Course Outcomes (COs):

CO No.	Course Outcome Statement (COs) *After learning the course, the students are able to -*
CO-1	Recall classification, properties, and fundamental concepts of materials.
CO-2	Explain synthesis approaches and characteristics of nanomaterials.
CO-3	Apply theoretical concepts to explain material behavior and synthesis methods.
CO-4	Analyze characterization data from techniques such as XRD, SEM, TEM, and spectroscopy.
CO-5	Evaluate the suitability of different materials for specific applications.
CO-6	Propose material selection strategies for advanced technological applications.

C. Contents:

Prerequisites	
Students should have basic knowledge of general chemistry, solid state chemistry, and chemical bonding, along with an understanding of basic physical chemistry concepts such as structure–property relationships. Familiarity with fundamental analytical and spectroscopic techniques will be helpful.	
Chapter 1: Introduction to Material Chemistry	**05 Hours**
• Definition, scope and importance in modern science. • Classification of materials: Metals, Ceramics, Polymers, Composites and Nanomaterials • Properties of materials: mechanical, electrical, magnetic, optical and thermal. • Challenges and Future Prospects. [Ref.1 Page 1-12, Ref.2 Page 1-16, Ref 5 Page 1-25]	

Chapter 2: Synthesis of Nanomaterials	07 Hours
Introduction and classification of nanomaterials; preparation of nanomaterials top-down and bottom-up approaches **Physical Methods**: Chemical Vapour Deposition (CVD) and Mechanical Methods, High Energy Ball Milling **Chemical Methods:** Sol-gel Method and Co-precipitation Method **Biological Methods:** Synthesis using Microorganism and using plant extracts. **[** Ref. 7 Page 1-37, Ref.4 187-225]	
Chapter 3: Material Characterization Techniques	**10 Hours**
Only basic introduction, principles overview and application of techniquies. • X-ray diffraction Methods (XRD) • Scanning Electron Microscopy (SEM) • Transmission Electron Microscopy (TEM) • UV-Vis Spectroscopy (UV-Vis) • FT-IR spectroscopy (FT-IR) [Ref.1 Page 65-73, 597-628, Ref.3 Page 45-144, Ref 6 Page 223-248, Ref. 8 page 2.107-2.108, 2.135, 2.149, 2.172, 2.30-2.31, 2.62-2.80]	
Chapter-4: Applications of Nanomaterials	**08 Hours**
Photocatalysis, 2. Nanocatalysts, 3. Nano sensors, 4. Food and Agriculture Industry, 5. Cosmetics and Consumers Goods, 6. Nanomaterial for Environmental Pollution Remediation, 7. Nano-Medical Applications, 8. Textiles, 9. Paints, 10. Energy, 11. Defence and Space Applications, 12. Structural Application. [Ref. 5 Page 108-148, Ref. 9 Page 29-43]	
References: 1. Materials Chemistry, Bradley D. Fahlman, Central Michigan University, John Wiley & Sons, 2nd Edition, 2011. 2. Materials Science and Engineering: An Introduction, William D. Callister Jr., David G. Rethwisch, Wiley Publication, 10th Edition, 2018. 3. Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, Yang Leng, John Wiley & Sons (Asia) Pte Ltd., 2008. 4. Solid State Chemistry and Its Applications, Anthony R. West, John Wiley & Sons, 2nd Edition (Student Edition), 2014. 5. Textbook of Nanoscience and Nanotechnology, B. S. Murty, P. Shankar, Baldev Raj,	

B. B. Rath, James Murday, Springer/Universities Press, 2013.

6. Solid State Chemistry and Its Applications, Anthony R. West, John Wiley & Sons, 2nd Edition, 2014.
7. Nanoscale Materials in Chemistry, K. J. Klabunde, R. M. Richards (Eds.), John Wiley & Sons, 2nd Edition, 2009.
8. Instrumental Methods of Chemical Analysis, Gurdeep R. Chatwal, Sham K. Anand, Himalaya Publishing House, 2011.
9. Advanced Nanomaterials and Their Applications in Renewable Energy, Jingbo Louise Liu, Sajid Bashir, Elsevier, 2015.

CHE-361-MJ-T: FORENSIC CHEMISTRY

Course Type: Major Elective Theory **Credits: 2**

A. Course Objectives:

1. To introduce the fundamentals and scope of forensic chemistry in crime investigation.
2. To explain the principles and applications of forensic analysis of narcotic drugs and psychotropic substances.
3. To develop understanding of analytical techniques used in forensic investigations.
4. To describe the legal framework (NDPS Act) and its relevance in forensic science.
5. To illustrate the concepts of crime scene investigation, management, and reconstruction.
6. To enable students to correlate scientific methods with forensic problem-solving.

B. Course Outcomes (COs):

CO No.	Course Outcome Statement (COs) *After learning the course, the students are able to -*
CO-1	Recall basic concepts, principles, and scope of forensic chemistry.
CO-2	Explain classification and effects of narcotic drugs and psychotropic substances.
CO-3	Apply analytical techniques for identification of drugs and forensic samples.
CO-4	Analyze forensic data related to drug testing and crime scene evidence.
CO-5	Evaluate procedures used in crime scene investigation and forensic analysis.
CO-6	Develop strategies for forensic investigation and reconstruction of crime scenes.

C. Contents:

Prerequisites	
Students should have a basic understanding of general and organic chemistry, including chemical bonding and reaction principles. Familiarity with basic analytical techniques and instrumentation will be helpful. A general awareness of scientific methods and fundamental concepts relevant to forensic applications is desirable.	
Chapter 1: History and Development of Forensic Science in India	**06 Hours**
Definition, scope, and need of forensic science and its importance in crime investigation and society. Functions and basic principles of forensic science, branches of forensic science and the historical development of forensic science in India. Frye standard and Daubert standard	

and their significance in forensic evidence admissibility. The qualifications, duties, and code of conduct of forensic scientists. Organization and functions of forensic science laboratories.	
Chapter 2: Introduction to Narcotics Drugs and Psychotropic Substances	**08 Hours**
Definition and classification of narcotic drugs and psychotropic substances, including narcotics, stimulants, depressants, and hallucinogens. It explains natural, synthetic, and semi-synthetic drugs and introduces the concept of designer drugs. The unit also covers drug tolerance, addiction, and withdrawal symptoms. An overview of the NDPS Act, 1985 is provided to create legal awareness regarding drug-related offenses and their forensic importance.	
Chapter 3: Analysis of Narcotic Drugs and Psychotropic Substances	**08 Hours**
Isolation techniques for purifying narcotics drugs and psychotropic substances – thin layer chromatography, gas-liquid chromatography and high-performance liquid chromatography. Presumptive and screening tests for narcotics drugs and psychotropic substances. Microcrystalline testing of Drug Abuse and Illicit Trafficking. Analysis of narcotics drugs and psychotropic substances in urine, and antemortem blood & in postmortem blood. Dope tests	
Chapter-4: Crime scene investigation, Management and reconstruction	**08 Hours**
Crime Scene Investigation: Definition and importance. Types of crime scenes – indoor, outdoor, mobile, and water. Classification based on nature of crime (homicide, suicide, accidental, theft). Crime scene protection and processing: assessment, observation, documentation, search, collection, and analysis. Documentation methods – notes, photography, videography, sketching, digital imaging. Search patterns – line, grid, spiral, zone. Collection, preservation of evidence and maintenance of chain of custody. Safety precautions and PPE. **Crime Scene Management:** Role of forensic experts and police personnel. Securing and preserving the scene. Contamination control. Scene survey and coordination among agencies. Use of mobile forensic kits and modern technologies. **Crime Scene Reconstruction:** Concept and importance. Steps – recognition, documentation, collection, evaluation, hypothesis development and testing. Application in accidents, shootings, hanging and burglary cases. Use of logical reasoning and digital tools (3D imaging, computer-aided reconstruction). Preparation of reconstruction report.	
References: 1. Forensic Science: An Introduction to Scientific and Investigative Techniques, S. H.	

James, J. J. Nordby, CRC Press, Boca Raton, 2nd Edition, 2005, pp. 1–13, 243–260, 667–678.

2. Introduction to Forensic Sciences, W. G. Eckert (Ed.), W. G. Eckert, R. K. Wright, CRC Press, Boca Raton, 2nd Edition, 1997, pp. 11–78.
3. Criminalistics, Richard Saferstein, Prentice Hall, New Jersey, 8th Edition, 2004, pp. 5–29.
4. Fisher's Techniques of Crime Scene Investigation, W. J. Tilstone, M. L. Hastrup, C. Hald, CRC Press, Boca Raton, 2013, pp. 26–149.
5. Criminalistics, Richard Saferstein, Prentice Hall, New Jersey, 8th Edition, 2004, pp. 10–26.
6. The Pathology of Drug Abuse, S. B. Karch, CRC Press, Boca Raton, 1996, pp. 429–638.
7. Forensic Toxicology, A. Poklis, in Introduction to Forensic Sciences, W. G. Eckert (Ed.), CRC Press, Boca Raton, 2nd Edition, 1997, pp. 116–141.
8. Fisher's Techniques of Crime Scene Investigation, W. J. Tilstone, M. L. Hastrup, C. Hald, CRC Press, Boca Raton, 2013, pp. 323–337.
9. The Narcotic Drugs and Psychotropic Substances Act, Government of India, 1985, Available at: https://dor.gov.in/files/acts_files/Narcotic-Drugs-and-Psychotropic-Substances-Act-1985_0.pdf
10. Undergraduate Instrumental Analysis, J. W. Robinson, Marcel Dekker Inc., New York, 5th Edition, 1995, pp. 721–797.
11. Analytical Techniques in Forensic Science, Rosalind Wolstenholme, Sue Jickells, Shari Forbes, John Wiley & Sons Ltd., 1st Edition, 2021, pp. 51–68.
12. Forensic Analytical Techniques, Barbara Stuart, John Wiley & Sons Ltd., 1st Edition, 2013, pp. 143–166.
13. Modi's Textbook of Medical Jurisprudence and Toxicology, K. Mathiharan, Amrit K. Patnaik, LexisNexis (RELX India Pvt. Ltd.), 28th Edition, 2025.

CHE-362-MJ-T: MEDICINAL CHEMISTRY

Course Type: Major Elective Theory **Credits: 2**

A. Course Objectives:

1. To introduce the fundamentals, scope, and importance of medicinal chemistry in drug discovery and development.
2. To understand physicochemical properties and their role in drug action and design.
3. To familiarize students with the chemistry, mode of action, and therapeutic applications of important drugs.
4. To develop knowledge of structure–activity relationship, drug–receptor interactions, and rational drug design.
5. To provide an understanding of pharmaceutical dosage forms and routes of drug administration.
6. To enhance the ability to relate chemical structure with biological activity and therapeutic effects.

B. Course Outcomes (COs):

CO No.	Course Outcome Statement (COs) *After learning the course, the students are able to -*
CO-1	Recall basic concepts, terminology, and classification of drugs.
CO-2	Explain physicochemical properties and mechanisms of drug action.
CO-3	Apply medicinal chemistry concepts to classify and study therapeutic agents.
CO-4	Analyze structure–activity relationships and drug–receptor interactions.
CO-5	Evaluate the therapeutic importance and pharmaceutical applications of drugs.
CO-6	Design approaches for rational drug development and dosage formulation.

C. Contents:

Prerequisites	
Students should have basic knowledge of organic chemistry, biochemistry, and human physiology. Familiarity with functional groups, stereochemistry, chemical bonding, and basic pharmacological terms is desirable.	
Chapter 1: Introduction to Medicinal Chemistry	**06 Hours**
Introduction, History and Development of Medicinal Chemistry, Definition, Scope, drug targets, Drug discovery, design and development, Sources of drugs (natural, synthetic), Classification of drugs (therapeutic/structural), Drugs and the medicinal chemist, Introduction	

to drug action, Physicochemical properties in relation to biological action.

(*Ref.1 Pages 9-23, Ref.2 Pages 11-26, Ref.3 Pages 37-55)*

Chapter 2: Bio-Physicochemical Properties in Drug Action and Design	**08 Hours**

Introduction, Acidity/Basicity, Solubility, Ionization, Hydrophobic and hydrophilic properties, Lipinski Rule, Terminology in Medicinal Chemistry: Pharmacology, Pharmacophore, Pharmacodynamics, Pharmacokinetics, metabolites, antimetabolites and therapeutic index. Importance of stereochemistry in drug action (Example: Ibuprofen), Concept of rational drug design: Structure activity relationship, Drug-receptor interactions and Clinical trials.

(Ref.3 Pages 57-75, 95-96, Ref.8 Pages 153, 189-274, 384-392, Ref. 7 Pages 29-61)

Chapter 3: Drugs for Infectious Diseases	**09 Hours**

Introduction, Structures, Example, Mode of Action and Applications:

A. **Anti-Cancer Agents (**e.g. Cis Platin, 6-Mercaptopurine)
B. **Anti-Viral Agents** (e.g. Valaciclovir, Desciclovir)
C. **Proton pump inhibitors** (e.g. Omeprazole, Lansoprazole)
D. **Anti-inflammatory and Analgesic Agents**: (e.g. Aspirin, Paracetamol)
E. **Antibacterial drugs-** (e.g. Sulfonamides: Sulfadiazine, sulfanilamide)
F. **Antibiotics:** (e.g., Penicillins, Cephalosporins)

(Ref.2 166-187), (Ref. 4 page 581-608, (Ref.5 Page 191-228), (Ref. 6 Page 265-291, Ref. 7 page 7, 78-109, 421, 514, Ref.8 468-473, 659-,680-685), Ref.9 Page 144-154)

Chapter-4: Pharmaceutical aspects	**07 Hours**

1] Routes of drug administration, Pharmaceutical Phase

2] Formulation of dosage forms, types of dosage forms

a) Solid (granules, tablets, capsule and powder),

b) Semisolid (gel, ointments)

c) Liquid (solutions, syrups),

d) Sterile (parenteral/ injectable),

e) Gaseous (spray, inhaler)

f) Biological (vaccines): Immunobiologicals

(Ref Page 3 Page 46-47, Ref 5 Page 3-1, Ref 5 156-177, Ref 10 Page 380-626)

References:

1. A Textbook of Medicinal Chemistry, K. G. Bothara, Nirali Prakashan, 2019.
2. An Introduction to Medicinal Chemistry, Graham L. Patrick, Oxford University Press,

Oxford/New York/Tokyo, 1995.

3. Fundamentals of Medicinal Chemistry, Gareth Thomas, John Wiley & Sons, 2003.
4. Medicinal Chemistry, Ashutosh Kar, New Age International (P) Limited, 4th Edition, 2007.
5. Wilson and Gisvold's Textbook of Organic Medicinal and Pharmaceutical Chemistry, John M. Beale Jr., John H. Block, Lippincott Williams & Wilkins, 12th Edition, 2011.
6. Textbook of Medicinal Chemistry, Volume II, V. Alagarsamy, Elsevier, 2010.
7. Foye's Principles of Medicinal Chemistry, Thomas L. Lemke, David A. Williams, Victoria F. Roche, S. William Zito, Wolters Kluwer (Lippincott Williams & Wilkins), 7th Edition, 2013.
8. An Introduction to Medicinal Chemistry, Graham L. Patrick, Oxford University Press, 5th Edition, 2013.
9. Introduction to Medicinal Chemistry, Alex Gringauz, Wiley-VCH, 1996.
10. Aulton's Pharmaceutics: The Design and Manufacture of Medicines, Michael E. Aulton, Kevin M. G. Taylor, Elsevier Ltd., 5th Edition, 2018.

CHE-363-MJP: INORGANIC CHEMISTRY PRACTICAL-II

Course Type: Major Elective Practical **Credits: 2**

A. Course Objectives:

1. To develop practical skills in quantitative inorganic analysis using volumetric and instrumental methods.
2. To train students in the operation and application of analytical instruments such as flame photometer and spectrophotometer.
3. To provide hands-on experience in separation and purification techniques including chromatography and ion-exchange methods.
4. To familiarize students with synthesis, characterization, and applications of inorganic nanomaterials and coordination compounds.
5. To enhance understanding of periodic trends, complex formation, and catalytic reactions through laboratory experiments.
6. To inculcate laboratory safety practices, scientific observation, data interpretation, and report writing skills in inorganic chemistry practicals.

B. Course Outcomes (COs):

CO No.	Course Outcome Statement (COs) *After learning the course, the students are able to -*
CO-1	Recall the principles, reactions, safety procedures, and analytical methods used in inorganic chemistry practicals.
CO-2	Explain the concepts of volumetric analysis, flame photometry, spectrophotometry, chromatography, and nanomaterial synthesis.
CO-3	Apply quantitative and instrumental analytical techniques for estimation, separation, purification, and synthesis experiments.
CO-4	Analyze experimental observations, spectral data, chromatographic separations, and periodic trends in inorganic systems.
CO-5	Evaluate the accuracy, precision, efficiency, and environmental significance of different inorganic experimental methods and reactions.
CO-6	Design and perform inorganic chemistry experiments involving nanomaterial synthesis, complex formation, and analytical determinations using suitable methodologies.

C. Contents:

Prerequisites
Students should have basic knowledge of inorganic chemistry, chemical reactions, and stoichiometry. Familiarity with laboratory practices, handling of glassware, and safety procedures is required.
A minimum of 12 experiments are to be completed.
A. Volumetric Estimations (Any 3) 1. Analysis of Talcum powder [Ref-9] 2. Estimation of Zinc and Magnesium in the given mixture solution. [Ref-10] 3. Analysis of Phosphate (PO_4^{3-}) from Fertilizer. [Ref-1] 4. Analysis of Iodine from Iodized salt. [Ref-2] 5. Analysis of Calcium from milk powder. [Ref-1] 6. Analysis of Cu from Cu-Fungicide. [Ref-1]
B.a) Flame Photometry (Any 3) [Ref-1] 1. Estimation of Na by flame photometry by calibration curve method. 2. Estimation of Na by flame photometry by regression method. 3. Estimation of K by flame photometry by calibration curve method. 4. Estimation of K by flame photometry by regression method.
b)Spectrophotometry: Estimation of cola drinks by molybdenum blue method using spectrophotometry. [Ref-2]
C. Column Chromatography (Compulsory) [Ref-1] 1. Purification of water using cation/anion exchange resin and analysis by qualitative analysis /Conductometry.
D. Separation of Ni(III), Co(II) and Zn(II) ions using paper chromatography method**.** [Ref-10]
E. Nanomaterial synthesis (Any 1) [Ref-3, 4] 1. Synthesis of Silver nanoparticles. 2. Green synthesis and characterization of aluminium oxide nanoparticle using *Neem* leaf extract. [Ref-7] 3. Synthesis of ZnO nanoparticles. 4. Green synthesis of Cu nanoparticles using *Neem* leafextract. [Ref-8]
E. Verification of periodic trends using solubility of alkaline earth metal hydroxides: Ca(OH)2,

$Mg(OH)_2$, $Cr(OH)_2$ and $Ba(OH)_2$. [Ref-1]

F. Synthesis of amine complexes of Ni(II) and its ligand exchange reaction (bidentate ligands like acac, DMG, Glycine) by substitution method.

OR

F. Determination of the Metal to ligand ratio (M : L) in complexes. [Ref-5]

G. Solvent free microwave assisted one pot synthesis of Phthalocyanin copper (II) complex.

OR

G. Fenton reaction: Degradation of H2O2 using Fe catalyst. [Ref-6]

H. Table work: Calculation Band gap for TiO_2/ SnO_2/ ZnO nanoparticles from electronic Spectra (UVVisible). [Ref-3, 4]

References:

1. Vogel's textbook of Inorganic Quantitative Analysis, Jeffery, Basset, Mendham Deney, 5th Ed, Longman Scientific Technical, USA (co-published with John Wiley Sons).
2. General Chemistry Experiment – Anil J Elias (University press).
3. Nanotechnology: Principles and Practices by Dr.Sulbha Kulkarni. Third Edition,Springer.
4. A laboratory course in nanoscience and nanotechnology, Dr. Gerrad Eddy Jai Poinem, CRC press.
5. Experimental Inorganic Chemistry, Mounir A. Malati, Horwood Series in Chemical Science (Horword Publishing, Chichester) 1999.
6. Environmental Chemistry Microscale Laboratory Experiments, Jorge G.Ibanez Margarita Hemandez-Esparza Carmen Doria-Serrano Arturo Fregoso-Infante, Springer.
7. Green synthesis and characterization of aluminum oxide nanoparticle using neem leaf extract (Azadirachta Indica), Imosobomeh L. Ikhioya a a, Agnes C. Nkele, Hybrid Advances 5 (2024) 100141.
8. Green synthesis of copper nanoparticles using neem (azadirachta indica) leaf extract and their antimicrobial activity, D. Gurudevi, Ch.Sirisha, Dogo Rangsang Research Journal, Vol-13, Issue-2, No. 1, February 2023, ISSN : 2347-7180.
9. Experimental Chemistry- D. V. Jahagirdar, Himalaya Publishing House.
10. Advanced Practical Chemistry, Jagdamba Singh, R.K.P. Singh, Jaya Singh, LDS Yadav, IR Siddiqui, Jaya Shrivastav, Pragati Edition.

CHE-371-VSC-P: APPLIED ANALYTICAL CHEMISTRY

Course Type: VSC **Credits: 2**

A. Course Objectives:

1. To introduce the principles and applications of spectroscopic, colorimetric, and electrochemical analytical techniques.
2. To develop skills in qualitative and quantitative chemical analysis used in pharmaceutical, forensic, food, and environmental laboratories.
3. To provide hands-on training in method development, validation, and instrumental analysis for chemical investigations.
4. To familiarize students with forensic chemistry techniques for identification and analysis of toxic substances and evidence materials.
5. To enhance practical knowledge of analytical methods used in agricultural, pharmaceutical, and industrial sample analysis.
6. To inculcate scientific reasoning, laboratory safety, data interpretation, and analytical report writing skills.

B. Course Outcomes (COs):

CO No.	Course Outcome Statement (COs) *After learning the course, the students are able to -*
CO-1	Recall principles and procedures of analytical techniques.
CO-2	Explain the working and applications of analytical methods.
CO-3	Apply analytical and instrumental techniques for sample analysis.
CO-4	Analyze experimental and instrumental data for interpretation of results.
CO-5	Evaluate accuracy and applicability of analytical methods.
CO-6	Design and perform analytical procedures using suitable techniques.

C. Contents:

Prerequisites
Students should have basic knowledge of analytical chemistry, qualitative and quantitative chemical analysis, stoichiometry, and laboratory safety practices. Familiarity with handling laboratory instruments, preparation of standard solutions, titration techniques, and basic spectroscopic concepts is desirable.
A minimum of 12 experiments are to be completed.
Part-I: Investigative Approach in Colorimetry

Experiment-1 and 2: Colorimetry: Development of green chemistry method of estimation of Fe(III) using tea extract / salicylic acid / 5-sulfosalicylic acid. a) determine best pH for estimation b) linearity range c) Molar absorbance d) detection limit e) estimation of iron from blade sample using developed method. [J. of Chemical Education: https://pubs.acs.org/doi/10.1021/acs.jchemed.9b00530]
[http://www.kinetics.nsc.ru/comp/comp2016/Pozdnyakov4.pdf;

Experiment-3 and 4: Development of method for estimation of Mn(II) using form-aldoxime method. a) determine best pH for estimation b) linearity range c) Molar absorbance d) detection limit e) estimation of Mn from Mn-steel sample using developed method. (https://pdf.benchchem.com/1209/Application_Notes_Formaldoxime_Colorimetric_Method_for_Manganese_Determination_in_Water.pdf); 10.1016/S0003-2670(00)88510-4

Part-II: Application of Qualitative Analysis in Forensic and Pharmaceutical Industry

Experiment-5-6: Identification tests and Limit test of iron, heavy metal, barium, carbonate, chloride, sulfate and nitrate in Dibasic calcium phosphate / Dextrose (glucose) or any other pharmaceutical as raw material in pharmaceutical industry. (Ref-1)

Experiment-7: Forensic Investigation - Qualitative and Confirmatory Tests for poisons (any ***four compounds*** from the least given in book): Test for aniline / para aminophenol, Test for antimony (No C.T.), Test for Borate (use talcum powder), Chlorate, Dinitrophenol pesticides, Ethanol / methanol, Formaldehyde, peroxides, Hypochlorites, Iodates, Nitrate / nitrite, Nitrobenzene, Oxalates; Paracetamol, Phenol, Salicylic acid its derivatives, Thiocynates (**Note:** Sample in the form of aqueous solutions shall be given containing slightly higher conc. of poison than prescribed conc. in monograph of the substance). (Ref-2). For the substance tested student should write toxicity effects. (Ref-2)

Experiment-8: Identification by IR spectroscopy a**) Pharmaceutical:** Use of IR spectroscopy for identification of pharmaceutical substance as per IP any of any four active pharmaceutical ingredients **b) Forensic Investigation**: Identification of fiber (Nylon, polyester, cotton) by IR spectroscopy for forensic investigation. (Ref.-1 and 3).

Part-III: Quantitative Analysis

Experiment-9: Determination of soil organic matter a) Determination of soil organic matter by loss on ignition b) Determination of easily oxidizable organic-C by Tinsley's wet combustion. (Ref-5).

Experiment-10: **Forensic quantitative analysis of nitrate**: Qualitative test of nitrate and its quantitative analysis by colorimetry. (Ref-2)

Experiment-11: **Quantitative separation and Analysis**: Analysis of Fe and Cr from blade sample (Fe-Gravimetric method Cr-volumetric method).

Experiment-12: Determination of Dextrose content DNA saline by Polarimetry and NaCl by Argentometric titration. (Ref-1)

Experiment-13: Determination of glucose content in three different glucose supplements by Volumetric method (Fehling Solution Method). (https://blamp.sites.truman.edu/files/2016/01/Fehling-final.pdf) (https://egyankosh.ac.in/bitstream/123456789/15896/1/Experiment-11)

Experiment-14: Determination of caffeine content in three different brands of tea powder by solvent extraction. (Ref-4)

Experiment-15: Determination of moisture (Loss on Drying), ash and sulfated ash in aspirin / instant coffee sample. (Ref-1 and 4)

Experiment-16: Determination of organic nitrogen by Kjeldahl's Method (ref-1) or Determination of organic plus ammonium-N by digestion and distillation

Experiment-17: Determination of effective cation exchange capacity (ECEC) (Ref-5)

Experiment-18: Visit to Forensic Laboratory or Pharmaceutical industry / Food Industry

References:

1. Basics of Analytical Toxicology, World Health Organization, Geneva, 1995.
2. Basic Principles of Forensic Chemistry, JaVed I. Khan • Thomas J. Kennedy Donnell R. Christian, Jr., Humana Press
3. FSSAI Manual for analysis of Coffee/Chicori/etc.
4. Methods in Agricultural Chemical Analysis A Practical Handbook; N.T. Faithfull, CABI Publishin

CHE-381-OJT: ON JOB TRAINING

Course Type: OJT **Credits: 4**

A. Course Objectives:

1. To provide hands-on training in chemistry-related industries, laboratories, and research organizations.
2. To develop laboratory skills, analytical abilities, and professional ethics among students.
3. To expose students to industrial practices, instrumentation, quality control, and safety procedures.
4. To enhance problem-solving, teamwork, communication, and technical skills.
5. To familiarize students with modern analytical instruments and industrial processes.
6. To create awareness regarding entrepreneurship and employment opportunities in chemistry.

B. Course Outcomes (COs):

CO No.	Course Outcome Statement (COs) *After learning the course, the students are able to -*
CO-1	Apply theoretical chemistry concepts in practical and industrial environments.
CO-2	Operate and understand basic analytical instruments and laboratory techniques.
CO-3	Demonstrate professional ethics, laboratory safety, and teamwork.
CO-4	Analyze chemical processes, observations, and experimental data effectively.
CO-5	Prepare technical reports and communicate scientific findings professionally.
CO-6	Develop employability and entrepreneurship skills in chemistry-related sectors.

C. Contents:

1. Introduction

The On-the-Job Training (OJT) course is designed to provide practical exposure, skill development, and industrial experience to T.Y.B.Sc. Chemistry students in accordance with NEP 2020 guidelines. The course aims to bridge the gap between theoretical chemistry knowledge and its real-life applications in industries, laboratories, research institutes, and entrepreneurship sectors. The OJT shall be conducted under the supervision of the Department of Chemistry and concerned industry/organization mentor.

2. Areas for OJT Training

Students may complete OJT in any one of the following areas:

A) Analytical Instrumentation Training

Hands-on training on selected instruments such as:

- UV-Visible Spectrophotometer
- FT-IR Spectrometer
- pH Meter
- Conductivity Meter
- Flame Photometer
- Colorimeter
- HPLC
- Gas Chromatography
- XRD
- Thermal Analyzer
- Raman Spectrometer
- CHN Analyzer
- NMR spectrometer
- Mass spectrometer
- Any other instrument related to chemistry

Note: Instruments selected should collectively complete the required 120 hours.

B) Industrial Training

Training in:

- Pharmaceutical industries
- Chemical manufacturing industries
- Food and beverage industries
- Fertilizer industries
- Polymer industries
- Paint and dye industries
- Water analysis laboratories
- Environmental monitoring laboratories
- Any other chemistry based industry

C) Research Laboratory Training

Training at:

- National laboratories
- Research institutes
- University research centers

- Testing laboratories
- Quality control laboratories

D) Entrepreneurship-Oriented Training

Students may undertake training related to preparation and packaging of:

- Soaps and detergents
- Phenyl and cleaning agents
- Herbal products
- Dyes and pigments
- Sanitizers
- Fertilizers
- Laboratory reagents
- Other chemistry-based products

3. General Guidelines

1. Every student must complete **120 hours** of OJT training.
2. OJT may be conducted during vacation, semester break, or as scheduled by the department.
3. Students must maintain discipline and follow the rules of the organization/institute.
4. Students shall maintain:
    - Daily diary/logbook
    - Attendance record
    - Activity record
5. Attendance during OJT is compulsory.
6. The training mentor/supervisor shall monitor the student's progress.
7. Students must submit a detailed OJT report at the end of training.
8. The report must be certified by the industry/research mentor and departmental coordinator.
9. Students shall give a presentation/viva voce during final evaluation.
10. Any malpractice or fake submission shall lead to cancellation of OJT.

4. Format of OJT Report

The report should contain the following sections:

1. Title Page
2. Certificate
3. Declaration
4. Acknowledgement

5. Index
6. Introduction
7. Objectives of Training
8. Organization/Industry Profile
9. Details of Work Performed
10. Instrumentation/Techniques Used
11. Observations and Learning Outcomes
12. Safety Measures Followed
13. Conclusion
14. References
15. Appendix
16. Attendance Sheet
17. Daily Logbook

5. Report Specifications

- Font: Times New Roman
- Font Size: 12
- Heading Size: 14–16
- Line Spacing: 1.5
- Margin:
  - Left: 1.5 inch
  - Others: 1 inch
- Report Binding: Black book/Spiral Binding
- Copies Required: 2 (Department & Student)

6. Evaluation Scheme for OJT (4 Credits)

Component	Marks
Internal Evaluation	30 Marks
External Evaluation	70 Marks
Total	100rks

A) Internal Evaluation (30 Marks)

The internal evaluation shall be carried out by the Departmental Coordinator/Faculty Supervisor based on student performance during the OJT period.

Sr. No.	Criteria	Marks
1	Attendance, Discipline and Punctuality	05
2	Maintenance of Daily Diary / Logbook	05
3	Laboratory Skills and Participation	05
4	Technical Knowledge and Learning Ability	05
5	Professional Behaviour, Communication and Teamwork	05
6	Progress Report / Mid-Term Review	05
Total		**30 Marks**

B) External Evaluation (70 Marks)

The external evaluation shall be conducted jointly by the External Examiner and Internal Examiner through report assessment, presentation, and viva-voce examination.

Sr. No.	Criteria	Marks
1	OJT Report and Documentation	20
2	Presentation / Demonstration	15
3	Viva-Voce Examination	10
4	Practical Understanding and Skill Proficiency	10
5	Overall Performance and Industrial Exposure	15
Total		**70 Marks**

C) Passing Criteria

1. Students must complete **120 hours** of On-the-Job Training.
2. Separate passing is mandatory in:
    - Internal Evaluation
    - External Evaluation
3. Submission of:
    - Attendance Sheet
    - Daily Diary/Logbook
    - Certified OJT Report is compulsory for external examination.
4. Students must appear for presentation and viva-voce examination.

D) Suggested Distribution of Responsibilities

Evaluation Component	Evaluator
Internal Evaluation	Departmental Supervisor / OJT Coordinator
External Evaluation	External Examiner + Internal Examiner