ANDHRA PRADESH STATE COUNCIL OF HIGHER EDUCATION

Model Syllabus for 4-Year UG Honours in B.Sc. (Chemistry) as Major in consonance with Curriculum framework w.e.f. AY 2025-26

COURSE STRUCTURE (for Semester I to VI)

Year	Semester	Course	Title of the Course	No. of Hrs /Week	No. of Credits
I	I	1	General Chemistry	3	3
			Qualitative Analysis of Simple Salt	2	1
		2	Inorganic Chemistry	3	3
			Inorganic Preparations	2	1
	II	3	Organic Chemistry – I (Structural Theory & Hydrocarbons)	3	3
			Organic Preparations	2	1
		4	Physical Chemistry – I (States of Matter, Phase rule & Surface Chemistry)	3	3
			Physical Chemistry – I Practical	2	1
II	III	5	Organic Chemistry – II (Halogenated Hydrocarbons and Oxygen Containing Functional Groups)	3	3
			Organic Qualitative Analysis	2	1
		6	Physical Chemistry – II (Solutions and Electrochemistry)	3	3
			Physical Chemistry – II Practical	2	1
		7	Coordination Chemistry	3	3
			Preparation of Coordination Compounds	2	1
	IV	8	Organic Chemistry-III (Nitrogen Containing Organic Compounds &Biomolecules)	3	3
			Organic Chemistry-III Practical	2	1
		9	Physical Chemistry – III (Ionic equilibrium and Thermodynamics)	3	3

Year	Semester	Course	Title of the Course	No. of Hrs /Week	No. of Credits
			Qualitative Analysis of Inorganic Mixture	2	1
		10	Applied and Physical Chemistry	3	3
			Applied and Physical Chemistry Practical	2	1
III	V	11	Organic Spectroscopy	3	3
			Organic Spectral Problems	2	1
		12 A	Analytical Methods in Chemistry	3	3
			Analytical Methods in Chemistry Practical	2	1
		OR			
		12 B	Synthetic Organic Chemistry	3	3
			Synthetic Organic Chemistry Practical	2	1
		13 A	Separation techniques and Chromatography	3	3
			Separation techniques and Chromatographic Techniques	2	1
		OR			
		13 B	Industrial Chemistry - Polymers	3	3
			Industrial Chemistry - Polymers Practical	2	1
	VI	14 A	Green Chemistry and Nanotechnology	3	3
			Green Chemistry and Nanotechnology - Practical	2	1
		OR			
		14 B	Industrial Chemistry-Fertilizers and Surface Coatings	3	3
			Industrial Chemistry-Fertilizers and Surface Coatings Practical	2	1
		15 A	Environment and Industrial Chemicals	3	3
			Environment and Industrial Chemicals Practical	2	1
		OR			
		15 B	Food Chemistry	3	3
			Food Chemistry Practical	2	1

Note: In the III Year (during the V and VI Semesters), students are required to select a pair of electives from one of the **Two** specified domains. **For example: if set 'A' is chosen, courses 12 to 15 to be chosen as 12 A, 13 A, 14 A and 15 A.** To ensure in-depth understanding and skill development in the chosen domain, students must continue with the same domain electives in both the V and VI Semesters.

SEMESTER-I

COURSE 1: GENERAL CHEMISTRY

Theory	**Credits: 3**	**3 hrs/week**

I. LEARNING OBJECTIVES:

1. To understand the structure of the atom and its relation to periodic properties.
2. To explain different types of chemical bonding-ionic, covalent, metallic, hydrogen bonding.
3. To apply bonding theories to predict molecular structure and bonding nature.
4. To correlate periodic trends with physical and chemical properties of elements.
5. To evaluate practical applications of nuclear chemistry in science and industry

II. COURSE OUTCOMES:

At the end of the course the student will be able to

1. Describe the electronic configuration of elements and periodic trends.
2. Analyze the formation and properties of ionic and covalent compounds.
3. Apply VSEPR, hybridization, and MOT to predict molecular geometry and bonding.
4. Explain metallic bonding, hydrogen bonding, and intermolecular forces and relate them to physical properties.
5. Explain types of radioactivity, nuclear reactions, and real-life applications.

III. SYLLABUS:

UNIT-1: ATOMIC STRUCTURE AND PERIODIC TABLE (9 h)

Electronic configuration-Aufbau principle, Hund's rule and Pauli's exclusion principle. Periodic law and arrangement of elements in the periodic table, horizontal, vertical, and diagonal relationships in the periodic table. Definition and periodic trends of atomic radii, ionic radii, covalent radii, ionization potential, electron affinity, and electronegativity, Pauling scale, variable valency, inert-pair effect.

UNIT-2: IONIC BOND (9 h)

Properties of ionic compounds, factors favouring the formation of ionic compounds, Lattice energy: definition, factors affecting lattice energy, Born-Haber cycle - enthalpy of formation of ionic compound and stability, Covalent character in ionic compounds - polarization and Fajan's rules, effects of polarization.

UNIT- 3: COVALENT BOND (9 h)

Valence Bond theory: Hybridization of atomic orbitals and geometry of molecules - $BeCl_2$, BF_3, CH_4, PCl_5, and SF_6

VSEPR model: Effect of bonding and nonbonding electrons on the structure of molecules - NH_3, H_2O, SF_4, ICl_2^- and XeF_4

Molecular orbital theory: LCAO method, construction of M.O. diagrams for homo nuclear and hetero nuclear diatomic molecules (N_2, O_2, CO and NO)

UNIT - 4: METALLIC AND HYDROGEN BONDS (9 h)

Metallic bond: Metallic properties, free electron theory, band theory of metals. Explanation of conductors, semiconductors and insulators.

Hydrogen bonding: Intra and Inter-molecular hydrogen bonding, influence on the physical properties of molecules, Van der waals forces, dipole-dipole interactions.

UNIT-5: NUCLEAR CHEMISTRY (9 h)

Definition, Isotopes, n/p ratio, binding energy, types of radioactivity, Soddy-Fajan's displacement law, Law of Radioactivity, Radioactive decay series, Nuclear Reactions- Fission and Fusion, Applications of radioactivity in agriculture and medicine.

IV. REFERENCES:

1. J.D. Lee, Concise Inorganic Chemistry, 5th ed., Blackwell Science, London, 1996.
2. B. R. Puri, L.R. Sharma, K.C. Kalia, Principles of Inorganic Chemistry, Shoban Lal Nagin Chand and Co.,1996.
3. D.F. Shriver and P.W. Atkins, Inorganic Chemistry, 3rd ed., W. H. Freeman and Co, London,
4. James E. Huheey, **Inorganic Chemistry: Principles of Structure and Reactivity**, 4thed., 2017.
5. W.U. Malik, G.D Tuli, R.D Madan, Selected Topics in Inorganic Chemistry, S. Chand Publishing, 1998.
6. H.J. Arnikar, Essentials of Nuclear Chemistry, New Age International Publishers, 2015.

V. PROPOSED ACTIVITIES:

1. Chart on periodic trends like radii, ionization energy, electronegativity across groups/periods.
2. Worksheet solving- MOT diagrams and hybridization problems.
3. Model Building-Build 3D structures using kits/software for CH_4, PCl_5, XeF_4 etc.

VI. CO-CURRICULAR ACTIVITIES AND ASSESSMENT METHODS

1. Continuous Internal Evaluation (CIA): Monitoring the progress of student's learning.
2. Class Tests, Worksheets, Quizzes, Industrial/Field visits, Student seminars, Poster and PPT presentations, Peer learning, Project-based learning, Assignments, Debates, Group Discussions: Enhances critical thinking skills.
3. Semester End Examination (SEE): Critical indicator of student's learning and teaching methods adopted by teachers throughout the semester.

SEMESTER-I

COURSE 1: QUALITATIVE ANALYSIS OF SIMPLE SALT

Practical **Credits: 1** **2 hrs/week**

I. LEARNING OBJECTIVES:

1. To understand the theoretical principles behind classical qualitative analysis of cations and anions.
2. To develop the ability to identify common cations and anions in inorganic salts.
3. To practice laboratory safety and correct handling of reagents.
4. To record and interpret observations accurately in systematic salt analysis.

II. COURSE OUTCOMES:

At the end of the course the student will be able to

1. Proper use of glassware, equipment and chemicals in the laboratory
2. Apply systematic procedures to identify one cation and one anion in a given inorganic salt.
3. Analyze reactions based on solubility, color changes, and precipitate formation.
4. Interpret results to draw conclusions and confirm the identity of ions.

III. SYLLABUS:

Analysis of simple salt containing **one anion and one cation** from the following:

Anions: Carbonate, sulphate, chloride, bromide, acetate, nitrate, borate, phosphate.

Cations: Lead, copper, iron, aluminium, zinc, nickel, manganese, calcium, strontium, barium, ammonium.

IV. REFERENCES

1. G. Svehla, Vogel's Textbook of Qualitative Inorganic Analysis, Pearson Education, 2008.
2. K. Nagaraj, S. Kamalesu, S. Lokhandwala, N.M. Parekh, Textbook of Semi-micro Inorganic Qualitative Analysis, Notion Press, 2023.
3. G. Pass, H. Sutcliff, Practical Inorganic Chemistry. 2nd edition, John-Wiley & Sons, 2020.

V. CO-CURRICULAR ACTIVITIES AND ASSESSMENT METHODS

1. Internal Practical Assessment
2. Lab Record Evaluation
3. Final Practical Examination
4. Oral/Viva Voce

SEMESTER-I

COURSE 2: INORGANIC CHEMISTRY

Theory	**Credits: 3**	**3 hrs/week**

I. LEARNING OBJECTIVES:

1. To explain preparation and uses of selected p-block compounds.
2. To understand the structural and chemical properties of selected p-block compounds.
3. To classify and analyze the characteristics of d- and f-block elements.
4. To compare the properties of lanthanides and actinides.
5. To understand the processes involved in the extraction of metals from their ores.

II. COURSE OUTCOMES:

At the end of the course the student will be able to

1. Explain the structures and preparation of key p-block compounds.
2. Classify d- and f-block elements and discuss their properties and oxidation states.
3. Analyze magnetic, catalytic, and color properties of transition metals.
4. Compare and contrast lanthanides and actinides based on electronic configuration.
5. Explain and differentiate various metallurgical processes used in the extraction of metals.

III. SYLLABUS:

UNIT-1: CHEMISTRY OF p-BLOCK ELEMENTS – I (9 h)

Group 13: Preparation and structure of Diborane, Borazine and (BN)x.

Group 14: Preparation, classification and uses of silicones.

Group 15: Preparation and structure of Phosphonitrilic Chloride $P_3N_3Cl_6$.

UNIT-2: CHEMISTRY OF p-BLOCK ELEMENTS – II (9 h)

Group 16: Classification of oxides, structures of oxides and oxoacids of sulphur.

Group 17: Preparation and structures of Interhalogen compounds, Pseudohalogens.

UNIT-3: CHEMISTRY OF d-BLOCK ELEMENTS (9 h)

Characteristics of d-block elements with special reference to electronic configuration, variable valency, colour, magnetic properties, catalytic properties and ability to form complexes. Stability of various oxidation states of 3d-series.

UNIT-4: CHEMISTRY OF f-BLOCK ELEMENTS (9 h)

Chemistry of Lanthanides: Electronic configuration, oxidation states, colour, magnetic properties, lanthanide contraction, consequences of lanthanide contraction.

Chemistry of Actinides: Electronic configuration, oxidation states, actinide contraction, comparison of lanthanides and actinides.

UNIT-5: GENERAL PRINCIPLES OF METALLURGY (9 h)

Occurrence of metals, minerals and ores, Concentration of ores- levigation, magnetic separation, froth floatation, leaching, Conversion of concentrated ores to oxide- calcination and roasting, reduction of oxide to the metal, Refining of crude metal-distillation, liquation, poling, electrolysis, zone refining and vapour phase refining, Corrosion and its prevention, Alloys.

IV. REFERENCES:

1. J. D. Lee, Concise Inorganic Chemistry, 5th ed., Blackwell Science, London, 1996.
2. B.R. Puri, L.R. Sharma, K.C. Kalia, Principles of Inorganic Chemistry, Shoban Lal Nagin Chand and Co.,1996.
3. D.F. Shriver, P.W. Atkins, Inorganic Chemistry, W. H. Freeman and Co, London,1999.
4. J.E. Huheey, **Inorganic Chemistry: Principles of Structure and Reactivity**, 4thed., 2017.
5. A.K. Das, Fundamentals of Metallurgy. Tata McGraw Hill Education, 2011.

V. PROPOSED ACTIVITIES:

1. Group discussion: Trends in d-block and f-block properties across periods and groups.
2. Comparative worksheet: Lanthanide vs Actinide behaviour.
3. Seminar: Uses of metals in daily life.

VI. CO-CURRICULAR ACTIVITIES AND ASSESSMENT METHODS:

1. Continuous Internal Evaluation (CIA): Monitoring the progress of student’s learning.
2. Class Tests, Worksheets, Quizzes, Industrial/Field visits, Student seminars, Poster and PPT presentations, Peer learning, Project based learning, Assignments, Debates, Group Discussions: Enhances critical thinking skills.
3. Semester End Examination (SEE): Critical indicator of student’s learning and teaching methods adopted by teachers throughout the semester.

SEMESTER-I

COURSE 2: INORGANIC PREPARATIONS

Practical	**Credits: 1**	**2 hrs/week**

I. LEARNING OBJECTIVES:

1. To understand and apply stoichiometry and principles of inorganic salt preparation.
2. To learn techniques such as crystallization, filtration, and drying.
3. To calculate percentage yields.
4. To handle reagents and lab apparatus safely and precisely

II. COURSE OUTCOMES:

At the end of the course the student will be able to

1. Demonstrate safe use of laboratory equipment and chemical handling.
2. Describe the theoretical background for the preparation of inorganic salts.
3. Perform synthesis of potash alum, ferrous salts, and cuprous chloride following proper procedures.
4. Analyze colour changes, crystal formation, and yields to evaluate reaction completion.

III. SYLLABUS:

1. Preparation of Potash alum.
2. Preparation of Ferrous oxalate
3. Preparation of Ferrous ammonium sulphate.
4. Preparation of Cuprous chloride.
5. Preparation of Chrome alum.

IV. REFERENCES:

1. G. Svehla, Vogel's Textbook of Qualitative Inorganic Analysis, Pearson Education, 2008.
2. G.H. Jeffery, J. Bassett, J. Mendham, R.C. Denney, Vogel's Textbook of Quantitative Chemical Analysis, John Wiley and Sons, 1989.

V. CO-CURRICULAR ACTIVITIES AND ASSESSMENT METHODS:

1. Internal Practical Assessment
2. Lab Record Evaluation
3. Final Practical Examination
4. Oral/Viva Voce

SEMESTER-II

COURSE 3: ORGANIC CHEMISTRY-I

Theory **Credits: 3** **3 hrs/week**

I. LEARNING OBJECTIVES:

1. To understand the structural theory behind reactivity in organic chemistry.
2. To identify and classify hydrocarbons, their reactions, and stability.
3. To explain organic reaction mechanisms and orientation in aromatic substitution.
4. To apply concepts like resonance, inductive effects, hyperconjugation, and aromaticity.
5. To analyze stereochemistry through molecular representations and optical activity.

II. COURSE OUTCOMES:

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

1. Study Inductive effect, Mesomeric effect, Hyperconjugation and its applications.
2. Explain the preparation and chemical properties of alkanes, alkenes, alkynes and benzene.
3. Analyze and apply Huckel's rule to benzenoid and non-benzenoid aromatic compounds.
4. Differentiate between Markownikoff and Anti-markownikoff addition, Ring activating and deactivating groups.
5. Interpret stereochemical representations and identify chiral molecules.

III. SYLLABUS:

UNIT-1: STRUCTURAL THEORY IN ORGANIC CHEMISTRY (9 h)

Functional groups in organic chemistry, Types of bond fission, Electrophiles, Nucleophiles, Reactive intermediates-carbocations, carbanions & free radicals. Inductive effect and its application: (a) Basicity of amines and (b) Acidity of carboxylic acids, Resonance or Mesomeric effect and its application: (a) Acidity of phenol, and (b) Acidity of carboxylic acids. Hyper conjugation and its application to the stability of carbonium ions.

UNIT-2: SATURATED HYDROCARBONS (ALKANES & CYCLOALKANES) (9 h)

Types of organic reactions: Addition, Elimination, Substitution and Rearrangement reactions.

Alkanes: Preparation of alkanes by Corey House synthesis, Substitution reactions of alkanes.

Cycloalkanes: Cycloalkanes and their relative stability, Baeyer strain theory, Cyclohexane conformations with energy diagram.

UNIT-3: UNSATURATED HYDROCARBONS (ALKENES & ALKYNES) (9 h)

Alkenes: Preparation of alkenes by dehydration of alcohols, Saytzeff and Hofmann eliminations, Electrophilic Additions of X_2, H_2O, HX to alkene, Markownikoff and Anti-markownikoff addition, Ozonolysis, Diels-Alder reaction, 1,2- and 1,4-addition reactions in conjugated dienes.

Alkynes: Additions of X_2, H_2O, HX to alkynes, acidity and alkylation of terminal alkynes.

UNIT-4: AROMATICITY, BENZENE AND ITS REACTIVITY (9 h)

Aromaticity: Concept of aromaticity, Huckel's rule - application to Benzenoid (Benzene, Naphthalene) and Non-Benzenoid compounds (cyclopropenylcation, cyclopentadienyl anion and tropylium cation). Electrophilic aromatic substitution benzene- Halogenation, Nitration, Friedel-Craft's alkylation and Friedel- Craft's acylation.

Orientation of aromatic substitution: Ortho, para and meta directing groups with examples, Ring activating and deactivating groups with examples.

UNIT- 5: STEREOCHEMISTRY OF CARBON COMPOUNDS (9 h)

Molecular representations - Wedge, Fischer, Newman and Saw-Horse formulae.

Optical isomerism: Optical activity, optical rotation and specific rotation. Chiral molecules- Symmetry elements-enantiomers and diastereomers, Explanation of optical isomerism with examples- Glyceraldehyde, Lactic acid, and Tartaric acid. Relative configuration (D, L-notation), CIP rules, Absolute configuration (R, S-Configuration)

IV. REFERENCES:

1. R.N. Morrison, R.N. Boyd, Organic Chemistry, Pearson Education, 7th edition, 2010.
2. Peter Sykes, Guidebook to Mechanism in Organic Chemistry, 6th edition, 1985.
3. S.P. Singh, O. Prakash, Reaction mechanism in organic chemistry, Laxmi Publications, 2017.
4. P.Y. Bruice, Organic Chemistry, 8th Edition, Pearson, 2017.
5. V.K. Ahluwalia, P. Bhagat, R. Aggarwal, R. Chandra, Intermediate for Organic Synthesis, I.K. International. 2005.
6. T.W.G. Solomons, C.B. Fryhle, S.A. Snyder, Organic Chemistry, 12th Edition, Wiley, 2016.
7. P.S. Kalsi, Stereochemistry, New Age International, 2015.
8. D. Nasipuri, Stereochemistryof organic compounds, New Age International, 2020.

V. PROPOSED ACTIVITIES:

1. Mechanism writing exercises- Electrophilic aromatic substitution, electrophilic additions.
2. Group quiz on directive effects and reactive intermediates.
3. Concept mapping-Properties of alkane, alkene, alkyne, benzene.

VI. CO-CURRICULAR ACTIVITIES AND ASSESSMENT METHODS:

1. Continuous Internal Evaluation (CIA): Monitoring the progress of student’s learning
2. Class Tests, Worksheets, Quizzes, Industrial/Field visits, Student seminars, Poster and PPT presentations, Peer learning, Project-based learning, Assignments, Debates, Group Discussions: Enhances critical thinking skills.
3. Semester End Examination (SEE): Critical indicator of student’s learning and teaching methods adopted by teachers throughout the semester.

SEMESTER-II

COURSE 3: ORGANIC PREPARATIONS

Practical	Credits: 1	2 hrs/week

I. LEARNING OBJECTIVES:

1. Understand mechanisms and conditions for common organic synthesis reactions (nitration, bromination, esterification, acetylation).
2. Perform organic synthesis using appropriate techniques such as heating, reflux, crystallization, and filtration.
3. Develop safe laboratory practices and chemical handling procedures.

II. COURSE OUTCOMES:

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

1. Describe the theoretical background and reaction mechanisms of organic preparations.
2. Synthesize organic compounds using standard laboratory procedures.
3. Analyze reaction steps and evaluate the melting point, and yield of synthesized products.
4. Relate synthesis methods to pharmaceutical and industrial applications.

III. SYLLABUS:

1. Preparation of tribromo aniline
2. Preparation of p-nitroacetanilide
3. Preparation of nerolin
4. Preparation of aspirin (Acetylsalicylic acid)
5. Preparation of paracetamol (Acetaminophen)

IV. REFERENCES:

1. B.S. Furniss, A.J. Hannaford, P.W.G. Smith, A.R.Tatchell, Vogel's Textbook of Practical Organic Chemistry, Pearson, 2012.
2. V.K. Ahluwalia, R. Agarwal, Comprehensive Practical Organic Chemistry, University Press, 2010.

V. CO-CURRICULAR ACTIVITIES AND ASSESSMENT METHODS:

1. Internal Practical Assessment
2. Lab Record Evaluation
3. Final Practical Examination
4. Oral/Viva Voce

SEMESTER-II

COURSE 4: PHYSICAL CHEMISTRY-I

Theory **Credits: 3** **3 hrs/week**

I. LEARNING OBJECTIVES:

1. To understand the theoretical principles governing gases, liquids, solids, and colloidal systems.
2. To apply gas laws and interpret the behavior of real and ideal gases.
3. To describe physical properties of matter in various states and relate them to structural features.
4. To interpret phase diagrams and apply Gibbs' phase rule to one- and two-component systems.

II. COURSE OUTCOMES:

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

1. Explain gas laws, ideal and real gases behaviour, and critical phenomena.
2. Describe properties of liquids and classify types and applications of liquid crystals.
3. Derive Bragg's equation and identify types of crystal defects.
4. Apply the phase rule to interpret phase diagrams and systems with eutectic/congruent/incongruent points.
5. Differentiate between types of adsorption and colloidal systems, and evaluate their applications.

III. SYLLABUS:

UNIT-1: GASEOUS STATE **(9 h)**

Gas laws, Ideal Gas equation, Vander Waal's equation of state, Andrew's isotherms of carbon dioxide, Critical phenomena, Relationship between critical constants and van der Waal's constants, Law of corresponding states, Joule-Thomson effect, Inversion temperature.

UNIT-2: LIQUID STATE **(9 h)**

Physical properties of liquids: Definition of vapour pressure, boiling point, surface tension and coefficient of viscosity, Effect of temperature and addition of solutes on surface tension and viscosity.

Liquid crystals: Mesomorphic state, Differences between liquid crystal and solid/liquid. Classification of liquid crystals into Smectic and Nematic, Application of liquid crystals as LCD devices.

UNIT-3: SOLID STATE **(9 h)**

Law of constancy of interfacial angles, The law of rationality of indices-Miller indices, Symmetry in crystals, definition of lattice point, space lattice, unit cell, Bravais lattices and crystal systems, X-ray diffraction and crystal structure, Bragg's law and its derivation, Defects in crystals: Stoichiometric and Non-stoichiometric defects.

UNIT-4: PHASE RULE **(9 h)**

The concept of phase, components, degrees of freedom, Gibbs phase rule, Phase diagram of one component system – water system, Definition and examples for systems having congruent and incongruent melting point, Study of Phase diagrams of Simple eutectic systems (i) Pb-Ag system, desilverisation of lead (ii) NaCl-Water system, freezing mixtures

UNIT-5: SURFACE CHEMISTRY **(9 h)**

Colloids: Definition and classification of Colloids, Coagulation of colloids, Hardy-Schulze rule. Stability of colloids, Protection of Colloids-Gold number.

Adsorption: Physical and chemical adsorption, Freundlich and Langmuir adsorption isotherm, applications of adsorption.

IV. REFERENCES:

1. P.W. Atkins, J.de., Paula, Atkin's Physical Chemistry, 10th Edition, Oxford University Press, 2014.
2. D.W. Ball, Physical Chemistry, 2nd Edition, Cengage Learning, 2017.
3. G.W. Castellan, Physical Chemistry, 4th Edition, Narosa, 2014.
4. K.L. Kapoor, A Textbook of Physical Chemistry, 6th Edition, McGraw-Hill Education, 2015.

V. PROPOSED ACTIVITIES:

1. Model building: Bravais lattices and symmetry in crystals
2. Chart preparation of phase diagrams (Water, Pb-Ag, NaCl-H2O)
3. PPT: Adsorption isotherms or colloidal behavior.
4. List out applications of Liquid crystals in different display devices.
5. Peer Teaching: Phase rule and eutectic systems

VI. CO-CURRICULAR ACTIVITIES AND ASSESSMENT METHODS:

1. Continuous Internal Evaluation (CIA): Monitoring the progress of student's learning
2. Class Tests, Worksheets, Quizzes, Industrial/Field visits, Student seminars, Poster and PPT presentations, Peer learning, Project-based learning, Assignments, Debates, Group Discussions: Enhances critical thinking skills.
3. Semester End Examination (SEE): Critical indicator of student's learning and teaching methods adopted by teachers throughout the semester.

SEMESTER-II

COURSE 4: PHYSICAL CHEMISTRY-I PRACTICAL

Practical **Credits: 1** **2 hrs/week**

I. LEARNING OBJECTIVES:

1. To understand the concepts of surface tension and viscosity of liquids.
2. To familiarize students with using different lab equipment and glassware for the determination of the coefficient of viscosity and surface tension.
3. To gain hands-on experience in preparing colloidal solutions.

II. COURSE OUTCOMES:

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

1. Use glassware, equipment and follow experimental procedures in the laboratory.
2. Determine surface tension and viscosity using standard experimental techniques.
3. Prepare colloidal solutions and study their stability.
4. Conduct adsorption experiments and verify Freundlich isotherm

III. SYLLABUS:

1. Determination of surface tension of liquid by drop count method.

2. Determination of surface tension of liquid by drop weight method.

3. Determination of coefficient of viscosity of an organic liquid.

4. Preparation of sols: $Al(OH)_3$, $Fe(OH)_3$ and starch.

5. Adsorption of acetic acid on animal charcoal, verification of Freundlich isotherm.

IV. REFERENCES:

1. B.D. Khosla, V.C. Garg, A. Gulati, Senior Practical Physical Chemistry, R. Chand & Co, New Delhi, 2015.
2. K.L. Kapoor, A Textbook of Physical Chemistry, McGraw-Hill Education, 2019.
3. C.W. Garland, J.W. Nibler, D.P. Shoemaker, Experiments in Physical Chemistry, 8th Edition, McGraw-Hill, New York, 2003.

V. CO-CURRICULAR ACTIVITIES AND ASSESSMENT METHODS:

1. Internal Practical Assessment
2. Lab Record Evaluation
3. Final Practical Examination
4. Oral/Viva Voce

SEMESTER-III

COURSE 5: ORGANIC CHEMISTRY-II

Theory **Credits: 3** **3 hrs/week**

I. LEARNING OBJECTIVES:

1. To understand the structure, reactivity, and mechanisms of halogenated organic compounds, alcohols and phenols.
2. To analyze the mechanisms of key reactions involving aldehydes and ketones.
3. To discuss the properties and synthetic applications of carboxylic acids.
4. To explore the importance and utility of active methylene compounds in organic synthesis.

II. COURSE OUTCOMES:

At the end of the course, the student will be able to

1. Describe and compare SN1 and SN2 mechanisms in halogen compounds
2. Illustrate the methods of preparation and reactions of alcohols and phenols including rearrangements.
3. Predict products and explain mechanisms of carbonyl compound reactions.
4. Demonstrate the preparation and properties of carboxylic acid with mechanisms.
5. Apply synthetic strategies using acetoacetic and malonic esters for target molecule synthesis

III. SYLLABUS:

UNIT-1: HALOGENATED HYDROCARBONS (9 h)

Alkyl halides: Nucleophilic substitution reactions – SN1 and SN2 mechanisms with energy profile diagrams, Comparison of SN1 and SN2 reactions.

Aryl halides: Nucleophilic aromatic substitution, relative reactivity of alkyl, allyl, vinyl, benzyl and aryl halides towards nucleophilic substitution reactions.

UNIT-2: ALCOHOLS AND PHENOLS (9 h)

Alcohols: Preparation of 1^o, 2^o, 3^o-alcohols from Grignard's reagent, Chemical properties: substitution of –OH by using PCl_5, PCl_3, $SOCl_2$ and HX / $ZnCl_2$, Oxidation of alcohols with PCC and PDC, Pinacol-Pinacolone rearrangement with mechanism.

Phenols: Preparation from diazonium salt, Reimer-Tiemann and Kolbe–Schmidt reaction with mechanism.

UNIT-3: CARBONYL COMPOUNDS (9 h)

Preparation from acid chlorides, Nucleophilic addition reactions with HCN, and alcohols, addition-elimination reactions with hydroxylamine, hydrazine, phenyl hydrazine, 2,4-DNP, semi-carbazide, Oxidation with $KMnO_4$, Clemmensen reduction, Wolf–Kishner reduction.

Reaction & Mechanism- Aldol condensation, Cannizzaro reaction, Perkin reaction, Benzoin condensation.

UNIT-4: CARBOXYLIC ACIDS (9 h)

Preparation of carboxylic acids from Grignard reagent, Reactions of carboxylic acids involving -H, -OH and-COOH groups: formation of salts, esters, acid chlorides, amides and anhydrides. Hunsdiecker reaction, Schmidt reaction, Arndt-Eistert synthesis, Hell-Volhard-Zelinsky reaction, Mechanism of acidic hydrolysis of esters.

UNIT- 5: ACTIVE METHYLENE COMPOUNDS (9 h)

Acetoacetic ester (AAE): Keto-enol tautomerism, preparation of Acetoacetic ester by Claisen condensation with mechanism, synthetic applications of AAE in the preparation of mono carboxylic acids, dicarboxylic acids, α, β-unsaturated acids and heterocyclic compounds.

Malonic ester: Preparation and synthetic applications of Malonic ester.

IV. REFERENCES:

1. R.N. Morrison, R.N. Boyd, Organic Chemistry, Pearson Education, 7th edition, 2010.
2. Peter Sykes, Guidebook to Mechanism in Organic Chemistry, 6th edition, 1985.
3. S.P. Singh, O. Prakash, Reaction mechanism in organic chemistry, Laxmi Publications, 2017.
4. P.Y. Bruice, Organic Chemistry, 8th Edition, Pearson, 2017.
5. V.K. Ahluwalia, P. Bhagat, R. Aggarwal, R. Chandra, Intermediate for Organic Synthesis, I.K. International. 2005.
6. T.W.G. Solomons, C.B. Fryhle, S.A. Snyder, Organic Chemistry, 12th Edition, Wiley, 2016.

V. PROPOSED ACTIVITIES:

1. Concept Mapping- Compare SN1 & SN2 mechanisms with energy diagrams.
2. Lab-based Demonstration-Tests for alcohols and phenols.
3. Problem Solving / Reaction Mapping- Interconversion exercises between carboxylic acid derivatives.
4. Group Discussion: How esters are used in perfumes, solvents, and food industries.

VI. CO-CURRICULAR ACTIVITIES AND ASSESSMENT METHODS:

1. Continuous Internal Evaluation (CIA): Monitoring the progress of student’s learning.
2. Class Tests, Worksheets, Quizzes, Industrial/Field visits, Student seminars, Poster and PPT presentations, Peer learning, Project-based learning, Assignments, Debates, Group Discussions: Enhances critical thinking skills.
3. Semester End Examination (SEE): Critical indicator of student’s learning and teaching methods adopted by teachers throughout the semester.

SEMESTER-III

COURSE 5: ORGANIC QUALITATIVE ANALYSIS

Practical **Credits: 1** **2 hrs/week**

I. LEARNING OBJECTIVES:

1. To identify functional groups in unknown organic compounds using systematic analysis.
2. To determine the physical constants of organic compounds accurately.
3. To prepare suitable solid derivatives to confirm the presence of functional groups.
4. To apply laboratory safety protocols and precise techniques during analysis.

II. COURSE OUTCOMES:

At the end of the course, the student will be able to

1. Proper use of glassware, equipment and chemicals in the laboratory.
2. Systematically analyze unknown organic compounds to identify functional groups.
3. Determine melting point or boiling point of organic compounds to assess purity.
4. Prepare derivatives for confirmation of functional groups.

III. SYLLABUS:

Systematic Qualitative Analysis of an organic compounds for functional group identification including the determination of melting point and boiling point with suitable derivatives: ***Alcohols, Phenols, Aldehydes, Ketones, Carboxylic acids, Aromatic primary amines, amides and simple sugars.***

IV. REFERENCES:

1. F.G. Mann, B.C. Saunders, Practical Organic Chemistry, Pearson Education, 2009.
2. B.S. Furniss, A.J. Hannaford, P.W.G. Smith, A.R. Tatchell, Vogel's Textbook of Practical Organic Chemistry, Pearson, 2012.
3. V.K. Ahluwalia, R. Aggarwal, (2004), Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press, 2004
4. V.K. Ahluwalia, S. Dhingra, (2004), Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press, 2004.

V. CO-CURRICULAR ACTIVITIES AND ASSESSMENT METHODS:

1. Internal Practical Assessment
2. Lab Record Evaluation
3. Final Practical Examination
4. Oral/Viva Voce

SEMESTER-III

COURSE 6: PHYSICAL CHEMISTRY-II

Theory **Credits: 3** **3 hrs/week**

I. LEARNING OBJECTIVES:

1. Understand the principles governing the behaviour of solutions.
2. Apply colligative properties to determine molecular weights and solution behaviours.
3. Describe and differentiate between thermal and photochemical reactions, Fluorescence, Phosphorescence, with mechanistic insights.
4. Explain and apply concepts of ionic conductance and perform conductometric titrations.
5. Analyze electrochemical cells, EMF, electrode potentials, and perform potentiometric titrations.

II. COURSE OUTCOMES:

At the end of the course the student will be able to

1. Understand Azeotropes, Raoult's law and Nernst distribution law.
2. Calculate colligative properties and molecular masses of solutes using various experimental methods.
3. Explain laws of photochemistry and mechanisms of photochemical reactions with qualitative concepts of fluorescence and phosphorescence.
4. Evaluate conductance behavior of electrolytes and perform conductometric titrations.
5. Illustrate working principles of electrochemical cells and perform potentiometric titrations.

III. SYLLABUS:

UNIT-1: SOLUTIONS **(9 h)**

Classification - miscible, partially miscible and Immiscible, Raoult's Law, Azeotropes, $HCl-H_2O$ system and ethanol-water system, Partially miscible liquids: phenol- water system, Critical solution temperature (CST), Effect of impurity on consolute temperature, Nernst distribution law, Calculation of the partition coefficient, Applications of Nernst distribution law.

UNIT- 2: COLLIGATIVE PROPERTIES **(9 h)**

Relative lowering of vapour Pressure, Elevation in boiling point, Depression in freezing point and Osmotic pressure. Determination of molecular mass of non-volatile solute by Ostwald- Walker method, Cottrell's method, Rast method and Berkeley-Hartley method.

UNIT - 3: PHOTOCHEMISTRY **(9 h)**

Difference between thermal and photochemical processes, Laws of photochemistry: Grothus-Draper's law and Stark-Einstein's law of photochemical equivalence, Quantum Yield, Photochemical reaction mechanism: Hydrogen-Chlorine and Hydrogen-Bromine reaction. Qualitative description of Fluorescence, Phosphorescence, Jablonski diagram, Chemiluminescence, and Photosensitization.

UNIT - 4: ELECTROCHEMISTRY-I **(9 h)**

Strong and weak electrolytes, Conductance, Specific conductance, Equivalent conductance and Molar conductance - effect of dilution. Cell constant. Kohlrausch's law and its applications. Application of conductivity measurements-conductometric titrations. Transport number and determination of transport number by Hittorf's method. Debye-Huckel - Onsager's equation for strong electrolytes (derivation excluded).

UNIT- 5: ELECTROCHEMISTRY-II **(9 h)**

Electrochemical Cells, Types of electrodes with examples: Metal- metal ion, Gas electrode, Inert electrode, Redox electrode, Metal-metal insoluble salt - salt anion. Single electrode potential, Standard electrode potential, Determination of EMF of a cell, Nernst equation, Potentiometric titrations.

IV. REFERENCES:

1. P.W. Atkins, J.de. Paula, Atkin's Physical Chemistry Ed., 10^{th} Edition, Oxford University Press, 2014.
2. G.W. Castellan, Physical Chemistry, 4^{th} Edition, Narosa., 2004.
3. K.L. Kapoor, A Textbook of Physical Chemistry, 3^{rd} Edition, McGraw-Hill Education, 2015.
4. B.R. Puri, L.R. Sharma, M.S. Pathania**,** *Principles of Physical Chemistry,* Vishal Publishing, 2020.
5. P. Bahadur, **Concepts of** *Physical Chemistry*, G.R. Bathla Publications, *2018.*

V. PROPOSED ACTIVITIES:

1. Experiment: Plot miscibility curves and CST.
2. Comparative worksheet: Thermal and photochemical reactions, Fluorescence and Phosphorescence.
3. Group Work: Determination of EMF and Conductivity.

VI. CO-CURRICULAR ACTIVITIES AND ASSESSMENT METHODS:

1. Continuous Internal Evaluation (CIA): Monitoring the progress of student's learning.
2. Class Tests, Worksheets, Quizzes, Industrial/Field visits, Student seminars, Poster and PPT presentations, Peer learning, Project-based learning, Assignments, Debates, Group Discussions: Enhances critical thinking skills.
3. Semester End Examination (SEE): Critical indicator of student's learning and teaching methods adopted by teachers throughout the semester.

SEMESTER-III

COURSE 6: PHYSICAL CHEMISTRY-II PRACTICAL

Practical **Credits: 1** **2 hrs/week**

I. LEARNING OBJECTIVES:

1. Determine critical solution temperature (CST) and study the effect of electrolytes.
2. Use conductometry to determine the concentrations of strong and weak acids.
3. Apply potentiometric methods for accurate titration of acid-base systems.
4. Develop precision, accuracy, and skill in handling electrochemical instruments.

II. COURSE OUTCOMES:

At the end of the course the student will be able to

1. Determine the CST of a partially miscible liquid system and interpret the effect of impurities.
2. Conduct and interpret conductometric and potentiometric titrations of strong and weak acids with a strong base.
3. Use and calibrate electrochemical instruments accurately in titrations.

III. SYLLABUS:

1. Determination of Critical Solution Temperature (CST) for Phenol-water system.
2. Study the effect of electrolyte on Critical Solution Temperature.
3. Conductometric titration- Determination of the concentration of HCl solution using standard NaOH solution.
4. Conductometric titration - Determination of the concentration of CH_3COOH solution using standard NaOH solution.
5. Potentiometric titration - Determination of the concentration of HCl using standard NaOH solution.

IV. REFERENCES:

1. B.D. Khosla, V.C. Garg, A. Gulati, Senior Practical Physical Chemistry, R. Chand & Co, New Delhi, 2015.
2. K.L. Kapoor, A Textbook of Physical Chemistry, McGraw-Hill Education, 2019.
3. C.W. Garland, J.W. Nibler, D.P. Shoemaker, Experiments in Physical Chemistry, 8th Edition, McGraw-Hill, New York, 2003.

V. CO-CURRICULAR ACTIVITIES AND ASSESSMENT METHODS:

1. Internal Practical Assessment
2. Lab Record Evaluation
3. Final Practical Examination
4. Oral/Viva Voce

SEMESTER-III

COURSE 7: COORDINATION CHEMISTRY

Theory **Credits: 3** **3 hrs/week**

I. LEARNING OBJECTIVES:

1. Understand the nomenclature, structure and isomerism of coordination compounds.
2. Apply VBT and CFT to explain bonding, geometry, magnetism, and reactivity in coordination complexes.
3. Analyze the stability of metal complexes using kinetic and thermodynamic principles.
4. Interpret the properties of organometallic compounds, especially metal carbonyls, using MO theory and the 18-electron rule.
5. Explore the roles of metal ions in biological systems and understand their physiological and toxicological effects.

II. COURSE OUTCOMES:

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

1. Classify ligands and write IUPAC names of coordination compounds.
2. Explain VBT and CFT concepts to predict structures of complexes.
3. Analyze substitution mechanisms and assess kinetic/thermodynamic stability of complexes.
4. Describe bonding, electron count and synergic bonding in metal carbonyls.
5. Examine the biological roles and toxicity of metal ions and apply chelation in medicine.

III. SYLLABUS:

UNIT-1: COORDINATION CHEMISTRY-I **(9 h)**

Types of Ligands-IUPAC nomenclature of Coordination compounds, structural and stereo isomerism in complexes with coordination numbers 4 and 6. Valence Bond Theory (VBT): Postulates- magnetic properties- Inner and outer orbital complexes - Limitations of VBT.

UNIT-2: COORDINATION CHEMISTRY-II **(9 h)**

Crystal Field Theory: Postulates of CFT, Splitting in Octahedral, tetrahedral, tetragonal and square planar fields. Crystal field stabilization energy (CFSE), Crystal field effects for weak and strong fields. Factors affecting the crystal field splitting energy, Spectrochemical series.

UNIT-3: INORGANIC REACTION MECHANISM AND STABILITY OF COMPLEXES **(9 h)**

Inorganic Reaction Mechanism: Labile and inert complexes, Substitution reactions in square planar complexes, Trans-effect and its applications, Cisplatin as an anti-cancer drug.

Stability of metal complexes: Thermodynamic stability and kinetic stability, factors affecting the stability of metal complexes, chelate effect, determination of composition of complex by Job's method.

UNIT- 4: ORGANOMETALLIC COMPOUNDS-METAL CARBONYLS (9 h)

Definition and classification of organometallic compounds based on bond type. **Metal carbonyls:** General methods of preparation of metal carbonyls of 3d series,18-electron rule, electron count of mononuclear and polynuclear carbonyls. Structures of mononuclear and binuclear carbonyls of Cr, Mn, Fe, Co and Ni using VBT, π-acceptor behaviour of CO, synergic effect.

UNIT- 5: BIOINORGANIC CHEMISTRY (9 h)

Metal ions present in biological systems, classification of elements according to their action in biological systems. Na / K- pump, carbonic anhydrase and carboxypeptidase. Toxicity of metal ions (Hg, Pb, Cd and As) and reasons for toxicity, Use of chelating agents in medicine. Haemoglobin - transfer of oxygen, Myoglobin-Storage and transfer of iron.

IV. REFERENCES:

1. P.W. Atkins, T.L. Overton, J.P. Rourke, M.T. Weller, F.A. Armstrong, Shriver and Atkins Inorganic Chemistry, 5th Edition, Oxford University Press, 2010.
2. G.L. Miessler, P.J. Fischer, D.A. Tarr, Inorganic Chemistry, 5th Edition, Pearson, 2014.
3. J.E. Huheey, E.A. Keiter, R.L. Keiter, O.K. Medhi, Inorganic Chemistry- Principles of Structure and Reactivity, Pearson Education, 2009.
4. B.W. Pfennig, Principles of Inorganic Chemistry. John Wiley & Sons, 2015.
5. F.A. Cotton & G. Wilkinson, Advanced Inorganic Chemistry Wiley-VCH, 1999.
6. J.D. Lee, **Concise Inorganic Chemistry**, Oxford University Press, 2008.

V. PROPOSED ACTIVITIES:

1. Worksheet on writing IUPAC names and isomer structures of complex compounds.
2. Electron-count assignments of metal carbonyls.
3. Chart: Role of metal ions in enzymes and metal toxicity.
4. Group project: Use of chelating agents in medicine

VI. CO-CURRICULAR ACTIVITIES AND ASSESSMENT METHODS:

1. Continuous Internal Evaluation (CIA): Monitoring the progress of student's learning
2. Class Tests, Worksheets, Quizzes, Industrial/Field visits, Student seminars, Poster and PPT presentations, Peer learning, Project-based learning, Assignments, Debates, Group Discussions: Enhances critical thinking skills.
3. Semester End Examination (SEE): Critical indicator of student's learning and teaching methods adopted by teachers throughout the semester.

SEMESTER-III

COURSE 7: PREPARATION OF COORDINATION COMPOUNDS

Practical **Credits: 1** **2 hrs/week**

I. LEARNING OBJECTIVES:

1. To develop safe laboratory practices and chemical handling procedures.
2. To synthesize and isolate coordination compounds.
3. To determine the composition of a metal-ligand complex in solution.

II. COURSE OUTCOMES:

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

1. Synthesize and purify coordination compounds.
2. Understand coordination numbers, geometries, and ligand types.
3. Demonstrate methods of complex preparation and analysis.
4. Apply Job's method to determine stoichiometric ratios of complexes.

III. SYLLABUS:

1. Preparation of Tetraamminecopper (II) sulphate.
2. Preparation of Potassium tri(oxalato)ferrate(III).
3. Preparation of hexaamminecobalt(III) chloride.
4. Acetylacetonate complexes of Cu^{2+}/Fe^{+3}.
5. Determination of the stoichiometry of a metal-ligand complex by the Jobs method.

IV. REFERENCES:

1. James E. Huheey, Inorganic Chemistry: Principles of Structure and Reactivity, Harper Collins College Publishers, 1993.
2. Vogel's Textbook of Quantitative Chemical Analysis, 6th Edition, Pearson Education, 2000.
3. R. Gopalan, P.S. Subramanian, Elements of Analytical Chemistry, Sultan Chand & Sons, 3rd Edition, 2003.
4. G. Svehla, Vogel's Qualitative Inorganic Analysis, 7th Edition, Prentice Hall, 1996.

V. CO-CURRICULAR ACTIVITIES AND ASSESSMENT METHODS:

1. Internal Practical Assessment
2. Lab Record Evaluation
3. Final Practical Examination
4. Oral/Viva Voce

SEMESTER-IV

COURSE 8: ORGANIC CHEMISTRY-III

Theory	**Credits: 3**	**3 hrs/week**

I. LEARNING OBJECTIVES:

1. To understand classification, synthesis, and reactions of amines and nitro hydrocarbons.
2. To interpret the chemistry and reactivity of heterocyclic compounds and their aromaticity.
3. To understand structural details and interconversions of carbohydrates.
4. To classify amino acids and explain their synthesis, structure, and properties.

II. COURSE OUTCOMES:

At the end of the course, the student will be able to

1. Describe the synthesis and chemical behaviour of amines and nitro hydrocarbons.
2. Understand the synthetic applications of diazonium salts.
3. Illustrate aromaticity and reactivity patterns in five- and six-membered heterocycles.
4. Explain the structural features, stereochemistry, and reactivity of carbohydrates.
5. Classify and synthesize amino acids and explain their biochemical behaviour.

III. SYLLABUS:

UNIT-1: AMINES (9 h)

Classification and Basicity of amines, Preparation- Gabriel synthesis and reduction of amides. Distinction between Primary, secondary and tertiary amines using Hinsberg's method. Hoffmann's exhaustive methylation with mechanism, Hoffmann and Cope elimination with mechanism.

Diazonium Salts: Preparation and synthetic applications of diazonium salts. Preparation of azo dyes.

UNIT-2: NITRO HYDROCARBONS (9 h)

Classification, Tautomerism of nitroalkanes leading to acid and keto form, Preparation of Nitroalkanes-from alkyl halides, oxidation of amines and oximes, Reactivity - halogenation, nitration, reaction with HONO, Nef reaction and Mannich reaction.

UNIT-3: HETEROCYCLIC COMPOUNDS (9 h)

Classification and nomenclature of heterocyclic compounds with one hetero atom,

Pyrrole, Furan, and Thiophene: Aromatic character, Preparation from 1,4-dicarbonyl compounds (Paul-Knorr synthesis). Electrophilic substitution reactions-Halogenation, Nitration, Sulphonation, Acylation and Formylation, Diels-Alder reaction in furan.

Pyridine: Basicity, Aromaticity, Synthesis from acetylene, Chichibabin Reaction.

UNIT-4: CARBOHYDRATES **(9 h)**

Structural elucidation of glucose and fructose, epimers and anomers, mutarotation, Haworth projections and conformational structures of glucose and fructose, Interconversions of aldoses and ketoses: Killiani-Fischer synthesis, Ruff degradation.

UNIT- 5: AMINO ACIDS **(9 h)**

Definition and classification of amino acids into alpha, beta, and gamma amino acids. Natural and essential amino acids - definition and examples, classification of alpha amino acids into acidic, basic and neutral amino acids with examples. Synthesis of amino acids-Strecker's synthesis and Gabriel-Phthalimide synthesis. Zwitter ion structure, Iso-electric point, Peptide bond.

IV. REFERENCES:

1. R.N. Morrison, R.N. Boyd, Organic Chemistry, Pearson Education, 7th edition, 2010.
2. P.Y. Bruice, Organic Chemistry, 8th Edition, Pearson, 2017.
3. V.K. Ahluwalia, P. Bhagat, R. Aggarwal, R. Chandra, Intermediate for Organic Synthesis, I.K. International. 2005.
4. F.A. Carey and R.J. Sundberg, Advanced Organic Chemistry, Springer, 2008.
5. T.L. Gilchrist, Heterocyclic Chemistry, Pearson Education,1997.
6. I.L. Finar, Organic Chemistry, Vols. 1 & 2, Pearson Education, 2002.
7. O.P. Agarwal, Chemistry of Organic Natural Products, Vols. 1&2, Goel Pubs, 2015.

V. PROPOSED ACTIVITIES:

1. Group debate on tautomerism and worksheets on named reactions.
2. Create Haworth projection models using paper/polystyrene.
3. Worksheet on epimer/anomer identification.

VI. CO-CURRICULAR ACTIVITIES AND ASSESSMENT METHODS:

1. Continuous Internal Evaluation (CIA): Monitoring the progress of student's learning.
2. Class Tests, Worksheets, Quizzes, Industrial/Field visits, Student seminars, Poster and PPT presentations, Peer learning, Project-based learning, Assignments, Debates, Group Discussions: Enhances critical thinking skills.
3. Semester End Examination (SEE): Critical indicator of student's learning and teaching methods adopted by teachers throughout the semester.

SEMESTER-IV

COURSE 8: ORGANIC CHEMISTRY-III PRACTICAL

Practical **Credits: 1** **2 hrs/week**

I. LEARNING OBJECTIVES:

1. To understand the principles and mechanisms involved in substitution reactions.
2. To apply laboratory safety protocols and precise techniques during organic synthesis.
3. To identify functional groups in amino acids using qualitative colour reactions such as the Ninhydrin and Xanthoproteic tests.
4. To detect simple carbohydrates by qualitative tests like Molisch’s, Benedict’s, Barfoed’s, and Seliwanoff’s tests.

II. COURSE OUTCOMES:

At the end of the course the student will be able to

1. Perform acylation, benzoylation and halogenation reactions.
2. Demonstrate skill in safe and accurate laboratory practices for organic compound synthesis.
3. Evaluate the differences between monosaccharides like glucose and fructose.
4. Identify functional groups in amino acids through characteristic colour reactions.

III. SYLLABUS:

1. Benzoylation of aniline.
2. Acetylation of aniline.
3. Bromination of aniline (Synthesis of p-Bromoaniline from Aniline).
4. Identification of Functional Groups in Amino Acids by Ninhydrin test & Xanthoproteic test.
5. Qualitative tests for Glucose/Fructose-Molisch’s, Benedict’s, Barfoed’s, and Seliwanoff’s tests.
6. Estimation of Glucose by using Fehling’s solution.

IV. REFERENCES:

1. B.S. Furniss, A.J. Hannaford, P.W.G. Smith, A.R. Tatchell, Vogel's Textbook of Practical Organic Chemistry, Pearson, 2012.
2. V.K. Ahluwalia, R. Aggarwal, Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press, 2004.
3. D.L. Pavia, G.M. Lampman, G.S. Kriz, R.G. Engel, Introduction to Organic Laboratory Techniques, Cengage Learning, 2014.

V. CO-CURRICULAR ACTIVITIES AND ASSESSMENT METHODS:

1. Internal Practical Assessment
2. Lab Record Evaluation
3. Final Practical Examination
4. Oral/Viva Voce

SEMESTER-IV

COURSE 9: PHYSICAL CHEMISTRY-III

Theory	Credits: 3	3 hrs/week

I. LEARNING OBJECTIVES:

1. To analyze ionic equilibria in aqueous solutions, including pH, buffer systems, and solubility.
2. To evaluate acid-base behaviour using various theories and apply the HSAB principle
3. To grasp fundamental thermodynamic concepts such as energy, enthalpy, and heat capacity.
4. To apply the first law of thermodynamics to chemical systems and calculate work and heat changes.
5. To explore entropy, spontaneity, and laws of thermodynamics in physical and chemical processes.

II. COURSE OUTCOMES:

At the end of the course the student will be able to

1. Compare and evaluate acid-base theories and explain HSAB applications in predicting chemical reactivity.
2. Interpret concepts of pH, buffer solutions, solubility product, and ionic equilibria.
3. Apply the first law of thermodynamics to closed and open systems.
4. Calculate thermodynamic parameters (q, w, U, H) for ideal gases under various conditions.
5. Analyze entropy changes and distinguish between reversible, irreversible, spontaneous, and non-spontaneous processes.

III. SYLLABUS:

UNIT - 1: ACIDS, BASES AND HSAB PRINCIPLE (9 h)

Definition of Acid and base- Arrhenius, Bronsted-Lowry, Lewis theories, the solvent system, Classification of solvents, pH, Types of salts, Salt hydrolysis.

Pearson's concept, HSAB principle and its application.

UNIT - 2: IONIC EQUILIBRIUM (9 h)

Degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. pH-scale, Buffer solutions, Henderson's equation.

Common ion effect and its applications, Solubility and solubility product of sparingly soluble salts, applications of solubility product.

UNIT- 3: THERMODYNAMICS- I **(9 h)**

Intensive and extensive variables, State function and Path function, Isolated, closed and open systems, Concept of heat (q), work (w), internal energy (U), First law of thermodynamics, Enthalpy (H), Heat capacities at constant volume and pressure and their relation.

UNIT - 4: THERMODYNAMICS- II **(9 h)**

Calculations of q, w, U and H for reversible, irreversible processes, Joule-Thomson effect-coefficient, Calculation of work for the expansion of perfect gas under isothermal and adiabatic conditions for reversible processes. Temperature dependence of the enthalpy of formation-Kirchoff's equation.

UNIT - 5: THERMODYNAMICS- III **(9 h)**

Second law of thermodynamics: Different Statements of the law, Carnot cycle and its efficiency, Concept of entropy, entropy as a state function, entropy changes in reversible and irreversible processes. Entropy changes in spontaneous and equilibrium processes. Spontaneous and non-spontaneous processes, Third law of thermodynamics.

IV. REFERENCES:

1. P.W. Atkins, J.de. Paula, Atkin's Physical Chemistry Ed., 10th Edition, Oxford University Press, 2014.
2. K.L. Kapoor, A Textbook of Physical Chemistry, 3rd Edition, McGraw-Hill Education, 2015.
3. B.R. Puri, L.R. Sharma, M.S. Pathania**,** *Principles of Physical Chemistry,* Vishal Publishing, 2020.
4. S. Glasstone, Thermodynamics for Chemists, Ewp, 2008.
5. W.U. Malik, G.D Tuli, R.D. Madan, Selected Topics in Inorganic Chemistry, S. Chand Publishing, 1998.

V. PROPOSED ACTIVITIES:

1. pH measurement of common household items using pH paper or indicators.
2. Case study- Analyze real-life use of acids and bases, HSAB principle in metallurgy/pharmaceuticals.
3. Buffer preparation and Henderson equation calculations.
4. Debate on spontaneous vs. non-spontaneous reactions.
5. Concept map activity linking the laws of thermodynamics and entropy.

VI. CO-CURRICULAR ACTIVITIES AND ASSESSMENT METHODS:

1. Continuous Internal Evaluation (CIA): Monitoring the progress of student's learning.
2. Class Tests, Worksheets, Quizzes, Industrial/Field visits, Student seminars, Poster and PPT presentations, Peer learning, Project-based learning, Assignments, Debates, Group Discussions: Enhances critical thinking skills.
3. Semester End Examination (SEE): Critical indicator of student's learning and teaching methods adopted by teachers throughout the semester.

SEMESTER-IV

COURSE 9: QUALITATIVE ANALYSIS OF INORGANIC MIXTURE

Practical	**Credits: 1**	**2 hrs/week**

I. LEARNING OBJECTIVES:

1. Handle laboratory reagents and equipment safely and responsibly
2. Understand group-wise separation and detection of cationic and anionic radicals.
3. Systematically analyze inorganic salt mixtures using confirmatory chemical tests.
4. Distinguish between interfering ions and eliminate them during analysis.

II. COURSE OUTCOMES:

At the end of the course the student will be able to

1. Demonstrate safe use of laboratory equipment and chemical handling.
2. Identify the presence of common anions and cations in a given salt mixture.
3. Apply group analysis techniques for systematic detection and separation.
4. Perform confirmatory tests and recognize characteristic colors, precipitates, and reactions.

III. SYLLABUS:

Analysis of a mixture salt containing two anions and two cations (From two different groups):

Anions: Carbonate, Sulphate, Chloride, Bromide, Acetate, Nitrate, Borate, Phosphate.

Cations: Lead, Copper, Iron, Aluminium, Zinc, Nickel, Manganese, Calcium, Strontium, Barium, magnesium and Ammonium.

Minimum of five mixtures should be analyzed.

IV. REFERENCES:

1. G. Svehla, Vogel's Textbook of Qualitative Inorganic Analysis, Pearson Education, 2008.
2. K. Nagaraj, S. Kamalesu, S. Lokhandwala, N.M. Parekh, Textbook of Semi-micro Inorganic Qualitative Analysis, Notion Press, 2023.
3. G. Pass, H. Sutcliff, Practical Inorganic Chemistry. 2nd edition, John-Wiley & Sons, 2020.

V. CO-CURRICULAR ACTIVITIES AND ASSESSMENT METHODS:

1. Internal Practical Assessment
2. Lab Record Evaluation
3. Final Practical Examination
4. Oral/Viva Voce

SEMESTER-IV

COURSE 10: APPLIED AND PHYSICAL CHEMISTRY

Theory	**Credits: 3**	**3 hrs/week**

I. LEARNING OBJECTIVES:

1. Understand polymer classification, methods of polymerization, and applications of commercial polymers.
2. Describe the fundamentals, properties, synthesis, and applications of nanomaterials.
3. Classify drugs, understand their development process, and identify their forms.
4. Apply rate laws to chemical reactions and determine kinetic parameters.
5. Analyze enzyme kinetics using rate theories and the Michaelis-Menten equation.

II. COURSE OUTCOMES:

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

1. Explain polymer classification and applications of commercial polymers.
2. Describe types, synthesis methods, and applications of nanomaterials.
3. Explain basic pharmaceutical concepts, including drug development and dosage forms.
4. Apply kinetic laws to analyze reaction rates and derive rate equations.
5. Evaluate the role of activation energy and enzyme catalysis in chemical reactions.

III. SYLLABUS:

UNIT-1: POLYMERS (9 h)

Classification of polymers, Methods of polymerization- addition, condensation, co-polymerization. Structure and applications of some important polymers: Polythene, PVC, Nylon, Polyesters, Bakelite, Natural rubber. Biodegradable and non-biodegradable polymers-examples.

UNIT-2: NANOMATERIALS (9 h)

Definition and classification of nanomaterials, Magnetic and mechanical properties of nanomaterials, Types of nanomaterials (metal-based, carbon-based, and polymer-based), Synthesis of nanomaterials by Top-down approach and Bottom-up approach, Applications of nanomaterials in medicine and environment.

UNIT-3: DRUGS (9 h)

Definition of Drug and Medicine, Drug discovery-preclinical and clinical trials, Classification of drugs based on therapeutic use. Classification of dosage forms-solid, liquid, gaseous and semisolid dosage forms, Generic and brand names of any four drugs, Introduction to Computer Aided Drug Design (CADD).

UNIT - 4: CHEMICAL KINETICS-I (9 h)

The concept of reaction rates. Factors affecting reaction rates. Order and molecularity of a reaction, Derivation of integrated rate equations for zero, first and second order reactions (similar reactants). Half–life of a reaction. General methods for the determination of the order of a reaction.

UNIT-5: CHEMICAL KINETICS-II (9 h)

Concept of activation energy and its calculation from Arrhenius equation. Theories of Reaction Rates: Collision theory and Activated Complex theory of bimolecular reactions. Enzyme catalysis- Specificity, factors affecting enzyme catalysis, Inhibitors and Lock & key model. Michaels- Menten equation- derivation.

IV. REFERENCES:

1. F.W. Billmeyer, Text Book of Polymer Science, Wiley Inter Science, 2007.
2. B.R. Puri, L.R. Sharma, M.S. Pathania, Principles of Physical Chemistry, Vishal Publishing, 2020.
3. Charles P. Poole Jr, Frank J. Owens, Introduction to nanotechnology, Wiley India, 2003.
4. K.K. Choudhary, Nanoscience and Nanotechnology, Narosa Publishing, 2016.
5. G. Patrick, Introduction to Medicinal Chemistry, Oxford University Press, 2017.
6. H. Singh, V.K. Kapoor, Medicinal & Pharmaceutical Chemistry, Vallabh Prakashan, 1996.
7. P.W. Atkins, J.de. Paula, Atkin's Physical Chemistry, Oxford University Press, 2014.
8. Gurudeep Raj, Advanced physical chemistry, Krishna Prakashan Media, 2016.

V. PROPOSED ACTIVITIES:

1. Industrial Visit: Visit to a plastic or rubber manufacturing plant
2. Seminar or case study on nanomedicine or nanofiltration
3. Solve numerical problems on half-life, Arrhenius equation, rate laws.

VI. CO-CURRICULAR ACTIVITIES AND ASSESSMENT METHODS:

1. Continuous Internal Evaluation (CIA): Monitoring the progress of student's learning
2. Class Tests, Worksheets, Quizzes, Industrial/Field visits, Student seminars, Poster and PPT presentations, Peer learning, Project-based learning, Assignments, Debates, Group Discussions: Enhances critical thinking skills.
3. Semester End Examination (SEE): Critical indicator of student's learning and teaching methods adopted by teachers throughout the semester.

SEMESTER-IV

COURSE 10: APPLIED AND PHYSICAL CHEMISTRY PRACTICAL

Practical **Credits: 1** **2 hrs/week**

I. LEARNING OBJECTIVES:

1. To develop practical skills in measuring the rate of chemical reactions and understanding factors affecting reaction rates.
2. To introduce students to basic nanomaterial synthesis with a focus on zinc oxide nanoparticles.
3. To develop an understanding of pharmaceutical terminology and differentiate between generic and brand names of common drugs.

II. COURSE OUTCOMES:

1. Evaluate the influence of concentration on the rate of a chemical reaction experimentally.
2. Analyze temperature dependence on reaction rate and interpret kinetic data.
3. Compare the strengths of different acids based on kinetic measurements in ester hydrolysis.
4. Synthesize zinc oxide nanoparticles and understand their significance in modern chemistry and nanotechnology.
5. Identify and categorize commonly used drugs by comparing their generic and brand names.

III. SYLLABUS:

1. Determination of the rate constant of acidic hydrolysis of an ester.
2. Study the effect of concentration on the rate of reaction between sodium thiosulphate and hydrochloric acid.
3. Study the effect of temperature on the rate of reaction between sodium thiosulphate and hydrochloric acid.
4. Comparison of the strengths of HCl and H_2SO_4 by studying the kinetics of hydrolysis of methyl acetate.
5. Preparation of Zinc oxide nano particles.
6. Prepare a chart of 10 commonly used drugs with their generic and brand names and therapeutic classification.

IV. REFERENCES:

1. B.R. Puri, L.R. Sharma, M.S. Pathania, Principles of Physical Chemistry, Vishal Publishing, 2020.
2. P.W. Atkins, J.de. Paula, Atkin's Physical Chemistry, Oxford University Press, 2014.
3. K.K. Choudhary, Nanoscience and Nanotechnology, Narosa Publishing, 2016..
4. Tripathi, K. D. Essentials of Medical Pharmacology (9th ed.). Jaypee Brothers Medical Publishers, 2021.

V. CO-CURRICULAR ACTIVITIES AND ASSESSMENT METHODS:

1. Internal Practical Assessment
2. Lab Record Evaluation
3. Final Practical Examination
4. Oral/Viva Voce

SEMESTER-V

COURSE 11: ORGANIC SPECTROSCOPY

Theory **Credits: 3** **3 hrs/week**

I. LEARNING OBJECTIVES:

1. **To understand** the principles of interaction of electromagnetic radiation with matter.
2. **To interpret** infrared (IR) spectra to identify functional groups and molecular vibrations in organic compounds.
3. **To analyze** the structure of organic molecules using chemical shifts, splitting patterns, and coupling constants in proton NMR spectroscopy.
4. **To apply** spectroscopic techniques (UV-Vis, IR, NMR, Mass) in a complementary manner to deduce the structure of simple organic compounds.

II. COURSE OUTCOMES:

At the end of the course the student will be able to

1. Describe the electromagnetic spectrum and principles behind UV-Visible, IR, and NMR, spectroscopy.
2. Analyze molecular structures using electronic transitions, chromophores, and λmax calculations.
3. Interpret IR spectra to identify functional groups and molecular vibrations.
4. Analyze NMR spectra for different compounds using chemical shifts and splitting patterns.
5. Interpret mass spectra using molecular ion peaks, fragmentation patterns, and rearrangements

III. SYLLABUS:

UNIT-1: ELECTROMAGNETIC RADIATION (EMR) & UV-VISIBLE SPECTROSCOPY: (9h)

Electromagnetic spectrum - Characteristics and classification of electromagnetic waves,

Selection rules for electronic spectra, types of electronic transitions in molecules, concept of chromophore and auxochrome, effect of conjugation, types of shifts, Woodward-Fieser rules for calculating λ_{max} of conjugated dienes.

UNIT- 2: IR SPECTROSCOPY **(9h)**

Principle of Infrared spectroscopy, types of molecular vibrations, fingerprint and functional group region. IR spectra of alkanes, alkenes, alkynes, simple alcohols, aldehydes, ketones, carboxylic acids and their derivatives.

UNIT- 3: NMR SPECTROSCOPY-I (PMR) **(9h)**

Nuclear spin, Principle of proton magnetic resonance, equivalent and non-equivalent protons, shielding and de-shielding effect, TMS, Position of signals. Chemical shift, Factors affecting chemical shift.

UNIT - 4: NMR SPECTROSCOPY-II **(9h)**

Splitting of NMR signals, spin-spin coupling and coupling constants.

Applications of NMR with suitable examples - ethyl bromide, ethanol, acetaldehyde, 2-butanone, propanoic acid, ethyl acetate and toluene.

UNIT - 5: MASS SPECTROMETRY **(9h)**

Basic principle of mass spectrometry - molecular ion peak, base peak, representation of mass spectrum, Nitrogen rule, McLafferty rearrangement, fragmentation pattern of butane, butyraldehyde and propanoic acid.

IV. REFERENCES:

1. D.L. Pavia, G.M. Lampman, G.S. Kriz, J.R. Vyvyan, Introduction to Spectroscopy, 5th Edition, Cengage Learning, 2014.
2. William Kemp, Organic Spectroscopy, 3rd Edition, Macmillan, 1991.
3. Y. R. Sharma, Elementary Organic Spectroscopy, Revised Edition, S. Chand Publishing, 2013.
4. P. S. Kalsi, Spectroscopy of Organic Compounds, 6th Edition, Wiley Eastern Ltd., 2007.
5. D.A. Skoog, F.J. Holler, S.R. Crouch, Principles of Instrumental Analysis, 7th Edition, Cengage Learning, 2017.
6. R.M. Silverstein, F.X. Webster, D.J. Kiemle, Spectrometric Identification of Organic Compounds, 7th Edition, Wiley, 2005.

V. PROPOSED ACTIVITIES:

1. Problem Solving - Calculate λmax using Woodward-Fieser rules for various conjugated systems.
2. Assignment - Analyze NMR spectra with different chemical environments.
3. Group Discussion - Discuss the effects of shielding and deshielding in common compounds.
4. Spectrum Interpretation - Analyze IR, NMR and Mass data of compounds.

VI. CO-CURRICULAR ACTIVITIES AND ASSESSMENT METHODS:

1. Continuous Internal Evaluation (CIA): Monitoring the progress of student’s learning.
2. Class Tests, Worksheets, Quizzes, Industrial/Field visits, Student seminars, Poster and PPT presentations, Peer learning, Project-based learning, Assignments, Debates, Group Discussions: Enhances critical thinking skills.
3. Semester End Examination (SEE): Critical indicator of student’s learning and teaching methods adopted by teachers throughout the semester.

SEMESTER-V

COURSE 11: ORGANIC SPECTRAL PROBLEMS

Practical **Credits: 1** **2 hrs/week**

I. LEARNING OBJECTIVES:

1. To interpret IR spectra to identify functional groups present in an organic molecule.
2. To analyze ^{1}H-NMR spectra and molecular formula to determine structural features of organic compounds.
3. **To evaluate** and deduce the most plausible structure of an organic compound using IR, NMR and Mass spectral data.

II. COURSE OUTCOMES:

At the end of the course the student will be able to

1. Identify functional groups in organic molecules using IR spectral features.
2. Derive molecular structure based on chemical shift and splitting in NMR spectra
3. Propose plausible structures using combined spectroscopic techniques.

III. SYLLABUS:

1. Identify the functional group of simple organic compounds using the given IR spectra.
2. Deduce the structural formula of an organic compound from the given NMR spectrum and molecular formula.
3. Identify the given organic compound by using the given IR, NMR and Mass spectral data.

IV. REFERENCES:

1. D.L. Pavia, G.M. Lampman, G.S. Kriz, J.R. Vyvyan, Introduction to Spectroscopy, 5th Edition, Cengage Learning, 2014.
2. William Kemp, Organic Spectroscopy, 3rd Edition, Macmillan, 1991.
3. Y. R. Sharma, Elementary Organic Spectroscopy, Revised Edition, S. Chand Publishing, 2013.
4. P. S. Kalsi, Spectroscopy of Organic Compounds, 6th Edition, Wiley Eastern Ltd., 2007.

V. CO-CURRICULAR ACTIVITIES AND ASSESSMENT METHODS:

1. Internal Practical Assessment.
2. Lab Record Evaluation.
3. Final Practical Examination.
4. Oral/Viva Voce.

SEMESTER-V

COURSE 12 A: ANALYTICAL METHODS IN CHEMISTRY

Theory **Credits: 3** **3 hrs/week**

I. LEARNING OBJECTIVES:

1. To introduce the basic concepts and principles of volumetric and gravimetric analysis.
2. To develop an understanding of various concentration terms and the preparation of standard solutions.
3. To familiarize students with common laboratory glassware and techniques used in analytical chemistry.
4. To impart knowledge of different types of titrations and the theoretical basis for choosing suitable indicators.
5. To provide an overview of data treatment, error analysis, and thermal analytical techniques, including thermogravimetry and its applications.

II. COURSE OUTCOMES:

At the end of the course the student will be able to

1. Perform volumetric titrations with a clear understanding of concentration terms, indicators, and standard solutions.
2. Demonstrate gravimetric techniques including precipitation, filtration, drying, and ignition with minimal procedural errors.
3. Accurately interpret analytical data using statistical measures such as standard deviation, confidence interval, and error types.
4. Utilize laboratory apparatus effectively and follow correct protocols for safe and precise chemical analysis.
5. Analyse materials using thermal methods and interpret thermogravimetric curves for compounds like $CuSO_4 \cdot 5H_2O$ and $CaC_2O_4 \cdot H_2O$.

III. SYLLABUS:

UNIT-1: BASICS OF ANALYTICAL CHEMISTRY (9 h)

Principles of volumetric analysis, Mole concept, Concentration terms- Molarity, Molality, Normality, Mole fraction, ppm and ppb, primary standards and secondary standards, standard solution. Description and use of common laboratory apparatus- volumetric flask, burette, pipette, measuring cylinders.

UNIT-2: VOLUMETRIC ANALYSIS: (9 h)

Principles of volumetric analysis: Theories of acid-base (including -choice of indicators), redox, complexometric and precipitation titrations.

UNIT 3 GRAVIMETRIC ANALYSIS **(9 h)**

Principles of gravimetric analysis: Steps involved in gravimetric analysis-sampling, precipitation, coagulation, peptization, coprecipitation, post precipitation, digestion, filtration, and washing of precipitate, drying and ignition.

UNIT-4: TREATMENT OF ANALYTICAL DATA **(9 h)**

Accuracy and Precision, Methods of expressing accuracy-Absolute and Relative error, Methods of expressing precision-Mean, Median and Standard deviation. Determinate and indeterminate errors, minimization of errors, Confidence interval, Significant figures and their importance.

UNIT-5: THERMAL METHODS OF ANALYSIS **(9 h)**

A. Thermal methods of analysis: Introduction, Types of Thermal methods.

B. Thermogravimetry (TG): Principle, Applications of Thermogravimetry – ($CuSO_4.5H_2O$ &$CaC_2O_4.H_2O$)

IV. REFERENCES:

1. Vogel's Textbook of Quantitative Chemical Analysis A.I. Vogel 6th Edition, Pearson Education, 2014.
2. Fundamentals of Analytical Chemistry Douglas A. Skoog, Donald M. West, F. James Holler, Stanley R. Crouch 9th Edition Cengage Learning, 2013.
3. Quantitative Chemical Analysis Daniel C. Harris 9th Edition W. H. Freeman and Company, 2016.
4. Instrumental Methods of Analysis H.H. Willard, L.L. Merritt, J.A. Dean, F.A. Settle 7th Edition CBS Publishers,1986.

V. PROPOSED ACTIVITIES:

1. Hands-on Laboratory Activity: Volumetric Titration Practice
2. Group Demonstration/Model: Gravimetric Analysis Workflow
3. Error Analysis Worksheet with Data Interpretation
4. Identification and Use of Laboratory Apparatus
5. Thermogravimetric Case Study Discussion

VI. CO-CURRICULAR ACTIVITIES AND ASSESSMENT METHODS

1. Continuous Internal Evaluation (CIA): Monitoring the progress of student's learning.
2. Class Tests, Worksheets, Quizzes, Industrial/Field visits, Student seminars, PPT presentations, Peer learning, Project based learning, Assignments, Debates, Group Discussions: Enhances critical thinking skills.
3. Semester End Examination (SEE): Critical indicator of student's learning and teaching methods adopted by teachers throughout the semester.

SEMESTER-V

COURSE 12 A: ANALYTICAL METHODS IN CHEMISTRY PRACTICAL

Practical **Credits: 1** **2 hrs/week**

I. LEARNING OBJECTIVES:

1. To develop practical skills in preparing and standardizing solutions used in titrimetric analysis.
2. To train students in performing acid-base, redox, complexometric, and precipitation titrations accurately.
3. To enable students to analyze mixtures containing multiple ions quantitatively.
4. To familiarize students with methods of estimation of metal ions and halide ions using appropriate indicators.

II. COURSE OUTCOMES:

At the end of the course the student will be able to

1. Understand and apply titrimetric methods for the quantitative estimation of inorganic ions and compounds in a given solution.
2. Perform complexometric titrations using EDTA for the estimation of metal ions like magnesium and zinc.
3. Analyze mixtures containing carbonate and bicarbonate using acid-base titrations and interpret the results accurately.
4. Demonstrate the use of redox titration and precipitation titration principles in the estimation of Iron (II) and chloride ions, respectively.

III. SYLLABUS:

1. Determination of Carbonate and bicarbonate in the given mixture using standardised HCl.
2. Estimation of Iron (II) using standard Potassium dichromate.
3. Estimation of Mg using EDTA.
4. Estimation of Zn using EDTA.
5. Determination of Chloride ion using Mohr's method.

IV. REFERENCES

1. **Vogel's Textbook of Quantitative Chemical Analysis**, J. Mendham, R.C. Denney, J.D. Barnes, M.J.K. Thomas Pearson Education, **6th Edition, 2000.**
2. Laboratory Manual of Analytical Chemistry Rajkumar Publisher: CBS Publishers & Distributors, 1st Edition, 2018.
3. Analytical Chemistry Gary D. Christia: Wiley India, 6th Edition, 2004

V. CO-CURRICULAR ACTIVITIES AND ASSESSMENT METHODS

1. Internal Practical Assessment
2. Lab Record Evaluation
3. Final Practical Examination
4. Oral/Viva Voce

SEMESTER-V

COURSE 12 B: SYNTHETIC ORGANIC CHEMISTRY

Theory **Credits: 3** **3 hrs/week**

I. LEARNING OBJECTIVES:

1. To understand and define pericyclic reactions and classify them based on their mechanistic characteristics.
2. To analyze the symmetry properties, phases, and nodes of molecular orbitals in conjugated systems like ethylene, 1,3-butadiene, and 1,3,5-hexatriene.
3. To differentiate between thermal and photochemical pericyclic reactions and understand their stereoelectronic requirements.
4. To explain the mechanism and stereochemistry (conrotation and disrotation) of electrocyclic reactions.
5. To apply the Frontier Molecular Orbital (FMO) approach to predict the outcomes of pericyclic reactions.

II COURSE OUTCOMES:

At the end of the course the student will be able to

1. Classify and explain various types of pericyclic reactions using molecular orbital theory.
2. Evaluate the symmetry and phase relationships in orbitals of conjugated systems to predict pericyclic reaction feasibility.
3. Distinguish between thermal and photochemical pericyclic processes and describe conditions favoring each.
4. Predict the stereochemical outcomes (conrotation vs disrotation) in electrocyclic reactions.
5. Utilize the Frontier Molecular Orbital approach to analyze and solve problems related to pericyclic reaction mechanisms.

III. SYLLABUS:

UNIT-1: PERICYCLIC REACTIONS (9 h)

Definition and classification of pericyclic reactions: Phases, nodes and symmetry properties of molecular orbital's in ethylene,1,3-butadiene,1,3,5-hexatriene. Thermal and photochemical reactions. Electro cyclic reactions: Definition and examples, definitions of con and dis rotation. FMO approach.

UNIT-2 : ORGANIC PHOTOCHEMISTRY (9 h)

Jablonski diagram-singlet and triplet States Photochemistry of Carbonyl compounds $n{-}\pi^*$ and $\pi{-}\pi^*$transitions, Norrish type-1and Norrish type-2 reactions, Paterno–Buchi reaction.

UNIT-3 : RETROSYNTHESIS (9 h)

Important terms in Retro synthesis with examples-Disconnection, Target molecule, FGI, Synthon, Retrosynthetic analysis, chemo selectivity, regio selectivity. Importance of Order of events in organic synthesis. Retrosynthetic analysis of Paracetamol.

UNIT-4 : SYNTHETIC REACTIONS (9 h)

Shapiro reaction, Stork - enamine reaction (only alkylation), Wittig reaction, Heck reaction, Suzuki coupling. Hoffmann Exhaustive Methylation, Curtius rearrangement, Reformatsky reaction.

UNIT-5 : REAGENTS IN ORGANIC CHEMISTRY (9 h)

Oxidizing agents: PDC, SeO_2 (Riley oxidation), NBS.

Reducing agents: $LiAlH_4$, $NaBH_4$, Metal-solvent reduction (Birch reduction), Catalytic reduction.

IV REFERENCES:

1. Pericyclic reactions by Ian Fleming, Second edition, Oxford University press.
2. Photochemistry and Pericyclic Reactions- Jagadamba singh and Jayasingh, 2006
3. Reaction Mechanism in Organic Chemistry by S.M. Mukherji and S.P. Singh, Revised edition, Trinity Press.
4. Pericyclic reactions – A Mechanistic study by S.M.Mukherji, Macmillan India.
5. Organic synthesis: The disconnection approach by Stuart Warren, John Wiley&Sons.
6. Organic chemistry by Jonathan Clayden, Nick Greeves and Stuart Warren, Second edition, Oxford university press.
7. Reactions, Reagents and Rearrangements by S.N. Sanyal, Bharati Bhawan Publishers &Distributors

V. PROPOSED ACTIVITIES:

1. Chart or digital chart: Jablonski diagrams showing singlet and triplet states with examples of $n \rightarrow \pi^*$ and $\pi \rightarrow \pi^*$ transitions.
2. Group activity: Flow chart of retrosynthetic pathways with justification for asprin, paracetamol.
3. Poster creation in groups to depict reactants, reaction conditions, key intermediates and mechanisms for important named reactions.

VI. CO-CURRICULAR ACTIVITIES AND ASSESSMENT METHODS

1. Continuous Internal Evaluation (CIA): Monitoring the progress of student's learning.
2. Class Tests, Worksheets, Quizzes, Industrial/Field visits, Student seminars, PPT presentations, Peer learning, Project based learning, Assignments, Debates, Group Discussions: Enhances critical thinking skills.
3. Semester End Examination (SEE): Critical indicator of student's learning and teaching methods adopted by teachers throughout the semester.

SEMESTER-V

COURSE 12 B: SYNTHETIC ORGANIC CHEMISTRY PRACTICAL

Practical **Credits: 1** **2 hrs/week**

I. LEARNING OBJECTIVES:

1. To understand the principles of acid-base and solubility-based extractions for the separation of organic compounds from mixtures.
2. To perform systematic separation techniques for mixtures containing acidic, basic, and neutral organic compounds using appropriate solvents.
3. To apply solvent extraction methods to isolate and purify organic compounds based on their solubility and chemical reactivity.
4. To demonstrate knowledge of photochemical reactions by carrying out the sunlight-induced photoreduction of benzophenone to benzopinacol.

II. COURSE OUTCOMES:

At the end of the course the student will be able to

1. Separate and identify components in binary mixtures using acid-base and solvent extraction techniques.
2. Select appropriate reagents and solvents for extraction based on the functional groups present in the mixture.
3. Carry out a photochemical reduction reaction and characterize the product using simple analytical techniques.
4. Record, analyze, and interpret experimental data systematically, maintaining safety and accuracy in the laboratory environment.

III. SYLLABUS:

1. Separation of organic compounds in a mixture (acidic compound + neutral compound) using solvent extraction.
2. Separation of organic compounds in a mixture (basic compound+ neutral compound) using solvent extraction.
3. Separation of organic compounds in a mixture (neutral (ether insoluble + neutral ether soluble compound) using solvent extraction.
4. Photo reduction of Benzophenone to Benzopinacol in the presence of sunlight.

IV. REFERENCES

1. Vogel A.I. Practical Organic Chemistry, Longman Group Ltd.
2. Bansal R.K. Laboratory Manual of Organic Chemistry, Wiley-Eastern
3. Ahluwalia V. K. and Aggarwal R. Comprehensive Practical Organic Chemistry, University Press.
4. Mann F.G and Saunders B.C, Practical Organic Chemistry, Pearson Education.

V. CO-CURRICULAR ACTIVITIES AND ASSESSMENT METHODS

1. Internal Practical Assessment
2. Lab Record Evaluation
3. Final Practical Examination
4. Oral/Viva Voce

SEMESTER-V

COURSE 13 A: SEPARATION TECHNIQUES AND CHROMATOGRAPHY

Theory	**Credits: 3**	**3 hrs/week**

I. COURSE OBJECTIVES:

1. To impart knowledge on various classical and modern separation techniques such as solvent extraction, ion exchange, and chromatography.
2. To develop a foundational understanding of chromatographic methods including paper, TLC, and column chromatography.
3. To explain the principles of spectrophotometry and its quantitative applications in chemical analysis.
4. To train students in the experimental aspects of separation and detection techniques.
5. To enhance analytical thinking by applying these techniques for the estimation of metal ions and complex mixtures.

II. COURSE OUTCOMES:

At the end of the course the student will be able to

1. Explain the principles and procedures of solvent extraction and ion exchange techniques.
2. Classify and apply chromatographic methods for qualitative and quantitative analysis.
3. Perform experiments using paper chromatography, TLC, and column chromatography for compound separation.
4. Understand the principle and functioning of single and double beam spectrophotometers.
5. Apply Beer-Lambert's law to estimate metal ions such as Fe^{2+}, Mn^{2+}, and Pb^{2+} using spectrophotometry.

III. SYLLABUS:

UNIT-1: SPECTROPHOTOMETRY

(9 h)

Principle, Instrumentation: Single beam and double beam spectrophotometer, Beer-Lambert's law- Derivation and deviations from Beer-Lambert's law, applications of Beer-Lambert's law- Quantitative determination of Fe^{+2}, $Mn^{+2}$and Pb^{+2}.

UNIT-2: SEPARATION TECHNIQUES

(9 h)

Solvent Extraction: Introduction, principle, techniques, factors affecting solvent extraction, Batch extraction, Continuous extraction and counter current extraction, Synergism, Application-Determination of Iron (III).

Ion Exchange method: Introduction, action of ion exchange resins, applications.

UNIT-3: CHROMATOGRAPHY-INTRODUCTION AND CLASSIFICATION
(9 h)

Principle, Classification of chromatographic methods, Nature of adsorbents, eluents, Rf-values, factors affecting Rfvalues

Paper chromatography: Principle, Experimental procedure, choice of paper and solvents, various modes of development- ascending, descending, radial and two dimensional, applications.

UNIT-4 THIN LAYER CHROMATOGRAPHY (9 h)

Thin layer chromatography: Principle, Experimental procedure, preparation of plates, adsorbents and solvents, development of chromatogram, detection of spots, applications and advantages

UNIT-5: COLUMN CHROMATOGRAPHY AND HPLC (9 HOURS)

Column chromatography: Principle, Experimental procedure, Stationary and Mobile phase, applications.

HPLC: Instrumentation and Applications

IV. REFERENCES:

1. A.I. Vogel, "Textbook of Quantitative Chemical Analysis", 6th Edition, Pearson Education, 2000.
2. G.R. Chatwal and S.K. Anand, "Instrumental Methods of Chemical Analysis", 5th Edition, Himalaya blishing House, 2014.
3. Douglas A. Skoog, Donald M. West, F. James Holler and Stanley R. Crouch, "Fundamentals of Analytical Chemistry", 9th Edition, Cengage Learning, 2014.
4. D.A. Skoog, "Principles of Instrumental Analysis", 6th Edition, Brooks/Cole, 2007.
5. Willard, Merritt, Dean and Settle, "Instrumental Methods of Analysis", 7th Edition, CBS Publishers, 1986.

V. PROPOSED ACTIVITIES:

1. Lab Activity: Perform a comparative analysis using ascending and radial paper chromatography to separate food dyes or amino acids.
2. Group Discussion: Factors affecting Rf values in TLC and strategies for optimization.
3. Mini Project: Design and construct a simple column chromatography setup and separate plant pigments or dye mixtures.

VI. CO-CURRICULAR ACTIVITIES AND ASSESSMENT METHODS

1. Continuous Internal Evaluation (CIA): Monitoring the progress of student's learning.
2. Class Tests, Worksheets, Quizzes, Industrial/Field visits, Student seminars, PPT presentations, Peer learning, Project based learning, Assignments, Debates, Group Discussions: Enhances critical thinking skills.
3. Semester End Examination (SEE): Critical indicator of student's learning and teaching methods adopted by teachers throughout the semester.

SEMESTER-V

COURSE 13 A: SEPARATION TECHNIQUES AND CHROMATOGRAPHY - PRACTICALS

Practical **Credits: 1** **2 hrs/week**

I. LEARNING OBJECTIVES:

1. To develop practical skills in preparing and standardizing solutions used in titrimetric analysis.
2. To train students in performing acid-base, redox, complexometric, and precipitation titrations accurately.
3. To enable students to analyze mixtures containing multiple ions quantitatively.
4. To familiarize students with methods of estimation of metal ions and halide ions using appropriate indicators.

II. COURSE OUTCOMES:

At the end of the course the student will be able to

1. Estimate carbonate and bicarbonate content in a mixture using standard HCl through acid-base titration.
2. Perform redox titrations to determine Fe(II) content using potassium dichromate with proper indicator selection.
3. Accurately determine magnesium and zinc concentrations using EDTA through complexometric titration.
4. Analyze chloride content using Mohr's method and understand the role of chromate indicator in precipitation titrations.

III. SYLLABUS:

1. Separation of a given dye mixture (methyl orange and methylene blue) using TLC
2. Separation of a mixture of methyl orange and methylene blue by column chromatography.
3. Separation of a given mixture of two amino acids using ascending paper chromatography.
4. Separation of food dyes using Column Chromatography.
5. Verification of Beer lambert's law. (Using potassium permanganate solution) using colorimeter / spectrophotometer.

IV. REFERENCES

1. Text book of Vogel's Quantitative Chemical Analysis, Sixth edition, Pearson.
2. Vogel A.I, Practical Organic Chemistry, Longman Group Ltd.
3. Bansal R.K. Laboratory Manual of Organic Chemistry, Wiley-Eastern.
4. Ahluwalia V. K. and Agarwal R. Comprehensive Practical Organic Chemistry, University press.
5. MannF.Gand Saunders B.C, Practical Organic Chemistry, Pearson Education.

V. CO-CURRICULAR ACTIVITIES AND ASSESSMENT METHODS

1. Internal Practical Assessment
2. Lab Record Evaluation
3. Final Practical Examination
4. Oral/Viva Voce

SEMESTER-V

COURSE 13 B: INDUSTRIAL CHEMISTRY-POLYMERS

Theory **Credits: 3** **3 hrs/week**

I. LEARNING OBJECTIVES:

1. To understand the fundamental concepts and classifications of polymers, including natural vs. synthetic, thermoplastics vs. thermosetting, and different types like elastomers, fibers, and resins.
2. To explore polymerization mechanisms, including free radical, ionic, and Ziegler-Natta polymerization, and their industrial applications.
3. To analyze the structure, composition, and uses of biodegradable polymers, both natural and synthetic.
4. To evaluate the characteristics and treatment methods of industrial solid waste, and understand the microbiological aspects of waste disposal.
5. To develop awareness and practical understanding of the 3Rs (Reduce, Reuse, Recycle**)** and their application in daily life and industrial practices.

II. COURSE OUTCOMES:

At the end of the course the student will be able to

1. Classify and describe various types of polymers and their properties based on their structure, origin, and application.
2. Explain different polymerization mechanisms and outline the industrial production of key polymers such as polystyrene and polymethacrylates.
3. Assess the types, structures, and functions of biodegradable polymers, and describe their relevance in sustainable material science.
4. Demonstrate knowledge of solid waste characteristics and disposal techniques, including composting and sanitary landfilling.
5. Apply the principles of waste minimization through Reduce, Reuse, and Recycle strategies and understand their environmental significance.

III. SYLLABUS:

UNIT-1: ORGANIC POLYMERS - I **(9 h)**

Basic definitions, degree of polymerization, classification of polymers-Natural and Synthetic polymers, Organic and Inorganic polymers, Thermo plastic and Thermosetting polymers, Plastics, Elastomers, Fibers and Resins, Linear, Branched and Cross-Linked polymers.

UNIT-2 : ORGANIC POLYMERS – II **(9 h)**

Addition polymers and Condensation polymers, mechanism of polymerization- Free radical, ionic and Zeigler-Natta polymerization. Industrial manufacturing and applications of following polymers: Polystyrene, Polyacrylonitrile, Polymethacrylate.

UNIT-3: BIODEGRADABLE POLYMERS (9 h)

Types of Biodegradable Polymers, Naturally derived-starch, cellulose, proteins, chitin, synthetically produced-Polylactic acid (PLA), Polyglycolic acid (PGA), para-caprolactone (PCL), poly-(butylene succinate) (PBS)-structure and composition of biodegradable polymers-applications

UNIT-4: INDUSTRIAL WASTE TREATMENT (9 h)

Characteristics of solid wastes, methods of solid waste treatment and disposal, microbiology involved in solid waste disposal, methods of solid waste disposal-composting, sanitary and filling - economic, aesthetic and environmental problems.

UNIT-5: REDUCE, REUSE, RECYCLE (9 h)

Define waste reduction and its importance, strategies for reducing waste in daily life, define reuse and its benefits, reusing materials in various context (eg., home, office, industry) define recycling and its role in resource conservation, recycling processes for various materials (paper, plastic).

IV. REFERENCES:

1. Polymer Science, Gowariker, V.R., Viswanathan, N.V., & Sreedhar, J. 2nd Edition, 2012
2. Textbook of Polymer Science, Billmeyer, Fred W. 3rd Edition, 2007
3. Handbook of Biodegradable Polymers, Bastioli, Catia (Editor), 1st Edition, 2005
4. Environmental Chemistry, De, A.K. 9th Edition, 2018.
5. Solid Waste Management, Murali Krishna, K.V.S.G., Revised Edition, 2011.

V. PROPOSED ACTIVITIES:

1. Create a detailed classification chart of polymers with examples.
2. Group activity - Act out different types of polymerization processes.
3. Visit a local waste management facility or take a virtual tour (videos provided by municipal bodies or YouTube) and submit a report.
4. Students implement a 3-day personal "3R Challenge" maintaining a logbook.

VI. CO-CURRICULAR ACTIVITIES AND ASSESSMENT METHODS

1. Continuous Internal Evaluation (CIA): Monitoring the progress of student’s learning.
2. Class Tests, Worksheets, Quizzes, Industrial/Field visits, Student seminars, PPT presentations, Peer learning, Project based learning, Assignments, Debates, Group Discussions: Enhances critical thinking skills.
3. Semester End Examination (SEE): Critical indicator of student’s learning and teaching methods adopted by teachers throughout the semester.

SEMESTER-V

COURSE 13 B: INDUSTRIAL CHEMISTRY-POLYMERS PRACTICALS

Practical **Credits: 1** **2 hrs/week**

I. LEARNING OBJECTIVES:

1. To understand the functioning and importance of solid and liquid waste management systems through direct observation and documentation.
2. To develop practical skills in reusing and upcycling plastic materials, promoting environmental awareness and creativity.
3. To Cultivate environmental responsibility and sustainable practices by engaging in hands-on waste reuse and recycling activities.

II. COURSE OUTCOMES:

At the end of the course the student will be able to

1. Demonstrate understanding of the processes involved in solid and wastewater treatment by recording and analyzing on-site observations.
2. Apply creative and practical skills to reuse plastic waste into useful or decorative items, such as planters or crafts.
3. Promote and practice sustainable waste management through experiential learning and participation in eco-friendly activities.

III. SYLLABUS:

1. Visit a nearby solid waste management unit and record your observations.
2. Visit a nearby wastewater treatment plant and record the various steps involved in the process.
3. Prepare a "Bottle planter" from used plastic bottles.
4. Create any decorative item using waste and used plastic things.
5. Synthesis of a polymer through cross-linking reactions using borax and PVA.

IV. REFERENCES

1. "Environmental Studies" by Erach Bharucha (UGC Recommended)
2. Covers solid waste management, sustainability, and practical eco-friendly activities.
3."Urban Gardening for Dummies" by Paul Simon & Charlie Nardozzi

V. CO-CURRICULAR ACTIVITIES AND ASSESSMENT METHODS

1. Internal Practical Assessment
2. Lab Record Evaluation
3. Final Practical Examination
4. Oral/Viva Voce

SEMESTER-VI

COURSE 14 A: GREEN CHEMISTRY AND NANOTECHNOLOGY

Theory **Credits: 3** **3 hrs/week**

I. LEARNING OBJECTIVES:

1. To introduce the foundational concepts, need, and guiding principles of green chemistry.
2. To familiarize students with eco-friendly reaction techniques such as sonochemistry, microwave-assisted synthesis, and the use of greener solvents.
3. To understand the role of green catalysis and renewable energy in sustainable chemical synthesis.
4. To understand the principles and applications of nanotechnology in promoting environmentally sustainable chemical processes and products.

II. COURSE OUTCOMES:

At the end of the course the student will be able to

1. Explain the principles and goals of green chemistry and evaluate chemical reactions based on atom economy.
2. Apply green solvents and alternative energy sources such as supercritical CO_2 and microwave energy in synthesis.
3. Demonstrate understanding of green catalysis methods and perform basic green synthetic reactions.
4. Evaluate the role of nanomaterials in green synthesis, catalysis, energy, and environmental remediation.
5. Analyze and compare conventional and green approaches in terms of sustainability, efficiency, and environmental safety.

III. SYLLABUS:

Unit-1: BASICS OF GREEN CHEMISTRY **9 h**

Introduction-Definition of green Chemistry, Need for green chemistry, Goals of Green chemistry, Basic principles of green chemistry. Green synthesis- Evaluation of the type of the reaction i) Rearrangements (100% atom economic), ii) Addition reaction (100% atom economic).

Unit- 2: GREENER SOLVENTS AND GREEN ENERGY **9 h**

A) Selection of solvent:

i) Aqueous phase reactions- Click reaction

ii) Reactions in ionic liquids, Heck reaction and Suzuki reaction

B) Supercritical CO_2: Preparation, properties of Supercritical CO_2, applications of Supercritical CO_2: decaffeination and dry cleaning.

Unit-3: MICROWAVE AND ULTRASOUND-ASSISTED GREEN SYNTHESIS 9 h

Apparatus required, examples of MAOS (synthesis of fused anthroquinones, Leukart reductive amination of ketones)-Advantages and disadvantages of MAOS. Aldol condensation –Cannizzaro reaction - Diels-Alder reactions- Strecker's synthesis.

Organic reactions by Sonication method: apparatus required and examples of sonochemical reactions (Hundsdiecker and Wittig reactions).

UNIT-4: GREEN CATALYSIS AND GREEN SYNTHESIS 9 h

Heterogeneous catalysis, use of zeolites, silica, alumina, supported catalysis (Only reactions) - Biocatalysis: Enzymes~~,~~ Phase transfer catalysis (micellar /surfactant)

Green synthesis of adipic acid and catechol.

UNIT-5: NANOTECHNOLOGY IN GREEN CHEMISTRY 9 h

Green synthesis of nanoparticles: Plant extracts, microbes, and eco-friendly routes. Metal and metal oxide nanoparticles in catalysis and pollutant degradation. Nanomaterials in green energy: hydrogen production. Nano-adsorbents in water purification and waste treatment. Environmental and health impacts of nanomaterials.

IV. REFERENCES:

1. Anastas, P.T., and Warner, J.C. – Green Chemistry: Theory and Practice, Oxford University Press, 1998.
2. Ahluwalia, V.K., and Malhotra, M. – Environmental Chemistry and Green Chemistry, 2nd Edition, Ane Books, 2019.
3. M.K. Parikh – Green Chemistry, 2nd Edition, CBS Publishers, 2020.
4. Tiwari, A. and Mishra, A. – Green Chemistry for Beginners, Alpha Science, 2016.
5. Gupta, B.K. and Vishwanathan, B. – Nanoscience and Nanotechnology, Narosa Publishing House, 2012.
6. Roco, M. C. (2004). Nanotechnology: Societal Implications - Maximizing Benefits for Humanity. National Science Foundation Report.

V. PROPOSED ACTIVITIES:

1. Poster Presentation: Showcase the preparation, properties, and applications of supercritical CO_2 in industrial processes (e.g., decaffeination).
2. Case Study: Compare traditional synthesis vs. green synthesis of adipic acid or catechol using green chemistry metrics.
3. Nanomaterials applications chart activity.
4. Group discussion on case studies (e.g., nano-TiO_2 in photocatalysis).

VI. CO-CURRICULAR ACTIVITIES AND ASSESSMENT METHODS

1. Continuous Internal Evaluation (CIA): Monitoring the progress of student's learning.
2. Class Tests, Worksheets, Quizzes, Industrial/Field visits, Student seminars, PPT presentations, Peer learning, Project based learning, Assignments, Debates, Group Discussions: Enhances critical thinking skills.
3. Semester End Examination (SEE): Critical indicator of student's learning and teaching methods adopted by teachers throughout the semester.

SEMESTER-VI

COURSE 14 A: GREEN CHEMISTRY AND NANOTECHNOLOGY-PRACTICAL

Practical | **Credits: 1** | **2 hrs/week**

I-LEARNING OBJECTIVES:

1. Understand and apply green chemistry principles to design and perform organic reactions that minimize the use of hazardous chemicals and reduce waste.
2. Develop practical skills in synthesizing and characterizing compounds using eco-friendly reagents and solvents (e.g., water, ethanol, or biodegradable catalysts).
3. Interpret the significance of reaction mechanisms such as acetylation, rearrangement, radical coupling, and photoreduction in the context of sustainable chemical practices.

II. COURSE OUTCOMES:

At the end of the course the student will be able to

1. Students will be able to synthesize organic and inorganic compounds using green chemistry methods and evaluate their environmental impact.
2. Students will demonstrate proficiency in experimental techniques for the preparation and characterization of products such as nanoparticles, biodiesel, and organic derivatives.
3. Students will be able to analyze experimental data and explain reaction mechanisms with an emphasis on greener alternatives and sustainability.

III. SYLLABUS:

1. Acetylation of 1^0 amine by green method: Preparation of acetanilide
2. Rearrangement reaction in green conditions: Benzil - Benzilic acid rearrangement
3. Preparation of Nanoparticles of copper using plant extracts.
4. Benzoin condensation using Thiamine Hydrochloride as a catalyst instead of cyanide.
5. Photoreduction of Benzophenone to Benzopinacol in the presence of sunlight

IV. REFERENCES

1. Anastas, P. T., & Warner, J. C. – Green Chemistry: Theory and Practice, Oxford University Press.
2. M. Lancaster – Green Chemistry: An Introductory Text, Royal Society of Chemistry.
3. V.K. Ahluwalia and M. Kidwai – New Trends in Green Chemistry, Springer.
4. R. S. Sangwan – Laboratory Manual of Green Chemistry Experiments, Campus Books International.
5. Z. Li and L. Zhang (Eds.) – *Green Chemistry in Scientific Literature: A User’s Guide*, Wiley.

V. CO-CURRICULAR ACTIVITIES AND ASSESSMENT METHODS

1. Internal Practical Assessment
2. Lab Record Evaluation
3. Final Practical Examination
4. Oral/Viva Voce

SEMESTER-VI

COURSE 14 B: INDUSTRIAL CHEMISTRY-FERTILZERS AND SURFACE COATINGS

Theory **Credits: 3** **3 hrs/week**

I. LEARNING OBJECTIVES:

1. To understand the types and industrial production methods of commonly used fertilizers and their role in agriculture.
2. To explore the composition, types, and manufacturing processes of silicates, including ceramics and cement.
3. To gain knowledge of surface coatings, their formulations, functions, and applications in various industries.
5. To study the industrial processes involved in the production of cane and beet sugar, including testing and estimation techniques.
6. To understand the manufacturing processes of pulp and paper, including chemical treatments and finishing processes.

II. COURSE OUTCOMES:

At the end of the course the student will be able to

1. Identify and explain the types, manufacturing methods, and applications of industrial fertilizers**, including mixed and compound fertilizers.**

2. Describe the ingredients, processes, and technological advancements in the production of ceramics and cement**, including high-tech applications.**

3. Classify various surface coatings and interpret the roles of paints, pigments, and additives **used in coating formulations.**

4. Demonstrate an understanding of sugar production methods **and apply basic analytical techniques for sugar testing and estimation.**

5. Explain the complete process of pulp and paper manufacturing**, including chemical pulping and surface treatments.**

III. SYLLABUS:

UNIT-1: FERTILIZERS
(9 h)

A brief introduction to industrial chemistry. Different types of fertilizers. Manufacture of the following fertilizers: Urea, Ammonium nitrate, Calcium ammonium nitrate, Ammonium phosphates; Polyphosphate, Superphosphate, Compound and mixed fertilizers.

UNIT-2: SILICATES **(9 h)**

Ceramics: Important clays and Feldspar. Ceramics - types, uses and manufacture. High technology ceramics and their applications.

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

UNIT- 3: SURFACE COATINGS **(9 h)**

Objectives of coatings surfaces, preliminary treatment of surface, classification of surface coatings. Paints and pigments - formulation, composition and related properties. Oil paint, modified oils, Pigments, toners and lake pigments, fillers, thinners, enamels, emulsifying agents. Special paints (Heat retardant, Fire retardant, Eco-friendly paint, Plastic paint), Water paint.

UNIT - 4: SUGAR CHEMISTRY **(9 h)**

Introduction- Manufacture and recovery of cane sugar from molasses, manufacture of sucrose from beet root, testing and estimation of sucrose.

UNIT - 5: PAPER INDUSTRY **(9 h)**

Pulp and Paper-Introduction, Manufacture of pulp, sulphate or Kraft pulp, soda pulp, sulphite pulp, rag pulp, beating, refining, filling, sizing and colouring of pulp, manufacture of paper.

IV. REFERENCES:

1. J.A. Kent, Riegel's Hand book of Industrial Chemistry, CBS Publishers, New Delhi.
2. P.C. Jain, M. Jain, Engineering Chemistry, Dhanpat Rai & Sons, Delhi.
3. R. Gopalan, D. Venkappayya, S. Nagarajan: Engineering Chemistry, Vikas Publications, New Delhi.
4. B.K. Sharma, Engineering Chemistry, Goel Publishing House, Meerut
5. O. P. Vermani, A. K. Narula: Industrial Chemistry, Galgotia Publications Pvt. Ltd., New Delhi.

V. PROPOSED ACTIVITIES:

1. Case Study - Students work in groups to research a real-life fertilizer manufacturing plant.
2. Individual/Group Activity – Student/s create simple models representing different ceramic products.
3. Analyze the labels of commercial paints to identify components.
4. Analyze sugar content in commercial foods using available data, in the lab.
5. Students attempt small-scale recycling of waste

VI. CO-CURRICULAR ACTIVITIES AND ASSESSMENT METHODS

1. Continuous Internal Evaluation (CIA): Monitoring the progress of student's learning.
2. Class Tests, Worksheets, Quizzes, Industrial/Field visits, Student seminars, PPT presentations, Peer learning, Project based learning, Assignments, Debates, Group Discussions: Enhances critical thinking skills.
3. Semester End Examination (SEE): Critical indicator of student's learning and teaching methods adopted by teachers throughout the semester.

SEMESTER-VI

COURSE 14 B: INDUSTRIAL CHEMISTRY-FERTILSERS AND SURFACE COATINGS PRACTICAL

Practical **Credits: 1** **2 hrs/week**

I. LEARNING OBJECTIVES:

1. To develop analytical skills to estimate the chemical components (acidity and phosphoric acid) in commercial fertilizers using titrimetric methods.
2. To understand and apply colorimetric techniques for the quantitative estimation of sucrose.
3. To enhance comprehension of industrial processes through visual representation and step-wise documentation of paper manufacturing.

II. COURSE OUTCOMES:

At the end of the course the student will be able to

1. Accurately determine the free acidity in ammonium sulphate and phosphoric acid in superphosphate using standard chemical analysis techniques.
2. Apply colorimetric methods to estimate the concentration of sucrose in a given solution with proper calibration and data interpretation.
3. Demonstrate understanding of paper production processes by preparing a clear, labeled, and informative process chart.

III. SYLLABUS:

1. Determination of free acidity in ammonium sulphate fertilizer.
2. Estimation of phosphoric acid in superphosphate fertilizer.
3. Estimation of sucrose by colorimetry.
4. Prepare a chart indicating various steps in the production of paper in paper industry.

IV. REFERENCES

4. Vogel's Textbook of Qualitative Inorganic Analysis – G. Svehla, Pearson Education, 2008.
5. Practical Chemistry, *O.P. Pandey, D.N. Bajpai, S. Giri*
6. Industrial Chemistry, B.K. Sharma, 33rd Edition, 2018.
7. Engineering Chemistry, Jain & Jain, 16TH Edition, 2015

V. CO-CURRICULAR ACTIVITIES AND ASSESSMENT METHODS

1. Internal Practical Assessment
2. Lab Record Evaluation
3. Final Practical Examination
4. Oral/Viva Voce

SEMESTER-VI

COURSE 15 A: ENVIRONMENT AND INDUSTRIAL CHEMICALS

Theory **Credits: 3** **3 hrs/week**

I. LEARNING OBJECTIVES:

1. To introduce students to the fundamental structure, components, and functions of ecosystems and energy flow in nature.
2. To familiarize learners with various environmental pollutants, toxic chemicals, and their biochemical impacts.
3. To understand the production, uses, and hazards of industrial gases in modern industry and research.
4. To explore various conventional and renewable energy sources and the environmental consequences of energy production and use.
5. To impart knowledge on water quality parameters, pollution monitoring, and treatment technologies.

II. COURSE OUTCOMES:

At the end of the course the student will be able to

1. Explain the components, types, and energy dynamics of ecosystems along with nutrient cycles.
2. Assess the toxicological effects of industrial and household chemicals on human health and the environment.
3. Describe the methods of handling and storing industrial gases along with their uses and hazards.
4. Evaluate renewable and non-renewable energy sources and suggest sustainable alternatives.
5. Analyze water quality using parameters such as BOD, COD, and dissolved oxygen, and understand modern purification methods

III. SYLLABUS:

UNIT-1: ECO SYSTEM (9 h)

Concepts–structure–Functions and types of ecosystem– Abiotic and biotic components – Energy flow and Energy dynamics of ecosystem– Food chains – Food web– Tropic levels–Biogeochemical cycles (carbon, nitrogen and phosphorus)

UNIT-2 : CHEMICAL TOXICOLOGY (9 h)

Toxic chemicals in the environment – effects of toxic chemicals – cyanide and its toxic effects – pesticides and its biochemical effects –Applications and hazards of HCl, HNO_3, H_2SO_4, NaOH and Bleaching powder, Toxicity of lead, mercury, arsenic and cadmium.

UNIT-3 : INDUSTRIAL GASES (9 h)

Large-scale production, uses storage and hazards in handling the following gases:
Oxygen, Nitrogen, Argon, Neon, Helium, Hydrogen, Acetylene, Carbon Monoxide, Chlorine, Fluorine, And Sulphur Dioxide.

UNIT-4 : ENERGY & ENVIRONMENT **(9 h)**

Sources of Energy- Renewable and non-renewable energy-Coal, petrol and natural gas. Nuclear fuels, solar, hydrogen, geothermal, tidal and hydel.

Nuclear Pollution: Disposal of nuclear waste, nuclear disaster and its management.

UNIT-5 : WATER QUALITY PARAMETERS **(9 h)**

Water quality parameters-dissolved solids, total hardness of water, turbidity, alkalinity, Dissolved oxygen, COD, BOD.

Water quality parameters for waste water, Industrial water and domestic water. Water treatment and purification – RO & Ion Exchange method.

IV. REFERENCES:

1. Cunningham, W. P., & Cunningham, M. A. (2020). *Environmental Science: A Global Concern* (15th ed.). McGraw Hill Education.
2. Manahan, S. E. (2017). *Environmental Chemistry* (10th ed.). CRC Press.
3. De, A. K. (2019). *Environmental Chemistry* (9th ed.). New Age International Publishers.
4. Sawyer, C. N., McCarty, P. L., & Parkin, G. F. (2018). *Chemistry for Environmental Engineering and Science* (5th ed.). McGraw-Hill Education.
5. Masters, G. M., & Ela, W. P. (2016). *Introduction to Environmental Engineering and Science* (3rd ed.). Pearson Education.

V. PROPOSED ACTIVITIES:

1. Constructing a Food Web Model- Understand the energy flow in an ecosystem.
2. Water Quality Testing Workshop -Analyze physical and chemical water parameters.
3. Toxicology Poster Presentation- Identify and communicate the hazards of heavy metals or pesticides.
4. Renewable Energy Survey Project-Study local awareness and usage of renewable energy source.

VI. CO-CURRICULAR ACTIVITIES AND ASSESSMENT METHODS

1. Continuous Internal Evaluation (CIA): Monitoring the progress of student’s learning.
2. Class Tests, Worksheets, Quizzes, Industrial/Field visits, Student seminars, PPT presentations, Peer learning, Project based learning, Assignments, Debates, Group Discussions: Enhances critical thinking skills.
3. Semester End Examination (SEE): Critical indicator of student’s learning and teaching methods adopted by teachers throughout the semester.

SEMESTER-VI

COURSE 15 A: ENVIRONMENT AND INDUSTRIAL CHEMICALS PRACTICAL

Practical **Credits: 1** **2 hrs/week**

I-LEARNING OBJECTIVES:

1. To introduce the basic analytical techniques for assessing water and soil quality parameters.
2. To train students in volumetric and instrumental methods used in environmental monitoring.
3. To enable students to understand and apply standard procedures for testing hardness, COD, BOD, pH, turbidity, and solids.
4. To foster analytical thinking and laboratory skills necessary for environmental and agricultural sample analysis.

II. COURSE OUTCOMES:

At the end of the course the student will be able to

1. Estimate water hardness using EDTA titration and interpret results based on water quality standards.
2. Analyze wastewater samples for COD and BOD to evaluate organic pollution levels.
3. Measure physical and chemical parameters like pH, turbidity, and total solids using appropriate instruments.
4. Assess soil pH accurately and understand its implications for soil health and agricultural practices.

III. SYLLABUS:

1. Determination of Hardness of water by EDTA titration.
2. Determination of Chemical Oxygen Demand(COD)
3. Determination of Biological Oxygen Demand(BOD)
4. Determination of pH, turbidity and total solids in water sample.
5. Determination of pH in soil samples using pHmetry.

IV. REFERENCES

1. Sawyer, C.N., McCarty, P.L., & Parkin, G.F. (2003). Chemistry for Environmental Engineering and Science (5th Edition). McGraw-Hill Education.
2. Trivedy, R.K. & Goel, P.K. (1986). Chemical and Biological Methods for Water Pollution Studies. Environmental Publications.
3. APHA (2023) Standard Methods for the Examination of Water and Wastewater (24th Edition). American Public Health Association.
4. Skoog, D.A., West, D.M., Holler, F.J., & Crouch, S.R. (2013). Fundamentals of Analytical Chemistry (9th Edition). Cengage Learning.

V. CO-CURRICULAR ACTIVITIES AND ASSESSMENT METHODS

1. Internal Practical Assessment
2. Lab Record Evaluation
3. Final Practical Examination
4. Oral/Viva Voce

SEMESTER-VI

COURSE 15 B: FOOD CHEMISTRY

Theory **Credits: 3** **3 hrs/week**

I. LEARNING OBJECTIVES:

1. To understand the chemical structure and functional roles of food proteins, enzymes, and lipids in various food systems.
2. To learn the nutritional importance of lipids, vitamins, and minerals, and their stability during food processing and storage.
3. To gain in-depth knowledge of the composition and chemistry of milk and milk-based products.
5. To understand the chemical transformations during dairy processing and the chemistry behind common dairy products.
6. To identify food additives and detect common adulterants and contaminants in food items.

II. COURSE OUTCOMES:

At the end of the course the student will be able to

1. Classify food proteins, describe their structures, and explain their functional properties in food processing.
2. Evaluate the nutritional and chemical roles of lipids, vitamins, and minerals, including deficiency symptoms and interactions.
3. Analyze the composition and chemical behavior of milk and understand its role as a base for dairy product processing.
4. Describe the chemistry involved in the manufacture and storage of various dairy products such as butter, cheese, and ice cream.
5. Detect food adulterants and explain the role and types of additives used in food preservation and flavoring.

III. SYLLABUS:

UNIT-1 FOOD CHEMISTRY **(9 h)**

Definition and scope of food chemistry, types and structure of food proteins (animal and plant), functional properties: solubility, gelation, emulsification, enzymes in food: role, specificity, applications (Dairy, baking, brewing)

UNIT-2: LIPIDS, VITAMINS & MINERALS **(9 h)**

Types of Lipids: saturated, unsaturated, trans fats, Rancidity and lipid oxidation, Role of lipids in flavour and nutrition. Classification and functions, stability, processing and storage, deficiency diseases related to food sources, mineral interactions and bioavailability.

UNIT-3: DAIRY CHEMISTRY I (9 h)

Introduction, composition of milk, milk proteins, milk lipids, carbohydrates and enzymes in milk, minerals and vitamins in milk,

UNIT-4: DAIRY CHEMISTRY II (9 h)

Chemical changes during milk processing, chemistry of dairy products- cream and butter, cheese, ice cream, ghee.

UNIT-5: FOOD ADULTERATION (9 h)

Classification: preservatives, colours, flavours, emulsifiers, Natural vs synthetic additives, food adulterants and detection, Residues: pesticides, antibiotics, heavy metals.

IV REFERENCES:

1. Food Chemistry by H.-D. Belitz, W. Grosch, P. Schieberle
2. Essentials of Food Science by Vickie A. Vaclavik
3. Food Chemistry by Meyer
4. Food Science by B. Srilakshmi (Indian context)
5. FSSAI Manuals and Guidelines (for practicals and regulatory insights)

V. PROPOSED ACTIVITIES:

1. Protein Solubility and Emulsification Demo (Group Activity)
2. Lipid Rancidity Test (Individual Activity)
3. Milk Composition Analysis (Lab Activity)
4. Model Dairy Product Flowchart (Group Activity)
5. Food Adulteration Detection Experiment (Individual/Group)

VI. CO-CURRICULAR ACTIVITIES AND ASSESSMENT METHODS

1. Continuous Internal Evaluation (CIA): Monitoring the progress of student’s learning.
2. Class Tests, Worksheets, Quizzes, Industrial/Field visits, Student seminars, PPT presentations, Peer learning, Project based learning, Assignments, Debates, Group Discussions: Enhances critical thinking skills.
3. Semester End Examination (SEE): Critical indicator of student’s learning and teaching methods adopted by teachers throughout the semester.

SEMESTER-VI

COURSE 15 B: FOOD CHEMISTRY PRACTICAL

Practical **Credits: 1** **2 hrs/week**

I. LEARNING OBJECTIVES:

1. To develop proficiency in estimating key nutritional components—moisture, ash, fat, and protein—in food samples.
2. To identify and detect common food adulterants using standard chemical tests.
3. To measure the acidity levels in various food samples and understand their impact on food quality.
4. To apply biochemical tests to determine the presence of macronutrients like carbohydrates and proteins in foods.
5. To interpret analytical results and understand their relevance to food safety and nutrition.

II. COURSE OUTCOMES:

At the end of the course the student will be able to

1. Accurately estimate the moisture, ash, fat, and protein content in a given food sample using basic lab techniques.
2. Detect common adulterants in food items such as milk, sugar, and tea.
3. Analyze and interpret acidity levels in food samples like curd and fruit juices using titration methods.
4. Identify the presence of carbohydrates and proteins in food using appropriate biochemical tests (e.g., Benedict's and Biuret tests).

III. SYLLABUS:

1. Estimation of moisture, ash, fat, and protein of a food sample
2. Identify common adulterants in foog products like milk, sugar, tea, etc.
3. Measure acidity levels in a food sample (e.g., milk, curd, fruit juice)
4. Identify the presence of carbohydrates and proteins in food samples.

IV. REFERENCES

1. Food Chemistry by H.D. Belitz, W. Grosch, and P. Schieberle, 4th Edition 2008.
2. Food Science by B. Srilakshmi, 7TH Edition, 2014.
3. Manual of Methods of Analysis of Foods – FSSAI (Food Safety and Standards Authority of India)

V. CO-CURRICULAR ACTIVITIES AND ASSESSMENT METHODS

1. Internal Practical Assessment
2. Lab Record Evaluation
3. Final Practical Examination
4. Oral/Viva Voce