

AC 27/2/13
Item No. 4.20

UNIVERSITY OF MUMBAI



Syllabus for sem V & VI

Program: B.Sc.

Course: CHEMISTRY

(Credit Based Semester and Grading System with
effect from the academic year 2013–2014)

**T.Y.B.Sc.
CHEMISTRY
Credit Based Semester and Grading System
To be implemented from the Academic year 2013-2014**

**SEMESTER V
Theory**

Course	UNIT	TOPICS	Credits	L / Week
USCH501	I	<p>1.1 Colligative Properties of Dilute Solutions (8L) 1.1.1 Dilute solution, colligative properties, Raoult's law, relative lowering of vapour pressure. 1.1.2 Elevation in boiling point of a solution, thermodynamic derivation relating elevation in the boiling point of a solution and the molar mass of the non-volatile solute. 1.1.3 Depression in freezing point of a solution, thermodynamic derivation relating the depression in the freezing point of a solution and the molar mass of the non-volatile solute. 1.1.4 Osmotic pressure, van't Hoff's equation for osmotic pressure, (derivation is expected) and determination of molar mass of the solute. Abnormal molar masses of solutes and van't Hoff factor (calculation of Degree of Association and Degree of Dissociation.) 1.2 Phase Rule (7L) 1.2.1 Gibb's phase rule and terms involved in the equation. 1.2.2 Application of phase rule to ONE component systems (i) water system, (ii) sulphur system 1.2.3 Application of phase rule to TWO component systems, condensed systems, condensed phase rule, eutectic systems (Lead-Silver system), desilverisation of lead. 1.2.4 Introduction to three component system, explanation of phase diagram for three liquids forming one immiscible pair.</p>	2.5	1

	<p style="text-align: center;">II</p>	<p>2.1 Surface Chemistry & Catalysis (9L) 2.1.1 Adsorption: Physical and Chemical Adsorption, types of adsorption isotherms . Langmuir’s adsorption isotherm (Postulates and derivation expected). B.E.T. equation for multilayer adsorption, (derivation not expected). significance of the terms involved in the equation is expected.),determination of surface area of an adsorbent using B.E.T. equation. Numericals on surface area determination are expected. 2.1.2 Catalysis: Homogeneous and heterogeneous catalysis, catalytic activity and selectivity, promoters, inhibitors, catalyst poisoning and deactivation, 2.1.3 Acid-Base catalysis, mechanism and kinetics of acid-base catalyzed reactions, effect of pH on acid-base catalyzed reactions. Mechanism and kinetics of enzyme catalyzed reaction (Michaelis-Menten equation). 2.2 Colloids (6L) 2.2.1 Introduction to colloidal state of matter. 2.2.2 Origin of charge on colloidal particles. Concept of electrical double layer, zeta potential, Helmholtz and Stern model, Electro-kinetic phenomena: 1.Electrophoresis ,2.Electrophoresis ,3. Streaming potential 4. Sedimentation potential . 2.2.3 Colloidal electrolytes. 2.2.4 Donnan Membrane Equilibrium. 2.2.5 Surfactants, micelle formation, applications of surfactants in detergents, food industry, in pesticide formulations.</p>		<p style="text-align: center;">1</p>
	<p style="text-align: center;">III</p>	<p>3.1 Electrochemistry – Electrochemical cells (15L) 3.1.1 Lewis concept of Activity and Activity coefficient, Mean ionic activity and mean ionic activity coefficient γ_{\pm} of an electrolyte, expression for activities of electrolytes of different valence type, ionic strength of a solution, Debye-Huckel limiting law (derivation not expected)</p>		<p style="text-align: center;">1</p>

	<p>3.1.2 Classification of cells: 1.chemical cells without transference 2.Concentration cells with and without transference (derivations of expression for concentration cell EMF are expected) Origin of liquid-liquid junction potential and its elimination using a salt bridge.</p> <p>3.1.3 Applications of EMF .measurements in the determination of 1. pH of a solution using quinhydrone and glass electrode. 2 solubility and solubility product of sparingly soluble salts using chemical cell and concentration cell method 3. determination of liquid-liquid junction potential .</p>		
<p style="text-align: center;">IV</p>	<p>4.1 Introduction to Polymers (8L) 4.1.1 Basic terms : macromolecule, monomer, repeat unit, degree of polymerization. 4.1.2. Classification of polymers based on (i) source, (ii) structure, (iii) thermal response, (iv) physical properties. 4.1.3. Molar masses of polymers: 1. Number average molar mass, 2.Weight average molar mass, 3. Viscosity average molar mass, monodispersity, polydispersity. 4.1.4. Methods of determining molar masses of polymers : 1. Ultracentrifuge method (Limiting velocity method only). Viscosity method (Mark-Houwink equation). 4.1.5. Introduction to light emitting polymers (characteristics, method of preparation and it's application are expected). 4.2 Crystalline State (7L) 4.2.1. Laws of Crystallography 4.2.2. Characteristics of simple cubic, face centered and body centered cubic system, inter planar distance in cubic lattices (only expressions for ratios of inter planar distances are expected). 4.2.3. Use of X- rays in the study of crystal structure, Bragg's equation (derivation expected), X- ray diffraction method of studying crystal lattices, structure of NaCl and KCl,</p>		<p style="text-align: center;">1</p>

		determination of Avagadro number. 4.2.4. Elementary idea of defects in crystals- Frenkel defect and Schottky defect.		
USCH502	I	<p>1. Chemical Bonding And Solid State Chemistry (15L)</p> <p>1.1 Molecular Symmetry (10L)</p> <p>1.1.1 Introduction and Importance.</p> <p>1.1.2 Symmetry elements and symmetry operations.</p> <p>1.1.3 Concept of a Point Group with illustrations using the following point groups: (i) $C_{\infty v}$ (HCl), (ii) $D_{\infty h}$ (H_2), (iii) C_{2v} (H_2O), (iv) C_{3v} (NH_3), (v) C_{2h} (trans – trichloroethylene), and (vi) D_{3h} (BCl_3).</p> <p>1.2 Molecular Orbital Theory for Polyatomic Species (5L)</p> <p>1.2.1 Simple triatomic species: H_3^+ and H_3 (correlation between bond angle and Molecular orbitals).</p> <p>1.2.2 Other molecules (considering only σ-bonding): i) BeH_2, ii) H_2O,</p>	2.5	1

	II	<p>2. Solid Materials (15L) 2.1 Structures of Solids (10L) 2.1.1 Importance of solid state chemistry. 2.1.2 Classification of solids on the basis of bonding. 2.1.3 Explanation of terms viz. crystal lattice, lattice points, unit cells and lattice constants. 2.1.4 Closest packing of rigid spheres (hcp, ccp), packing density in simple cubic, bcc, fcc and hcp lattices (numerical problems expected). 2.1.5 Structure metallic solids. 2.1.6 Tetrahedral and octahedral interstitial voids in ccp lattice, tetrahedral holes, limiting radius ratios for different coordination numbers and their significance, calculation of limiting radius ratio for coordination number 4. 2.1.7 Structures of sodium chloride and cesium chloride. 2.2 Superconductivity (05L) 2.2.1 Superconductivity, Meissner effect. 2.2.2 Different superconducting materials viz, conventional superconductors, organic superconductors, alkali metal fullerenes (A_3C_{60}) and high temperature Superconductors. 2.2.3 Applications of superconducting materials.</p>		1
	III	<p>3. Chemistry of elements (15L) 3.1 Inner transition elements (3L) 3.1.1 Introduction: position of f-block elements and comparison between lanthanides and actinides 3.1.2 The shapes of <i>f</i>-orbitals. 3.1 Lanthanides Series (10L) 3.2.1 Chemistry of lanthanides with reference to (i) lanthanide contraction, (ii) Oxidation states (iii) magnetic and spectral properties, 3.2.2 Occurrence, extraction and separation of lanthanides by Solvent extraction. 3.2.3 Applications of lanthanides.</p>		1

		<p>3.3 Actinides Series (2L) 3.3.1 Chemistry of Uranium and with reference to occurrence, extraction (solvent extraction method), 3.3.2 Properties and applications.</p>		
	IV	<p>4. Solution Chemistry 4.1 Acid-base Chemistry in Aqueous Medium (8L) 4.1.1 Acidity of mono- and polyatomic cations. 4.1.2 Basicity of mono- and polyatomic anions (discussion for 4.1.1 as well as 4.1.2 to Include Latimer equation and predominance diagrams). 4.2 Chemistry in Non-aqueous Solvents (7L) 4.2.1 Classification of solvents and importance of non-aqueous solvents. 4.2.2 Characteristics and study of liquid ammonia, dinitrogen tetraoxide and acetic acid as non-aqueous solvents with respect to (i) acid-base reactions and (ii) redox reactions.</p>		1
USCH503	I	<p>1.1. Mechanism of Organic Reactions (15L) 1.1.1 Thermodynamic and Kinetic control of organic reactions: Concept with mechanisms of the following reactions: addition of HX to butadiene; sulfonation of naphthalene. Nucleophilicity/ electrophilicity vs Basicity/acidity. 1.1.2 Mechanism of elimination reactions, with stereochemistry: E1 and E2 reactions: regioselectivity (Saytzeff and Hofmann rules). 1.1.3 Mechanism of reactions of carbonyl compounds with nucleophiles: 1.1.3.1 Formation of acetals/ketals from aldehydes and ketones. 1.1.3.2 Reaction of aldehydes and ketones with primary and secondary amines. 1.1.3.3 Acyl nucleophilic substitution (tetrahedral mechanism): Acid catalysed esterification of Carboxylic acids and base promoted hydrolysis of esters. 1.1.4 Mechanism of rearrangements with examples and stereochemistry wherever applicable. 1.1.4.1 Migration to electron deficient carbon: Pinacol,</p>	2.5	1

		<p>Benzylic acid. 1.1.4.2 Migration to electron deficient nitrogen: Beckmann, Hofmann.</p> <p>1.1.5 Mechanism of the following reacts with synthetic application: Claisen condensation, Michael addition.</p>	
	II	<p>2. Stereochemistry (15L)</p> <p>2.1.1 Molecular chirality and element of symmetry: Mirror Plane symmetry (inversion centre), rotation-reflection (alternating) axis, Chirality of compounds without stereogenic centre: cummulenes, spirans and biphenyls.</p> <p>2.1.2 Stability of cycloalkanes: Strains in cycloalkanes-angle, eclipsing, transannular (3 to 8 membered). Conformations of cyclohexane, mono- and di- alkyl cyclohexanes and their relative stabilities.</p> <p>2.1.3 Stereo selectivity and Stereo specificity: Idea of enantioselectivity (ee) and diastereoselectivity (de). Topicity-enantiotopic and diastereotopic atoms, groups and faces.</p> <p>Stereochemistry of-</p> <p>(1) Substitution reactions- S_N1, S_N2, S_Ni (reaction of alcohol with thionyl chloride). (2) E_2-anti-elimination-Base induced dehydrohalogenation of 1-bromo-1,2- diphenylpropane. (3) Addition reactions to olefins-i) catalytic hydrogenation ii) bromination (electrophilic anti addition) (iii) syn-hydroxylation (molecular addition) with OsO_4 and $KMnO_4$.</p>	1
	III	<p>3.1 Carbohydrates (10L)</p> <p>3.1.1 Introduction: Classification, Sources, Reducing and non-reducing sugars DL notation.</p> <p>3.1.2 Structures of monosaccharides: Fischer projection (4-6 carbon monosaccharides and Haworth formula-Furanose and pyranose forms of pentoses and hexoses. Interconversion :open and Haworth forms of monosaccharides with 5 and 6 carbons. Chair conformation with stereochemistry of D-glucose and D-fructose. Stability of chair forms of D-</p>	1

	<p>glucose.</p> <p>3.1.3 Determination of open chain configuration- of D-glucose assuming the configuration of D-arabinose; and of D-fructose assuming the configuration of D-glucose.</p> <p>3.1.4 Anomers and epimers of monosaccharides. Enantiomers and diastereomers of glucose. Mutarotation (with mechanism) in D-glucose.</p> <p>3.1.5 Chain lengthening and shortening reaction: Modified kiliani-fischer synthesis. Wohl method.</p> <p>3.1.6 Reactions of D-glucose and D-fructose: (a) osazone formation (b) reduction- H_2/Ni, $NaBH_4$ c)oxidation- bromine water, HNO_3, HIO_4. D) interconversion of D-glucose and D-fructose e) acetylation f) methylation [e and f with cyclic pyranose form].</p> <p>3.1.7 Commercial importance of carbohydrates in pharmaceutical, paper, food and Textile industries.</p> <p>3.2. IUPAC Nomenclature (5L) IUPAC systematic and accepted trivial nomenclature of the following classes of compounds, including substituted ones (up to 2 substituents/ functional groups):</p> <p>3.2.1 (a) Bicyclic compounds- spiro-, fused, and bridged (upto 11 carbon atoms)-saturated and unsaturated compounds.</p> <p>3.2.2 (b) Biphenyls.</p> <p>3.2.3 (c) Cummulenes upto 3 double bonds (d) Monocyclic (5 and 6 membered) aromatic and non-aromatic heterocyclic compounds containing a maximum of two hetero atoms among N,O,S.</p> <p>3.1.1 Introduction: Classification, Sources, Reducing and non-reducing sugars DL notation.</p> <p>3.1.2 Structures of monosaccharides: Fischer projection (4-6 carbon monosaccharides and Haworth formula-Furanose and pyranose forms of pentoses and hexoses. Interconversion :open and Haworth forms of monosaccharides with 5 and 6 carbons. Chair conformation with</p>		
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	<p>IV</p>	<p>4.1. Heterocyclic Chemistry (8L)</p> <p>4.1.1 Introduction: Electronic structure and aromaticity of furan, pyrrole, thiophene and pyridine.</p> <p>4.1.2 Synthesis: Synthesis of furans, pyrroles, and thiophenes by Paal-Knor synthesis. Pyridines by Hantzsch synthesis and from 1,5-diketones.</p> <p>4.1.3 Reactivity: Reactivity towards electrophilic substitution reactions- of furan, pyrrole and thiophene on basis</p>		<p>1</p>

of stability of intermediate; and of pyridine on the basis of electron distribution. Nucleophilic substitution reaction of pyridine on the basis of electron distribution.

4.1.4 Reactions of heterocycles: The following reactions of furan, pyrrole and thiophene: Halogenation, Nitration, Sulphonation, Vilsmeier formylation reaction, Friedel-Crafts reaction. Furan: Diels-Alder reaction. Ring opening of furan. Pyrrole: Acidity and basicity of pyrrole-Comparison of basicity of pyrrole and pyrrolidine, Acid catalyzed polymerization of pyrrole. Pyridine: Basicity. Comparison of basicity of pyridine, pyrrole and piperidine. Sulphonation of pyridine, with and without catalyst. Reduction. Oxidation of alkyl pyridines and action of sodamide (Chichibabin reaction). N-methylation of pyridine. Quaternization of piperidine, pyrrolidine and Hofmann elimination of the quaternary salts.

4.2. Organic Synthesis (7L)

4.2.1 Introduction: Criteria for ideal organic synthesis. Yield and selectivity. Multi-component synthesis – with examples, Mannich reaction, Hantzsch synthesis of pyridines (without mechanism).

4.2.2 Illustrative synthesis of industrially important compounds: Ibuprofen (chiral synthesis), paracetamol (green synthesis), L-ascorbic acid (from D-glucose), norfloxacin, thyroxine, vanillin, methyl dihydrojasmonate (Hedione), Bifenox-I, pigment red 242, indigo, 2-hydroxy-3-amino-5-nitrobenzene sulphonic acid.

4.2.3 Newer methods of organic synthesis: Introduction to the use of the following in organic synthesis: Ultrasound, microwaves, PTC.

4.1.1 Introduction: aromaticity of furan, pyrrole, thiophene and pyridine.

4.1.2 Synthesis: Synthesis of furans, pyrroles, and thiophenes by Paal-Knorr synthesis. Pyridines by Hantzsch

synthesis and from 1,5-diketones. **4.1.3**

Reactivity: Reactivity towards electrophilic substitution reactions- of furan, pyrrole and thiophene on basis of stability of intermediate; and of pyridine on the basis of electron distribution. Nucleophilic substitution reaction of pyridine on the basis of electron distribution.

4.1.4 Reactions of heterocycles: The following reactions of furan, pyrrole and thiophene: Vilsmeier formylation reaction, Friedel-Crafts reaction. Furan: Diels-Alder reaction. Ring opening of furan. Pyrrole: Acidity and basicity of pyrrole-Comparison of basicity of pyrrole and pyrrolidine, Acid catalyzed polymerization of pyrrole. Pyridine: Basicity.

Comparison of basicity of pyridine, pyrrole and piperidine. Sulphonation of pyridine, with and without catalyst. Reduction. Oxidation of alkyl pyridines and action of sodamide (Chichibabin reaction). N-methylation of pyridine. Quaternization of piperidine, pyrrolidine and Hofmann elimination of the quaternary salts.

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4.2.3 Newer methods of organic synthesis: Introduction to the use of the following in organic synthesis: Ultrasound, microwaves, PTC.

USCH504	I	<p>1. Treatment of analytical data-I and sampling (15 L)</p> <p>1.1 Treatment of Analytical Data (7L) Types of errors, determinate and indeterminate errors, minimization of errors, constant and proportionate errors, accuracy and precision, measures of dispersion and central tendency: mean, median, average deviation, relative average deviation, standard deviation, variance, coefficient of variation.[Numerical problems expected]</p> <p>1.2 Sampling (8L) Terms involved, importance of sampling, sampling techniques, sampling of gases, ambient and stack sampling, equipment used, sampling of homogeneous and heterogeneous liquids, sampling of static and flowing liquids, methods and equipments used, sampling of solids, importance of particle size and sample size, samples used, need for the reduction in the sample size, methods of reduction in sample size, collection, preservation and dissolution of the sample.</p>	2.5	1
	II	<p>2. Titrimetric analysis-I and UV-Visible spectroscopy. (15L)</p> <p>2.1 Acid-base Titrations (5L) Construction of titration curves and choice of indicators in the titration of [1] strong acid and strong base, [2] strong acid and weak base, [3] weak acid and strong base, [4] weak acid and weak base.</p> <p>2.2 Precipitation titrations (4L) Argentometric titrations, construction of the titration curve, Volhard's method, Mohr's method, adsorption indicators, theory and applications.</p> <p>2.3 U.V. Visible Spectroscopy (4L) Photometers and spectrophotometers, Instrumentation in the case of single and double beam spectrophotometers, Qualitative and quantitative analysis, calibration curve method.</p>		1

	III	<p>3. Methods of separation-I (15L) 3.1 Solvent Extraction (8L) Partition coefficient and distribution ratio, extraction efficiency, separation factor, role of complexing agents in solvent extraction, chelation, ion pair formation, solvation, types of solvent extraction: batch, continuous. [Numerical problems expected]</p> <p>3.2 Chromatography (2L) Introduction to chromatographic techniques, classification of chromatographic techniques.</p> <p>3.3 Planar Chromatography (5L) Principle, techniques and applications of [1] Paper chromatography [2] Thin layer chromatography</p>		1
	IV	<p>4. Optical methods (15L) 4.1 Atomic Spectroscopy (7L) Absorption and emission spectra, energy level diagrams, process involved in atomization, flame photometry, flame atomizer, types of burners, monochromators and detectors, atomic absorption spectroscopy; flame and electrothermal atomizer, sources, instrumentation, quantitative applications of atomic absorption and flame photometry, calibration curve method, standard addition and internal standard method.</p> <p>4.2 Molecular Fluorescence and Phosphorescence Spectroscopy (4L) Theory, instrumentation and applications</p> <p>4.3 Turbidimetry and Nephelometry (4L) Scattering of light, effect of concentration, particle size and wavelength on light scattering, instrumentation and applications.</p>		1

Practicals

USCHP05	<p style="text-align: center;">Practicals of Course USCH501</p> <p><u>Physical Practical</u></p> <p>Chemical Kinetics – To determine the order between $K_2S_2O_8$ & KI by fractional change method.</p> <p>Viscosity – To determine the molecular weight of high polymer polyvinyl alcohol (PVA) by viscosity measurement.</p> <p style="text-align: center;">OR</p> <p>To determine the radius of a glycerol molecule by viscosity measurement.</p> <p>Potentiometry –</p> <ol style="list-style-type: none">1. To determine the amount of Fe(II) in the given solution by titration with a standard $K_2Cr_2O_7$ solution and hence to find the formal redox potential of Fe^{3+}/Fe^{2+}2. To determine the solubility product and solubility of AgCl potentiometrically using chemical cell. <p style="text-align: center;">OR</p> <ol style="list-style-type: none">3. To determine the solubility product and solubility of AgCl potentiometrically using concentration cell. <p>Colorimetry – To determine the amount of Fe(III) present in the given solution by using salicylic acid by colorimetric titration.(static method) ($\lambda=525$ nm)</p> <p>pH –Metry – To determine acidic and basic dissociation constants of amino acid hence to calculate isoelectric point.</p> <p>Course USCH502</p> <p><u>Inorganic Practical</u></p> <p>Inorganic preparations</p> <ol style="list-style-type: none">1. $Tris(en)_2 Ni(II)S_2O_3$2. Tetra-amminecopper (II)Sulphate3. $CuCl_2 \cdot 2DMSO$	3	8
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	<p>Inorganic estimation/analysis</p> <ol style="list-style-type: none"> 1. Ni complexometrically using Murexide indicator 2. Cu by iodometric method 		
USCHP06	<p>Practicals of Course USCH503</p> <p><u>Organic Practicals</u> Binary Mixture Separation & identification (Solid + Solid)</p> <p>Course USCH504</p> <p><u>Analytical Practicals</u></p> <ol style="list-style-type: none"> 1. Estimation of persulphate in the given sample by the method of back titration. 2. Determination of the calcium and the magnesium content of a dolomite sample. 3. Determination of glucose content of a honey sample by Wilstater's method. 4. Determination of the amount of fluoride in the given solution colorimetrically. 5. Determination of Vitamin C content of a given tablet by titration with sodium hydroxide pH metrically 	3	8

**T.Y.B.Sc.
Chemistry
Credit Based Semester and Grading System
To be implemented from the Academic year 2013-2014**

**SEMESTER VI
Theory**

Course	UNIT		Credits	L / Week
USCH601	I	<p>1.1 Molecular Spectroscopy -I</p> <p>1.1.1 Dipole moment: Dipole moment, polarization of a bond, bond moment, dipole moment and molecular structure.</p> <p>1.1.2 Rotational Spectrum: 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 inter nuclear distance and isotopic shift.</p> <p>1.1.3 Vibration (IR) spectrum: Vibrational motion, degrees of freedom, modes of vibration, vibrational spectrum of a diatomic molecule, simple harmonic oscillator, energy levels, zero point energy, conditions for obtaining vibrational spectrum, selection rule, nature of spectrum.</p> <p>1.1.4 Vibration-Rotation spectrum of diatomic molecule vibrating rotor, energy levels, selection rule, nature of spectrum, R and P branches, anharmonic oscillator : energy levels, selection rule, fundamental band, overtones . Application of vibration-rotation spectrum in determining Force constant, determination and significance. Introduction to infrared spectra of simple molecules like H₂O and CO₂</p> <p>1.1.5 Raman Spectroscopy : 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, comparative study of IR and Raman spectra, rule of mutual exclusion.(example of CO₂molecule).</p>	2.5	1
	II	<p>2.1 Basics of Quantum Chemistry (10L)</p> <p>2.1.1 Classical mechanics, limitations of classical mechanics, Black body radiation, photoelectric effect, Compton effect.</p> <p>2.1.2 Introduction to quantum mechanics,</p>		1

		<p>Planck's theory of quantization, wave particle duality, de-Broglie equation, Heisenberg's uncertainty principle.</p> <p>2.1.3 Progressive and standing waves, boundary conditions, Schrodinger's time independent wave equation(derivation not expected)., interpretation and properties of wave function.</p> <p>2.1.4 Postulates of quantum mechanics (following are to be considered),1. state function and it's significance2. Concept of operators : definition, addition, subtraction and multiplication of operators, commutative and non- commutative operators, linear operator, Hamiltonian operator, 3. Eigen function and eigen value, eigen value equation.</p> <p>2.2 Applied Electrochemistry (5L)</p> <p>2.2.1 Polarization, concentration polarization and it's elimination</p> <p>2.2.2 Decomposition potential, experimental determination of decomposition potential, factors affecting decomposition potential (nature of electrolyte, nature of electrodes and temperature) Tafel's equation for hydrogen overvoltage, Overvoltage, experimental determination of over-voltage, 2.2.3 Electroplating ---objectives and procedures</p>		
	<p>III</p>	<p>3.1 Renewable Energy Sources (5L)</p> <p>3.1.1. Lithium ion cell.</p> <p>3.1.2. Fuel cells; Choice of fuel and oxidant, Bacon's H₂ and O₂ fuel cell.</p> <p>3.1.3. Solar cells, solar energy, photovoltaic effect, semiconductors as solar energy converters, silicon solar cell</p> <p>3.1.4. Hydrogen : Fuel of the future, production of hydrogen by direct electrolysis of water, advantages of hydrogen as a universal energy medium.</p> <p>3.2 Nuclear Magnetic Resonance Spectroscopy (6L)</p> <p>3.2.1. Nuclear spin, magnetic moment, nuclear 'g' factor, energy levels, Larmor precession, Relaxation processes in n.m.r. (spin-spin relaxation and spin-lattice relaxation).</p> <p>3.2.2. NMR Spectrometer, chemical shift, shielding and deshielding of protons, low resolution n.m.r. spectrum of methanol and ethanol.</p>		<p>1</p>

		<p>3.3 Chemical Kinetics (4 L)</p> <p>3.3.1 Collision theory of reaction rates, application of collision theory to 1. uni-molecular reaction and 2. bimolecular reaction (Lindemann theory, derivation expected). Merits and drawbacks of collision theory.</p> <p>3.3.2 Classification of reactions as slow, fast and ultra-fast. study of kinetics of fast reactions by Stop flow method.</p>		
	IV	<p>4.1 Nuclear Chemistry</p> <p>4.1.1 Types of nuclear radiations and their characteristics, behaviour of ion pairs in electric field, detection and measurement of nuclear radiations using G. M. Counter and Scintillation Counter.</p> <p>4.1.2 Kinetics of radioactive decay, units of radioactivity (Curie, Becquerel, Rutherford)</p> <p>4.1.3 Radioactive equilibrium (secular and transient), determination of radioactive constants for radio-elements having 1. moderate half life, 2. long half life 3. extremely long or short half life.</p> <p>4.1.4 Use of radioisotopes as tracers in 1. chemical investigations- reaction mechanism, 2. age determination- dating by carbon-14</p> <p>4.1.5 Nuclear reactions – nuclear transmutation, artificial radioactivity Q-value of nuclear reaction, threshold energy.</p> <p>4.1.6 Fissile and fertile material, nuclear fission, chain reaction, factor controlling fission process. (multiplication factor and critical size or mass of fissionable material), nuclear power reactor and breeder reactor.</p>		1
USCH602	I	<p>Coordination Chemistry (15L)</p> <p>1.1 Crystal Field Theory (CFT) (7L)</p> <p>1.1.1 Basic tenets of Crystal field theory and effect of crystal field on central metal valence orbitals.</p> <p>1.1.2 Splitting of <i>d</i> orbitals in octahedral, tetrahedral and square planar complexes.</p> <p>1.1.3 Crystal field splitting energy ($10\Delta_o/\Delta_o$) for octahedral complexes and factors affecting the magnitude of Δ_o.</p> <p>1.1.4 Crystal field stabilization energy (CFSE), calculation of CFSE, for octahedral and tetrahedral complexes with</p>	2.5	1

		<p>d^1 to d^{10} metal ion configurations.</p> <p>1.1.5 Effect of crystal field splitting on i) Ionic radius and ii) Lattice energy.</p> <p>1.1.6 Theoretical failure of the CFT model.</p> <p>1.1.7 Experimental evidence for covalence in co-ordination compounds. (i) ESR spectrum of $[\text{IrCl}_6]^{2-}$ (ii) NMR spectrum of tris (acetyl acetanato) vanadium complex, (iii) Intensities of $d-d$ transitions, and (iv) Nephelauxetic effect.</p> <p>1.2 Molecular Orbital Theory (MOT) of Coordination Complexes (4L)</p> <p>1.2.1 Application to octahedral complexes in case of (i) $[\text{Ti}(\text{H}_2\text{O})]^{3+}$, (ii) Fluoro complexes of Fe(II) and Fe (III) and (iii) Cyano complexes of Fe(II) and Fe (III).</p> <p>1.2.2 Effect of pi-bonding an ligand field splitting parameter in $\text{M} \rightarrow \text{L}$ and $\text{L} \rightarrow \text{M}$ interactions.</p> <p>1.3 Electronic States and Terms for Polyelectronic Atoms (4L)</p> <p>1.3.1 Introduction: electronic configuration and electronic states, Term symbols, coupling of spin momenta (M_s), orbital momenta (M_l) and spin-orbit coupling or Russell-Saunders coupling.</p> <p>1.3.2 Determination of Terms for p^2 electronic configuration (as in a carbon atom).</p> <p>1.3.3 Terms and micro-states for transition metal atoms/ions.</p>		
	II	<p>2. Properties of Coordination compounds (15L)</p> <p>2.1 Stability of Complexes (5L)</p> <p>2.1.1 Thermodynamic stability and kinetic stability of complexes with examples.</p> <p>2.1.2 Stability constants: Stepwise and overall constants and their inter-relationship.</p> <p>2.1.3 Factors affecting thermodynamic stability.</p> <p>2.1.4 Potentiometric method of determination of stability constants with example of silver-ammonia complex.</p> <p>2.2 Substitution Reactions in Octahedral Complexes (5L)</p> <p>2.2.1 Introduction, types of reactions in complexes.</p> <p>2.2.2 Ligand substitution reactions: basic mechanisms.</p> <p>2.2.3 Inert and labile complexes and</p>		1

		<p>electronic configurations and lability of complexes.</p> <p>2.2.4 Acid hydrolysis, base hydrolysis and anation reactions.</p> <p>2.3 Electronic Spectra (5L)</p> <p>2.3.1 Types of electronic transitions like intra –ligand transitions, charge transfer transitions and intra-metal transitions and (<i>d-d</i> or ligand field transitions for transition metals).</p> <p>2.3.2 Rules for electronic transitions: Spin and Orbital or Laporte selection rules.</p> <p>Orgel Diagrams for D Terms (i.e, d^1, d^4 and d^6.d^9 electronic configurations) and its use in interpretation of visible electronic absorption spectra of these configurations.</p>		
	III	<p>Organometallic Chemistry (15L)</p> <p>3.1 Organometallic Compounds of main group metals (6L)</p> <p>3.1.1 Introduction: General synthetic methods: (i) Oxidative addition, (ii) Metal-Metal exchange (Transmetallation), (iii) Carbanion-Halide exchange, (iv) Metal Hydrogen exchange and (v) Methylene insertion reactions.</p> <p>3.1.2 Chemical reactions: (i) Reactions with oxygen, (ii) Alkylation and arylation reactions (iii) Reactions with protic reagents and (iv) Complex formation reactions.</p> <p>3.2 Organometallic compounds of transition metals (9L)</p> <p>3.2.1 Synthesis , structure, reactions and of ferrocene.</p> <p>3.2.2 Bonding in ferrocene on the basis of VBT.</p> <p>3.2.3 Bonding in Re and Mo halide complexes.</p>		1
	IV	<p>Some Selected Topics (15L)</p> <p>4.1 Inorganic Polymers (3L)</p> <p>4.1.1 Various methods of classification with examples.</p> <p>4.1.2 Chemistry of borazine with reference to preparation , properties, structures, bonding and applications.</p> <p>4.2 Characteristics and Treatment</p>		1

		<p>of Liquid Effluent (06L)</p> <p>4.2.2 Characterization of waste: biochemical oxygen demand (BOD), chemical oxygen demand (COD), total organic carbon (TOC), aerobic and anaerobic processes.</p> <p>4.2.3 Removing of solid contaminants, physical and chemical principles such as coagulation, flocculation and sedimentation.</p> <p>4.2.4 Primary, secondary and tertiary of liquid effluents.</p> <p>4.3 Nanomaterials (04L)</p> <p>4.3.2 Introduction and importance of nanomaterials.</p> <p>4.3.3 Properties (Comparison between bulk and nanomaterials): (i) Optical properties, (ii) Electrical conductivity, and (iii) Mechanical properties.</p> <p>4.3.4 Forms of nanomaterials: nanofilms, nanolayers, nanotubes, nanowires, and nanoparticles.</p> <p>4.3.5 Chemical methods of preparation: (i) Colloidal route, and (ii) Sol-gel method.</p> <p>4.5 Inorganic Pharmaceuticals (2L)</p> <p>4.4.2 Gastrointestinal agents viz., (i) antacids (aluminium hydroxide, milk of magnesia, sodium bicarbonate and (ii) cathartics (magnesium sulphate and sodium phosphate).</p> <p>Topical agents viz., (i) protectives and adsorbents (talc, calamine), (ii) antimicrobial agents (potassium permanganate, tincture iodine, boric acid) and astringents (alum).</p>		
<p>USCH603</p>	<p>I</p>	<p>1.1 Spectroscopy (15L)</p> <p>1.1.1 Introduction : Electromagnetic spectrum, units of wavelength and frequency.</p> <p>1.1.2 UV- Visible Spectroscopy: Basic theory, solvents, nature of UV-VIS spectrum, concept of Chromophore, auxochrome, bathochromic shift, Hypsochromic shift hyperchromic</p>	<p>2.5</p>	<p>1</p>

		<p>effect and chromophore-auxochrome interactions.</p> <p>1.1.3 IR Spectroscopy: Basic theory, nature of IR spectrum, selection rule, fingerprint region.</p> <p>1.1.4 PMR Spectroscopy: Basic theory of NMR, nature of PMR spectrum, chemical shift (δ unit), standard for PMR, solvents used. Factors affecting chemical shift: (1) inductive effect (2) anisotropic effect (with reference to C=C, C\equivC, C=O and benzene ring). Spin-spin coupling and coupling constant. Proton exchange-application of deuterium exchange, Application of PMR in structure determination.</p> <p>1.1.5 Spectral characteristics of following classes of organic compounds, including benzene and monosubstituted benzenes, with respect to UV-VIS, IR, PMR: (1) alkanes (2) alkenes and polyenes (3) alkynes (4) haloalkanes (5) alcohols (6) carbonyl compounds (7) ethers (8) carboxylic acids (9) esters (10) amines (11) amides (broad regions characteristic of different groups are expected).</p> <p>1.1.6 Mass Spectrometry: Basic theory. Nature of mass spectrum. General rules of fragmentation. Importance of molecular ion peak, isotopic peaks, base peak, Nitrogen rule. Illustrative fragmentation of alkanes and aliphatic carbonyl compounds (No McLafferty rearrangement).</p> <p>1.1.7 Problems of structure elucidation of simple organic compounds using individual or combined use of the above spectroscopic techniques are expected. (index of hydrogen deficiency should be the first step in solving the problems).</p>		
	II	<p>2.1 Polymers (11L)</p> <p>2.1.1 Introduction: General idea of monomers, polymers, and polymerization, natural and synthetic polymers. Homopolymers and copolymers. Classification of polymers- Plastic, fibres, resins, elastomers. Thermoplastics and thermosets. Copolymers-alternating, block, random, graft.</p> <p>2.1.2 Mechanism of free radical addition</p>		1

		<p>polymerization.</p> <p>2.1.3 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>2.1.4 Stereochemistry of polymers: Tacticity. Role of Ziegler-Natta catalyst (co- ordination polymerization) in directing the tacticity in polypropylene (no mechanism).</p> <p>2.1.5 Preparation & use of polymers: (1) Addition polymers: (a) polyethylene (b) polypropylene (c) PVC (d) polystyrene (e) polyacrylonitrile (f) polyvinylalcohol (g) Teflon. (2) Condensation Polymers: (a) Polyesters (b) polyamides (c) polyurethans (d) phenol-formaldehyde resin (e) epoxy resin (f) polycarbonates.</p> <p>2.1.6 Recyclable polymers. Biodegradable polymers and their uses. Biomedical use of polymers.</p> <p>2.1.7 Additives to polymers: Plasticizers ,stabilizers and fillers.(The students are expected to identify monomers in a given polymer and draw the structure of a polymer from a given set of monomers).</p> <p>2.2 Photochemistry</p> <p>2.2.1 Introduction: Difference between thermal and photochemical reactions. Jablonski diagram, singlet and triple states, allowed and forbidden transitions, fate of excited molecules, photosensitization.</p> <p>2.2.2 Photochemical reactions of olefins: photoisomerisation, photochemical rearrangement of 1,4-dienes (di π methane)</p> <p>2.2.3 Photochemistry of carbonyl compounds: Norrish I, Norrish II cleavages, Photo reduction (e.g. benzophenone to benzpinacol).</p>		
	III	<p>3.1 Catalysts and Reagents (5L) Study of the following catalysts and reagents with respect to functional group transformations and selectivity (no mechanism).</p> <p>3.1.1 Catalysts: Catalysts for hydrogenation: Raney Ni, Pt and PtO₂: C=C, CN, NO₂, aromatic ring; Pd/C: C=C, COCl → CHO (Rosenmund); Lindlar catalyst: alkynes; Wilkinson's catalyst for</p>		1

		<p>stereo selective reduction of olefins.</p> <p>3.1.2 Reagents: (1) LiAlH₄ and Red-Al: reduction of CO, COOR, CN, NO₂. (2) NaBH₄: reduction of CO (3) SeO₂: hydroxylation of allylic and benzylic positions, oxidation of CH₂, alpha to CO to CO. (5) mCPBA and R-OOH/H₂O₂ for epoxidation of C=C. (6) NBS: allylic and benzylic bromination of position alpha to CO.</p> <p>3.2 Natural Products (10L)</p> <p>3.2.1 Introduction: Primary and secondary metabolites. Introduction to the following natural products with respect to the sources and classes. (Structures of the compounds specified below are expected).</p> <p>(a) Terpene: Isoprene and special isoprene rule. α-terpeniol, citral, camphor, α-pinene.</p> <p>(b) Alkaloids: nicotine, atropine.</p> <p>(c) Vitamins: Vitamins A and C.</p> <p>(d) Hormones: adrenaline, thyroxine.</p> <p>(e) Steroids: cholesterol, progesterone.</p> <p>3.2.2 Structure determination of natural products: 3.2.2.1 Ozonolysis in terpenoids- Examples of open chain and monocyclic monoterpenes. 3.2.2.2 Hofmann exhaustive methylation and degradation in alkaloids – simple open chain and monocyclic amines. 3.2.2.3 Structure determination of citral and nicotine through degradation studies. Total synthesis of degradation studies. Total synthesis of (i) Citral from 3-methylbutan-1-ol (ii) Nicotine from nicotinic acid.</p> <p>3.2.4 Commercial importance of terpenoids and alkaloids: Synthesis of camphor from α-pinene, α and β ionones, geraniol and nerol from citral.</p> <p>3.2.5</p>		
	<p>IV</p>	<p>4.1 Organometallic Chemistry (5L)</p> <p>4.1.1 Introduction: Carbon-metal bond- Nature, types reactivity.</p> <p>4.1.2 Organo magnesium Compounds: Grignard reagent :Preparation, structure, and stability, Reaction with compounds containing acidic hydrogen, carbonyl compounds, cyanides and CO₂.</p> <p>4.1.3 Organolithium Compounds : Preparation using alkyl/aryl halides. Reactions with compounds containing</p>		<p>1</p>

		<p>acidic hydrogen, alkyl halides, carbonyl compounds, cyanides and CO₂. Lithium dialkyl cuprates: Preparation and reactions with aliphatic /aromatic/vinyllic halides.</p> <p>4.1.4 Organozinc compounds: Preparation of dialkyl zinc. Reaction with water, acid chlorides and alkyl halides. Reformatsky reaction (with mechanism).</p> <p>4.2 Chemistry of some Important Biomolecules: (10L)</p> <p>4.2.1 α-Amino acids: Structure, configuration, Essential amino acids and their abbreviations, classification, Properties: pH dependency of ionic structure and isoelectric point. Methods of preparations: Strecker synthesis, amidomalonate synthesis, Erlenmeyer azalactone synthesis.</p> <p>4.2.2 Polypeptides and Proteins: Polypeptides: Peptide bond. Nomenclature and representation of polypeptides. Merrifield's solid phase peptide synthesis (example of di- and tri- peptides for nomenclature and synthesis). Proteins: Sources, types, functions, colloidal nature, separation based on isoelectric point, denaturation and functions. Partial and total hydrolysis. General idea of primary, secondary, tertiary and quaternary structures.</p> <p>4.2.3 Nucleic acids: Selective hydrolysis of nucleic acids. Sugars and bases in nucleic acids. Structures of nucleosides and nucleotides in DNA and RNA. Structure of nucleic acids (DNA and RNA): Base pairing in nucleic acids. Importance of nucleic acids-self duplication, protein synthesis.</p>		
USCH604	I	<p>Electroanalytical methods. (15L)</p> <p>1.1 D.C. Polarography (11L): Polarizable and nonpolarizable electrodes, basic principles, residual current, diffusion current, limiting current, dropping mercury electrode, supporting electrolyte half wave potential, derivation of the polarographic wave equation for a reversible reaction. Ilkovic equation, oxygen interference and its removal, maxima and maxima suppressors, polarographic cell, qualitative</p>	2.5	1

		<p>and quantitative analysis, calibration curve and standard addition method, applications. [Numerical problems expected]</p> <p>1.2 Amperometric Titrations: Basic principles, rotating platinum electrode and nature of the titration curves, applications, advantages and limitations.</p>		
	II	<p>Methods of separation-II (15L)</p> <p>2.1 Gas chromatography (6L): Gas liquid chromatography, basic principles retention time, retention volume, resolution, peak width theoretical plates. HETP, instrumentation, columns, detectors, applications.</p> <p>2.2 High Performance Liquid Chromatography (4L): Instrumentation, types of elution, U.V. and I.R. detector and applications</p> <p>2.3 Ion Exchange Chromatography (5L): Types of ion exchangers, mechanism of ion exchange, selectivity coefficients and separation factors, capacity and its determination, factors affecting the separation of ions, applications.</p>		1
	III	<p>Treatment of analytical data-II and Titrimetric analysis-II (15L)</p> <p>3.1 Treatment of Analytical Data (6L): Distribution of random errors, Gaussian curve, students' t, confidence limits and confidence interval, criteria for rejection of result: 2.5d rule, 4.0 rule and Q test, F test, testing for significance, null hypothesis, method of averages, least squares method. Numerical problems expected]</p> <p>3.2 Complexometric Titrations (5L): General introduction, EDTA titrations, advantages and limitations of EDTA as the titrant, absolute and conditional formation constants of metal EDTA complexes, construction of titration curves, types of EDTA titrations, methods of increasing the selectivity of EDTA as a titrant, metallochromic indicators, theory and applications.</p> <p>3.3 Redox Titrations (4L): General introduction, theory of redox indicators, criterion for choosing an indicator for a redox titration, construction of the titration curves in the case of (1) Fe (II) Vs. Ce(IV)</p>		1

		(2) Fe (II) Vs. dichromate, use of diphenyl amine and ferroin as redox indicators.		
	IV	<p>Concepts in Quality and miscellaneous methods (15L)</p> <p>4.1 Total quality management (5L) : concept of quality, quality control, quality assurance total quality management, ISO series, Good laboratory practices</p> <p>4.2 Mass Spectrometry (2L): Basic principles, introduction of components only</p> <p>4.3 Thermal Methods (5L): Classification of thermal methods, thermogravimetric analysis, basic principles, instrumentation factors affecting the TG curve, applications</p> <p>4.4 Introduction to Radio Analytical Techniques (3L): Classification of the techniques, introduction to neutron activation analysis and its applications.</p>		1

Practicals

	Practicals of Course USCH601		
	<u>Physical Practicals</u>		
	Chemical Kinetics –		
	To determine the energy of activation for the acid catalysed hydrolysis of methyl acetate.		
	Partition coefficient		
	To determine the equilibrium constant for the reaction $KI + I_2 \rightleftharpoons KI_3$ by partition method. (Partition coefficient of I_2 between CCl_4 and water is to be given)		
USCHP07	Potentiometry –	3	8
	<ol style="list-style-type: none"> To determine the strength of the given strong acid (HCl) by potentiometric titration using quinhydrone electrode (Calculation of pH from E_{cell} and the plot of (a) $\frac{\Delta E}{\Delta V}$ against V (b) pH against V graphs are expected). <p style="text-align: center;">OR</p> <ol style="list-style-type: none"> To determine pKa value of the given weak monobasic acid (CH_3COOH) by e.m.f. measurements. To determine E_{cal} at room temperature 		

	<p>and using this value, determine standard reduction potential of Ag/Ag^+ electrode at room temperature.</p> <p>Conductometry – To determine the amount of dibasic acid (Oxalic acid) by conductometric titration against strong base.</p> <p style="text-align: center;">OR</p> <p>To determine the relative strength of monochloroacetic acid and acetic acid conductometrically.</p> <p>Course USCH602 <u>Inorganic Practicals</u> Inorganic preparations</p> <ol style="list-style-type: none"> 1. 8-(hydroxyquinoliao) magnesium (II) 2. Tris-(acetylacetonato) iron (III) 3. Bis-(Dimethylglyoximato) nickel (II) <p>Inorganic estimations/ Analysis</p> <ol style="list-style-type: none"> 1. Acidity of a water sample. 2. Fe (II) using KMnO_4 Al (back titration) complexometrically 		
USCHP08	<p style="text-align: center;">Practicals of Course USCH603</p> <p><u>Organic Practicals</u> Binary Mixture Separation Separation of mixture containing (VL + NVL) & (S + VL) components.</p> <p>Organic Preparations</p> <ol style="list-style-type: none"> 1. Aniline/p-toluidine → N-Acetyl derivative 2. Salicylic acid/nitrobenzene/ Acetanilide → Nitro derivative 	3	8

3. β - naphthol \rightarrow Methyl Ether derivative (Using dimethyl sulphate)
4. Acetanilide \rightarrow p-bromoacetanilide derivative
5. Aniline/ p-toluidine \rightarrow Schiff base with benzaldehyde
6. Hydroquinone/beta naphthol \rightarrow Acetyl derivative
7. Methyl salicylate/ethyl benzoate \rightarrow Acid derivative (Hydrolysis)
8. Benzaldehyde/p-nitrobenzaldehyde \rightarrow Acid (Oxidation)

Course USCH604

Analytical Practicals

1. Determination of chemical oxygen demand of a water sample.
2. Determination of percentage purity of a sample of common salt using a cation exchanger.
3. Determination of potassium content of a commercial salt sample by flame photometry.
4. Determination of acetic acid content of a vinegar sample by potentiometric titration with sodium hydroxide using quinhydrone.
5. Determination of Cr (VI) in the given solution as dichromate by the method of least squares, spectrophotometrically