Department of Chemistry

Core papers:

1. Atomic Structure, Bonding, General Organic Chemistry & Aliphatic Hydrocarbons
2. Atomic Structure, Bonding, General Organic Chemistry & Aliphatic Hydrocarbons Lab
3. Chemical Energetics, Equilibria & Functional Group Organic Chemistry-I
4. Chemical Energetics, Equilibria & Functional Group Organic Chemistry-I Lab
5. Conductance, Electrochemistry & Functional Group Organic Chemistry-II
6. Conductance, Electrochemistry & Functional Group Organic Chemistry-II Lab
7. Transition Metal & Coordination Chemistry, States of Matter and Chemical Kinetics
8. Transition Metal & Coordination Chemistry, States of Matter and Chemical Kinetics Lab

Discipline Specific Elective papers

1. Analytical Methods in Chemistry
2. Analytical Methods in Chemistry Lab
3. Molecules of Life
4. Molecules of Life Lab
5. Quantum Chemistry, Spectroscopy & Photochemistry
6. Quantum Chemistry, Spectroscopy & Photochemistry Lab
7. Polymer Chemistry
8. Polymer Chemistry Lab
9. Organometallics, Bioinorganic chemistry, Polynuclear hydrocarbons and UV, IR Spectroscopy
10. Organometallics, Bioinorganic chemistry, Polynuclear hydrocarbons and UV, IR Spectroscopy Lab
11. Chemistry of Main Group Elements, Theories of Acids and Bases
12. Chemistry of Main Group Elements, Theories of Acids and Bases Lab

Skill Enhancement Courses:

1. Basic Analytical Chemistry
2. Fuel Chemistry
3. Chemical Technology & Society
4. Pharmaceutical Chemistry
5. Chemistry of Cosmetics & Perfumes
6. Pesticide Chemistry

1. Name of the Department: Chemistry						
2. Course Name	Atomic Structure, Bonding, General Organic Chemistry & Aliphatic Hydrocarbons	**L**	**T**	**P**		
3. Course Code	09010115	4	0	0		
4. Type of Course (use tick mark)	**Core (✓)**	**DSE ()**	**AEC ()**	**SEC ()**	**OE ()**	
5. Pre-requisite (if any)	NA	**6. Frequency (use tick marks)**	Even ()	Odd (✓)	Either Sem ()	Every Sem ()
7. Total Number of Lectures, Tutorials, Practicals.						
Lectures = 52	**Tutorials = 0**	**Practical = 0**				

8. Course Description:

Chemistry is essential to the understanding of the world around us. This core paper in Chemistry will help Science students understand and rationalize bonding in compounds, basic shapes and structures of molecules and even predict properties, which may have potential applications as materials, nanostructured materials and devices.

The course highlights the uses and limitations of the Schrodinger wave equation and explains the concept of quantization of energy followed by an explanation of the rules governing the filling up of electrons in various orbitals and the electronic configuration of the atoms and ions. Atomic properties give rise to three models of chemical bonding- ionic, covalent, and metallic.

Energetics behind the formation of ionic bonds (Born Landè Equation), the forces of interaction operating in covalent molecules (bond energy) and the band theory of metals will be explained in detail.

Organic chemistry is probably the most active and important field of chemistry, due to its diverse applications in life and industry. Organic Chemistry involves basic principles governing life and applications of these principles. The course highlights the fundamentals of these carbon containing compounds with emphasis on inductive effect, hyper-conjugation, resonance and how they affect the properties of these compounds. Nucleophilic and electrophilic behavior of organic compounds and the intermediates formed during reactions; carbocations; carbanions; and free radicals will be exaplined along with along with studying the effects of functional groups on reactions.

Stereochemistry of organic compounds, which involves the study of the relative spatial arrangement of atoms that form the structure of molecules and their manipulation along with the applications, will be discussed at length. Many important reactions and their mechanisms would also be discussed.

9. Course Objectives:

The objectives of this course are to:

1. Introduce students to Schrödinger wave equation, quantization of energy and electronic configuration of atoms and ions.
2. Explain three types of chemical bonding- ionic, covalent and metallic- and understand energetics of bond formation.
3. Introduce properties of organic compounds with special emphasis on inductive effect, hyperconjugation and resonance.
4. Understand electrophilicity and nucleophilicity and impact of functional groups on reactions
5. Understand stereochemistry of compounds
6. Explain important reactions and mechanisms

10. Course Outcomes (COs):

Upon successful completion of this course, the student will be able to:

1. Understand and quantization of energy and determine electronic configurations of atoms and ions
2. Explain chemical bonding in atoms and molecules
3. Explain electronic displacements in organic molecules with special emphasis on inductive, resonance, electromeric effects and hyperconjugation

4. Explain nucleophilic and electrophilic behavior of organic species
5. Explain spatial arrangement of atoms on organic molecules
6. Identify important properties and reactions of aliphatic hydrocarbons (alkanes, alkenes and alkynes)

11. Unit wise detailed content

Unit-1	**Number of lectures = 12**	**Title of the unit: Atomic Structure**

Atomic Structure: Review of: Bohr's theory and its limitations, dual behaviour of matter and radiation, de Broglie's relation, Heisenberg Uncertainty principle. Hydrogen atom spectra. Need of a new approach to Atomic structure.

What is Quantum mechanics? Time independent Schrodinger equation and meaning of various terms in it. Significance of ψ and $\psi 2$, Schrödinger equation for hydrogen atom. Radial and angular parts of the hydogenic wavefunctions (atomic orbitals) and their variations for 1s, 2s, 2p, 3s, 3p and 3d orbitals (Only graphical representation). Radial and angular nodes and their significance. Radial distribution functions and the concept of the most probable distance with special reference to 1s and 2s atomic orbitals. Significance of quantum numbers, orbital angular momentum and quantum numbers ml and ms. Shapes of s, p and d atomic orbitals, nodal planes. Discovery of spin, spin quantum number (s) and magnetic spin quantum number (ms).

Rules for filling electrons in various orbitals, Electronic configurations of the atoms. Stability of half-filled and completely filled orbitals, concept of exchange energy. Relative energies of atomic orbitals, Anomalous electronic configurations.

Unit – 2	**Number of lectures = 14**	**Title of the unit: Chemical Bonding and Molecular structure**

Ionic Bonding: General characteristics of ionic bonding. Energy considerations in ionic bonding, lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds. Statement of Born-Landé equation for calculation of lattice energy, Born-Haber cycle and its applications, polarizing power and polarizability. Fajan's rules, ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character.

Covalent bonding: VB Approach: Shapes of some inorganic molecules and ions on the basis of VSEPR and hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements.

Concept of resonance and resonating structures in various inorganic and organic compounds.

MO Approach: Rules for the LCAO method, bonding and antibonding MOs and their characteristics for s-s, s-p and p-p combinations of atomic orbitals, nonbonding combination of orbitals, MO treatment of homonuclear diatomic molecules of 1st and 2nd periods (including idea of s-p mixing) and heteronuclear diatomic molecules such as CO, NO and NO^+. Comparison of VB and MO approaches.

Unit – 3	**Number of lectures = 16**	**Title of the unit: Fundamentals of Organic Chemistry and Stereochemistry**

Fundamentals of Organic Chemistry

Physical Effects, Electronic Displacements: Inductive Effect, Electromeric Effect, Resonance and Hyperconjugation. Cleavage of Bonds: Homolysis and Heterolysis.

Structure, shape and reactivity of organic molecules: Nucleophiles and electrophiles. Reactive Intermediates: Carbocations, Carbanions and free radicals.

Strength of organic acids and bases: Comparative study with emphasis on factors affecting pK values. Aromaticity: Benzenoids and Hückel's rule.

Stereochemistry

Conformations with respect to ethane, butane and cyclohexane. Interconversion of Wedge Formula, Newmann, Sawhorse and Fischer representations. Concept of chirality (up to two carbon atoms).

Configuration: Geometrical and Optical isomerism; Enantiomerism, Diastereomerism and Meso compounds). Threo and erythro; D and L; cis - trans nomenclature; CIP Rules: R/ S (for upto 2 chiral carbon atoms) and E / Z Nomenclature (for upto two C=C systems).

Unit – 4	**Number of lectures = 10**	**Title of the unit: Aliphatic Hydrocarbons**

Aliphatic Hydrocarbons : Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure.

Alkanes: (Upto 5 Carbons). Preparation: Catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from Grignard reagent. Reactions: Free radical Substitution: Halogenation.

Alkenes: (Upto 5 Carbons) Preparation: Elimination reactions: Dehydration of alkenes and dehydrohalogenation of alkyl halides (Saytzeff's rule); cis alkenes (Partial catalytic hydrogenation) and trans alkenes (Birch reduction). Reactions: cis addition (alk. KMnO4) and trans-addition (bromine), Addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis, oxymecuration-demercuration, Hydroboration-oxidation.

Alkynes: (Upto 5 Carbons) Preparation: Acetylene from CaC_2 and conversion into higher alkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinal-dihalides. Reactions: formation of metal acetylides, addition of bromine and alkaline $KMnO_4$, ozonolysis and oxidation with hot alk. $KMnO_4$.

13. Books Recommended

1. Lee, J.D. Concise Inorganic Chemistry ELBS, 1991.
2. Cotton, F.A., Wilkinson, G. & Gaus, P.L. Basic Inorganic Chemistry, 3rd ed., Wiley.
3. Douglas, B.E., McDaniel, D.H. & Alexander, J.J. Concepts and Models in Inorganic Chemistry, John Wiley & Sons.
4. Huheey, J.E., Keiter, E.A., Keiter, R.L. & Medhi, O.K. Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Education India, 2006.
5. Graham Solomon, T.W., Fryhle, C.B. & Dnyder, S.A. Organic Chemistry, John Wiley & Sons (2014).
6. McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
7. Sykes, P. A Guidebook to Mechanism in Organic Chemistry, Orient Longman, New Delhi (1988).
8. Eliel, E.L. Stereochemistry of Carbon Compounds, Tata McGraw Hill education, 2000.
9. Finar, I.L. Organic Chemistry (Vol. I & II), E.L.B.S.
10. Morrison, R.T. & Boyd, R.N. Organic Chemistry, Pearson, 2010.
11. Bahl, A. & Bahl, B.S. Advanced Organic Chemistry, S. Chand, 2010.

1. Name of the Department: Chemistry							
2. Course Name	Atomic Structure, Bonding, General Organic Chemistry & Aliphatic Hydrocarbons Lab		**L**		**T**		**P**
3. Course Code	09010116		0		0		4
4. Type of Course (use tick mark)		**Core (✓)**	**DSE ()**	**AEC ()**		**SEC ()**	**OE ()**
5. Pre-requisite (if any)	NA	**6. Frequency (use tick marks)**	Even ()	Odd (✓)	Either Sem ()	Every Sem ()	
7. Total Number of Lectures, Tutorials, Practicals							
Lectures = 0		**Tutorials = 0**		**Practical = 52**			

8. Course Description:

The lab work emphasizes learning of basic skills helpful not only to chemistry students but all those who want to pursue any experimental science. It includes volumetric analysis of compounds, crystallization of compounds, determining the purity, melting and boiling point of compounds and simple chromatographic techniques.

9. Course Objectives:

The objectives of this course are to:

1. Estimate various components in a mixture
2. Estimate oxalic acid, water of crystallization in Mohr's salt, Fe(II) ions and Cu(II) ions by volumetric analysis
3. Detect various elements in organic compounds
4. Separate mixture by various types of chromatography

10. Course Outcomes (COs):

Upon successful completion of this course, the student will be able to:

1. Separate mixtures of Sodium carbonate and Sodium hydrogen carbonate
2. Determine strengths of solutions of oxalic acid and water of crystallization in Mohr's salt with $KMnO_4$.
3. Determine strengths of Fe(II) solutions with $K_2Cr_2O_7$
4. Determine strengths of Cu(II) solutions iodometrically with $Na_2S_2O_3$
5. Detect heteroatoms (N, S, Cl, Br, I) in organic compounds
6. Separate amino acids with paper chromatography
7. Separate sugars with paper chromatography

11. List of Experiments (Student has to perform ten experiments – at least two from each section)

Section A: Inorganic Chemistry - Volumetric Analysis

1. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture.
2. Estimation of oxalic acid by titrating it with $KMnO_4$.
3. Estimation of water of crystallization in Mohr's salt by titrating with $KMnO_4$.
4. Estimation of Fe (II) ions by titrating it with $K_2Cr_2O_7$ using internal indicator.
5. Estimation of Cu (II) ions iodometrically using $Na_2S_2O_3$.

Section B: Organic Chemistry

1. Detection of extra elements (N, S, Cl, Br, I) in organic compounds (containing upto two extra

elements)

2. Separation of mixtures by Chromatography: Measure the Rf value in each case (combination of two compounds to be given)
3. Identify and separate the components of a given mixture of two amino acids (glycine, aspartic acid, glutamic acid, tyrosine or any other amino acid) by paper chromatography
4. Identify and separate the sugars present in the given mixture by paper chromatography.

12. **Books Recommended**

1. Svehla, G. Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012.
2. Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009.
3. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G.,
4. Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.
5. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry Orient-Longman,1960.

1. Name of the Department: Chemistry							
2. Course Name	Chemical Energetics, Equilibria, Functional Organic Chemistry	**L**	**T**	**P**			
3. Course Code	09010214	4	0	0			
4. Type of Course (use tick mark)		**Core (✓)**	**DSE ()**	**AEC ()**	**SEC ()**	**OE ()**	
5. Pre-requisite (if any)	NA	**6. Frequency (use tick marks)**	Even (✓)	Odd ()	Either Sem ()	Every Sem ()	
7. Total Number of Lectures, Tutorials, Practicals							
Lectures = 52		**Tutorials = 0**		**Practical = 0**			

8. Course Description:

This course aims to explain the physical world around us by describing important principles and definitions of thermochemistry. Through Laws of thermodynamics, energetics of reactions will be explained. Calculation of bond energy, bond dissociation energy, resonance energy, entropies and enthalpies will be demonstrated. In addition, concepts related to chemical equilibrium (Gibb's Free Energy, Le Chatlier's Principle) will be discussed.

Equilibria in term of ions will also be explained. Important concepts include strong, moderate and weak electrolytes; ionization of water; ionization of weak acids and bases; common ion effect; pH scale; buffer solutions; and solubility of sparingly soluble salts.

In Organic Chemistry, preparation and reactions of aromatic hydrocarbons; alkyl and aryl halides; alcohols, phenols and ethers will be discussed. Important reactions and their mechanisms will be explained.

9. Course Objectives:

The objectives of this course are to:

1. Introduce students to energetics of chemical reactions through Laws of Thermodynamics
2. Demonstrate calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data.
3. Explain thermodynamic derivation of the law of chemical equilibrium (be able to distinguish between ΔG and ΔG^0, Le Chatlier's Principle)
4. Understand the difference between strong, moderate and weak electrolytes; degree of ionization and ionic product of water
5. Understand ionization of weak acids and bases and related concepts
6. Understand reactions and preparations of aromatic hydrocarbons; aryl and alkyl halides; alcohols, phenols and ethers; aldehydes and ketones.

10. Course Outcomes (COs):

Upon successful completion of this course, the student will be able to:

1. Explain energetics of chemical reactions through important principles and definitions of thermo chemistry
2. Understand free energy change in a chemical reaction
3. Explain degree of ionization and the differences between strong, moderate and weak electrolytes
4. Explain important concepts associated with the ionization of weak acids and bases
5. Explain preparation and reactions of aromatic hydrocarbons; aryl and alkyl halides; alcohols, phenols and ethers; aldehydes and ketones.

11. Unit wise detailed content

Section A: Physical Chemistry (26 Lectures)

Unit-1	**Number of lectures = 8**	**Title of the unit: Chemical Energetics**

Review of thermodynamics and the Laws of thermodynamics

Important principles and definitions of thermochemistry. Concept of standard state and standard enthalpies of formations, integral and differential enthalpies of solution and dilution. Calculation and bond energy, bond dissociation energy and resonance energy from thermochemical data. Variation of enthalpy of a reaction with temperature- Kirchoff's equation.

Statement of Third Law of thermodynamics and calculation of absolute entropies of substances.

Unit – 2	**Number of lectures = 18**	**Title of the unit: Chemical Equilibrium and Ionic Equilibria**

Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Distinction between ΔG and ΔG^0, Le Chatlier's Principle.

Relationships between K_p, K_c and K_x for reactions involving ideal gases.

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect. Salt hydrolysis- calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions. Solubility and solubility product of sparingly soluble salts- applications of solubility product principle.

Section B: Organic Chemistry (26 Lectures)

Unit – 3	**Number of lectures = 14**	**Title of the unit: Aromatic Hydrocarbons; Alkyl and aryl halides**

Functional group approach for the following reactions (preparations and reactions) to be studied in context to their structure.

Aromatic Hydrocarbons

Preparation : (Case benzene): from phenol, by decarboxylation, from acetylene, from benzene sulphonic acid

Reactions: (Case benzene): Electrophilic substitution: nitration, halogenation and sulphonation. Friedel-Craft's reaction (alkylation and acylation) (up to 4 carbons on benzene). Side chain oxidation of alkyl benzenes (up to 4 carbons on benzene).

Alkyl and aryl halides

Alkyl halides (upto 5 carbons) Types of Nucleophiles (S_N1, S_N2 and S_Ni) reactions.

Preparation: From alkenes and alcohols

Reactions: Hydrolysis, nitrite and nitro formation, nitrile and isonitrile formation, Williamson's ether synthesis: Eliminations vs. substitution.

Aryl Halides

Preparation : (Chloro, bromo and iodo benzene case): from phenol, Sanmeyer & Gattermann reactions.

Reactions: (Chlorobenzene): Aromatic nucleophilic substitution (replacement by -OH group) and effect of nitro substituent. Benzyne mechanism: KNH_2/NH_2 (or $NaNH_2/NH_3$).

Reactivity and relative strength of C-Halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides.

Unit 4	**No. of Lectures = 12**	**Title of the unit: Alcohols, Phenols and ethers (Up to 5 Carbons)**

Alcohols:

Preparation: Preparation of 1^o, 2^o and 3^o alcohols using Grignard reagent, Ester hydrolysis, Reduction of aldehydes, ketones, carboxylic acids and esters.

Reactions: With Sodium, HX (Lucas test), esterification, oxidation (with PCC, alk. $KMnO_4$, acidic dichromate, conc. HNO_3). Oppenauer oxidation

Diols: (Upto 6 Carbons), oxidation of diols. Pinacol-Pinacolone rearrangement.

Phenols: (Phenol case)

Preparation: Cumene hydroperoxide method, from diazonium salts.

Reactions: Electrophilic substitution: Nitration, halogenation and sulphonation. Reimer-Tiemann Reaction, Gattermann-Koch Reaction, Houben-Hoesch Condensation, Schotten-Baumann Reaction.

Ethers (aliphatic and aromatic): Cleavage of ethers with HI.

Aldehydes and ketones (aliphatic and aromatic): (Formaldehyde, acetaldehyde, acetone and benzaldehyde)

Preparation: from acid chlorides and nitriles

Reactions: Reaction with HCN, ROH, $NaHSO_3$, NH_2-G derivatives. Iodoform test, Aldol condensation, Canizzaro's reaction, Wittig reaction, Benzoin condensation.

Clemensen reduction and Wolff Kishner reduction. Meerwein-Pondorff Verley reduction.

13. Books Recommended

1. Graham Solomon, T.W., Fryhle, C.B. & Dnyder, S.A. Organic Chemistry, John Wiley & Sons (2014).
2. McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
3. Sykes, P. A Guidebook to Mechanism in Organic Chemistry, Orient Longman, New Delhi (1988).
4. Finar, I.L. Organic Chemistry (Vol. I and II), E.L.B.S.
5. Morrison, R.T. & Boyd, R.N. Organic Chemistry, Pearson, 2010.

1. Name of the Department: Chemistry						
2. Course Name	Chemical Energetics, Equilibria, Functional Organic Chemistry Lab		**L**	**T**		**P**
3. Course Code	09010215		0	0		4
4. Type of Course (use tick mark)		**Core (✓)**	**DSE ()**	**AEC ()**	**SEC ()**	**OE ()**
5. Pre-requisite (if any)	NA	**6. Frequency (use tick marks)**	Even ()	Odd (✓)	Either Sem ()	Every Sem ()
7. Total Number of Lectures, Tutorials, Practicals						
Lectures = 0	**Tutorials = 0**		**Practical = 52**			

8. Course Description:

The lab work emphasizes learning of basic skills helpful not only to chemistry students but all those who want to pursue any experimental science. It includes using instruments to determine physical parameters, *e.g.*, heat capacity, enthalpy, solubility and pH; crystallization of compounds, determining the purity, melting and boiling point of compounds and simple chromatographic techniques. Syntheses of selected organic compounds will also be performed and their mechanisms will be discussed.

9. Course Objectives:

1. Determination of heat capacity of calorimeter
2. Determination of enthalpy of selected reactions
3. Studying the solubility of benzoic acid in water
4. Determination of pH of various solutions, for instance, aerated drinks, fruit juices, shampoos and soaps.
5. Preparation of buffer solutions and determination of their pH
6. Purification of organic compounds by crystallization and distillation
7. Preparation of selected organic compounds and discussion about their mechanism.

10. Course Outcomes (COs):

Upon successful completion of this course, the student will be able to:

1. Determine heat capacity of calorimeter for different volumes.
2. Determine enthalpy of
   a. Neutralization of hydrochloric acid with sodium hydroxide
   b. Ionization of acetic acid
   c. Solution of salts (KNO_3, NH_4Cl)
   d. Hydration of Copper Sulphate
3. Study solubility of benzoic acid in water
4. Measure pH of different solutions, for instance, aerated drinks, fruit juices, shampoos and soaps
5. Prepare buffer solutions (one acidic and basic each) and determine their pH
6. Purify organic compounds by crystallization and distillation and determine their purity with melting and boiling points
7. Conduct the following syntheses and determine their mechanisms
   a. Bromination of Phenol/Aniline
   b. Benzoylation of amines/phenols
   c. Oxime and 2,4-dinitrophenylhydrazone of aldehyde/ketone

11. List of Experiments(Student has to perform ten experiments – at least two from each section)

Section A: Physical Chemistry

Thermochemistry

1. Determination of heat capacity of calorimeter for different volumes.
2. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
3. Determination of enthalpy of ionization of acetic acid.
4. Determination of integral enthalpy of solution of salts (KNO3, NH4Cl).
5. Determination of enthalpy of hydration of copper sulphate.
6. Study of the solubility of benzoic acid in water and determination of *H*.

Ionic equilibria

1. pH measurements
2. Measurement of pH of different solutions like aerated drinks, fruit juices, shampoos and soaps (use dilute solutions of soaps and shampoos to prevent damage to the glass electrode) using pH-meter.
3. Preparation of buffer solutions:
4. Sodium acetate-acetic acid
5. Ammonium chloride-ammonium hydroxide
6. Measurement of the pH of buffer solutions and comparison of the values with theoretical values.

Section B: Organic Chemistry

1. Purification of organic compounds by crystallization (from water and alcohol) and distillation.
2. Criteria of Purity: Determination of melting and boiling points.
3. Preparations: Mechanism of various reactions involved to be discussed. Recrystallisation, determination of melting point and calculation of quantitative yields to be done.
4. Bromination of Phenol/Aniline
5. Benzoylation of amines/phenols
6. Oxime and 2,4-dinitrophenylhydrazone of aldehyde/ketone

12. **Books Recommended**

1. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G.,
2. Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.
3. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry Orient-Longman,1960.
4. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).

1. Name of the Department: Chemistry						
2. Course Name	Solutions, Phase Equilibrium, Conductance, Electrochemistry & Functional Organic Chemistry-II		**L**		**T**	**P**
3. Course Code	09010314		4		0	0
4. Type of Course (use tick mark)		**Core (✓)**	**DSE ()**	**AEC ()**	**SEC ()**	**OE ()**
5. Pre-requisite (if any)	NA	**6. Frequency (use tick marks)**	Even ()	Odd (✓)	Either Sem ()	Every Sem ()
7. Total Number of Lectures, Tutorials, Practicals.						
Lectures = 52	**Tutorials = 0**		**Practical = 0**			

8. Course Description:

This course will delve deeper into the thermodynamics of solutions- ideal and non-ideal. Raoult's Law which governs the behavior of ideal solutions will be explained. In addition, miscibility of liquids (partial and immiscibility) will be discussed. Principles of steam distillation, Nernst distribution law and its application, and solvent extraction will be highlighted.

This course will also explain equilibrium between phases. Phases, components and degrees of freedom of a system will be explained. In addition, phase diagrams of one-component systems (water and Sulphur) and selected two-component systems involving eutectics, congruent and incongruent melting points will be discussed.

Conductivity, transference number and ionic mobility will be explained as a foundation for electrochemistry. Important concepts in electrochemistry include measuring EMF of a cell; Nernst equation; standard electrode potential and the electrochemical series; concentration cells; pH determination; and potentiometric titrations.

In organic chemistry, preparation and reactions of carboxylic acids and their derivatives (acid chlorides, esters, amides, anhydrides); amines and Diazonium salts; amino acids, peptides and proteins; and carbohydrates will be discussed.

9. Course Objectives:

The objectives of this course are to:

1. Introduce students to thermodynamics of ideal solutions and Raoult's law
2. Familiarize students with principles governing miscibility of liquids
3. Explain phase diagrams of one component system (water and Sulphur) and two component systems (Pb-Ag, $FeCl_3$-H_2O and Na-K) involving eutectics, congruent and incongruent melting points
4. Explain molar conductivity, transference number and ionic mobility
5. Understand how to measure EMF of a cell
6. Understand how to determine pH using Hydrogen electrode
7. Explain preparation and reactions of Carboxylic acids and derivatives; amines and diazonium salts; amino acids, peptides and proteins; and carbohydrates.

10. Course Outcomes (COs):

Upon successful completion of this course, the student will be able to:

1. Understand the behavior of ideal solutions and Raoult's law and deviations from Raoult's law
2. Explain phase diagrams for selected one component and two component systems
3. Explain migration of ions

4. Determine degree of ionization of weak electrolytes; solubility products of sparingly soluble salts; ionic product of water; and hydrolysis constant of a salt
5. Determine EMF of a cell and from the EMF data, □G, □H and □S.
6. Explain preparation and reactions of Carboxylic acids and derivatives; amines and diazonium salts; amino acids, peptides and proteins; and carbohydrates.

11. Unit wise detailed content

Section A: Physical Chemistry II (26 Lectures)

Unit-1	**Number of lectures = 14**	**Title of the unit: Solutions and Phase Equilibrium**

Thermodynamics of ideal solutions: Ideal solutions and Raoult's Law, deviations from Raoult's law- non-ideal solutions. Vapour pressure-composition and temperature-composition curves of ideal and non-ideal solutions. Distillation of solutions. Lever rule. Azeotropes.

Partial miscibility of liquids: Critical solution temperature, effect of impurity on partial miscibility of liquids. Immiscibility of liquids- Principle of steam distillation, Nernst distribution law and its application, solvent extraction.

Phases, components and degrees of freedom of a system, criteria of phase equilibrium. Gibbs Phase Rule and its thermodynamic derivation. Derivation of Clausius-Clapeyron equation and its importance in phase equilibria. Phase diagrams of one-component systems (water and Sulphur) and two component systems involving eutectics, congruent and incongruent melting points (lead-silver, $FeCl_3$-H_2O and Na-K only)

Unit – 2	**Number of lectures = 12**	**Title of the unit: Conductance and Electrochemistry**

Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Kohlrausch law of independent migration of ions.

Transference number and its experimental determination using Hittorf and Moving boundary methods. Ionic mobility. Application of conductance measurements, determination of degree of ionization of weak electrolyte, solubility and solubility products of sparingly soluble salts, ionic product of water, hydrolysis constant of a salt. Conductometric titrations (only acid-base).

Reversible and irreversible cells. Concept of EMF of a cell. Measurement of EMF of a cell. Nernst equation and its importance. Types of electrodes, Standard electrode potential. Electrochemical series. Thermodynamics of a reversible cell, calculation of thermodynamic properties: □G, □H and □S from EMF data.

Calculation of equilibrium constant from EMF data. Concentration cells with transference and without transference. Liquid junction potential and salt bridge.

pH determination using hydrogen electrode and quinhydrone electrode.

Potentiometric titrations- qualitative treatment (acid-base and oxidation-reduction only).

Section B: Organic Chemistry -II (26 Lectures)

Unit – 3	**Number of lectures = 10**	**Title of the unit: Carboxylic Acids and their derivatives; Amines and Diazonium Salts**

Functional group approach for the following reactions (preparations and reactions) to be studied in context to their structure.

Carboxylic acids and their derivatives

Carboxylic acids (aliphatic and aromatic)

Preparation: Acidic and Alkaline hydrolysis of esters

Reactions: Hell-Vollhard-Zelinsky Reaction

Carboxylic acid derivatives (Upto 5 carbons)

Preparation: Acid chlorides, Anhydrides, Esters and Amides from acids and their interconversion.

Reactions: Comparative study of nucleophilicity of acyl derivatives. Reformatsky Reaction, Perkin condensation.

Amines and Diazonium Salts

Amines (Aliphatic and Aromatic) (Upto 5 Carbons)

Preparation: from alkyl halides, Gabriel's Phthalimide synthesis, Hofmann Bromamide reaction.

Reactions: Hofmann vs. Saytzeff elimination, Carbylamine test, Hinsberg test with HNO2, Schotten-Baumann Reaction, Electrophilic substitution (case aniline), nitration, bromination, sulphonation.

Diazonium salts

Preparation: from aromatic amines

Reactions: conversion to benzene, phenol, dyes.

Unit 4	**No. of Lectures = 16**	**Title of the unit: Amino acids, peptides and proteins; Carbohydrates**

Preparation of Amino Acids: Strecker synthesis using Gabriel's phthalimide synthesis. Zwitterion, Isoelectric point and Electrophoresis.

Reactions of amino acids: ester of -COOH group, actylation of -NH2 group, complexation with Cu2+ ions, ninhydrin test

Overview of Primary, Secondary, Tertiary and Quaternary structure of proteins

Determination of primary structure of peptides by degradation. Edmann degradation (N-terminal) and C-terminal (thiohydantoin and with carboxypeptidase enzyme).

Synthesis of simple peptides (upto dipeptides) by N-protection (t-butyloxycarbonyl and phthaloyl) and C-activating groups and Merrifield solid-phase synthesis.

Classification, and General Properties, Glucose and Fructose (open chain and cyclic structure), Determination of configuration of monosaccharides, absolute configuration of Glucose and Fructose, Mutarotation, ascending and descending in monosaccharides. Structure of disaccharides (sucrose, cellulose, maltose, lactose) and polysaccharides (starch and cellulose) excluding their structure elucidation.

13. Books Recommended

1. Barrow, G.M. Physical Chemistry Tata McGraw Hill (2007)
2. Castellan, G.W. Physical Chemistry 4th Ed. Narosa (2004)
3. Kotz, J.C., Treichel, P.M. & Townsend, J.R. General Chemistry, Cengage Learning India Pvt. Ltd.: New Delhi (2009).
4. Mahan, B.H. University Chemistry, 3rd Ed. Narosa (1998).
5. Petrucci, R.H. General Chemistry, 5th Ed., Macmillan Publishing Co.: New Delhi (1985).
6. Morrison, R.T. & Boyd, R.N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education)
7. Finar, I.L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education)
8. Finar, I.L. Organic Chemistry (Volume 2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education)
9. Nelson, D.L. & Cox, M.M. Lehninger's Principles of Biochemistry 7th Ed., W.H. Freeman.
10. Berg, J.M., Tymoczko, J.L. & Stryer, L. Biochemistry, W.H. Freeman, 2002.

1. Name of the Department: Chemistry							
2. Course Name	Solutions, Phase Equilibrium, Conductance, Electrochemistry & Functional Organic Chemistry-II Lab		**L**		**T**		**P**
3. Course Code	09010315		0		0		4
4. Type of Course (use tick mark)			**Core (✓)**	**DSE ()**	**AEC ()**	**SEC ()**	**OE ()**
5. Pre-requisite(if any)	NA	**6. Frequency (use tick marks)**	Even ()	Odd (✓)	Either Sem ()		Every Sem ()
7. Total Number of Lectures, Tutorials, Practicals.							
Lectures = 0		**Tutorials = 0**		**Practical = 52**			

8. Course Description:

The lab work emphasizes learning of basic skills helpful not only to chemistry students but all those who want to pursue any experimental science. It includes studying equilibria by distribution methods; construction of the phase diagram of a binary system and determining its critical temperature and composition; determination of cell constant, conductance and degree of dissociation; perform conductometric titrations; perform potentiometric titrations; qualitative analysis of organic compounds; simple chromatographic techniques; and miscellaneous experiments in organic chemistry, *e.g.*, titration of glycine and determination of its concentration, studying the action of salivary amylase on starch, and differentiating between a reducing and nonreducing sugar.

9. Course Objectives:

1. Studying the equilibrium of selected reactions by distribution method
2. Construction of phase diagram of a binary system (simple eutectic) using cooling curves and determination of critical temperatures and composition.
3. Determination of a cell constant, conductance and degree of dissociation of a weak acid
4. Perform conductometric and potentiometric titrations
5. Perform qualitative analyses of selected organic compounds possessing monofunctional groups
6. Separation of amino acids by paper chromatography
7. Titration of glycine and determination of its concentration
8. Studying the action of salivary amylase on starch
9. Differentiation between a reducing and a nonreducing sugar

10. Course Outcomes (COs):

Upon successful completion of this course, the student will be able to:

1. Explain the equilibrium of selected reactions by distribution method
2. Construct phase diagrams of binary systems (simple eutectic) with cooling curves and determine critical parameters
3. Determine cell constant, conductance and degree of dissociation of an acid
4. Perform conductometric and potentiometric titrations
5. Perform qualitative analyses of selected organic compounds possessing monofunctional groups
6. Separation of amino acids by paper chromatography
7. Titrate glycine and determine its concentration

8. Study the action of salivary amylase on starch
9. Differentiate between a reducing and a nonreducing sugar

11. **List of Experiments(Student has to perform ten experiments – at least two from each section)**

Section A: Physical Chemistry

Distribution

1. Study of the equilibrium of one of the following reactions by the distribution method:

$$I_2(aq) + I^-(aq) \longrightarrow I_3^-(aq)$$

$$Cu^{2+}(aq) + xNH_2(aq) \longrightarrow [Cu(NH_3)_x]^{2+}$$

Phase equilibria

1. Construction of the phase diagram of a binary system (simple eutectic) using cooling curves.
2. Determination of the critical solution temperature and composition of the phenol water system and study of the effect of impurities on it.
3. Study of the variation of mutual solubility temperature with concentration for the phenol water system and determination of the critical solubility temperature.

Conductance

1. Determination of cell constant
2. Determination of equivalent conductance, degree of dissociation and
3. dissociation constant of a weak acid.
4. Perform the following conductometric titrations:
5. Strong acid vs. strong base
6. Weak acid vs. strong base

Potentiometry

1. Perform the following potentiometric titrations:
2. Strong acid vs. strong base
3. Weak acid vs. strong base
4. Potassium dichromate vs. Mohr's salt

Section B: Organic Chemistry

1. Systematic Qualitative Organic Analysis of Organic Compounds possessing monofunctional groups (-COOH, phenolic, aldehydic, ketonic, amide, nitro, amines) and preparation of one derivative.
2. Separation of amino acids by paper chromatography
3. Determination of the concentration of glycine solution by formylation method.
4. Titration curve of glycine
5. Action of salivary amylase on starch
6. Effect of temperature on the action of salivary amylase on starch.
7. Differentiation between a reducing and a nonreducing sugar

12. Books Recommended

1. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.
2. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry Orient-Longman,1960.
3. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
4. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry, Universities Press.

1. Name of the Department : Chemistry						
2. Course Name	Transition Metal & Coordination Chemistry, States of matter & Chemical kinetics	**L**	**T**		**P**	
3. Course Code	09010412	4	0		0	
4. Type of Course (use tick mark)		**Core (✓)**	**DSE ()**	**AEC ()**	**SEC ()**	**OE ()**
5. Pre-requisite (if any)	NA	**6. Frequency (use tick marks)**	Even (✓)	Odd ()	Either Sem ()	Every Sem ()

7. Total Number of Lectures, Tutorials, Practical		
Lectures = 52	**Tutorials = 0**	**Practical = 0**

8. Course Description:

This course will give an excellent opportunity to study and use the knowledge of Transition Elements, coordination chemistry, Gaseous State, Liquid State, Solid State and Chemical Kinetics.

9. Course Objectives:

The objectives of this course are to:

1. Study the properties of transisition elements.
2. Understand the key features of coordination compounds
3. Discuss the various properties of solids, liquids and gases.
4. Study the reaction rates, theories of reaction rates and different order reactions.

10. Course Outcomes (COs):

Upon successful completion of this course, the student will be able to:

1. Identify the behavior of transition elements
2. Recognize the types of isomers and nomenclature and applications of coordination compounds.
3. Become familiar with the various applications of molecules in different states..
4. Describe how the rate of a chemical reaction changes as a function of time.

11. Unit wise detailed content

Unit-1	**Number of lectures = 11**	**Title of the unit: Transition Elements (3d series)**

General group trends with special reference to electronic configuration, variable valency, colour, magnetic and catalytic properties, ability to form complexes and stability of various oxidation states (Latimer diagrams) for Mn, Fe and Cu. Lanthanoids and actinoids: Electronic configurations, oxidation states, colour, magnetic properties, lanthanide contraction, separation of lanthanides (ion exchange method only).

Unit – 2	**Number of lectures = 11**	**Title of the unit: Coordination Chemistry**

Valence Bond Theory (VBT): Inner and outer orbital complexes of Cr, Fe, Co, Ni and Cu (coordination numbers 4 and 6). Structural and stereoisomerism in complexes with coordination numbers 4 and 6. Drawbacks of VBT. IUPAC system of nomenclature. Crystal Field Theory, octahedral symmetry. Crystal field stabilization energy (CFSE), Crystal field effects for weak and strong fields. Tetrahedral symmetry. Factors affecting the magnitude of D. Spectrochemical series. Comparison of CFSE for Oh and Td complexes, Tetragonal distortion of octahedral geometry. Jahn-Teller distortion, Square planar coordination.

Unit – 3	**Number of lectures = 15**	**Title of the unit: Gaseous Sate and Liquid State**

Gaseous State: Postulates of Kinetic Theory of Gases and derivation of the kinetic gas equation. Deviation

of real gases from ideal behaviour, compressibility factor, causes of deviation. van der Waals equation of state for real gases. Boyle temperature (derivation not required). Critical phenomena, critical constants and their calculation from van der Waals equation. Andrews's isotherms of CO_2. Maxwell Boltzmann distribution laws of molecular velocities and molecular energies (graphic representation – derivation not required) and their importance. Temperature dependence of these distributions.

Liquid State: Surface tension and its determination using stalagmometer. Viscosity of a liquid and determination of coefficient of viscosity using Ostwald viscometer. Effect of temperature on surface tension and coefficient of viscosity of a liquid (qualitative treatment only).

Unit – 4	**Number of lectures = 15**	**Title of the unit: Solid State and Chemical Kinetics**

Solid State: Forms of solids. Symmetry elements, unit cells, crystal systems, Bravais lattice types and identification of lattice planes. Laws of Crystallography - Law of constancy of interfacial angles, Law of rational indices. Miller indices. X–Ray diffraction by crystals, Bragg's law. Structures of NaCl, KCl and CsCl (qualitative treatment only). Defects in crystals. Glasses and liquid crystals.

Chemical Kinetics: The concept of reaction rates. Effect of temperature, pressure, catalyst and other factors on reaction rates. Order and molecularity of a reaction. Derivation of integrated rate equations for zero, first and second order reactions. Half–life of a reaction. General methods for determination of order of a reaction. Concept of activation energy and its calculation from Arrhenius equation. Theories of Reaction Rates: Collision theory and Activated Complex theory of bimolecular reactions. Comparison of the two theories (qualitative treatment only).

12. Books Recommended

1. Barrow, G.M. Physical Chemistry Tata McGraw-Hill (2007).
2. Castellan, G.W. Physical Chemistry 4th Ed. Narosa (2004).
3. Kotz, J.C., Treichel, P.M. & Townsend, J.R. General Chemistry Cengage Learning India Pvt. Ltd., New Delhi (2009).
4. Mahan, B.H. University Chemistry 3rd Ed. Narosa (1998).
5. Petrucci, R.H. General Chemistry 5th Ed. Macmillan Publishing Co.: New York (1985).
6. Cotton, F.A. & Wilkinson, G. Basic Inorganic Chemistry, Wiley.
7. Shriver, D.F. & Atkins, P.W. Inorganic Chemistry, Oxford University Press.
8. Wulfsberg, G. Inorganic Chemistry, Viva Books Pvt. Ltd.
9. Rodgers, G.E. Inorganic & Solid State Chemistry, Cengage Learning India Ltd., 2008.

1. Name of the Department : Chemistry						
2. Course Name	Transition Metal & Coordination Chemistry, States of matter & Chemical kinetics Lab			**L**	**T**	**P**
3. Course Code	09010413			0	0	4
4. Type of Course (use tick mark)		**Core (✓)**	**DSE ()**	**AEC ()**	**SEC ()**	**OE ()**
5. Pre-requisite (if any)	NA	**6. Frequency (use tick marks)**	Even (✓)	Odd ()	Either Sem ()	Every Sem ()
7. Total Number of Lectures, Tutorials, Practical						
Lectures = 0		**Tutorials = 0**		**Practical = 52**		

8. Course Description:

This course provides practical training in inorganic qualitative analysis, surface tension and viscosity measurements and kinetics of chemical reactions which enable students to solve the technical problems during the separation of mixtures.

9. Course Objectives:

The objectives of this course are to:

1. Identify different cataions and anions in an inorganic mixture.
2. Perform experiment on surface tension and viscosity
3. Study the kinetics of chemical reactions.

10. Course Outcomes (COs):

Upon successful completion of this course, the student will be able to:

1. Separate the components in an inorganic mixture
2. Identify quality of any chemical and any formulation.
3. Apply Arrhenius equation to study different chemical reactions.

11. List of Experiments(Student has to perform ten experiments – at least two from each section)

Inorganic Chemistry :

I. Semi-micro qualitative analysis (using H_2S or other methods) of mixtures - not more than four ionic species (two anions and two cations, excluding insoluble salts) out of the following:

Cations : NH_4^+, Pb^{2+}, Bi^{3+}, Cu^{2}+, Cd^{2}+, Fe^{3+}, Al^{3+}, Co^{2+}, Ni^{2}+, Mn^{2+}, Zn^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}, K^+

Anions : CO_3^{2-} , S^{2-}, SO_2^-, $S_2O_3^{2-}$, NO_3^-, CH_3COO^-, Cl^-, Br^-, I^-, NO_3^-, SO_4^{2-}, PO_{43-}, BO_3^{3-}, $C_2O_4^{2-}$, F^-

(Spot tests should be carried out wherever feasible)

II. Estimations

1. Estimate the amount of nickel present in a given solution as bis(dimethylglyoximato) nickel(II) or aluminium as oximate in a given solution gravimetrically.
2. Estimation of (i) Mg+ or (ii) Zn+ by complexometric titrations using EDTA.
3. Estimation of total hardness of a given sample of water by complexometric titration.

Physical Chemistry:

I. Surface tension measurement (use of organic solvents excluded)

a. Determination of the surface tension of a liquid or a dilute solution using a stalagmometer.

b. Study of the variation of surface tension of a detergent solution with concentration.

II. Viscosity measurement (use of organic solvents excluded).

a. Determination of the relative and absolute viscosity of a liquid or dilute solution using an Ostwald's viscometer.

b. Study of the variation of viscosity of an aqueous solution with concentration of solute.

III. Chemical Kinetics

Study the kinetics of the following reactions.

1. Initial rate method: Iodide-persulphate reaction
2. Integrated rate method:
   a. Acid hydrolysis of methyl acetate with hydrochloric acid.
   b. Saponification of ethyl acetate.
   c. Compare the strengths of HCl and H2SO4 by studying kinetics of hydrolysis

12. Books recommended

1. Svehla, G. Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012.
2. Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009.
3. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).

1. Name of the Department : Chemistry						
2. Course Name	Analytical Methods in Chemistry		**L**		**T**	**P**
3. Course Code	09010517		4		0	0
4. Type of Course (use tick mark)		**Core ()**	**DSE (✓)**	**AEC ()**	**SEC ()**	**OE ()**
5. Pre-requisite (if any)	NA	**6. Frequency (use tick marks)**	Even ()	Odd (✓)	Either Sem ()	Every Sem ()

7. Total Number of Lectures, Tutorials, Practicals

Lectures = 52	**Tutorials = Nil**	**Practical = Nil**

8. Course Description:

This course provides an excellent opportunity to learn about Sampling, evaluation of analytical data, analyzing and identifying samples using different spectroscopic techniques like Infra-red, UV, Visible, flame absorption spectrometry. This course also emphasizes on applications of thermogravimetry, electrochemistry and separation methods like chromatography**.**

9. Course Objectives:

The objectives of this course are to:

1. Learn the basic principles of different instrumentation.
2. Introduce Origin of spectra, fundamental laws of spectroscopy and selection rules.
3. Theory of thermogravimetry (TG) and its application.
4. Understand the mechanism and efficiency of separation techniques like solvent extraction, chromatography.
5. Introduce electro analytical methods to study different types of titrations.
6. Learn the basic principle of flame photometry and techniques of atomization and sample introduction.

10. Course Outcomes (COs):

Upon successful completion of this course, the student will be able to

1. Identify choice of source, monochromator and detector for single and double beam instrument in spectrometry.
2. Apply and verify Lambert Beer's Law.
3. Use Flame photometers for the quantitative estimation of trace level of metal ions from water samples
4. Explain mechanism of extraction: extraction by solvation and chelation. Technique of extraction:
5. Calculate Enantiomeric excess (ee)/ diastereomeric excess (de) ratios and determination of enantiomeric composition using NMR, Chiral solvents and chiral shift reagents.
6. Understand the advantage of determining the equivalence point by performing conductometric and potentiometric titrations over volumetric titration.
7. Determine pKa values using pH meter.

11. Unit wise detailed content

Unit-1	**Number of lectures = 08**	**Title of the unit: Qualitative and quantitative aspects of analysis**

Sampling, evaluation of analytical data, errors, accuracy and precision, methods of their expression, normal law of distribution if indeterminate errors, statistical test of data; F, Q and t test, rejection of data, and confidence intervals.

Unit – 2	Number of lectures = 20	Title of the unit: Optical methods of analysis

UV-Visible Spectrometry: Basic principles of instrumentation (choice of source, monochromator and detector) for single and double beam instrument; Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, validity of Beer-Lambert's law.

Basic principles of quantitative analysis: Estimation of metal ions from aqueous solution, geometrical isomers, keto-enol tautomers. Determination of composition of metal complexes using Job's method of continuous variation and mole ratio method.

Infrared Spectrometry: Basic principles of instrumentation (choice of source, monochromator & detector) for single and double beam instrument; sampling techniques. Structural illustration through interpretation of data, Effect and importance of isotope substitution.

Flame Atomic Absorption and Emission Spectrometry: Basic principles of instrumentation (choice of source, monochromator, detector, choice of flame and Burner designs. Techniques of atomization and sample introduction; Method of background correction, sources of chemical interferences and their method of removal. Techniques for the quantitative estimation of trace level of metal ions from water samples.

Unit – 3	Number of lectures = 10	Title of the unit: Thermal methods of analysis and Electroanalytical methods

Theory of thermogravimetry (TG), basic principle of instrumentation. Techniques for quantitative estimation of Ca and Mg from their mixture. Classification of electro analytical methods, basic principle of pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence points. Techniques used for the determination of pKa values.

Unit – 4	Number of lectures = 14	Title of the unit: Separation Techniques

Solvent extraction: Classification, principle and efficiency of the technique. Mechanism of extraction: extraction by solvation and chelation. Technique of extraction: batch, continuous and counter current extractions. Qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and nonaqueous media.

Chromatography: Classification, principle and efficiency of the technique,Mechanism of separation: adsorption, partition & ion exchange. Development of chromatograms: frontal, elution and displacement methods. Qualitative and quantitative aspects of chromatographic methods of analysis: IC,

GLC, GPC, TLC and HPLC. Stereoisomeric separation and analysis: Measurement of optical rotation, calculation of Enantiomeric excess

12. Books Recommended

1. Jeffery, G.H., Bassett, J., Mendham, J. & Denney, R.C. Vogel's Textbook of Quantitative Chemical Analysis, John Wiley & Sons, 1989.
2. Willard, H.H., Merritt, L.L., Dean, J. & Settoe, F.A. Instrumental Methods of Analysis, 7th Ed. Wadsworth Publishing Company Ltd., Belmont, California, USA, 1988.
3. Christian, G.D; Analytical Chemistry, 6th Ed. John Wiley & Sons, New York, 2004.
4. Harris, D. C. Exploring Chemical Analysis, Ed. New York, W.H. Freeman, 2001.
5. Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age, International Publisher, 2009.
6. Skoog, D.A. Holler F.J. & Nieman, T.A. Principles of Instrumental Analysis, Cengage Learning India Ed.
7. Mikes, O. Laboratory Hand Book of Chromatographic & Allied Methods, Elles Harwood Series on Analytical Chemistry, John Wiley & Sons, 1979.
8. Ditts, R.V. Analytical Chemistry; Methods of Separation, van Nostrand, 1974.

1. Name of the Department: Chemistry						
2. Course Name	Analytical Methods in Chemistry Lab		**L**	**T**		**P**
3. Course Code	09010518		0	0		4
4. Type of Course (use tick mark)		**Core ()**	**DSE (✓)**	**AEC ()**	**SEC ()**	**OE ()**
5. Pre-requisite	NA	**6. Frequency (use tick marks)**	Even ()	Odd (✓)	Either Sem ()	Every Sem ()

7. Total Number of Lectures, Tutorials, Practicals.		
Lectures = 0	**Tutorials = 0**	**Practical = 52**

8. Course Description:

Practical work has had a central and distinct role in chemistry education (from school to university) for more than a century. The aim of chemistry is to increase our understanding of the composition, properties and change of matter. Claims and explanations in chemistry should be supported by observational data.

The module designed here for students is to understand the basic principles and learn the experimental techniques of classical titrimetric and gravimetric methods of analysis. The student will also be introduced to common instrumental techniques including chromatography, spectrophotometry, ion exchange resins and electro-analytical methods.

9. Course Objectives:

The objectives of this course are to:

1. Understand the basic principles and learn the experimental techniques of classical titrimetric methods of analysis,
2. Understand the theory behind the instrumental techniques of chromatography, spectrophotometry ,ion exchange and electro-analytical methods
3. Perform experiments with samples of water to determine BOD and COD and dissolved oxygen.
4. Determine the acidity and alkalinity in soil samples.
5. Study and apply the principle of complexometry for detecting metals in samples at the ppm level.
6. Use flame photometry method for detecting alkali metals in sample as they give characteristic colors in flame.

10. Course Outcomes (COs):

Upon successful completion of this course, the student will be able to:

1. Refer to the chemical theory behind the use of modern instrumental techniques for quantitative chemical analysis.
2. Identify and estimate traces of metals using the theory of complexation with EDTA
3. Analyze soil for its pH and total soluble salt content.
4. Determine Na, Ca and Li In fruit juices and cola drinks by applying flame photometric technique.
5. Use chromatography to separate mixtures of metal ions, dyes, sugars, amino acids and various other samples and calculate their Rf values.

11.List of Experiments(Student has to perform ten experiments – at least two from each section)

I. Chromatography

1. Paper chromatographic separation of Fe3+, Al3+, and Cr3+.
2. Separation and identification of the monosaccharides present in the given mixture (glucose & fructose) by paper chromatography. Reporting the Rf values.
3. Separate a mixture of Sudan yellow and Sudan Red by TLC technique and identify them on the basis of their Rf values.
4. Chromatographic separation of the active ingredients of plants, flowers and juices by TLC

II. Solvent Extractions:

1. To separate a mixture of Ni2+ & Fe2+ by complexation with DMG and extracting the Ni2+-DMG complex in chloroform, and determine its concentration by spectrophotometry.
2. Solvent extraction of zirconium with amberliti LA-1, separation from a mixture of irons and gallium.
3. Determine the pH of the given aerated drinks fruit juices, shampoos and soaps.
4. Determination of Na, Ca, Li in cola drinks and fruit juices using flame photometric techniques.
5. Analysis of soil:

Ion exchange:

I. Determination of exchange capacity of cation exchange resins and anion exchange resins.

II. Separation of metal ions from their binary mixture.

III. Separation of amino acids from organic acids by ion exchange chromatography.

III. Spectrophotometry

1. Determination of pKa values of indicator using spectrophotometry.
2. Structural characterization of compounds by infrared spectroscopy.
3. Determination of dissolved oxygen, (COD) and (BOD).in water.
4. Determine the composition of the ferric-salicylate/ ferric-thiocyanate complex by Job's method.

12. Books Recommended

1. Jeffery, G.H., Bassett, J., Mendham, J. & Denney, R.C. Vogel's Textbook of Quantitative Chemical Analysis, John Wiley & Sons, 1989.
2. Willard, H.H., Merritt, L.L., Dean, J. & Settoe, F.A. Instrumental Methods of Analysis, 7th Ed. Wadsworth Publishing Company Ltd., Belmont, California, USA, 1988.
3. Christian, Gary D; Analytical Chemistry, 6th Ed. John Wiley & Sons, New York, 2004.
4. Harris, Daniel C: Exploring Chemical Analysis, Ed. New York, W.H. Freeman, 2001.
5. Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age, International Publisher, 2009.
6. Skoog, D.A. Holler F.J. & Nieman, T.A. Principles of Instrumental Analysis, Cengage Learning India Ed.
7. Mikes, O. Laboratory Hand Book of Chromatographic & Allied Methods, Elles Harwood Series on Analytical Chemistry, John Wiley & Sons, 1979.
8. Ditts, R.V. Analytical Chemistry; Methods of Separation, van Nostrand, 1974.

1. Name of the Department: Chemistry						
2. Course Name	Molecules of Life	**L**	**T**		**P**	
3. Course Code	09010519	4	0		0	
4. Type of Course (use tick mark)		**Core ()**	**DSE (✓)**	**AEC ()**	**SEC ()**	**OE ()**
5. Pre-requisite (if any)	NA	**6. Frequency (use tick marks)**	Even ()	Odd (✓)	Either Sem ()	Every Sem ()

7. Total Number of Lectures, Tutorials, Practical

Lectures = 52	**Tutorials = 0**	**Practical = 0**

8. Course Description:

The complexity of even the simplest of life forms, the single cell cannot be overstated. From a chemical perspective, cellular components can be segregated into macromolecules (DNA, RNA, proteins etc.) and relatively simpler molecules (amino acids, monosaccharaides and lipids). This course highlights the classification, synthesis, structure and properties of these molecules of life. This course also includes the chemistry of these biomolecules and their roles in metabolism.

9. Course Objectives:

The objectives of this course are to:

1. Study the classification and general properties of carbohydrates, proteins, amino acids, enzymes and lipids.
2. Understand the difference between monosaccharaides, disaccharides' and polysaccharides.
3. Determine primary structure of peptides and synthesize simple peptides.
4. Explain about enzymes and their mode of action
5. Understand how DNA carries genetic information, and how it is put into action by cells and organisms,
6. Study the concept of energy and conversion of food into energy.
7. Understand the interrelationships in the metabolic pathways of Proteins, Fats and Carbohydrates.

10. Course Outcomes (COs):

Upon successful completion of this course, the student will be able to

1. Identify the different biomolecules and elucidate their structure.
2. Explain Specificity of enzyme action, Enzyme inhibitors and their importance.
3. Differentiate between oil and fats; calculate saponification value and iodine number.
4. Get detail knowledge about Nucleic acids, and DNA in particular, which are key macromolecules for the continuity of life. DNA bears the hereditary information that's passed on from parents to children
5. Describe the Outline of catabolic pathways of Carbohydrate- Glycolysis, Fermentation, Krebs cycle, and other biomolecules.

11. Unit wise detailed content

Unit-1	**Number of lectures = 20**	**Title of the unit: Carbohydrates and Proteins**

Classification of carbohydrates, reducing and non-reducing sugars, General properties of glucose and fructose, their open chain structure. Epimers, mutarotation and anomers. Determination of configuration of Glucose (Fischer proof). Cyclic structure of glucose. Haworth projections. Cyclic structure of fructose. Linkage between monosaccharaides, structure of disaccharides (sucrose, maltose, lactose) and polysaccharides (starch

and cellulose) excluding their structure elucidation.

Classification of Amino Acids, Zwitterion structure and Isoelectric point. Overview of Primary, Secondary, Tertiary and Quaternary structure of proteins. Determination of primary structure of peptides, determination of N-terminal amino acid (by DNFB and Edman method) and C–terminal amino acid (by thiohydantoin and with carboxypeptidase enzyme). Synthesis of simple peptides (upto dipeptides) by N-protection (tbutyloxycarbonyl and phthaloyl) & C-activating groups and Merrifield solid phase synthesis.

Unit – 2	**Number of lectures = 12**	**Title of the unit: Enzymes and correlation with drug action**

Mechanism of enzyme action, factors affecting enzyme action, Coenzymes and cofactors and their role in biological reactions, Specificity of enzyme action (including stereospecificity), Enzyme inhibitors and their importance, phenomenon of inhibition(Competitive and Non- competitive inhibition including allosteric inhibition). Drug action-receptor theory. Structure –activity relationships of drug molecules, binding role of –OH group,-NH2 group, double bond and aromatic ring,

Unit – 3	**Number of lectures = 10**	**Title of the unit: Nucleic Acids and lipids**

Components of nucleic acids: Adenine, guanine, thymine and Cytosine (Structure only), other components of nucleic acids, Nucleosides and nucleotides **(nomenclature**), Structure of polynucleotides; Structure of DNA (Watson-Crick model) and RNA (**types of RNA**), Genetic Code, Biological roles of DNA and RNA: Replication, Transcription and Translation. Introduction to lipids, classification. Oils and fats: Common fatty acids present in oils and fats, Omega fatty acids, Trans fats, Hydrogenation, Saponification value, Iodine number. Biological importance of triglycerides, phospholipids, glycolipids, and steroids (cholesterol).

Unit – 4	**Number of lectures = 10**	**Title of the unit: Concept of Energy in Biosystems**

Calorific value of food. Standard caloric content of carbohydrates, proteins and fats. Oxidation of foodstuff (organic molecules) as a source of energy for cells. Introduction to Metabolism (catabolism, anabolism), ATP: the universal currency of cellular energy, ATP hydrolysis and free energy change.Conversion of food into energy. Outline of catabolic pathways of Carbohydrate-Glycolysis, Fermentation, Krebs Cycle. Overview of catabolic pathways of Fats and Proteins. Interrelationships in the metabolic pathways of Proteins, Fats and Carbohydrates.

12. Books Recommended

1. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). 98
3. Finar, I. L. Organic Chemistry (Volume 2), Dorling Kindersley (India) Pvt.Ltd. (Pearson Education).
4. Nelson, D. L. & Cox, M. M. Lehninger's Principles of Biochemistry 7th Ed.,W. H. Freeman.
5. Berg, J.M., Tymoczko, J.L. & Stryer, L. Biochemistry, W.H. Freeman, 2002.

1. Name of the Department: Chemistry						
2. Course Name	Molecules of Life Lab	**L**	**T**		**P**	
3. Course Code	09010520	0	0		4	
4. Type of Course (use tick mark)	**Core ()**	**DSE (✓)**	**AEC ()**	**SEC ()**	**OE ()**	
5. Pre-requisite	NA	**6. Frequency (use tick marks)**	Even ()	Odd (✓)	Either Sem ()	Every Sem ()

7. Total Number of Lectures, Tutorials, Practicals		
Lectures = 0	**Tutorials = 0**	**Practical = 52**

8. Course Description:

Practical work has had a central and distinct role in chemistry education (from school to university) for more than a century. The aim of chemistry is to increase our understanding of the composition, properties and change of matter. Claims and explanations in chemistry should be supported by observational data.
This course provides practical training to the students to use various methods to estimate, separate, detect or analyze samples containing biomolecules. Different techniques like chromatography , extraction method , acid base titrations ,organic synthesis are introduced.

9. Course Objectives:

The objectives of this course are to:

1. independently carry out organic synthesis
2. Enable students to prepare their own solutions for experiment having complete knowledge about normality, molality, molarity, mole fraction, as measures of concentration.
3. plan and carry out acid-base titrations; justify choice of indicator and interpret titration curve
4. to differentiate the reducing and non reducing sugar.

10. Course Outcomes (COs):

Upon successful completion of this course, the student will be able to:

1. Prepare Biochemical reagent for various solutions with respect to different Normality, Molarity, % Solutions (W/V), (V/V) & Numericals.
2. Perform titrations with suitable indicators to detect the sharp end point and quantitatively estimate the desired samples.
3. Use chromatographic methods to separate mixture of amino acids.
4. Prepare chromatogram, separate pigments from extracts of leaves and flowers/ink mixtures and determine of Rf value
5. Determine iodine value and saponification value of fat/oil.

11. List of Experiments

1. Separation of amino acids by paper chromatography
2. To determine the concentration of glycine solution by formylation method.
3. Study of titration curve of glycine
4. Action of salivary amylase on starch
5. Effect of temperature on the action of salivary amylase on starch.
6. To determine the saponification value of an oil/fat.
7. To determine the iodine value of an oil/fat
8. Differentiate between a reducing/ nonreducing sugar.
9. Extraction of DNA from onion/cauliflower
10. To synthesise aspirin by acetylation of salicylic acid and compare it with the ingredient of an aspirin tablet by TLC.

12. Books Recommended

1. Furniss, B.S.; Hannaford, A.J.; Rogers, V.; Smith, P.W.G.; Tatchell, A.R. Vogel's Textbook of Practical Organic Chemistry, ELBS.
2. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry, Universities Press.

1. Name of the Department: Chemistry						
2. Course Name	Quantum Chemistry, Spectroscopy & Photochemistry		**L**	**T**		**P**
3. Course Code	09010521		4	0		0
4. Type of Course (use tick mark)		**Core ()**	**DSE (✓)**	**AEC ()**	**SEC ()**	**OE ()**
5. Pre-requisite (if any)	NA	**6. Frequency (use tick marks)**	Even ()	Odd (✓)	Either Sem ()	Every Sem ()
7. Total Number of Lectures, Tutorials, Practicals						
Lectures = 52		**Tutorials = 0**		**Practical = 0**		

8. Course Description:

The course is divided into three different sections,

The first unit deals with the introduction to the quantum mechanical model of the atom:Thinking about electrons as probabilistic matter waves using the de Broglie wavelength, the Schrödinger equation, and the Heisenberg's Uncertainty Principle.

The second part focuses on the five key spectroscopic methods used by chemists and biochemists to analyse the molecular and electronic structure of atoms and molecules. These are Vibrationional, Rotational, Electronic, Raman and Nuclear Magnetic Resonance (NMR) spectroscopies for understanding the molecular structure and nature of chemical bonding. This course provides a thorough knowledge of the methods of Quantum mechanics and the different types of spectroscopic techniques.

In nature, photochemistry is of immense importance as it is the basis of photosynthesis, vision, and the formation of vitamin D with sunlight. Photochemical reactions proceed differently than temperature-driven reactions. This course also highlights the basic laws of photochemistry, energy levels, quantum yield and examples of photochemical reactions.

9. Course Objectives:

The objectives of this course are to:

1. Introduce students to Schrödinger wave equation, quantization of energy and electronic configuration of atoms and ions.
2. Discuss chemical bonding using valence bond and molecular orbital approaches and apply them to various hydrogen like atoms.
3. Learn the basic principles of molecular spectroscopy.
4. Understand the theory of electromagnetic radiation and concepts of absorption and emission spectra.
5. Study the origin of selection rules that governs the transitions to occur between two Eigen states.
6. Understand the Role of photochemical reactions in biochemical processes, photostationary states, and chemiluminescence.
7. Study the principles and laws of photochemistry and apply them in field of chemistry, biology, biochemistry, biomedicine etc.

10. Course Outcomes (COs):

Upon successful completion of this course, the student will be able to

1. understand and explain the differences between classical and quantum mechanics
2. understand the idea of wave function
3. understand the uncertainty relations

4. solve Schrödinger equation for simple potentials
5. Define Bonding and antibonding orbitals and apply LCAO-MO treatment to homonuclear and heteronuclear diatomic molecules (HF, LiH).
6. Identify the unknown molecules and measure their bond length from the values of their rotational constants.
7. Determine the Force constant associated with the chemical bonds.
8. Qualitatively order the molecular energy levels into electronic, vibrational, rotational and other energy levels.
9. Calculate the relative population of these energy levels. Identify the regions of the electromagnetic spectrum corresponding to different molecular transitions.
10. Calculate larmor frequency, chemical shift and shielding constant in NMR
11. Differentiate between NMR and ESR.
12. Determine whether the molecular vibrations of a triatomic molecule are Raman active and explain the difference between Stokes and anti-Stokes lines in a Raman spectrum.
13. Distinguish between the energy levels of a rigid and a non-rigid rotor.
14. Distinguish between harmonic and anharmonic vibrations.
15. Apply the laws of photochemistry, Lambert-Beer's law, define terms like photosensitization, quenching, chemiluminescence etc.

11. Unit wise detailed content

Unit-1	**Number of lectures = 16**	**Title of the unit: Quantum Chemistry**

Postulates of quantum mechanics, quantum mechanical operators, Schrödinger equation and its application to free particle and "particle-in-a-box" (rigorous treatment), quantization of energy levels, zero-point energy and Heisenberg Uncertainty principle; wave functions, probability distribution functions, nodal properties, Extension to two and three dimensional boxes, separation of variables, degeneracy.

Qualitative treatment of simple harmonic oscillator model of vibrational motion: Setting up of Schrödinger equation and discussion of solution and wave functions. Vibrational energy of diatomic molecules and zero-point energy.

Angular momentum: Commutation rules, quantization of square of total angular momentum and z-component. Rigid rotator model of rotation of diatomic molecule. Schrödinger equation, transformation to spherical polar coordinates. Separation of variables. Spherical harmonics. Discussion of solution.

Qualitative treatment of hydrogen atom and hydrogen-like ions: setting up of Schrödinger equation in spherical polar coordinates, radial part, and quantization of energy (only final energy expression). Average and most probable distances of electron from nucleus.

Setting up of Schrödinger equation for many-electron atoms (He, Li). Need for approximation methods. Statement of variation theorem and application to simple systems (particle-in-a-box, harmonic oscillator, hydrogen atom).

Unit-2	**Number of lectures = 10**	**Title of the unit: Chemical Bonding.**

Covalent bonding, valence bond and molecular orbital approaches, LCAO-MO treatment of H_2^+. Bonding and antibonding orbitals. Qualitative extension to H_2. Comparison of LCAO-MO and VB treatments of H_2 (only wave functions, detailed solution not required) and their limitations. Refinements of the two approaches (Configuration Interaction for MO, ionic terms in VB). Qualitative description of LCAO-MO treatment of homonuclear and heteronuclear diatomic molecules (HF, LiH). Localised and non-localised molecular orbitals treatment of triatomic (BeH_2, H_2O) molecules. Qualitative MO theory and its application to AH_2 type molecules.

Unit 3	Number of lectures = 20	Title of the unit: Molecular Spectroscopy

Interaction of electromagnetic radiation with molecules and various types of spectra; Born-Oppenheimer approximation. Rotation spectroscopy: Selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution

Vibrational spectroscopy: Classical equation of vibration, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibration, concept of group frequencies.

Vibration-rotation spectroscopy: diatomic vibrating rotator, P, Q, R branches

Raman spectroscopy: Qualitative treatment of Rotational Raman effect; Effect of nuclear spin, Vibrational Raman spectra, Stokes and anti-Stokes lines; their intensity difference, rule of mutual exclusion.

Electronic spectroscopy: Franck-Condon principle, electronic transitions, singlet and triplet states, fluorescence and phosphorescence, dissociation and predissociation, calculation of electronic transitions of polyenes using free electron model.

Nuclear Magnetic Resonance (NMR) spectroscopy: Principles of NMR spectroscopy, Larmor precession, chemical shift and low resolution spectra, different scales, spin spin coupling and high resolution spectra, interpretation of PMR spectra of organic molecules.

Electron Spin Resonance (ESR) spectroscopy: Its principle, hyperfine structure, ESR of simple radicals.

Unit – 4	Number of lectures =6	Title of the unit: Photochemistry

Characteristics of electromagnetic radiation, Lambert-Beer's law and its limitations, physical significance of absorption coefficients. Laws, of photochemistry, quantum yield, actinometry, examples of low and high quantum yields, photochemical equilibrium and the differential rate of photochemical reactions, photosensitized reactions, quenching. Role of photochemical reactions in biochemical processes, photostationary states, chemiluminescence.

12. Books Recommended

1. Banwell, C. N. & McCash, E. M. Fundamentals of Molecular Spectroscopy 4th Ed. Tata McGraw-Hill: New Delhi (2006)
2. Chandra, A. K. Introductory Quantum Chemistry Tata McGraw-Hill (2001).
3. House, J. E. Fundamentals of Quantum Chemistry 2nd Ed. Elsevier: USA (2004)
4. Lowe, J. P. & Peterson, K. Quantum Chemistry, Academic Press (2005).
5. Kakkar, R. Atomic & Molecular Spectroscopy: Concepts & Applications, Cambridge University Press (2015).

1. Name of the Department: Chemistry						
2. Course Name	Quantum Chemistry, Spectroscopy & Photochemistry Lab		**L**	**T**		**P**
3. Course Code	09010522		0	0		4
4. Type of Course (use tick mark)		**Core ()**	**DSE (✓)**	**AEC ()**	**SEC ()**	**OE ()**
5. Pre-requisite .	NA	**6. Frequency (use tick marks)**	Even ()	Odd (✓)	Either Sem ()	Every Sem ()
7. Total Number of Lectures, Tutorials, Practical						
Lectures = 0		**Tutorials = 0**		**Practical = 52**		

8. Course Description:

A spectrophotometer is a photometer that can measure the intensity of light as a function of its wavelength. Single beam and double beam are the two major classes of spectrophotometers This course provides practical training to handle UV spectrophotometer and study absorbance spectra of various samples in the visible range. Solutions of transition metal ions can be colored (i.e., absorb visible light) because d electrons within the metal atoms can be excited from one electronic state to another. The colour of metal ion solutions is strongly affected by the presence of other species, such as certain anions or ligands. For instance, the colour of a dilute solution of copper sulfate is a very light blue; adding ammonia intensifies the colour and changes the wavelength of maximum absorption (λ_{max}).

Organic compounds, especially those with a high degree of conjugation, also absorb light in the UV or visible regions of the electromagnetic spectrum. (Organic solvents may have significant UV absorption; not all solvents are suitable for use in UV spectroscopy. Ethanol absorbs very weakly at most wavelengths.) Solvent polarity and pH can affect the absorption spectrum of an organic compounds.

9. Course Objectives:

The objectives of this course are to:

1. To measure the absorbance of the sample at different wavelengths.
2. To find out the unknown concentration of the sample.
3. Verification of Beer-Lambert's Law.

10. Course Outcomes (COs):

Upon successful completion of this course, the student will be able to:

1. Record the spectra of different organic compounds.
2. Determine the concentration of KMnO4 and K2Cr2O7 in a mixture.
3. Study the effect of pH on spectra of compounds.
4. to determine the kinetics or rate constant of a chemical reaction

11. List of Experiments

I. UV/Visible spectroscopy

1. Study the 200-500 nm absorbance spectra of KMnO4 and K2Cr2O7 (in 0.1 M H_2SO_4) and determine the λmax values. Calculate the energies of the two transitions in different units (J molecule-1, kJ mol-1, cm-1, eV).
2. Study the pH-dependence of the UV-Vis spectrum (200-500 nm) of K2Cr2O7.
3. Record the 200-350 nm UV spectra of the given compounds (acetone, acetaldehyde, 2-propanol, acetic acid) in water. Comment on the effect of structure on the UV spectra of organic compounds.

II. Colourimetry

1. Verify Lambert-Beer's law and determine the concentration of $CuSO_4/KMnO_4/K_2Cr_2O_7$ in a solution of unknown concentration
2. Determine the concentrations of $KMnO_4$ and $K_2Cr_2O_7$ in a mixture.
3. Study the kinetics of iodination of propanone in acidic medium.
4. Determine the amount of iron present in a sample using 1,10-phenathroline.
5. Determine the dissociation constant of an indicator (phenolphthalein).
6. Study the kinetics of interaction of crystal violet/ phenolphthalein with sodium hydroxide.
7. Analyse the given vibration-rotation spectrum of HCl(g)

12. Books Recommended

1. Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009.
2. Khosla, B. D.; Garg, V. C. & Gulati, A., Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
3. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed.; McGraw-Hill: New York (2003).
4. Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co.: New York (2003).

1. Name of the Department : Chemistry						
2. Course Name	Polymer Chemistry	**L**	**T**		**P**	
3. Course Code	09010617	4	0		0	
4. Type of Course (use tick mark)		**Core ()**	**DSE (✓)**	**AEC ()**	**SEC ()**	**OE ()**
5. Pre-requisite (if any)	NA	**6. Frequency (use tick marks)**	Even (✓)	Odd ()	Either Sem ()	Every Sem ()

7. Total Number of Lectures, Tutorials, Practicals

Lectures = 52	**Tutorials = 0**	**Practical = 0**

8. Course Description:

Introduction and history of polymeric materials , Classification, Functionality and its importance, Kinetics of Polymerization, Crystallization and crystallinity, Nature and structure of polymers, Determination of molecular weight of polymers, Glass transition temperature (Tg) and determination of Tg, Polymer Solution and properties of the polymers.

9. Course Objectives:

1. To gain the basic knowledge of polymer science
2. To develop synthetic skills of polymeric product

10. Course Outcomes (COs):

The students will achieve

1. basic knowledge of Polymer science
2. The skills for the synthesis of polymeric products with different techniques.

11. Unit wise detailed content

Unit-1	**Number of lectures = 12**	**Title of the unit: Introduction and Functionality of polymeric materials**

Different schemes of classification of polymers, Polymer nomenclature, Molecular forces and chemical bonding in polymers, Texture of polymers. Nature and structure of polymers-Structure Property relationships. Criteria for synthetic polymer formation, classification of polymerization processes, Relationships between functionality, extent of reaction and degree of polymerization. Bi-functional systems, Poly-functional systems.

Unit – 2	**Number of lectures = 13**	**Title of the unit: Kinetics of Polymerization and crystallinity**

Mechanism and kinetics of step growth, radical chain growth, ionic chain (both cationic and anionic) and coordination polymerizations, Mechanism and kinetics of copolymerization, polymerization techniques.

Determination of crystalline melting point and degree of crystallinity, Morphology of crystalline polymers, Factors affecting crystalline melting point.

Unit – 3	**Number of lectures = 13**	**Title of the unit: Molecular weight, Glass transition temperature (Tg) and determination of Tg, Polymer Solution**

Determination of molecular weight of polymers (*Mn*, *Mw*, etc) by end group analysis, viscometry, light scattering and osmotic pressure methods. Molecular weight distribution and its significance.

Polydispersity index. Glass transition temperature (Tg) and determination of Tg: Free volume theory, WLF equation, Factors affecting glass transition temperature (Tg). Criteria for polymer solubility, Solubility parameter, Thermodynamics of polymer solutions, entropy, enthalpy, and free energy change of mixing of polymers solutions, Flory- Huggins theory, Lower and Upper critical solution temperatures.

Unit – 4	**Number of lectures = 14**	**Title of the unit: Properties of Polymer**s

Properties of Polymers (Physical, thermal, flow & mechanical properties). Brief introduction to preparation, structure, properties and application of the following polymers: polyolefins, polystyrene and styrene copolymers, poly(vinyl chloride) and related polymers, poly(vinyl acetate) and related polymers, acrylic polymers, fluoro polymers, polyamides and related polymers. Phenol formaldehyde resins (Bakelite, Novalac), polyurethanes, silicone polymers, polydienes, Polycarbonates, Conducting Polymers, [polyacetylene, polyaniline, poly(p-phenylene sulphide polypyrrole, polythiophene)].

12. Books Recommended

1. Seymour, R.B. & Carraher, C.E. Polymer Chemistry: An Introduction, Marcel
2. Dekker, Inc. New York, 1981.
3. Odian, G. Principles of Polymerization, 4th Ed. Wiley, 2004.
4. Billmeyer, F.W. Textbook of Polymer Science, 2nd Ed. Wiley Interscience, 1971.
5. Ghosh, P. Polymer Science & Technology, Tata McGraw-Hill Education, 1991.
6. Lenz, R.W. Organic Chemistry of Synthetic High Polymers. Interscience Publishers, New York, 1967.

1. Name of the Department: Chemistry						
2. Course Name	Polymer Chemistry Lab	**L**	**T**	**P**		
3. Course Code	09010618	0	0	4		
4. Type of Course (use tick mark)	**Core ()**	**DSE (✓)**	**AEC ()**	**SEC ()**	**OE ()**	
5. Pre-requisite (if any)	NA	**6. Frequency (use tick marks)**	Even (✓)	Odd ()	Either Sem ()	Every Sem ()
7. Total Number of Lectures, Tutorials, Practicals						
Lectures = 0	**Tutorials = 0**	**Practical = 52**				

8. Course Description:

Experiments in this class are broadly aimed at acquainting students with the range of properties of polymers, methods of synthesis, purification and characterization including instrumental techniques such as IR, DSC, etc. Some examples of laboratory work include solution polymerization of styrene (St), Interfacial polymerization: polyester preparation, Redox polymerization of acrylamide, Precipitation polymerization of acrylonitrile, Determination of molecular weight by viscometry, Testing of mechanical properties of polymers.

9. Course Objectives:

1. To gain the basic knowledge of polymer synthesis
2. To develop synthetic skills of purification and characterization of polymers.

10. Course Outcomes (COs):

Students will be able

1. To synthesize polymeric compounds
2. To characterize polymeric compounds by using different methods.

11. List of Experiments: (Student has to perform ten experiments)

1. Free radical solution polymerization of styrene (St) / Methyl Methacrylate (MMA) / Methyl Acrylate (MA) Acrylic acid (AA).
   a. Purification of monomer
   b. Polymerization using benzoyl peroxide (BPO) / 2,2'-azo-bisisobutylonitrile (AIBN)
2. Preparation of nylon 6,6
3. Redox polymerization of acrylamide
4. Precipitation polymerization of acrylonitrile
5. Preparation of urea-formaldehyde resin
6. Preparations of novalac resin/resold resin.
7. Determination of molecular weight by viscometry:
   a. Polyacrylamide-aq.$NaNO_2$ solution
   b. (Poly vinyl proplylidine (PVP) in water
8. Determination of the viscosity-average molecular weight of poly(vinyl alcohol) (PVOH) and the fraction of "head-to-head" monomer linkages in the polymer.
9. Determination of molecular weight by end group analysis: Polyethylene glycol (PEG) (OH group).
10. Determination of hydroxyl number of a polymer using colorimetric method.

11. Estimation of the amount of HCHO in the given solution by sodium sulphite method.

12. Preparation of polyacrylamide and its electrophoresis

12. Books Recommended

1. M.P. Stevens, Polymer Chemistry: An Introduction, 3rd Ed., Oxford University Press, 1999.
2. H.R. Allcock, F.W. Lampe & J.E. Mark, Contemporary Polymer Chemistry, 3rd ed. Prentice-Hall (2003)
3. F.W. Billmeyer, Textbook of Polymer Science, 3rd ed. Wiley-Interscience (1984)
4. J.R. Fried, Polymer Science and Technology, 2nd ed. Prentice-Hall (2003)
5. P. Munk & T.M. Aminabhavi, Introduction to Macromolecular Science, 2nd ed. John Wiley & Sons (2002)
6. L. H. Sperling, Introduction to Physical Polymer Science, 4th ed. John Wiley & Sons (2005)
7. M.P. Stevens, Polymer Chemistry: An Introduction 3rd ed. Oxford University Press (2005).
8. Seymour/ Carraher's Polymer Chemistry, 9th ed. by Charles E. Carraher, Jr. (2013).

1. Name of the Department: Chemistry						
2. Course Name	Organometallics,bioinorganic chemistry, polynuclear hydrocarbons and UV, IR spectroscopy		**L**	**T**	**P**	
3. Course Code	09010619		4	0	0	
4. Type of Course (use tick mark)		**Core ()**	**DSE (✓)**	**AEC ()**	**SEC ()**	**OE ()**
5. Pre-requisite (if any)	NA	**6. Frequency (use tick marks)**	Even (✓)	Odd ()	Either Sem ()	Every Sem ()

7. Total Number of Lectures, Tutorials, Practical		
Lectures = 52	**Tutorials = 0**	**Practical = 0**

8. Course Description:

Chemistry of 3d metals, Organometallic Compounds, Bio-Inorganic Chemistry, Polynuclear and heteronuclear aromatic compounds, Active methylene compounds, Application of Spectroscopy to Simple Organic Molecule.

9. Course Objectives:

The objectives of this course are to:

1. Introduce the knowledge of organic and inorganic chemistry
2. Introduce the knowledge of spectroscopic applications.

10. Course Outcomes (COs):

The students will acquire knowledge of

1. Applications of Inorganic and organic chemistry including spectroscopic techniques.
2. Applications organometallics,chemistry of 3d metals and bio inorganic chemistry.

11. Unit wise detailed content

Unit-1	**Number of lectures = 14**	**Title of the unit: Chemistry of 3d metals and Organometallic Compounds**

Oxidation states displayed by Cr, Fe, Co, Ni and Co. A study of the following compounds (including preparation and important properties); Peroxo compounds of Cr, K2Cr2O7, KMnO4, K4[Fe(CN)6], sodium nitroprusside, [Co(NH3)6]Cl3, Na3[Co(NO2)6].

Definition and Classification with appropriate examples based on nature of metalcarbon bond (ionic, s, p and multicentre bonds). Structures of methyl lithium, Zeiss salt and ferrocene. EAN rule as applied to carbonyls. Preparation, structure, bonding and properties of mononuclear and polynuclear carbonyls of 3d metals. p-acceptor behaviour of carbon monoxide. Synergic effects (VB approach)- (MO diagram of CO can be referred to for synergic effect to IR frequencies).

Unit – 2	**Number of lectures = 12**	**Title of the unit: Bio-Inorganic Chemistry**

A brief introduction to bio-inorganic chemistry. Role of metal ions present in biological systems with special reference to Na+, K+ and Mg2+ ions: Na/K pump; Role of Mg2+ ions in energy production and chlorophyll. Role of Ca2+ in blood clotting, stabilization of protein structures and structural role (bones).

Unit – 3	**Number of lectures = 12**	**Title of the unit: Polynuclear, heteronuclear aromatic compounds, and Active methylene compounds**

Properties of the following compounds with reference to electrophilic and nucleophilic substitution: Naphthalene, Anthracene , Furan, Pyrrole, Thiophene, and Pyridine.

Preparation: Claisen ester condensation. Keto-enol tautomerism.

Reactions: Synthetic uses of ethylacetoacetate (preparation of non-heteromolecules having upto 6 carbon).

Unit – 4	**Number of lectures = 14**	**Title of the unit: Application of Spectroscopy to Simple Organic Molecules**

Application of visible, ultraviolet and Infrared spectroscopy in organic molecules. Electromagnetic radiations, electronic transitions, λmax & εmax, chromophore, auxochrome, bathochromic and hypsochromic shifts. Application of electronic spectroscopy and Woodward rules for calculating l max of conjugated dienes and α,β – unsaturated compounds.

Infrared radiation and types of molecular vibrations, functional group and fingerprint region. IR spectra of alkanes, alkenes and simple alcohols (inter and intramolecular hydrogen bonding), aldehydes, ketones, carboxylic acids and their derivatives (effect of substitution on >C=O stretching absorptions).

12. Books Recommended

1. J.D. Lee: A New Concise Inorganic Chemistry, E.L.B.S.
2. F.A. Cotton & G. Wilkinson: Basic Inorganic Chemistry, John Wiley & Sons.
3. I.L. Finar: Organic Chemistry (Vol. I & II), E.L.B.S.
4. R.M. Silverstein, G.C. Bassler & T.C. Morrill: Spectroscopic Identification of Organic Compounds, John Wiley & Sons.
5. R.T. Morrison & R.N. Boyd: Organic Chemistry, Prentice Hall.
6. Arun Bahl and B. S. Bahl: Advanced Organic Chemistry, S. Chand.
7. dvanced Organic Chemistry, S. Chand.

1. Name of the Department: Chemistry						
2. Course Name	Organometallics, bioinorganic chemistry, Polynuclear hydrocarbons and UV, IR spectroscopy Lab		**L**	**T**	**P**	
3. Course Code	09010620		0	0	4	
4. Type of Course (use tick mark)		**Core ()**	**DSE (✓)**	**AEC ()**	**SEC ()**	**OE ()**
5. Pre-requisite (if any)	NA	**6. Frequency (use tick marks)**	Even (✓)	Odd ()	Either Sem ()	Every Sem ()

7. Total Number of Lectures, Tutorials, Practical		
Lectures = 0	**Tutorials = 0**	**Practical = 52**

8. Course Description:

This course provides students with practical experience of the techniques used in basic inorganic and organic chemistry. Some examples of the experiment are Separation of mixtures by paper chromatography, Preparation of the complexes and measurement of their conductivity, Qualitative Organic Analysis of Organic Compounds.

9. Course Objectives:

To develop the qualitative technique skills in students including preparation of the metal complexes, chromatographic separation.

10. Course Outcomes (COs):

The students will acquire knowledge of

1. preparation and purification of metal complexes by using chromatographic separation techniques
2. Qualitative Organic Analysis of Organic Compounds

11. List of Experiments: (Student has to perform any ten experiments)

1. Separation of mixtures by chromatography: Measure the *Rf* value in each case. (Combination of two ions to be given)
   a. Paper chromatographic separation of Fe3+, A13+ and Cr3+ or
   b. Paper chromatographic separation of Ni2+, Co2+, Mn2+ and Zn2+
2. Preparation of any two of the following complexes and measurement of their conductivity:
   a. tetraamminecarbonatocobalt (III) nitrate
   b. tetraamminecopper (II) sulphate
   c. potassium trioxalatoferrate (III) trihydrate
3. Compare the conductance of the complexes with that of M/1000 solution of NaCl,MgCl2 and LiCl3.
4. Systematic Qualitative Organic Analysis of Organic Compounds possessing monofunctional groups (-COOH, phenolic, aldehydic, ketonic, amide, nitro, amines) and preparation of one derivative.

12. **Books Recommended**

1. A.I. Vogel: Qualitative Inorganic Analysis, Prentice Hall, 7th Edn.
2. A.I. Vogel: Quantitative Chemical Analysis, Prentice Hall, 6th Edn.
3. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.
4. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry Orient-Longman,1960.

1. Name of the Department: Chemistry						
2. Course Name	Chemistry of main group elements, theories of acids and bases		**L**	**T**		**P**
3. Course Code	09010621		4	0		0
4. Type of Course (use tick mark)		**Core ()**	**DSE (✓)**	**AEC ()**	**SEC ()**	**OE ()**
5. Pre-requisite (if any)	NA	**6. Frequency (use tick marks)**	Even (✓)	Odd ()	Either Sem ()	Every Sem ()

7. Total Number of Lectures, Tutorials, Practical

Lectures = 52	**Tutorials = 0**	**Practical = 0**

8. Course Description:

This course provides students the knowledge of Acids and Bases, General Principles of Metallurgy, *s*- and *p*-Block Elements, Noble gases, inorganic polymers, etc.

9. Course Objectives:

The objectives of this course are to:

1. Introduce the knowledge of acids, bases and Metallurgy
2. Introduce the knowledge of *s*- and *p*-Block Elements, Noble gases and inorganic polymers.

10. Course Outcomes (COs):

Students will gain an understanding of:

1. Acids, bases, *s*- and *p*-Block Elements, Noble gases and inorganic polymers
2. General Principles of Metallurgy and their applications

11. Unit wise detailed content

Unit-1	**Number of lectures = 13**	**Title of the unit: Acids, Bases and General Principles of Metallurgy**

Brönsted–Lowry concept, conjugate acids and bases, relative strengths of acids and bases, effects of substituent and solvent, differentiating and levelling solvents. Lewis acid-base concept, classification of Lewis acids and bases, Lux-Flood concept and solvent system concept. Hard and soft acids and bases (HSAB concept),applications of HSAB process.

Chief modes of occurrence of metals based on standard electrode potentials, Ellingham diagrams for reduction of metal oxides using carbon and carbon monoxide as reducing agents. Hydrometallurgy with reference to cyanide process for gold and silver. Methods of purification of metals (Al, Pb, Ti, Fe, Cu, Ni, Zn, Au): electrolytic refining, zone refining, van Arkel-de Boer process, Parting Process, Mond's process and Kroll Process.

Unit - 2	**Number of lectures = 13**	**Title of the unit: *s*- and *p*-Block Elements**

Periodicity in *s*- and *p*-block elements with respect to electronic configuration, atomic and ionic size, ionization enthalpy, electron gain enthalpy, electro negativity (Pauling scale). General characteristics of *s*-block metals like density, melting and boiling points, flame colour and reducing nature. Oxidation states of *s*- and *p*-block elements, inert-pair effect, diagonal relationships and anomalous behaviour of first member of each group. Allotropy in C, P and S. Complex forming tendency of *s* block elements and a preliminary idea of crown ethers and cryptates, structures of basic beryllium acetate, salicylaldehyde/ acetylacetonato complexes of Group 1 metals. Solutions of alkali metals in liquid ammonia and their properties. Common features, such as ease of formation, solubility and stability of oxides, peroxides, superoxides, sulphates and carbonates of *s*-block metals.

Unit – 3	**Number of lectures = 12**	**Title of the unit: Structure, bonding ,properties and Applications**

Structure, bonding and properties (acidic/ basic nature, oxidizing/ reducing nature and hydrolysis of the following compounds and their applications in industrial and environmental chemistry wherever

applicable: Diborane and concept of multicentre bonding, hydrides of Groups 13 (BH_3), 14, 15, 16 and 17.

Oxides of N and P, Oxoacids of P, S and Cl. Halides and oxohalides of P and S (PCl_3, PCl_5, $SOCl_2$ and SO_2Cl_2) .Interhalogen compounds. A brief idea of pseudohalides

Unit – 4	**Number of lectures = 14**	**Title of the unit: Noble gases and Inorganic Polymers**

Rationalization of inertness of noble gases, clathrates, preparation and properties of XeF_2, XeF_4 and XeF_6 ,bonding in these compounds using VBT and shapes of noble gas compounds using VSEPR Theory. Types of inorganic polymers and comparison with organic polymers, structural features, classification and important applications of silicates. Synthesis, structural features and applications of silicones. Borazines and cyclophosphazenes – preparation, properties and reactions. Bonding in $(NPCl_2)_3$.

12. Books Recommended

1. Lee, J.D. Concise Inorganic Chemistry ELBS, 1991.
2. Cotton, F.A., Wilkinson, G. & Gaus, P.L. Basic Inorganic Chemistry, 3rd ed., Wiley.
3. Douglas, B.E., McDaniel, D.H. & Alexander, J.J. Concepts and Models in Inorganic Chemistry, John Wiley & Sons.
4. Greenwood, N.N. & Earnshaw. Chemistry of the Elements, Butterworth-Heinemann. 1997.
5. Rodger, G.E. Inorganic and Solid State Chemistry, Cengage Learning India Edition, 2002.
6. Miessler, G. L. & Donald, A. Tarr. Inorganic Chemistry 4th Ed., Pearson, 2010.
7. Atkin, P. Shriver & Atkins' Inorganic Chemistry 5th Ed. Oxford University Press (2010).

1. Name of the Department: Chemistry						
2. Course Name	Chemistry of main group elements, theories of acids and bases Lab		**L**	**T**		**P**
3. Course Code	09010622		0	0		4
4. Type of Course (use tick mark)		**Core ()**	**DSE (✓)**	**AEC ()**	**SEC ()**	**OE ()**
5. Pre-requisite (if any)	NA	**6. Frequency (use tick marks)**	Even (✓)	Odd ()	Either Sem ()	Every Sem ()
7. Total Number of Lectures, Tutorials, Practicals						
Lectures = 0		**Tutorials = 0**		**Practical = 52**		

8. Course Description:

This course provides students with practical experience of the techniques of analysis of quantitative data. It is addressed to students who have little or no experience of using quantitative data and it aims to enable students to develop an understanding of basic and intermediate quantitative chemical analysis methods and the ability to use these methods. This course includes iodimetric and gravimetric titrations by considering the example of date to date life.

9. Course Objectives:

To develop quantitative technique skills in students.

10. Course Outcomes (COs):

Students will gain an understanding of:

1. the application of analytical methods based on titrations such iodometric, gravimetric, and isolation, separations methods, etc
2. solving most important problems of quantitative analysis
3. Applications of the quantitative analysis in daily life.

11. List of experiments

1. Iodometric estimation of potassium dichromate and copper sulphate
2. Iodimetric estimation of antimony in tartaremetic
3. Estimation of amount of available chlorine in bleaching powder and household bleaches
4. Estimation of iodine in iodized salts.
5. Iodimetric estimation of ascorbic acid in fruit juices.
6. Estimation of dissolved oxygen in water samples.
7. Gravimetric estimation of sulphate as barium sulphate.
8. Gravimetric estimation of aluminium as oximato complex
9. Preparation of the following: potash alum, chrome alum, tetraamminecopper(II) sulphate monohydrate, potassium trioxalatoferrate(III) any two, including one double salt and one complex).

12. Books Recommended

1. Svehla, G. Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012.
2. Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009.

1. Name of the Department : Chemistry						
2. Course Name	Basic Analytical Chemistry	**L**		**T**	**P**	
3. Course Code	09010526	2		0	0	
4. Type of Course (use tick mark)		**Core ()**	**DSE ()**	**AEC ()**	**SEC (✓)**	**OE ()**
5. Pre-requisite (if any)	NA	**6. Frequency (use tick marks)**	Even ()	Odd (✓)	Either Sem ()	Every Sem ()

7. Total Number of Lectures, Tutorials, Practical		
Lectures = 26	**Tutorials = 0**	**Practical = 0**

8. Course Description:

This course provides students with practical experience of analytical chemistry. Some of the examples of the experiments are soil, water, food product, and cosmetic analysis. Chromatographic and instrumental techniques will also be practiced.

9. Course Objectives:

1. To develop analytical and chromatographic skills
2. To develop instrumental technique skills in students.

10. Course Outcomes (COs):

1. The students will gain an understanding of application of analytical methods in day to day life such soil, water, food product and cosmetic analysis.
2. The students will gain hands-on practices on chromatographic and instrumental techniques.

11. Unit wise detailed content

Unit-1	**Number of lectures = 13**	**Title of the unit: Introduction to Analytical Chemistry**

Introduction to Analytical Chemistry and its interdisciplinary nature. Concept of sampling. Importance of accuracy, precision and sources of error in analytical measurements. Presentation of experimental data and results, from the point of view of significant figures. Composition of soil, Concept of pH and pH measurement, Complexometric titrations, Chelation, Chelating agents, use of indicators. Definition of pure water, sources responsible for contaminating water, water sampling methods, water purification methods. Nutritional value of foods, idea about food processing and food preservations and adulteration.

a. Identification of adulterants in some common food items like coffee powder, asafoetida, chilli powder, turmeric powder, coriander powder and pulses, etc.

b. Analysis of preservatives and colouring matter.

c. Analysis of cosmetics: Major and minor constituents and their function

Unit – 2	**Number of lectures = 13**	**Title of the unit: Analysis of water and food products**

1. Analysis of deodorants and antiperspirants, Al, Zn, boric acid, chloride, sulphate.
2. Determination of constituents of talcum powder: Magnesium oxide, Calcium oxide,
3. Zinc oxide and Calcium carbonate by complexometric titration.
4. To study the use of phenolphthalein in trap cases.
5. To analyze arson accelerants.
6. To carry out analysis of gasoline.

7. Estimation of macro nutrients: Potassium, Calcium, Magnesium in soil samples by flame photometry
8. Determination of pH, acidity and alkalinity of a water sample.
9. Determination of dissolved oxygen (DO) of a water sample.
10. Determination of pH of soil samples.
11. Estimation of Calcium and Magnesium ions as Calcium carbonate by complexometric titration.

12. Books Recommended

1. Willard, H.H., Merritt, L.L., Dean, J. & Settoe, F.A. Instrumental Methods of Analysis. 7th Ed. Wadsworth Publishing Co. Ltd., Belmont, California, USA, 1988.
2. Skoog, D.A.; West, D.M. & Holler, F.J. Fundamentals of Analytical Chemistry 6th Ed., Saunders College Publishing, Fort Worth (1992).
3. Day, R. A. & Underwood, A. L. Quantitative Analysis, Prentice Hall of India.
4. Freifelder, D. Physical Biochemistry 2nd Ed., W.H. Freeman and Co., N.Y. USA (1982).
5. Vogel, A. I. Vogel's Qualitative Inorganic Analysis 7th Ed., Prentice Hall.
6. Robinson, J.W. Undergraduate Instrumental Analysis 5th Ed., Marcel Dekker, Inc., New York (1995).

1. Name of the Department : Chemistry						
2. Course Name	Fuel Chemistry	**L**	**T**		**P**	
3. Course Code	09010527	2	0		0	
4. Type of Course (use tick mark)		**Core ()**	**DSE ()**	**AEC ()**	**SEC (✓)**	**OE ()**
5. Pre-requisite (if any)	NA	**6. Frequency (use tick marks)**	Even ()	Odd (✓)	Either Sem ()	Every Sem ()
7. Total Number of Lectures, Tutorials, Practical						
Lectures = 26		**Tutorials = 0**		**Practical = 0**		

8. Course Description:

This course includes study of energy sources (renewable and nonrenewable) which includes fuels, coal, gasification and liquefaction techniques, Petroleum and its applications in industries, and lubricants.

9. Course Objectives:

Objectives of this course are to:

1. Make the students aware of the renewable and non-renewable energy sources.
2. To build up knowledge of the concepts and theories of fuel chemistry.
3. To be familiar with the fundamental physical and chemical principles regarding formation and control of air pollutants in industrial and technological processes.
4. Give students an awareness of the Petroleum and Petrochemical Industry applications.

10. Course Outcomes (COs):

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

1. Identify and characterize various renewable and non-renewable energy sources.
2. Develop an understanding of the Petrochemical Industry applications.
3. Use techniques such as coal liquefaction, solvent refining and gasification, etc.

11. Unit wise detailed content

Unit-1	**Number of lectures = 13**	**Title of the unit: Fuels and Coal**

Review of energy sources (renewable and non-renewable). Classification of fuels and their calorific value.Uses of coal (fuel and nonfuel) in various industries, its composition, carbonization of coal.Coal gas, producer gas and water gas—composition and uses.Fractionation of coal tar, uses of coal tar bases chemicals, requisites of a good metallurgical coke, Coal gasification (Hydro gasification and Catalytic gasification), Coal liquefaction and Solvent Refining.

Unit – 2	**Number of lectures = 13**	**Title of the unit: Petroleum and Lubricants**

Composition of crude petroleum, Refining and different types of petroleum products and their applications. Fractional Distillation (Principle and process), Cracking (Thermal and catalytic cracking), Reforming Petroleum and non-petroleum fuels (LPG, CNG, bio-gas, fuels derived from biomass), fuel from waste, synthetic fuels (gaseous and liquids), clean fuels. Petrochemicals: Vinyl acetate, Propylene oxide, Isoprene, Butadiene, Toluene and its derivatives Xylene. Classification of lubricants, lubricating oils (conducting and nonconducting), Solid and semisolid lubricants, synthetic lubricants. Properties of lubricants (viscosity index, cloud point, pore point) and their determination.

12. Books Recommended

1. Stocchi, E. Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK (1990).
2. Jain, P.C. & Jain, M. Engineering Chemistry Dhanpat Rai & Sons, Delhi.
3. Sharma, B.K. & Gaur, H. Industrial Chemistry, Goel Publishing House, Meerut (1996).

1. Name of the Department: Chemistry						
2. Course Name	Chemical Technology & Society		**L**		**T**	**P**
3. Course Code	09010528		2		0	0
Type of Course (use tick mark)		**Core ()**	**DSE ()**	**AEC ()**	**SEC (✓)**	**OE ()**
5. Pre-requisite (if any)	NA	**6. Frequency (use tick marks)**	Even ()	Odd (✓)	Either Sem ()	Every Sem ()
7. Total Number of Lectures, Tutorials, Practicals.						
Lectures = 26	**Tutorials = 0**		**Practical = 0**			

8. Course Description:

This course will introduce students to basic principles of chemical technology. Important processes and equipment employed will be described. Students will also be familiarized with how processes finalized in the Research and Development Laboratories are scaled up in pilot plants and plants.

Scientific literacy will be inculcated in order to gain a better understanding of complex environmental issues that face the modern world, *e.g.*, air and water pollution, energy from natural sources, impact of nuclear fission, impact of genetic engineering and manufacture of drugs.

9. Course Objectives:

The objectives of this course are to:

1. Introduce students to basic principles of chemical technology
2. Explain important processes employed in chemical technology, *e.g.*, distillation, solvent extraction, solid-liquid leaching etc.
3. Familiarize students with special equipment needed in chemical technology, *e.g.*, reactors, distillation columns, pumps etc.
4. Familiarize students with principles of clean technology
5. Discuss societal and technological issues from a chemical perspective
6. Induce scientific literacy to understand interdisciplinary issues, *e.g.*, are and water pollution, energy from natural sources, drugs manufacture and genetic engineering etc.

10. Course Outcomes (COs):

Upon successful completion of this course, the student will be able to:

1. Explain basic principles of chemical technology
2. Explain key processes used in chemical technology
3. Identify key equipment employed in chemical technology
4. Understand clean technology
5. Attain understanding of complex societal and technological issues from a scientific viewpoint

11. Unit wise detailed content

Unit-1	**Number of lectures = 13**	**Title of the unit: Chemical Technology**

Basic principles of distillation, solvent extraction, solid-liquid leaching and liquid-liquid extraction, separation by absorption and adsorption. An introduction into the scope of different types of equipment needed in chemical technology, including reactors, distillation columns, extruders, pumps, mills, emulgators. Scaling up operations in chemical industry. Introduction to clean technology.

Unit – 2	**Number of lectures = 13**	**Title of the unit: Society**

Exploration of societal and technological issues from a chemical perspective. Chemical and scientific literacy as a means to better understand topics like air and water (and the trace materials found in them that are referred to as pollutants); energy from natural sources (i.e. solar and renewable forms), from fossil fuels

and from nuclear fission; materials like plastics and polymers and their natural analogues, proteins and nucleic acids, and molecular reactivity and interconversions from simple examples like combustion to complex instances like genetic engineering and the manufacture of drugs.

13. Books Recommended

1. John W. Hill, Terry W. McCreary & Doris K. Kolb, *Chemistry for changing times* 13th Ed.

1. Name of the Department: Department of Chemistry						
2. Course Name	Pharmaceutical Chemistry	**L**	**T**		**P**	
3. Course Code	09010529	2	0		0	
Type of Course (use tick mark)		**Core ()**	**DSE ()**	**AEC ()**	**SEC (✓)**	**OE ()**
5. Pre-requisite (if any)	NA	**6. Frequency (use tick marks)**	Even ()	Odd (✓)	Either Sem ()	Every Sem ()

7. Total Number of Lectures, Tutorials, Practicals.		
Lectures = 26	**Tutorials = 0**	**Practical = 0**

8. Course Description:

The search for new drugs to treat serious diseases such as cancer, heart disease and bacterial and viral infections remains at the forefront of cutting edge medical research. There is a demand in the pharmaceutical industry graduates with a strong background in organic chemistry, mixed with a broad understanding of pharmacology and related biochemical areas. This course offers the opportunity to study subjects allied to medical and pharmaceutical industries.

9. Course Objectives:

The objectives of this course are to:

1. Introduce students to drug discovery, design and development
2. Introduce students to basic retrosynthetic approach
3. Familiarize students with synthesis of representative drugs of classes, *e.g.*, analgesic agents, antipyretic agents, anti-inflammatory agents, antibiotics etc.
4. Explain aerobic and anaerobic fermentation and its use in production of selected products.
5. To provide hands-on experience in synthesis if aspirin and antacid.

10. Course Outcomes (COs):

Upon successful completion of this course, the student will be able to:

1. Understand drug discovery, design and development
2. Recognize representative classes of drugs, *e.g.*, analgesic agents, antipyretic agents, antibiotics etc.
3. Explain the production of selected drugs and Vitamins *via* the fermentation process.

11. Unit wise detailed content

Unit-1	**Number of lectures = 20**	**Title of the unit: Drugs & Pharmaceuticals**

Drug discovery, design and development; Basic Retrosynthetic approach. Synthesis of the representative drugs of the following classes: analgesics agents, antipyretic agents, anti-inflammatory agents (Aspirin, paracetamol, lbuprofen); antibiotics (Chloramphenicol); antibacterial and antifungal agents (Sulphonamides; Sulphanethoxazol, Sulphacetamide, Trimethoprim); antiviral agents (Acyclovir), Central Nervous System agents (Phenobarbital, Diazepam), Cardiovascular (Glyceryl trinitrate), antilaprosy (Dapsone), HIV-AIDS related drugs (AZT- Zidovudine).

Aerobic and anaerobic fermentation. Production of Ethyl alcohol and citric acid, Antibiotics: Penicillin, Cephalosporin, Chloromycetin and Streptomycin, Lysine, Glutamic acid, Vitamin B2, Vitamin B12 and Vitamin C

12. List of Experiments	**Number of lectures = 06**

1. Preparation of Aspirin and its analysis.
2. Preparation of magnesium bisilicate (Antacid).

13. Books Recommended

1. G.L. Patrick: Introduction to Medicinal Chemistry, Oxford University Press, UK.
2. Hakishan, V.K. Kapoor: Medicinal and Pharmaceutical Chemistry, Vallabh Prakashan, Pitampura, New Delhi.
3. William O. Foye, Thomas L.,Lemke , David A. William: Principles of Medicinal Chemistry, B.I. Waverly Pvt. Ltd. New Delhi

1. Name of the Department : Chemistry						
2. Course Name	Chemistry of Cosmetics & Perfumes	**L**	**T**	**P**		
3. Course Code	09010530	2	0	0		
4. Type of Course (use tick mark)		**Core ()**	**DSE ()**	**AEC()**	**SEC (✓)**	**OE ()**
5. Pre-requisite (if any)	NA	**6. Frequency (use tick marks)**	Even ()	Odd (✓)	Either Sem ()	Every Sem ()
7. Total Number of Lectures, Tutorials, Practical						
Lectures = 26		**Tutorials = 0**	**Practical = 0**			

8. Course Description:

This course provides training in chemistry with applications in perfumery and cosmetic science. You will have an integrated learning experience where you will build a strong chemistry foundation and apply your knowledge in specific applications using your senses.

9. Course Objectives:

The objectives of this course are to:

1. Understand the science behind Perfumes and Cosmetics.
2. To understand the various safety testing methods to evaluate the quality of the products.
3. To understand the preparation methods of various Perfumes and Cosmetics.

10. Course Outcomes (COs):

Upon successful completion of this course, the student will be able to:

1. To discover social and scientific concepts of human beauty
2. To deliver the safety of cosmetics and perfumes.
3. To deliver the history and science of cosmetics and perfumes.

11. Unit wise detailed content

Unit-1	**Number of lectures = 15**	**Title of the unit:** Chemistry of Cosmetics & Perfumes

A general study including preparation and uses of the following: Hair dye, hair spray, shampoo, suntan lotions, face powder, lipsticks, talcum powder, nail enamel, creams (cold, vanishing and shaving creams), antiperspirants and artificial flavours. Essential oils and their importance in cosmetic industries with reference to Eugenol, Geraniol, sandalwood oil, eucalyptus, rose oil, 2-phenyl ethyl alcohol, Jasmone, Civetone, Muscone.

12. List of experiments | **Number of lectures = 11**

1. Preparation of talcum powder.
2. Preparation of shampoo.
3. Preparation of enamels.
4. Preparation of hair remover.
5. Preparation of face cream.
6. Preparation of nail polish and nail polish remover.

13. Books Recommended

1. E. Stocchi: Industrial Chemistry, Vol -I, Ellis Horwood Ltd. UK.
2. P.C. Jain, M. Jain: Engineering Chemistry, Dhanpat Rai & Sons, Delhi.
3. Sharma, B.K. & Gaur, H. Industrial Chemistry, Goel Publishing House,Meerut (1996).

1. Name of the Department : Department of Chemistry						
2. Course Name	Pesticide Chemistry	**L**	**T**		**P**	
3. Course Code	09010531	2	0		0	
4. Type of Course (use tick mark)		**Core ()**	**DSE ()**	**AEC()**	**SEC (✓)**	**OE ()**
5. Pre-requisite (if any)	NA	**6. Frequency (use tick marks)**	Even ()	Odd (✓)	Either Sem ()	Every Sem ()

7. Total Number of Lectures, Tutorials, Practicals.		
Lectures = 26	**Tutorials = Nil**	**Practical = Nil**

8. Course Description:

This course provides training in chemistry with applications in perfumery and cosmetic science. You will have an integrated learning experience where you will build a strong chemistry foundation and apply your knowledge in specific applications using your senses.

9. Course Objectives:

The objectives of this course are to:

1. Understand the science behind pesticides.
2. Understand the classification of pesticides.
3. Understand the preparation methods of various pesticides.

10. Course Outcomes (COs):

Upon successful completion of this course, the student will be able to:

1. To deliver the usage of pesticides.
2. To deliver the importance of pesticides.

11. Unit wise detailed content

Unit-1	**Number of lectures = 15**	**Title of the unit:** Pesticide Chemistry

General introduction to pesticides (natural and synthetic), benefits and adverse effects, changing concepts of pesticides, structure activity relationship, synthesis and technical manufacture and uses of representative pesticides in the following classes: Organochlorines (DDT, Gammexene,); Organophosphates (Malathion, Parathion); Carbamates (Carbofuran and carbaryl); Quinones (Chloranil), Anilides (Alachlor and Butachlor).

12. List of experiments	**Number of lectures = 11**

1. To calculate acidity/alkalinity in given sample of pesticide formulations as per BIS specifications.
2. Preparation of simple organophosphates, phosphonates and thiophosphates

13. Books Recommended

1. Cremlyn, R. Pesticides. Preparation and Modes of Action, John Wiley & Sons, New York, 1978.
2. Ohkawa.H, Miyagawa.H and Lee.P.W. Pesticide chemistry,Wiley-VCH verlag Gmbh & Co.2007.