

# **SOPHIA COLLEGE (AUTONOMOUS)**

**Affiliated To The University Of Mumbai**



**SYLLABUS FOR TYBSc (6 UNITS)**

**COURSE: CHEMISTRY**

**With effect from the academic year 2020-21**

## **SYLLABUS FOR APPROVAL**

<b>Sr. No.</b>	<b>Heading</b>	<b>Particulars</b>
<b>1.</b>	<b>Title of course</b>	<b>TYBSc (6 Units) Chemistry</b>
<b>2.</b>	<b>Passing marks</b>	<b>40%</b>
<b>3.</b>	<b>Ordinance/Regulation (if any)</b>	
<b>4.</b>	<b>No. of Semester</b>	<b>Two</b>
<b>5.</b>	<b>Level</b>	<b>UG</b>
<b>6.</b>	<b>Pattern</b>	<b>Semester</b>
<b>7.</b>	<b>To be implemented from Academic year</b>	<b>2020-21</b>

**Date:**

**Dr. I. A. Mendes**  
BOS Chairperson

**Prof. Santosh Haram**  
Convener

**TYBSc CHEMISTRY (6 UNITS)  
SEMESTER V**

Course Code	Title of the paper	Unit	Topic	Credits	L/Week
<b>SBSCHE501</b>	<b>Physical Chemistry</b>	<b>I</b>	1.1Molecular Spectroscopy	2.5	4
		<b>II</b>	2.1Surface Chemistry 2.2 Colloidal State		
		<b>III</b>	3.1Nuclear Chemistry		
		<b>IV</b>	4.1 Dilute Solutions 4.2 Chemical Kinetics - III		
<b>SBSCHE502</b>	<b>Inorganic Chemistry</b>	<b>I</b>	1.1 Molecular Symmetry 1.2 Molecular Orbital theory	2.5	4
		<b>II</b>	2.1Solid State Chemistry 2.2 Super Conductivity		
		<b>III</b>	3.1Chemistry of Inner Transition elements		
		<b>IV</b>	4.1 Comparative chemistry of group 16 4.2 Nanomaterials 4.3 Non aqueous solvents		
<b>SBSCHE503</b>	<b>Organic Chemistry</b>	<b>I</b>	1.1 Mechanism of Organic reactions	2.5	4
		<b>II</b>	2.1 IUPAC Nomenclature 2.2 Stereochemistry –III		
		<b>III</b>	3.1 Catalysts and Reagents 3.2 Organometallic Compounds		
		<b>IV</b>	4.1 Natural products 4.2 Photochemistry		
<b>SBSCHE504</b>	<b>Analytical Chemistry</b>	<b>I</b>	1.1 Statistical treatment of data – I 1.2 Sampling	2.5	4
		<b>II</b>	2.1 Chemical Calculations 2.2 Methods of Separation – Solid and solvent Extraction		
		<b>III</b>	3.1 Atomic Absorption Spectroscopy 3.2 Molecular, Florescence and Phosphorescence Spectroscopy 3.3 Turbidimetry and Nephelometry		
		<b>IV</b>	4.1 Chromatography 4.2 Ion exchange chromatography 4.3High performance liquid chromatography		
<b>Practicals Semester V</b>					
<b>SBSCHEP5</b>	<b>Chemistry Practical</b>	-	-	6	16

**TYBSc CHEMISTRY (6 UNITS)  
SEMESTER VI**

Course Code	Title of the paper	Unit	Topic	Credits	L/Week
<b>SBSCHE601</b>	<b>Physical Chemistry</b>	<b>I</b>	1.1 Electrochemistry – III 1.2 Renewable energy resources	2.5	4
		<b>II</b>	2.1 Polymers 2.2 Phase Equilibria - II and thermodynamic relationships		
		<b>III</b>	3.1 Basics of Quantum Chemistry		
		<b>IV</b>	4.1 Molecular Spectroscopy - IV		
<b>SBSCHE602</b>	<b>Inorganic Chemistry</b>	<b>I</b>	1.1 Theories of metal ligand bond- I	2.5	4
		<b>II</b>	Theories of metal ligand bond – II 2.1 Stability of metal complexes 2.2 Reactivity of metal complexes 2.3 Electronic spectra		
		<b>III</b>	3.1 Organo metallic chemistry 3.2 Metallocenes 3.3 Catalysis		
		<b>IV</b>	4.1 Chemistry of group 17 4.2 Chemistry of group 18		
<b>SBSCHE603</b>	<b>Organic Chemistry</b>	<b>I</b>	1.1 Spectroscopy- I (UV-VIS, IR AND <sup>1</sup> H NMR)	2.5	4
		<b>II</b>	2.1 Stereochemistry- IV 2.2 Name reactions		
		<b>III</b>	3.1 Carbohydrates 3.2 Amino acids and proteins 3.3 Nucleic acids		
		<b>IV</b>	4.1 Polymers 4.2 Heterocyclic Chemistry		
<b>SBSCHE604</b>	<b>Analytical Chemistry</b>	<b>I</b>	1.1 Redox titrations 1.2 Complexometric titrations 1.3 Precipitation titrations	2.5	4
		<b>II</b>	2.1 Thin Layer Chromatography 2.2 Paper Chromatography 2.3 Gas Chromatography		
		<b>III</b>	3.1 Polarography 3.2 Amperometric titrations		
		<b>IV</b>	4.1 Thermal methods 4.2 Radioanalytical methods 4.3 Mass Spectroscopy		
<b>Practicals Semester VI</b>					
<b>SBSCHEP6</b>	<b>Chemistry Practical</b>	-	-	6	16

<b>PHYSICAL CHEMISTRY</b> <b>SEMESTER V</b> <b>COURSE CODE: SBSCHE501</b>		
	<p><b>Learning Objectives:</b></p> <ul style="list-style-type: none"> <li>● To understand different types of spectroscopy - rotational, vibrational and raman spectroscopy and numericals based on them</li> <li>● To study different types of adsorption isotherms, properties of colloidal solutions and applications of surfactants</li> <li>● To study different transmutation reactions, applications of radioisotopes, fission and fusion processes and to calculate the Q-values</li> <li>● To study the influence of ionic strength, hydrostatic pressure, dielectric constant and effect of substituents on the rate of reactions</li> </ul> <p><b>Learner's Outcome: Learner will be able to</b></p> <ul style="list-style-type: none"> <li>● solve numericals based on energy levels, wavenumbers and raman spectra</li> <li>● determine the surface area of an adsorbent using B.E.T. equation</li> <li>● explain the electrical properties of colloids, micellization and classify surfactants</li> <li>● calculate the Q-values, explain the nuclear reactor, fissile material and applications of radioisotopes as tracers</li> <li>● understand and apply the Hammett equation, also comment on how ionic strength affects the rate of reactions using numericals</li> </ul>	
UNIT	TOPIC	
<b>I</b>	<b>MOLECULAR SPECTROSCOPY</b>	<b>15L</b>
<b>1.1</b>	<p><b>Rotational Spectrum</b> - Introduction to dipole moment, polarization of a bond, bond moment, molecular structure, Rotational spectrum of a diatomic molecule, rigid rotor, moment of inertia, energy levels, conditions for obtaining pure rotational spectrum, selection rule, nature of spectrum, determination of internuclear distance and isotopic shift (Numericals expected)</p>	
<b>1.2</b>	<p><b>Vibrational Spectrum</b> - Vibrational motion, degrees of freedom, modes of vibration, vibrational spectrum of a diatomic molecule, simple harmonic oscillator, energy levels, zero point energy (Numericals expected), conditions for obtaining vibrational spectrum, selection rule and nature of spectrum.</p>	
<b>1.3</b>	<p><b>Vibrational-Rotational Spectrum of Diatomic Molecule</b> - Energy levels, selection rule, nature of spectrum, P and R branch lines. Anharmonic Oscillator - energy levels, selection rule, fundamental band, overtones (Numericals expected). Application of vibrational-rotational spectrum in determination of force constant; its significance. Infrared spectra of simple molecules like H<sub>2</sub>O and CO<sub>2</sub>.</p>	
<b>1.4</b>	<p><b>Raman Spectroscopy</b> - Scattering of electromagnetic radiation, Rayleigh scattering, Raman scattering, nature of Raman spectrum, Stoke's lines, Anti-Stoke's lines, Raman shift, quantum theory of Raman spectrum (Numericals expected), comparative study of IR and Raman spectra, rule of mutual exclusion - CO<sub>2</sub> molecule.</p>	

<b>II</b>	<b>2.1 SURFACE CHEMISTRY</b>	<b>8L</b>
	<b>Adsorption</b> - Physical and Chemical Adsorption, types of adsorption isotherms, Langmuir's adsorption isotherm, B.E.T equation for multilayer adsorption, (derivation not expected). Determination of surface area of an adsorbent using B.E.T. equation (Numericals expected)	
	<b>2.2 COLLOIDAL STATE</b>	<b>7L</b>
<b>2.2.1</b>	<b>Introduction to Colloids</b> - Emulsions, Gels, Sols.	
<b>2.2.2</b>	<b>Electrical properties of colloids</b> - Origin of charge on colloidal particles, Concept of electrical double layer, Zeta potential, Helmholtz and Stern model, Electro-kinetic phenomena- Electrophoresis, Electro-osmosis, Streaming potential, Sedimentation potential; Donnan Membrane Equilibrium.	
<b>2.2.3</b>	<b>Colloidal Electrolytes</b> - Introduction, classification; Properties of colloidal electrolytes, types of ionic micelles, micellization, Critical Micelle Concentration.	
<b>2.2.4</b>	<b>Surfactants:</b> Introduction, Classification, reverse micelles, solubilization of surfactant solutions; applications of surfactants in detergents, insecticides and food industry.	
<b>III</b>	<b>NUCLEAR CHEMISTRY</b>	<b>15</b>
<b>3.1</b>	<b>Law of disintegration</b> (Numericals expected)	
<b>3.2</b>	<b>Detection of radiation</b> - Characteristics of nuclear radiations, behavior of ion pairs in electric field, GM counter, Scintillation counter	
<b>3.3</b>	<b>Application of radioisotopes</b> - Use of radioisotopes as tracers	
<b>3.4</b>	<b>Nuclear reactions</b> - Nuclear transmutation, artificial radioactivity, Q – value of nuclear reaction, threshold energy (Numericals expected)	
<b>3.5</b>	<b>Fission process</b> - Fissile and fertile material, nuclear fission, chain reaction, factor controlling fission process- Multiplication factor and Critical size or mass of fissionable materials, nuclear power reactor and breeder reactor.	
<b>3.6</b>	<b>Fusion process</b> - Thermonuclear reactions occurring on stellar bodies and earth.	
<b>IV</b>	<b>4.1 DILUTE SOLUTIONS</b>	<b>8</b>
	<b>Colligative properties</b> - Vapour pressure and relative lowering of vapour pressure – Raoult's Law. Measurement of lowering of vapour pressure- Static and Dynamic method. <b>Elevation of Boiling point</b> - Thermodynamic derivation relating elevation in boiling point of the solution and molar mass of non- volatile solute (Numericals expected). <b>Depression of Freezing point</b> - Thermodynamic derivation relating depression in the freezing point of the solution and molar mass of non- volatile solute (Numericals expected) <b>Osmotic pressure</b> - Introduction, thermodynamic derivation of Van't Hoff equation, Van't Hoff factor (Numericals expected), Measurement of Osmotic Pressure- Berkeley and Hartley's method, Reverse Osmosis- principle and method.	
<b>4.2.1</b>	<b>Influence of solvent dielectric constant</b>	
<b>4.2.2</b>	<b>Influence of ionic strength (Numericals expected)</b>	
<b>4.2.3</b>	<b>Influence of hydrostatic pressure</b>	
<b>4.2.4</b>	<b>Linear Gibbs energy relationships- (Hammett's equation)</b> -Substituent constant, reaction constant, equation, reaction mechanism, $\sigma$ constant	

	<p><b>PRACTICALS</b></p> <p><b>Learning Objectives:</b></p> <ul style="list-style-type: none"> <li>To train the students to handle different instruments and maintain laboratory discipline</li> <li>To carry out the experiments mentioned in the course and thereby be able to correlate the importance of the theory with the practical experiments</li> </ul> <p><b>Learning Outcome: Learner will be able to</b></p> <ul style="list-style-type: none"> <li>understand the handling of instruments and correlate practical experiments with theoretical knowledge</li> <li>set up different electrochemical cells</li> <li>practice laboratory safety measures and precautions to be taken while handling the instrument, electrodes and different chemicals</li> </ul>	
	<ol style="list-style-type: none"> <li>To investigate the adsorption of acetic acid on activated charcoal and test the validity of Freundlich adsorption isotherm.</li> <li>To determine the Critical Micelle Concentration of sodium lauryl sulfate from the measurement of conductance at different concentrations.</li> <li>To determine the solubility product and solubility of AgCl potentiometrically using a chemical cell.</li> <li>To determine the amount of iodide, bromide and chloride in the mixture by potentiometric titration.</li> <li>To determine the half-life, decay constant and the average life of a radioactive element graphically.</li> <li>To study the influence of ionic strength on reaction between potassium persulphate and potassium iodide.</li> <li>To determine the Hamette's constant of ortho-, meta- and para- amino/nitro benzoic acid by pH measurements.</li> </ol>	
<b>I</b>	<b>1.1 ELECTROCHEMISTRY- III</b>	<b>9</b>
<b>1.1.1</b>	<b>Activity and Activity coefficient</b> - Lewis concept, ionic strength (Numericals expected), Mean ionic activity and mean ionic activity coefficient of an electrolyte, expression for activities of electrolytes. Debye-Huckel limiting law (No derivation).	
<b>1.1.2</b>	<b>Chemical and concentration cells</b> - Chemical cells with and without transference, Electrode concentration cells and Electrolyte concentration cells with and without transference (Numericals expected)	
<b>1.1.3</b>	<b>Polarization</b> - Concentration polarization and its elimination	
<b>1.1.4</b>	<b>Decomposition potential and Overvoltage</b> - Introduction, decomposition potential and its experimental determination, overvoltage, relationship between decomposition potential and overvoltage, factors affecting decomposition potential, Tafel's theory of overvoltage, Tafel's equation for hydrogen overvoltage, experimental determination of overvoltage (Numericals expected).	
	<b>1.2 RENEWABLE ENERGY RESOURCES</b>	<b>6</b>
<b>1.2.1</b>	<b>Fuel Cells-</b> Principle, construction and working of Bacon's fuel cell, types and applications	
<b>1.2.2</b>	<b>Hydrogen as a Fuel</b> - Future fuel, production of hydrogen by direct electrolysis of water, advantages of hydrogen as a universal energy medium.	

<b>II</b>	<b>2.1 POLYMERS</b>	<b>8</b>
<b>2.1.1</b>	<b>Basic terms involved</b> - Monomer, degree of polymerization.	
<b>2.1.2</b>	<b>Classification of polymers</b> - Classification based on source, structure, thermal response and physical properties	
<b>2.1.3</b>	<b>Molar Mass of Polymers</b> - Number average, Weight average, Viscosity average molar mass, Monodispersity and Polydispersity Index (Numericals expected)	
<b>2.1.4</b>	<b>Methods of determining Molar Masses of polymers</b> - Viscosity method using Ostwald Viscometer, Sedimentation method	
	<b>2.2 PHASE EQUILIBRIA II &amp; THERMODYNAMIC RELATIONSHIPS</b>	<b>7</b>
<b>2.2.1</b>	<b>Three component system</b> formation of one pair of partially miscible liquids	
<b>2.2.2</b>	<b>Maxwell relations</b> —derivation and application to ideal gases	
<b>2.2.3</b>	<b>Fugacity</b> - definition, experimental method of determination	
<b>III</b>	<b>BASICS OF QUANTUM CHEMISTRY</b>	<b>15</b>
<b>3.1</b>	<b>Classical theory</b> - Introduction, limitations of classical mechanics, Black body radiation, photoelectric effect, Compton effect.	
<b>3.2</b>	<b>Quantum theory</b> - Introduction, Plank's theory of quantization, wave particle duality, de-Broglie's equation, Heisenberg's uncertainty principle (Numericals expected)	
<b>3.3</b>	<b>Progressive and Standing waves</b> - Introduction, boundary conditions, interpretation and properties of wave function, Schrodinger's time independent wave equation (No derivation expected)	
<b>3.4</b>	<b>Functions and Operators</b> - State function and its significance, concept of operators, definition, addition, subtraction and multiplication of operators, commutative and non-commutative operators, linear operator, Hamiltonian operator, Eigen function and Eigen value (Numericals expected)	
<b>IV</b>	<b>MOLECULAR SPECTROSCOPY –IV</b>	<b>15</b>
<b>4.1</b>	<b>NMR-</b> Principle and theory, Nuclear spin, magnetic moment, nuclear 'g' factor, energy levels, Larmor precession, Relaxation processes in NMR (spin-spin relaxation and spin-lattice relaxation), chemical shift, $\delta$ scale, low resolution spectra. Instrumentation - NMR Spectrometer	
<b>4.2</b>	<b>ESR-</b> Principle, Fundamental equation, g-value - dimensionless constant or electron g -factor, hyperfine splitting, hyperfine structure, Instrumentation – ESR, spectrum of hydrogen and deuterium	
<b>4.3</b>	<b>Laser Spectroscopy</b> – Principle, types and applications	
	<b>PRACTICALS</b>	<b>24</b>
	<p><b>Learning Objectives:</b></p> <ul style="list-style-type: none"> <li>● To train the students to handle different instruments and maintain laboratory discipline</li> <li>● To carry out the experiments mentioned in the course and thereby be able to correlate the importance of the theory with the practical experiments</li> <li>● To interpret information from the graphs plotted</li> </ul> <p><b>Learning Outcome: Learner will be able to</b></p> <ul style="list-style-type: none"> <li>● understand the handling of instruments and correlate practical experiments with theoretical knowledge</li> </ul>	



	<ul style="list-style-type: none"> <li>● set up different types of electrochemical cells</li> <li>● practice laboratory safety measures and precautions to be taken while handling the instrument, electrodes and chemicals</li> </ul>	
	<ol style="list-style-type: none"> <li>1. To determine the molecular weight of poly vinyl alcohol from viscosity measurements.</li> <li>2. To determine the activity coefficient of Ag ions using a concentration cell without transference.</li> <li>3. To study the phase diagram of the three-component system water – chloroform / toluene – acetic acid.</li> <li>4. To titrate a mixture of weak acid and strong acid against a strong base and to determine the amount of each acid in the mixture conductometrically.</li> <li>5. To plot the graphs of mathematical functions – linear, exponential and trigonometric and identify whether they are acceptable or non-acceptable</li> <li>6. To determine the number of electrons in the redox reaction between ferrous ammonium sulphate and ceric sulphate potentiometrically</li> <li>7. To determine acidic and basic dissociation constants of amino acid and hence to calculate the isoelectric point.</li> </ol>	
	<b>REFERENCE – THEORY</b>	
	<ol style="list-style-type: none"> <li>1. Physical Chemistry, Ira Levine, 5th Edition, 2002 Tata McGraw Hill Publishing Co. Ltd.</li> <li>2. Physical Chemistry, P.C. Rakshit, 6<sup>th</sup> Edition, 2001, Sarat Book Distributors, Kolkata.</li> <li>3. Fundamental of Molecular Spectroscopy, 4<sup>th</sup> Edn. Colin N Banwell and Elaine McCash Tata McGraw Hill Publishing Co. Ltd. New Delhi, 2008.</li> <li>4. Physical Chemistry, G.M. Barrow, 6<sup>th</sup> Edition (2007), Tata McGraw Hill Publishing Co. Ltd. New Delhi.</li> <li>5. The Elements of Physical Chemistry, P.W. Atkins, 2<sup>nd</sup> Edition, Oxford University Press Oxford.</li> <li>6. Polymer Science, V.R. Gowariker, N.V. Viswanathan, Jayadev Sreedhar, New Age International (P) Ltd., Publishers, 2005.</li> <li>7. Essentials of Nuclear Chemistry, Arnika, Hari Jeevan, New Age International (P) Ltd., Publishers, 2011.</li> <li>8. Physical Chemistry, Keith J Laidler, John H. Meiser, 2<sup>nd</sup> Edition, CBS publication and distributors Pvt. Ltd.</li> </ol>	

	<b>REFERENCE - PRACTICAL</b>	
	<ol style="list-style-type: none"> <li>1. Experiments in Physical Chemistry C.W. Garland, J.W. Nibler and D.P. Shoemaker, McGraw Hill New York 8<sup>th</sup> Edition (2003)</li> <li>2. Practical Physical chemistry, Vishwanathan B. and Raghavan P.S. Viva Books (2017)</li> <li>3. Experimental Physical Chemistry, V.D. Athawale and P. Mathur, New Age International Publishers, 2001</li> </ol>	
<b>INORGANIC CHEMISTRY</b> <b>SEMESTER V</b> <b>COURSE CODE: SBSCHE502</b>		
<b>Learning objectives</b> <ul style="list-style-type: none"> <li>● To expose students to the concept of symmetry and symmetry elements</li> <li>● To understand structure of crystalline solids and defects</li> <li>● To learn the preparation and properties of superconductors and nanomaterials</li> <li>● To familiarize with chemistry of inner transition elements</li> </ul>		
<b>Learning outcomes: Learner will be able to</b> <ul style="list-style-type: none"> <li>● interpret the symmetry of simple inorganic molecules and assign appropriate point groups</li> <li>● classify crystalline solids based on structures</li> <li>● write synthesis, properties and application of superconductors and nanomaterials</li> <li>● compare properties of inner transition elements and transition elements</li> </ul>		
<b>UNIT</b>	<b>TOPIC</b>	
<b>I</b>	<b>MOLECULAR SYMMETRY AND CHEMICAL BONDING</b>	<b>Lec</b>
<b>1.1</b>	<b>Molecular symmetry:</b> Introduction, importance, symmetry elements and operations. Concept of point groups with illustrations.	<b>8</b>
<b>1.2</b>	<b>Chemical bonding:</b> MOT of heteronuclear diatomic and polyatomic species (BeH <sub>2</sub> , H <sub>2</sub> O, H <sub>3</sub> <sup>+</sup> ). Molecular shapes of linear and angular molecules. Walsh correlation diagrams of H <sub>2</sub> O and H <sub>3</sub> <sup>+</sup> .	<b>7</b>
<b>II</b>	<b>SOLID STATE CHEMISTRY</b>	
<b>2.1</b>	<b>Structure of solids:</b> Explanation of terms, closest packing of rigid spheres (SC, BCC, FCC, HCP) packing density, concept of voids, limiting radius ratio. Point defects in solids: ionic (Frenkel and Schottky) and non-ionic (vacancy and interstitial)	<b>8</b>
<b>2.2</b>	<b>Solid state synthesis:</b> Film deposition using dip coating, spin coating, chemical vapor deposition.	<b>4</b>
<b>2.3</b>	<b>Superconductivity:</b> Discovery, types, explanation of terms and applications	<b>3</b>

<b>III</b>	<b>CHEMISTRY OF INNER TRANSITION ELEMENTS</b>	
<b>3.1</b>	<b>Chemistry of lanthanides:</b> Position in the periodic table and electronic configuration. Properties, occurrence, extraction and separation of Lanthanides; Applications of lanthanides	<b>12</b>
<b>3.2</b>	<b>Chemistry of actinides (only Uranium):</b> Occurrence, extraction and application	<b>3</b>
<b>IV</b>	<b>MISCELLANEOUS TOPICS</b>	
<b>4.1</b>	<b>Comparative Chemistry of group 16:</b> Electronic configuration, trends in physical properties, allotropy. Manufacture of sulfuric acid by Contact process	<b>5</b>
<b>4.2</b>	<b>Nano materials:</b> Introduction, properties (optical and electrical), methods of synthesis and applications	<b>5</b>
<b>4.3</b>	<b>Non aqueous solvents:</b> Classification and importance of non-aqueous solvents. Characteristics and study of liquid ammonia and liquid dinitrogen tetroxide as non-aqueous solvents with respect to acid-base and redox reactions. Supercritical carbon dioxide and ionic liquids as solvents	<b>5</b>
	<b>PRACTICALS</b> <b>Learning objectives</b> <ul style="list-style-type: none"> <li>To train students to prepare simple inorganic complexes, silver nanoparticles and to analyze given inorganic complexes</li> <li>to analysis metal ions from variety of samples by complexometry</li> <li>to train students to perform titrimetric analysis under non-aqueous conditions</li> </ul> <b>Learning outcomes: The learner will be able to</b> <ul style="list-style-type: none"> <li>prepare and analyze simple inorganic complexes</li> <li>prepare and characterize silver nanoparticles using UV spectrophotometer</li> <li>estimate metal ions from an unknown sample with high degree of accuracy complexometrically</li> <li>carry assay of given drug samples by non-aqueous titrations</li> </ul>	<b>24</b>
	<ol style="list-style-type: none"> <li>Preparation of trisethylenediammine nickel thiosulphate complex.</li> <li>Preparation of tetra amine copper complex.</li> <li>Estimation of copper (complexometrically/iodometrically) in tetra amine copper complex.</li> <li>Estimation of lead complexometrically (Standardization of EDTA expected)</li> <li>Estimation of calcium from milk sample by EDTA back titration.</li> <li>Preparation of silver nanoparticles and their spectroscopic characterization.</li> <li>Estimation of two commercial drug samples using non aqueous titration.</li> </ol>	
<b>SEMESTER VI</b> <b>COURSE CODE: SBSCHE602</b>		
<b>Learning objectives</b> <ul style="list-style-type: none"> <li>To build basic concepts of coordination chemistry using crystal field and molecular orbital theory</li> <li>To introduce basic concepts of inorganic spectroscopy</li> <li>To understand methods of preparation and reactions of organometallic compounds of main group elements</li> </ul>		

- To understand properties of group 17 & 18 elements and to learn preparation of interhalogen and pseudohalogens

**Learning outcomes: Learner will be able to**

- calculate crystal field energies of given molecules
- construct molecular orbital diagrams for coordination complexes
- calculate ground term symbols for simple inorganic molecules
- write general methods of preparations and reactions of organometallic compounds of main group elements
- compare and contrast properties of group 17 & 18
- write synthesis and assign structures to interhalogens and pseudohalogens

<b>I</b>	<b>THEORY OF METAL LIGAND BOND – I</b>	
<b>1.1</b>	Introduction to Crystal field theory, splitting of d orbitals in octahedral, tetrahedral and square planar complexes. Distortions from octahedral geometry. Crystal field splitting parameter: calculation and factors affecting it. Spectrochemical series. Consequences of crystal field splitting. Limitations of CFT. Evidence for covalent bonding in complexes.	<b>11</b>
<b>1.2</b>	Molecular orbital theory for coordination compounds, molecular orbital diagrams depicting sigma bonding only for $[\text{Ti}(\text{H}_2\text{O})_6]^{3+}$ , $[\text{FeF}_6]^{4-}$ , $[\text{Fe}(\text{CN})_6]^{4-}$ , $[\text{Co}(\text{NH}_3)_6]^{3+}$ , $[\text{CoF}_6]^{3-}$	<b>4</b>
<b>II</b>	<b>THEORY OF METAL LIGAND BOND – II</b>	
<b>2.1</b>	<b>Stability of complexes:</b> Types of stability- thermodynamic and kinetic, factors affecting thermodynamic stability. Stability constants and inter-relationship.	<b>5</b>
<b>2.2</b>	<b>Reactivity of complexes:</b> Types of reactions, inert and labile complexes. Ligand substitution reactions (associative and dissociative mechanism), acid and base hydrolysis and anation reactions.	<b>5</b>
<b>2.3</b>	<b>Electronic spectra:</b> Origin, types of electronic transition in coordination compounds. Selection rules. Term and term symbols for ground state determination	<b>5</b>
<b>III</b>	<b>ORGANOMETALLIC CHEMISTRY – II</b>	
<b>3.1</b>	<b>Organometallic compounds of the main group:</b> Introduction, general methods of preparation and reactions, application in medicine and agriculture.	<b>6</b>
<b>3.2</b>	<b>Metallocenes with special reference to Ferrocene:</b> Introduction, methods of preparation, physical and chemical properties, structure on the basis of VBT.	<b>3</b>
<b>3.3</b>	<b>Catalysis:</b> Overview of catalysis (homogenous and heterogenous catalysis), basic steps involved in homogeneous catalysis. Important catalytic reactions with mechanism (hydroformylation, coupling reaction, cross coupling reaction)	<b>6</b>

<b>IV</b>	<b>Chemistry of group 17 &amp;18 elements.</b>	
<b>4.1</b>	<b>Comparative Chemistry of group 17 elements:</b> Introduction and general properties. Anomalous behavior of fluorine. Oxyacids of chlorine and structure (VSEPR). Inter halogens: Preparation, properties and structure (VSEPR). Pseudo halogens: Preparation, properties and structure (VSEPR)	<b>8</b>
<b>4.2</b>	<b>Comparative Chemistry of group 18 elements:</b> Introduction, historical perspective and general properties. Isolation of gases. Application of inert gases. Compounds of Xenon (oxides, fluorides, oxyfluorides) - preparation and structure (VSEPR).	<b>7</b>
	<b>PRACTICALS</b> <b>Learning objectives</b> <ul style="list-style-type: none"> <li>● To prepare ,characterize and estimate inorganic complexes</li> <li>● To learn to perform complexometric titrations for given metal ions</li> <li>● To estimate chlorine from a commercial sample</li> </ul> <b>Learning outcomes: The learner will be able to</b> <ul style="list-style-type: none"> <li>● synthesis ,analyze and calculate crystal field stabilization energy of inorganic complexes</li> <li>● estimate metal ions from a given sample complexometrically</li> <li>● analyze commercial sample for chlorine content by redox titration</li> </ul>	<b>24</b>
	<ol style="list-style-type: none"> <li>1. Preparation of bisethylenediammine iron sulphate complex.</li> <li>2. Preparation of tris acetylacetonato iron complex.</li> <li>3. Estimation of iron (redox titration) in tris acetylacetonato iron complex.</li> <li>4. Estimation of aluminium complexometrically. (Standardization of EDTA expected)</li> <li>5. Estimation of chlorine (iodometrically) in a commercial sample of bleaching powder.</li> <li>6. Controlled synthesis of copper oxalate hydrate complexes.</li> <li>7. To determine the wavelength of maximum absorption and calculate the value of 10Dq for any two complexes spectrophotometrically.</li> </ol>	
	<b>REFERENCE- THEORY</b>	
	<ol style="list-style-type: none"> <li>1. Concise Inorganic Chemistry, J.D. Lee, 4th Edn , ELBS</li> <li>2. Inorganic Chemistry: Principles of Structure and Reactivity, James E. Huheey</li> <li>3. Mechanisms of Inorganic Chemistry, Basolo F and Pearson R.C., John Wiley &amp; Sons, NY,</li> <li>4. Organometallic Chemistry: A Unified Approach, Ram Charan Mehrotra, New Age International.</li> <li>5. Inorganic Chemistry, D. F. Shriver and P. W. Atkins, 3<sup>rd</sup> edition, Oxford University Press (1999)</li> <li>6. Advanced Inorganic Chemistry, Cotton and Wilkinson, 3<sup>rd</sup> Edition.</li> </ol>	

	<b>REFERENCE- PRACTICAL</b>	
	<ol style="list-style-type: none"> <li>1. Practical Inorganic Chemistry, Shikha Gulati, JL Sharma, Shagun Manocha, CBS Publishers and distributors.</li> <li>2. Vogel Textbook of Quantitative Chemical Analysis G.H. Jeffery, J. Basset.</li> <li>3. Advanced Experiments in Inorganic Chemistry, G. N. Mukherjee, 1<sup>st</sup> Edn, 2010, U.N. Dhur &amp; Sons Pvt Ltd.</li> </ol>	
<b>ORGANIC CHEMISTRY</b> <b>SEMESTER V</b> <b>COURSE CODE: SBSCHE503</b>		
<b>Learning Objectives: To Understand the</b> <ul style="list-style-type: none"> <li>● Mechanisms of reactions and name reactions</li> <li>● Method of naming organic compounds</li> <li>● Stereochemistry of compounds without stereogenic center and cycloalkanes</li> <li>● Catalysts and reagents involved in reactions</li> <li>● Natural products and their structure determination and synthesis</li> <li>● Basic principles of photochemistry and some of the reactions</li> <li>● Preparation and mechanism of reactions of organometallic compounds</li> </ul>		
<b>Learning Outcomes: Learner will be able</b> <ul style="list-style-type: none"> <li>● To identify the mechanism of reactions studied with different substrates</li> <li>● Apply various catalysts and reagents for interconversion of functional groups</li> <li>● Identify the optical activity of molecules without stereogenic center and stereospecific and stereoselective reactions</li> <li>● Understand the application of polymers in day to day life</li> <li>● Elucidate the structural determination of some natural products</li> </ul>		
<b>UNIT</b>	<b>TOPIC</b>	
<b>I</b>	<b>MECHANISM OF ORGANIC REACTIONS</b>	<b>15L</b>
<b>1.1</b>	Basics terms and concepts - bond fission, reaction intermediates, electrophiles and nucleophiles, ligand, base, electrophilicity vs. acidity and nucleophilicity vs basicity.	
<b>1.2</b>	Thermodynamic and kinetic control of organic reactions - concept with mechanism of the following addition of HX to butadiene; sulfonation of naphthalene	
<b>1.3</b>	Neighbouring group participation in nucleophilic substitution reactions - participation of lone pair of electrons, kinetics and stereochemical outcome.	
<b>1.4</b>	Pyrolytic elimination - Cope, Chugaev, pyrolysis of acetates.	
<b>1.5</b>	Pericyclic reactions – introduction, definition, characteristics and types - Electro cyclic reactions (ring opening and ring closing), cycloaddition, sigma tropic rearrangement, cheletropic reaction	
<b>1.6</b>	Frontier Molecular orbitals FMO approach towards cycloaddition reactions (Diels Alder reaction and ethene dimerization), Woodward Hofmann rules	
<b>1.7</b>	Molecular rearrangements - mechanism of following rearrangements with examples and stereochemistry wherever applicable a) Migration to electron deficient carbon: Pinacol, Benzylic acid b) Migration to electron deficient nitrogen- Beckmann, Hofmann c) Migration involving a carbanion - Favorskii.	

<b>II</b>	<b>2.1 IUPAC NOMENCLATURE OF THE FOLLOWING CLASSES OF COMPOUNDS</b>	<b>7</b>
<b>2.1.1</b>	Bicyclic Compounds- spiro fused and bridged (up to 1 carbon atom) - saturated and unsaturated.	
<b>2.1.2</b>	Cumulenes, up to 3 double bonds.	
<b>2.1.3</b>	Biphenyls	
<b>2.1.4</b>	Monocyclic (5 and 6 membered) aromatic and non-aromatic heterocyclic compounds containing a maximum of two hetero atom among N,O,S	
	<b>2.2 STEREOCHEMISTRY III</b>	<b>8</b>
<b>2.2.1</b>	Recapitulation of important concepts including R/S configuration.	
<b>2.2.2</b>	Molecular chirality and element of symmetry: Mirror plane symmetry, inversion centre, rotation-reflection (alternating) axis.	
<b>2.2.3</b>	Chirality of compounds without stereogenic centre: cummulenes, spirans and biphenyls.	
<b>2.2.4</b>	Conformations of cyclohexane, mono, disubstituted cyclohexanes and their relative stabilities	
<b>III</b>	<b>3.1 CATALYSTS AND REAGENTS</b>	<b>8</b>
<b>3.1.1</b>	Study of the following catalysts and reagents with respect to functional group transformations and selectivity (no mechanism)	
<b>3.1.2</b>	Catalysts - Catalysts for hydrogenation - Raney Ni, Pt and PtO <sub>2</sub> - C=C, CN, NO <sub>2</sub> , aromatic ring; Pd/C - C=C, COCl → CHO (Rosenmund); Lindlar catalyst	
<b>3.1.3</b>	Reagents - (a) LiAlH <sub>4</sub> and Red-Al - reduction of CO, -COOR, -CN, and NO <sub>2</sub> (b) NaBH <sub>4</sub> - reduction of CO (c) SeO <sub>2</sub> - hydroxylation of allylic and benzylic positions, oxidation of CH <sub>2</sub> to CO (d) m-CPBA epoxidation of C=C (e) NBS - allylic and benzylic bromination (f) KMnO <sub>4</sub> OsO <sub>4</sub> - oxidation of C=C (g) Jones reagent, PCC and PDC oxidation of alcohols	
<b>3.1.4</b>	Designing synthesis via functional group interconversion.	
	<b>3.2 ORGANOMETALLIC CHEMISTRY</b>	<b>7</b>

<p><b>3.2.1</b></p> <p><b>3.2.2</b></p> <p><b>3.2.3</b></p>	<p>Organolithium/ magnesium compounds - Preparation using alkyl/aryl halides. Reactions with compounds containing acidic hydrogen, alkyl halides, carbonyl compounds, cyanides and CO<sub>2</sub>. Lithium dialkylcuprates - Preparation and reactions with aliphatic/ aromatic/ vinylic halides. Micheal addition</p> <p>Organozinc compounds - Preparation and application in Simmons-Smith reaction with mechanism.</p> <p>Organopalladium compounds - Heck reaction and Suzuki coupling and basic catalytic cycle for coupling reaction.</p>	
<p><b>IV</b></p>	<p><b>4.1 NATURAL PRODUCTS</b></p>	<p><b>10</b></p>
<p><b>4.1.1</b></p> <p><b>4.1.2</b></p> <p><b>4.1.3</b></p> <p><b>4.1.4</b></p>	<p><b>Natural products</b> - Introduction, sources, classification and functions (Structures of the compounds specified are expected)</p> <p>a) Terpenoids (isoprene rule) – i) citral ii) <math>\alpha</math>-terpeniol iii) camphor iv) <math>\alpha</math>-pinene b) Alkaloids – i) nicotine ii) atropine c) Vitamins – i) vitamin A ii) vitamin C d) Hormones – i) adrenaline ii) thyroxine e) Steroids – i) cholesterol ii) progesterone</p> <p>Structure determination of natural products - Ozonolysis in terpenoids, examples of open chain and monocyclic monoterpenoids ; Hofmann exhaustive methylation and degradation in alkaloids - simple open chain and monocyclic amines; Structure determination of citral and nicotine through degradation studies; Total synthesis – a) citral from 3-methylbutan-1-ol b) nicotine from nicotinic acid.</p> <p>Commercial synthesis - i) camphor from <math>\alpha</math>-pinene ii) <math>\alpha</math>- and <math>\beta</math>- ionones from citral</p> <p>Introduction to primary and secondary metabolites and broad classification of natural products based on biosynthesis</p>	
	<p><b>4.2 PHOTOCHEMISTRY</b></p>	<p><b>5</b></p>
<p><b>4.2.1</b></p> <p><b>4.2.2</b></p> <p><b>4.2.3</b></p>	<p>Introduction - Difference between thermal and photochemical reactions; Jablonski diagram, singlet and triplet states, allowed and forbidden transitions, fate of excited molecules, photosensitization.</p> <p>Photochemical reactions of olefins – i) photoisomerisation ii) photochemical rearrangement of 1,4-dienes (di-<math>\pi</math> methane)</p> <p>Photochemistry of carbonyl compounds – i) Norrish I ii) Norrish II cleavages iii) photoreduction (e.g. benzophenone to benzpinacol).</p>	
	<p><b>PRACTICALS</b></p>	<p><b>24</b></p>



	<p><b>Organic Separation</b>  Separation of a binary mixture - Type of mixture, Separation and identification (microscale) of one of the components through systematic scheme of identification.  Type: Solid + Solid (no carbohydrates to be given ) Mass of solid: 3 g</p> <p><b>Learning objective:</b></p> <ul style="list-style-type: none"> <li>● To understand the method and concept of separation of a binary mixture quantitatively</li> <li>● To train the learners to perform qualitative analysis and identify a component</li> <li>● To understand the method of purification of the components.</li> <li>● To develop the skill of determining physical constant of compounds</li> </ul> <p><b>Learning outcomes:</b></p> <ul style="list-style-type: none"> <li>● Learners will be able to identify the nature of a binary mixture and separate the mixture quantitatively.</li> <li>● To enable the students to develop skills in organic qualitative analysis</li> <li>● To enable students to purify compounds by recrystallization technique</li> </ul>	
<p><b>SEMESTER VI</b>  <b>COURSE CODE: SBSsche603</b></p> <p><b>Learning Objectives:</b>  <b>Learner will understand the basic principles of</b></p> <ul style="list-style-type: none"> <li>● Molecular spectroscopy</li> <li>● stereochemical reactions</li> <li>● Biomolecules</li> <li>● polymers and polymerisation</li> <li>● Heterocyclic compounds of one heteroatom</li> </ul> <p><b>Learner will be able to:</b></p> <ul style="list-style-type: none"> <li>● interpret spectral data in identification of various organic molecules</li> <li>● identify stereospecific and stereoselective reactions</li> <li>● Convert open chain and Haworth structures of carbohydrates.</li> <li>● identify the mono, di and polysaccharides</li> </ul>		
<b>I</b>	<b>SPECTROSCOPY-I (UV-VIS, IR AND <sup>1</sup>H NMR)</b>	<b>15</b>

<p>1.1 1.2  1.3  1.4  1.5  1.6  1.7</p>	<p>Introduction - Electromagnetic spectrum, units of wavelength and frequency UV-VIS spectroscopy - Basic theory, solvents, nature of UV-VIS spectrum, concept of chromophore, auxochrome, bathochromic shift, hypsochromic shift, hyperchromic and hypochromic effects, chromophore- chromophore and chromophore – auxochrome interactions. Calculation of absorption maxima by Woodward - Fischer Rule for conjugated polyenes. Applications of UV-VIS spectroscopy IR Spectroscopy- Basic theory, selection rule, nature of IR spectrum, characteristic vibrational frequencies of functional groups, fingerprint region. Applications of IR Spectroscopy. 1H NMR Spectroscopy - Basic theory of 1H NMR, nature of 1H NMR spectrum, chemical shift (<math>\delta</math> unit), standard for 1H NMR, solvents used. Factors affecting chemical shift - inductive effect and anisotropic effect (with reference to C=C, C<math>\equiv</math>C, C=O and benzene ring). Spin- spin coupling and coupling constant. Application of deuterium exchange technique. Application of 1H NMR in structure determination Mass Spectrometry- Basic theory. Nature of mass spectrum. General rules of fragmentation. Importance of molecular ion peak, isotopic peaks, base peak, Nitrogen rule. Fragmentation of alkanes and aliphatic carbonyl compounds including McLafferty rearrangement. Spectral characteristics of following classes of organic compounds, including benzene and mono substituted benzenes with respect to UV-VIS, IR, 1H NMR - a) alkanes b) alkenes and polyenes c) alkynes d) haloalkanes e) alcohols f) carbonyl compounds g) ethers h) carboxylic acids i) esters j) amines k) amides (broad regions characteristic of different groups are expected). Problems of structure elucidation of simple organic compounds using individual or combined use of the UV-VIS, IR, 1H NMR and Mass spectroscopic techniques. (Index of hydrogen deficiency expected).</p>	
<p><b>II</b></p>	<p><b>2.1 STEREOCHEMISTRY- IV</b></p>	<p><b>7</b></p>
<p>2.1.1  2.1.2 2.1.3  2.1.4</p>	<p>Stereoselectivity and stereospecificity - Idea of enantioselectivity (ee) and diastereoselectivity (de), Topicity - enantiotopic and diastereotopic atoms, groups and faces. Substitution reactions - SN<sub>1</sub>, SN<sub>2</sub>, SN<sub>i</sub> (reaction of alcohol with thionyl chloride). Elimination reactions - E<sub>2</sub>-Base induced dehydrohalogenation of 1-bromo-1, 2-diphenylpropane. Addition reactions to olefins - a) catalytic hydrogenation b) bromination (electrophilic anti addition) c) HX d) synhydroxylation with OsO<sub>4</sub> and KMnO<sub>4</sub> e) epoxidation followed by hydrolysis.</p>	
	<p><b>2.2 NAME REACTIONS AND SYNTHETIC APPLICATIONS</b></p>	<p><b>8</b></p>

	a) Claisen Condensation b) Michael Reaction c) Oppenauer Oxidation d) Stobbe Condensation e) Wolff-Kishner Reduction f) McMurry Reaction	
<b>III</b>	<b>3.1 CARBOHYDRATES</b>	<b>10</b>
<b>3.1.1</b>	Introduction - Sources, classification, reducing and non-reducing sugars, D and L-notations.	
<b>3.1.2</b>	Structures of Monosaccharides - Open chain structures of aldoses and ketoses, ring structures of aldohexoses, aldopentoses and ketohexoses.	
<b>3.1.3</b>	Inter conversions - open chain and Haworth forms of monosaccharides with 5 and 6 carbons	
<b>3.1.4</b>	Determination of open chain configurations of Monosaccharides - Configuration of D (+) Glucose and D (-) Fructose	
<b>3.1.5</b>	Stereoisomers of Monosaccharides - Enantiomers and diastereoisomers of monosaccharides, epimers, anomers, mutarotation (with mechanism) in D-Glucose Chain lengthening and shortening reactions: Kiliani-Fischer synthesis, Wohl's method.	
<b>3.1.6</b>	Disaccharides – introduction and structures of sucrose and maltose.	
<b>3.1.7</b>	Glycosides - General structure giving indican as an example.	
<b>3.2</b>	<b>AMINO ACIDS AND PROTEINS</b>	<b>3</b>
<b>3.2.1</b>	Amino acids - Introduction, Classification, syntheses of amino acids-Strecker synthesis, Amidomalonnate synthesis and Erlenmeyer Azalactone synthesis	
<b>3.2.2</b>	Polypeptides - Introduction, peptide bond, Merrifields solid phase peptide synthesis, Bergmann method	
<b>3.2.3</b>	Proteins - Structure, classification, properties, denaturation	
<b>3.2.4</b>	Separation and purification of proteins - Gel filtration chromatography, electrophoresis	
	<b>3.3 NUCLEIC ACIDS</b>	<b>2</b>
<b>3.3.1</b>	Introduction, classification of nucleic acids.	
<b>3.3.2</b>	Structures of sugars and bases in nucleic acids.	
<b>3.3.3</b>	Structures of nucleosides and nucleotides in DNA and RNA	
<b>3.3.4</b>	Base pairing in nucleic acids	
<b>3.3.5</b>	Importance of nucleic acids - self duplication and protein synthesis	

<b>IV</b>	<b>4.1 POLYMERS</b>	<b>8</b>
<p><b>4.1.1</b></p> <p><b>4.1.2</b></p> <p><b>4.1.3</b></p> <p><b>4.1.4</b></p> <p><b>4.1.5</b></p> <p><b>4.1.6</b></p> <p><b>4.1.7</b></p>	<p>Introduction - General idea of monomers, polymers and polymerization, natural and synthetic polymers, homopolymers and copolymers, classification of polymers. Copolymers – alternating, block, random and graft.</p> <p>Mechanism of free radical, cationic and anionic addition polymerisation.</p> <p>Stereochemistry of polymers -Tacticity, role of Ziegler–Natta catalyst (coordination polymerization) in directing the tacticity in polypropylene (no mechanism).</p> <p>Elastomers - Natural and synthetic rubbers. Diene polymerization - 1,2-and 1,4-addition (cis and trans) polymerization of isoprene. 1,3-Butadiene- styrene copolymer.</p> <p>Preparation and uses of polymers- (a) Addition polymers - (i) polyethylene (ii) polypropylene (iii) PVC (iv) polystyrene (v) polyacrylonitrile (vi) polyvinylalcohol (vii) poly (tetrafluoroethelyene); b) Condensation polymers – (i) polyesters (ii) polyamides ( Nylon-6, Nylon-66) (iii) polyurethans (iv) phenol-formaldehyde resin (v) urea- formaldehyde resin (vi) epoxy resin (vii) polycarbonates (viii) saran (ix) SAN (x) ABS</p> <p>Additives to polymers - Plasticizers, stabilizers and fillers.</p> <p>Recyclable polymers - Biodegradable polymers and their uses. Biomedical uses of polymers.</p> <p>(*Identification of monomers in a given polymer and knowing the structure of a polymer from a given set of monomers is expected)</p>	

	<b>4.2 HETEROCYCLIC CHEMISTRY</b>	<b>7</b>	
<p><b>4.2.1</b> Introduction - Electronic structure and aromaticity of furan, pyrrole, thiophene and pyridine</p> <p><b>4.2.1</b> Synthesis - Synthesis of furans, pyrroles, and thiophenes by Paal Knorr synthesis. Pyridine by Hantzsch synthesis from 1,5-diketones</p> <p><b>4.2.2</b> Reactivity - Reactivity towards electrophilic substitution reactions- of furan, pyrrole, thiophene on the basis of stability of intermediate and pyridine on the basis of electron distribution. Nucleophilic substitution of pyridine on the basis of electron distribution</p> <p><b>4.2.3</b> Reactions of heterocycles - furan, pyrrole and thiophene: Halogenation, Nitration, sulphonation, Vilsmeierformylation reaction, Friedal-crafts reaction</p> <p><b>4.2.4</b> Furan - Diels-Alder reaction, ring opening of furan</p> <p>Pyrrole - Acidity and basicity of pyrrole- comparison of basicity of pyridine, pyrrole and pyrrolidine, Acid catalysed polymerisation of pyrrole</p> <p><b>4.2.5</b> Pyridine - Basicity, Comparison of basicity of pyridine pyrrole and piperidene</p> <p><b>4.2.6</b> Sulphonation of pyridine, with and without catalyst. Reduction. Oxidation of alkyl pyridines and action of sodamide (Chichibabin reaction)</p> <p><b>4.2.7</b></p>			
	<p><b>PRACTICALS</b></p> <p><b>Learning objective:</b></p> <ul style="list-style-type: none"> <li>● To understand the method and concept of separation of a binary mixture quantitatively <b>by physical method</b></li> <li>● To train the learners to perform qualitative analysis and identify a component</li> <li>● To understand the method of purification of the components.</li> <li>● To develop the skill of determining physical constant of compounds</li> <li>● <b>To help learners to prepare synthetically useful organic compounds.</b></li> <li>● To acquaint learners with chromatographic techniques</li> <li>● To interpret spectrum</li> </ul> <p>Learning outcomes:</p> <ul style="list-style-type: none"> <li>● Learners will be able to identify the nature of a binary mixture and separate the mixture quantitatively.</li> <li>● To enable the students to develop skills in organic qualitative analysis</li> </ul>		<b>24</b>

	<ul style="list-style-type: none"> <li>● To enable students to purify compounds by distilling technique</li> <li>● To prepare organic compounds and understand the course of the reaction with the help of TLC</li> <li>● To elucidate the structure of a compound based on the spectral data</li> </ul>	
	<ol style="list-style-type: none"> <li>1. Organic Separation: Separation of a binary mixture: Type of mixture, separation and identification (micro scale) of one component through systematic scheme of identification.</li> <li>2. Types: a) Volatile Liquid + Solid b) Volatile Liquid + Non-volatile liquid (Volatile ~ 6-8mL, Non-volatile ~ 4-6 mL)</li> <li>3. Preparation of organic compounds: Preparation of organic compound as per the procedure given, measuring the mass of crude, purification of the separated product by crystallization and recording of the m.p. (Quantity of the reactant to be given: 1 g)</li> <li>4. Preparations: <ol style="list-style-type: none"> <li>a) 2- Naphthol to Methyl-2-naphthyl ether</li> <li>b) Phthalic anhydride to Phthalimide</li> <li>c) p-Bromoacetanilide to p-bromoaniline.</li> <li>d) Phthalic anhydride to anthranilic acid ( 2 step preparation).</li> </ol> </li> </ol> <p><b>*Demonstration of TLC for any of the above reactions to understand the progress of the reaction</b></p> <ol style="list-style-type: none"> <li>5. Students will identify the compound based on the spectra provided (NMR, IR and Mass) and plan a synthesis for the same compound.</li> </ol>	
	<p><b>REFERENCE- THEORY</b></p>	

	<ol style="list-style-type: none"> <li>1. Organic chemistry, T.W Graham, Solomons Craig, B Fryhle</li> <li>2. Organic Chemistry, Jonathan Clayden, Nick Greeves, Stuart Warren and Peter Wothers, Oxford University Press.</li> <li>3. A Guidebook to mechanism in Organic Chemistry, Peter Sykes, 6<sup>th</sup> Edition, Pearson Education, New Delhi.</li> <li>4. Organic Chemistry, 8<sup>th</sup> Edition John McMurry.</li> <li>5. Stereochemistry By Nasipuri</li> <li>6. Stereochemistry, P.S. Kalsi, 4<sup>th</sup> Edition, New age International Limited.</li> <li>7. Name Reactions in Heterocyclic Chemistry-Jie Jack Li, Wiley Interscience publications, 2005.</li> <li>8. Name Reactions- Jie Jack Li, 4<sup>th</sup> Edition, Springer Pub.</li> <li>9. Lehninger Principles of Biochemistry, 7<sup>th</sup> Edition, David Nelson and Michael Cox, Publisher W.H Freeman</li> <li>10. IUPAC Nomenclature by S.C.Pal</li> <li>11. Chemistry of Natural Products, O.P. Agarwal</li> <li>12. Chemistry of Natural Products, Chatwal Anand Vol I and II</li> </ol>	
	<b>REFERENCE- PRACTICAL</b>	
	<ol style="list-style-type: none"> <li>1. Practical Organic Chemistry – A.I. Vogel</li> <li>2. Practical Organic Chemistry- Middleton</li> <li>3. Practical Organic Chemistry- O.P. Aggarwal</li> </ol>	

**ANALYTICAL CHEMISTRY  
SEMESTER V  
COURSE CODE: SBSCHE504**

**Learning Objectives:**

- To introduce the importance of statistical analysis of data and learn about parameters affecting accuracy and precision of the data.
- To impart knowledge about different sampling techniques used for sampling of solids, liquids and gases and various sub sampling methods used in chemical analysis.
- To introduce various concentration units, their interconversion and importance of limiting reagent concepts. To apply the knowledge acquired to solve a hypothetical problem.
- To learn about solvent extraction and SPE as a tool of pre-concentration and separation.
- To introduce the learner to the various types of chromatographic separation methods used in the field of analytical chemistry.
- To learn principle, working and applications of atomic spectroscopy

**Learning Outcomes: The learner will be able to**

- apply statistical tests to the given data or the data generated in the laboratory to comment on the accuracy and precision of a given method and to correlate between two different methods used for the same sample.
- understand and select appropriate tools to be used for different samples and the importance of sub-sampling.
- work comfortably with different concentration units, inter-convert them as per requirement and understand controlling of reactant concentration to increase yield in the lab and also at industrial level.
- compare different spectroscopic methods with regards to working, limitations and advantages
- to calculate concentrations of unknown compounds from given data
- learn the uniqueness of each separation method, understand and apply the methods for separation of mixtures and to compare with other instrumental methods of separation.

UNIT	TOPIC	L
<b>I</b>	<b>1.1 STATISTICAL TREATMENT OF DATA – I</b>	<b>8</b>
<b>1.1.1</b>	Treatment of Analytical Data - Criteria for rejection of doubtful data - (i) 2.5 d rule (ii) 4 d rule (iii) Q test	
<b>1.1.2</b>	Concept of Confidence limit, confidence interval and its computation using - (i) Population standard deviation (ii) Student's t-test (ii) Range	
<b>1.1.3</b>	Test of significance- (i) Null hypothesis (ii) F-test (variance ratio test)	
<b>1.1.4</b>	Graphical representation of data and obtaining best fitting straight line i) line passing through origin ii) not passing through the origin (Derivation is not expected); i) Method of averages ii) Method of least squares	



	<b>1.2 SAMPLING</b>	<b>7</b>
<b>1.2.1</b>	Sampling - Terms involved, importance, types	
<b>1.2.2</b>	Sampling of gases - ambient and stack sampling, equipments used	
<b>1.2.3</b>	Sampling of liquids - homogeneous and heterogeneous, static and flowing	
<b>1.2.4</b>	Sampling of solids- free flowing and compact; importance of particle and sample size	
<b>1.2.5</b>	Reduction of sample size – need and methods (i) Coning and quartering (ii) Riffling	
<b>II</b>	<b>2.1 CHEMICAL CALCULATIONS</b>	<b>5</b>
<b>2.1.1</b>	Interconversion of various concentration units	
<b>2.1.2</b>	Percent composition of elements in chemical compounds	
<b>2.1.3</b>	Stoichiometry-limiting reagent <b>(Numericals expected)</b>	
	<b>2.2 METHODS OF SEPARATION - SOLVENT AND SOLID EXTRACTION</b>	<b>10</b>
<b>2.2.1</b>	Partition coefficient, distribution ratio and separation factor	
<b>2.2.2</b>	Single step, multistep extraction, percentage extraction and extraction efficiency <b>(Numericals expected)</b>	
<b>2.2.3</b>	Role of complexing agents in solvent extraction, chelation, ion pair formation	
<b>2.2.4</b>	Types of solvent extraction: Batch and continuous, Craig's counter current extraction	
<b>2.2.5</b>	Solid phase extraction - Principle, process and applications	
<b>2.2.6</b>	Comparison of solid phase extraction with solvent extraction	
<b>III</b>	<b>3.1 Optical Methods – II</b>	
<b>3.1.1</b>	Atomic Spectroscopy: Flame Emission Spectroscopy (FES) and Atomic Absorption Spectroscopy (AAS) – Introduction	<b>7</b>
<b>3.1.2</b>	Energy level diagram, Atomic, Absorption and Emission spectra	
<b>3.1.3</b>	Flame Photometry – Principle; Instrumentation – Flame Atomizers, Types of burners, wavelength selectors, detectors	
<b>3.1.4</b>	Atomic Absorption Spectroscopy- Principle; Instrumentation- source, chopper, flame and electro-thermal atomizer	
<b>3.1.5</b>	Quantification, methods of FES and AAS- Calibration curve, Standard addition and Internal standard methods	
<b>3.1.6</b>	Comparison between FES and AAS	
<b>3.1.7</b>	Applications, advantages and limitations of FES and AAS	
	<b>3.2 Molecular Fluorescence and Phosphorescence Spectroscopy</b>	<b>4</b>
<b>3.2.1</b>	Introduction and Principle (Jablonski Diagram)	
<b>3.2.2</b>	Relationship between Fluorescence intensity with concentration	
<b>3.2.3</b>	Factors affecting Fluorescence and Phosphorescence	
<b>3.2.4</b>	Instrumentation and Applications of Molecular Fluorescence and Phosphorescence Spectroscopy	
	Comparison of Fluorimetry and Phosphorimetry	

3.2.5. 3.2.6	Comparison of Fluorimetry and Phosphorimetry with Absorptions methods	
	<b>3.3 TURBIDIMETRY AND NEPHELOMETRY</b>	<b>4</b>
3.3.1 3.3.2 3.3.3	Introduction and Principle Factors affecting scattering of radiation – Concentration, particle size, wavelength and refractive index Instrumentation and Applications of Turbidimetry and Nephelometry	
<b>IV</b>	<b>CHROMATOGRAPHY-I</b>	
4.1	Chromatography - Introduction to chromatographic techniques, Classification of chromatographic techniques. Separation based on partition, adsorption, ion-exchange and size exclusion.	<b>2</b>
	<b>4.2 ION EXCHANGE CHROMATOGRAPHY</b>	<b>8</b>
4.2.1 4.2.2 4.2.3 4.2.4 4.2.5	Introduction, Principle Types of ion-exchanger, Ideal properties of resin Ion exchange equilibria and mechanism, selectivity coefficient and separation factor; Factors affecting separation of ions Ion exchange capacity and its determination for cation and anion exchangers Applications - Preparation in demineralized water, Separation of halides, concentration of trace elements, separation of amino acids and preparation of primary standard solutions	
	<b>4.3 HIGH PERFORMANCE LIQUID CHROMATOGRAPHY</b>	<b>5</b>
4.3.1 4.3.2 4.3.3	Principle and Instrumentation, Normal and Reverse phase HPLC Detectors – Universal detectors – RI and specific detector - UV Applications of HPLC	

## **PRACTICALS PIV**

### **Learning Objectives:**

- **To train learners to prepare standard solutions of known concentration.**
- **To train learners to handle and standardize analytical instruments for its optimum use.**
- **To introduce the learner to various classical and instrumental methods of analysis to real life and commercial samples.**

### **Learning Outcomes: The learner will be able to**

- **decide suitability of an instrument for its use in analysis.**
- **learn to prepare and standardise solutions with the highest degree of accuracy.**
- **analyse different samples using various methods of chemical analysis.**

	<ol style="list-style-type: none"> <li>1. Determination of sodium carbonate in washing soda by pH metry titration.</li> <li>2. Estimation of the amount of Cr (VI) in the given solution as dichromate by the method of least squares spectrophotometrically</li> <li>3. Estimation of the amount of vitamin C in the given solution by redox titration with Ce (IV)</li> <li>4. Determination of saponification value of given oil</li> <li>5. Determination of the amount of acetic acid in a sample of vinegar by the potentiometric titration with a standard base using quinhydrone electrode</li> <li>6. Determination of the amount of Fe(III) using bioreagent in the given solution spectrophotometrically</li> <li>7. Determination of the amount of potassium in commercial sample by flame photometry using calibration curve method</li> </ol>	
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**SEMESTER VI  
COURSE CODE: SBSCHE604**

**Learning objectives:**

- To study various types of classical methods of titration and to determine their end point graphically and by calculation.
- To learn about complexometric titrations with regards to theory, suitability and applications.
- To understand the theory behind precipitation titration and its importance in the determination of halides.
- To learn classical methods of chromatography as a tool for separation and identification.
- To learn gas chromatography as a technique for separation and identification of volatile compounds.
- To understand the principle, instrumentation and application of polarography and amperometry
- To know about different thermal methods and to study thermogravimetric analysis of various compounds as a tool for identification and quantification.
- To get basic knowledge of NAA as a radio analytical method.

**Learning outcomes : Learner will be able to**

- calculate the theoretical end point of titrations graphically and by calculations.
- comprehend theory, working and applications of TLC, PC and GC.
- decide a suitable method for a given halide depending on the conditions.
- explain principle and working of polarography and amperometry
- calculate polarographic parameters using Ilkovic equation for given data
- plot and interpret the thermogram for a given compound.
- understand and write applications of TGA and NAA.

<b>I</b>	<b>CLASSICAL METHODS OF ANALYSIS (TITRIMETRY)</b>	
	<b>1.1 REDOX TITRATION</b>	<b>5</b>

<b>1.1.1</b>	Introduction to Redox titrations	
<b>1.1.2</b>	Construction of the titration curves and calculation of Esystem in aqueous medium in case of i) One electron system ( $\text{Fe}^{+2}$ Vs $\text{Ce}^{+4}$ ) ii) Multielectron system ( $\text{Fe}^{+2}$ Vs $\text{MnO}_4^-/\text{Cr}_2\text{O}_7^{2-}$ ) (*Numericals expected)	
<b>1.1.3</b>	Theory of redox indicators, use of diphenyl amine and ferroin as indicators	
	<b>1.2 COMPLEXOMETRIC TITRATIONS</b>	<b>5</b>
<b>1.2.1</b>	Introduction, construction of titration curves	
<b>1.2.2</b>	Use of EDTA as a titrant, absolute and conditional formation constant of metal EDTA complexes, effect of pH ion EDTA equilibria.	
<b>1.2.3</b>	Types of EDTA titrations	
<b>1.2.4</b>	Factors enhancing selectivity of EDTA as a titrant	
<b>1.2.5</b>	Metallochromic indicators: Theory, examples and applications	
	<b>1.3 PRECIPITATION TITRATIONS</b>	<b>5</b>
<b>1.3.1</b>	Argentimetric titrations, construction of the titration curves (Numericals expected)	
<b>1.3.2</b>	Volhard's method and Mohr's method	
<b>1.3.3</b>	Adsorption indicators (Fajan's method), theory and applications	
<b>II</b>	<b>CHROMATOGRAPHY II</b>	
	<b>2.1 THIN LAYER CHROMATOGRAPHY</b>	<b>4</b>
<b>2.1.1</b>	Introduction and Principle; Stationary and mobile phase, Sample application	
<b>2.1.2</b>	Methods of detection of developed spots, qualitative and quantitative analysis	
<b>2.1.3</b>	Applications - i) Determining purity of a given solute (ii) Following progress of a given reaction	
	<b>2.2 PAPER CHROMATOGRAPHY</b>	<b>4</b>
<b>2.2.1</b>	Principle, Techniques and different modes of development - Ascending, descending and circular	
<b>2.2.2</b>	Applications - Separation of cations	
	<b>2.3 GAS CHROMATOGRAPHY</b>	<b>7</b>
<b>2.3.1</b>	Introduction and Principle of Gas chromatography (GC); Theory and terms involved	
<b>2.3.2</b>	Instrumentation - Block diagram and components, Types of columns, Stationary phases in GSC and GLC; Detectors: TCD, FID and ECD	
<b>2.3.3</b>	Interpretation of gas chromatogram, terms involved - Retention time, retention volume, relative retention, resolution and HETP	
<b>2.3.4</b>	Applications - Qualitative and quantitative analysis	
<b>2.3.5</b>	Comparison between GSC and GLC	
<b>2.3.6</b>	GC in hyphenated techniques	
<b>III</b>	<b>ELECTROANALYTICAL TECHNIQUES</b>	

	<b>3.1 POLAROGRAPHY</b>	<b>11</b>
<b>3.1.1</b>	Difference between potentiometry and voltammetry, polarizable and non-polarizable electrodes	
<b>3.1.2</b>	Basic principle of polarography, H shaped polarographic cell, DME- construction, working, advantages and limitations.	
<b>3.1.3</b>	DC polarogram - Terms involved- Residual current, Diffusion current, Limiting current, Half wave potential; Role and selection of supporting electrolyte, Interference of Oxygen and its removal, Polarographic maxima and maxima suppressors, Qualitative aspects of polarography - Half wave potential $E_{1/2}$ , factors affecting $E_{1/2}$ , Quantitative aspect of polarography - Ilkovic's Equation -terms involved (No derivation)	
<b>3.1.4</b>	Quantification of Polarogram by - i) Wave height ii) Internal standard method (iii) Standard addition method	
<b>3.1.5</b>	Applications, Advantages and Limitations of Polarography	
	<b>3.2 AMPEROMETRIC TITRATIONS</b>	<b>4</b>
<b>3.2.1</b>	Principle of Amperometric titrations; Rotating Platinum Electrode - Construction, advantages and limitations	
<b>3.2.2</b>	Titration curves with examples of Amperometric titrations	
<b>3.2.3</b>	Advantages and limitations of Amperometric titrations	
<b>IV</b>	<b>MISCELLANEOUS METHODS</b>	
	<b>4.1 THERMAL METHODS</b>	<b>7</b>
<b>4.1.1</b>	Introduction to various thermal methods -TGA, DTA, DSC and Thermometric titrations	
<b>4.1.2</b>	Thermogravimetric analysis (TGA) – Instrumentation - Block diagram of thermobalance, balance, furnace, temperature measurement and control, recorder)	
<b>4.1.3</b>	Factors affecting thermogram - Instrumental factors and sample characteristics	
<b>4.1.4</b>	Thermogram of $\text{CaC}_2\text{O}_4 \cdot \text{H}_2\text{O}$ and $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$	
<b>4.1.5</b>	Applications: i) Determination of drying and ignition temperature range ii) Determination of percent composition of binary mixtures (Estimation of calcium and magnesium oxalate)	
	<b>4.2 RADIOANALYTICAL METHODS</b>	<b>5</b>
<b>4.2.1</b>	Introduction, classification of radio analytical methods	
<b>4.2.2</b>	Neutron activation analysis (NAA) - Principle, basic theory, Calibration curve method	
<b>4.2.3</b>	Advantages, limitations and applications of NAA	
	<b>4.3 MASS SPECTROMETRY</b>	<b>3</b>
<b>4.3.1</b>	Introduction, principle and basic theory of Mass Spectroscopy (MS)	
<b>4.3.2</b>	Instrumentation- Schematic diagram, components of mass spectrometer	
<b>4.3.3</b>	Applications of MS	

	<p><b>PRACTICALS</b></p> <p><b>Learning Objectives:</b></p> <ul style="list-style-type: none"> <li>● <b>To train learners to prepare standard solutions of known concentration.</b></li> <li>● <b>To train learners to handle and standardize analytical instruments for its optimum use.</b></li> <li>● <b>To introduce the learner to various classical and instrumental methods of analysis to real life and commercial samples.</b></li> </ul> <p><b>Learning Outcomes: The learner will be able to</b></p> <ul style="list-style-type: none"> <li>● <b>decide suitability of an instrument for its use in analysis.</b></li> <li>● <b>learn to prepare and standardise solutions with the highest degree of accuracy.</b></li> <li>● <b>analyse different samples using various methods of chemical analysis.</b></li> </ul>	
	<ol style="list-style-type: none"> <li>1. Estimation of Magnesium from talcum powder</li> <li>2. Determination of Vitamin C content of a given tablet by titration against NaOH by pH metry</li> <li>3. Determination of percentage purity of a common salt using a cation exchanger (Amberlite IR120)</li> <li>4. Determination of the amount of fluoride in the given solution colorimetrically</li> <li>5. Determination of phosphoric acid in cola sample using pH metry</li> <li>6. Estimation of glucose in honey by Wilstatter's method</li> <li>7. Statistical Evaluation of data: Rejection of data and Test of significance.</li> </ol>	
	<p><b>REFERENCES – THEORY AND PRACTICAL</b></p>	
	<ol style="list-style-type: none"> <li>1. Fundamentals of analytical Chemistry, 8<sup>th</sup> Edition :Skoog , West, Holler and Crouch, India Edition</li> <li>2. Analytical Chemistry –G.D. Christian, 6<sup>th</sup> Edition, John Wiley and Sons.</li> <li>3. Instrumental Analysis - Skoog, Holler and Crouch (2007), Cenage Learning India Private Limited (2007)</li> <li>4. Modern analytical Chemistry- David Harvey, 2000</li> <li>5. Thermal Methods, James Todd-Analytical Chemistry by Open Learning</li> <li>6. Vogel's Quantitative Chemical Analysis, 3<sup>rd</sup> edition</li> <li>7. Analytical Chemistry-Krupadanam David, University Press; 2012</li> <li>8. Instrumental Methods of Analysis-Willard, Merritt, Dean and Settle, 7<sup>th</sup> Edition.</li> <li>9. Instrumental Methods of Chemical Analysis –Chatwal Anand, 5<sup>th</sup> Edition, 2005. Himalaya Publishing House.</li> </ol>	

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