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Item 4.14

UNIVERSITY OF MUMBAI

Syllabus for the S.Y.B.Sc.
Program: B.Sc.
Course : Chemistry

(Credit Based Semester and Grading System with effect from the academic year 2012–2013)

UNIVERSITY OF MUMBAI

S.Y.B.Sc. CHEMISTRY Syllabus
Credit Based and Grading System
To be implemented from the Academic year 2012-2013

SEMESTER III

Course Code	UNIT	TOPICS	Credits	L / Week
USCH301	I	Chemical Thermodynamics	2	1
	II	Solution of Electrolytes		1
	III	Introduction to Analytical Chemistry and Visible Spectroscopy		1
USCH302	I	Chemical bonding and Molecular structure	2	1
	II	Chemistry of transition Elements		1
	III	Industrial Inorganic chemistry		1
USCH303	I	Nomenclature Mechanism of organic Reactions Aromatic Electrophilic Substitution Reactions		1
	II	Aromatic Hydrocarbons Haloarenes Phenols Ether and Epoxides		1
	III	Sources of Organic compounds Chemical Industry Environmental aspects of chemical Industry		1
USCHP3	Practicals based on both courses in theory		3	9

SEMESTER IV

Course Code	UNIT	TOPICS	Credits	L / Week
USCH401	I	Phases in Equilibria	2	1
	II	Electrochemical cells & Ionic equilibria		1
	III	Introduction to Titrimetric Analysis & use of Instrumental methods in titrimetric analysis		1
USCH402	I	Acids and Bases,Chemistry of elements and organometallic		1
	II	Chemistry of Group-17 & Group-15 elements and Bio-inorganic chemistry		1
	III	Industrial inorganic chemistry		1
USCH403	I	Aromatic Nitrogen compounds Aromatic Aldehydes and Ketones		1
	II	Aromatic acids		1
	III	Stereochemistry Structure determination and Multistep synthesis Green Chemistry Manufacture of some bulk Chemicals including flow diagrams		1
USCHP4	Practicals based on both courses in theory		3	9

Semester I **CREDITS 3**		SEMESTER II **CREDITS 3**	
Type of Experiment	**Expts**	**Type of Experiment**	**Expts**
Physical- Instrumental Non Instrumental	 03 02	Physical- Instrumental Non Instrumental	 03 02
Organic Derivatives Estimations	 07 04	Organic Spotting	 12
Inorganic SMQA	 08	Inorganic Gravimetric Volumetric	 03 03
	24		**23**

In each semester, total marks for Practical Examination are 150.PRACTICAL EXAMINATION IS TO BE CONDUCTED FOR TWO HRS PER PAPER.

Instrumental: Semester I: 1. To verify Ostwald's dilution law conductometrically. 2. To determine amount of strong acid present in the given solution by titrating against stong base pHmetrically. 3. To determine standard emf of the cell potentiometrically.

Non-Instrumental: 1. To determine dissolved oxygen in the given waste water sample. 2. To carry out assay of commercial sample of Aspirin.

Semester II: Instrumental:Semester I: 1. To titrate strong acid against strong base conductometrically. 2. To determine dissociation constant of weak acid using Henderson's equation by the method of incomplete titration pHmetrically. 3. To determine λ_{max} and molar extinction coefficient for KMNO4 solution using photometer.

Non-Instrumental: 1. To investigate the reaction between equimolar concentration of $K_2S_2O_8$ and KI. 2. To determine partition coefficient of oxalic acid/succinic acid between water and CCl_4.

The pattern of semester-wise Practical examination is as follows: **Semester III------- CREDITS 3**

Session	External Component Practical Examination		Internal Component	
	Experiment	Marks	Details	Marks
I	Physical- Instrumental/ Non Instrumental	30	2 Best Practicals Journal Viva-Voce	10 05 05
II	Organic Derivatives/Estimations	30	2 Best Practicals Journal Viva-Voce	10 05 05
III	Inorganic SMQA	30	2 Best Practicals Journal Viva-Voce	10 05 05
		90		60

Semester I V------- CREDITS 3

Session	External Component Practical Examination		Internal Component	
	Experiment	Marks	Details	Marks
I	Physical- Instrumental/ Non Instrumental	30	2 Best Practicals Journal Viva-Voce	10 05 05
II	Organic Spotting	30	2 Best Practicals Journal Viva-Voce	10 05 05
III	Inorganic Gravimetric/Volumetric	30	2 Best Practicals Journal Viva-Voce	10 05 05
		90		60

SEMESTER III

Course Code	UNIT	TOPICS	Credits	L / Week
USCH 301	I	Chemical Thermodynamics: 15L 1) Gibbs free energy and He,mboltz's free energy, variation of Gibbs's free energy with temperature and pressure, Gibb's-Helmholtz equation. 2) Physical equilibbria involving pure substances, Clayperon's equation and variation of vapour pressure with temperature, Clausius-Clayperon equation and its application. Partial molal properties, partial molal valume and chemical potential, Gibbs-Duhem equation. 3) Variation of chemical potential potential with pressure and temperature, fugacity, activity and their relationship with chemical potential, activity and activity coefficient. 4) Thermodynamic derivation of Law of mass action, Kp, Kc and their inter-relation, van't Hoff's reaction isotherm and reaction isochore.	2	1
	II	**Solutions of Electrolyte: (15L)** 1) Electronic and electrolytic conductors, conductance, specific conductance, equivalent conductance, molar conductance, determination of molar conductance, variation of molar conductance with concentration for strong and weak electrolytes, concept of limiting molar conductance, 2) Debye-Huckel theory of conductance of strong electrolytes, ionic atmosphere, relaxation effect, electrophoretic effect. 3) Kohlrausch's law of independent migration of ions. Applications of Kohlrausch's law a) Determination of limiting molar conductance of a weak electrolyte. b) Determination of dissociation constant of a weak acid. c) Determination of solubility product of a sparingly soluble salt. 4) Migration of ions, transport number, dependence		1

		of transport number on the velocity of the ion, Hittorf's rule for unattackable electrodes illustrate with ions having equal and unequal speeds, moving boundary method for the determination of the transport number, factors affecting the transport number of an ion. 5) Relationship between transport number ionic mobility, and equivalent conductance.		
	III	Introduction to Analytical Chemistry and Visble Spectroscopy **(15L)** (A) Introduction to analytical chemistry 1) Analytical chemistry, qualitative and quantitative analysis, analytical chemistry and chemical analytical methods with emphasis on detection limit and sensitivity. 2) Steps involved in chemical analysis: sampling, obtaining a sample, processing the sample, the sample, selection of a method for analysis, calibration and actual analysis, data collection, data processing, presentation of results and interpretation. 3) Performance characteristics of an analytical method: accuracy, precision, detection limit, dynamic range, sensitivity, selectivity. 4) Quantitative analysis with calibration curve and standard addition method. 5) Applications of analytical methods in various fields such as organic, pharmaceuticals, electronic and environmental analysis. (B) Visible Spectroscopy 1) U. V. and Visible spectroscopy, absorption spectroscopy, terms involved; radiant power, absorbance, transmittance, percentage transmittance, wavelength of maximum absorption. 2) Statement of the Beer's law and the Lambert's law, (derivation expected) combined expression, molar extinction coefficient deviations from the Beer-Lambert's Law, limitations. 3) Components of an optical instrument, photometers and spectrophotometers, construction of a single beam photometer.		**1**

USCH 302	**I**	Chemical Bonding and Molecular Structure **15L** 1. Valence Bond Theory (VBT) **5L** (i) Hydridization involving the use of 'd' orbitals as in BaCl2 (sd), MnO4 (sd3) and PCl5 (sp3d) (ii) Concept of Resonance and Resonance Energy, Formal Charge, with examples. (iii) Limitations of VBT. **2.** Molecular Orbital Theory (MOT): **10L** (i) Conditions for the formation of molecular orbitals. (ii) Linear combination of atomic orbitals to obtain molecular orbitals (LCAO-MO approach) (iii) Application of LCAO-M) approach to the formation of: a. Homo-nuclear diatomic molecules: H_2, He_2, Li_2, Be_2, C_2, N_2, O_2, F_2 and Ne_2. (Discussion should include 2s-2p interaction; stabilization of p($2p_x$, $2p_y$ orbitals) Mos in B_2, C_2 and N_2 with experimental evidences; bond order and correlation with stability, bond length, bond energy and magnetic properties of all the homo-nuclear diatomic molecules mentioned). b. Bond order in O_2, O_2^+, O_2, O_2^- and examples of the occurrence of the molecular ions in $(O_2) + (PtF_6)^-$, KO_2 and Na_2O_2. c. Hetero-nuclear diatomic molecules or molecular ions: CO, No, CN-, and HCl. (Discussion should include comparison with the approach for homo-nuclear diatomic molecules, molecular orbital diagrams with explanations of bond order. Stability, magnetic and polarity)	**2**	**1**
	II	1. Transition Elements: **3L** (i) Definition and general characteristics of transition elements. (ii) Chemistry of 3d-transition elements with reference to:		**1**

		(a) Electronic Configuration (b) Oxidation States (c) Colour and Magnetic property (d) Formation of Coordination compounds (e) Application in general. 2. Bonding in Coordination Compounds: Valence bond Theory **4L** (i) Application to 4,5,6-Coordinate compounds (ii) Electro-neutrality principle and back-bonding. 3. Gravimetric Analysis: **8L** (i) Definition and Types of gravimetric analysis (ii) Precipitation Gravimetry with respect to Theory and Practice: (a) Solubility considerations: Common ion effect; diverse ion effect, pH, temperature and nature of solubility (b) Controlling particle size. (iii) Treatment of precipitates in gravimetry: (a) Digestion (b) Filtration and Washing (c) Drying and Ignition (iv) Use of Organic Reagents in gravimetric analysis (Numerical problems on this topic expected.		
	III	1. Physico-Chemical Principles: (i) Criteria for spontaneity of Chemical Reactions (ii) Electrolysis (iii) Effect of catalysts (iv) General Principles of Metallurgy 2. Manufacture of Bulk Chemicals: (i) Sulfuric acid (by Contact process) (ii) Ammonia (by Haber's process) 3. Extraction and Purification of: **5L** (i) Copper (from pyrites) by pyrometallurgy and electrolysis (ii) Silver by hydrometallurgy (iii) Aluminium by electrometallurgy.		**1**

USCH 303	**I**	1. Nomenchlature Nomenclature of polysbstituted aromatic compounds containing different functional Groups : Polysubstituted benzenes, tri substituted napgthalenes, disubstituted anthracences. Nomenclature of ethers, expoxides, and sulphur compounds. 2. Mechanism of organic reaction **7L** 2.1 The mechanism of reactions involving the following reactive intermediates: 2.1.1 Carbocations : Different types of carbocations, such as alkyl, allyl, benzyl. SN^1 reaction. Electrophilic addition across an olefinic double bond. Elimination – El mechanism. Reareeagement Wagner Meerwein rearrangement. 2.1.2 Carbanions : concept of cabon acid. Alkylation of carbon acids (active methelene compounds and terminal alkynes) using alkyl halides, and synthetic applications of these reactions. Reactions of Grignard reagents at carbonyl group. Aldol addition. 2.1.3 Carbon radicals : General reactions of radicals – abstraction, addition to C = C, combination, disproportination . Addition of HBr to alkenes in presence of perozide. Polymerization, Redox reaction – Kolbe electrolytic method. 2.1.4 Carbenes : Generation of cabenes : through alpha elimination, from diazolakanes, from ketenes. Sturcture and stability. Reactions : insertion into C-H bond and addition to olefin. 2.2 Tautomerism : Keto-enol tautomerism in adlehudes and keyones, acid and base catalysed		**1**

		enolisation, enol content and stability enols B-ketoester, B-diketones, phenols. 3. Aromatic Electrophilic Substitution Reaction **6L** 3.1 Huckel rule of aromaticity and its application to carbocyclic benzenoid and nonbenxenoid compounds and ions. Concept of antiaromaticity and homoaromaticity. 3.2 General mechamism of aromatic electrophilic substation reaction with energy profile diagram. 3.3 Drawing resonance structure of monosubstituted benzens – Activited and deactivated aromatic rings. 3.4 Effect of electron withdrawing and election donating substituents on the orientation of an incoming electrophile on the basis of – (i) electron density distribution (ii) stability of intermediate. Cases of studied : Monosubstituted benezenes containing groups – Alkyl, amino, hedroxyl, alkoxy, halo, formyl, acyl, nitril, nitro, carboxy.		
	II	**1. Aromatic Hydrocabon** **3L** 1.1 Stucture of benzene, naphthalene, linear and angular acenes. 1.2 Alky arenes : Preparation of alkyl arences through reforming, Fridedel – Crafts Alkyation, with mechanism, using – Olefins, alcohols, alkylgalides. 1.3 Reactions of alkyl arenes – side chian oxidation, ring vs side chain halogenations (mechanism) 1.4		**1**

2.Haloarenes **4L**

1.5 Preparation of haloarenes : Halogenation of arenes – Halogenation of benzene and substituted benezenes with molecular halogens (mechanism), limitations.

1.6 Reactions of haloarenes : Lack of reactivity of arylhaides under S_nl and S_N2 reactions. General mechanism (addition – elimination) of aromatic nucleophilic substitutents on the reaction – hydrolysis and animation of haloarenes. Benzyne intermediate mechamism (elimination – addition) of aromatic nucleophilic substitution reaction (cine substitution) Grignard reagent formation. Ullmann reaction.

1.7 Applications of aromatic halogen compounds.

2. Phenols **3L**

2.1 Preparation of phenols : Preparation from (i) halobenzenes, (ii) from aromatic sulphonic acids (benezene and naphthalene sulhonic acids) (iii) isopropyl and 2-butylbenzene by hydroperoxide method.

2.2 Reaction of phenols : Acidity of phenols – effect of substituents on acidity of phenols. Salt formation, Etherification – direct reaction with alcohol, Williamson Synthesis O-acylation, Halogenation, Nitration, Fries rearrangement of aryl caboxylates, Claisen rearrangement of allyloxyarence

2.3 Applications of phenols

3. Ether and Epoxides **5L**

3.1 Ethers :

3.1.1 Preparation : Dehydration of alcohols (mechanism), Willamson synthesis (mechanism)

		3.1.2 Reactions : Acid catalyzed cleavage reaction with HX (mechanism) 3.1.3 Applications : Application of ethers, Crown ethers : Structure; 12-crown-4 and 18 crown-6 and their uses. 3.2 Epoxides : 3.2.1 Preparation : Oxidation of olefins – ethylene oxide; Reactions of per acids with olefins; from vicinal halohydrins 3.2.2 Reactions : Reactivity. Ring opening reactions by nucleophiles (a) In acid conditions: hydrolysis, reaction with – HX, alcohol, HCN (b) In neutral or basic conditions ; ammonia, amines metal cyanides, Grignard reagents, alkoxides 3.2.3 Applications of epoxides.		
	III	**1. Sources of Organic Compounds** **8L** 1.1 Sources : (a) Non-renewable : coalm petroleum (crude oil) and natural gas. (b) Renewable : biomass 1.2 Coal : Stuctuture and types of coal, origin of coal. Distructive distillation of coal, coal tar refining, coal liquefaction (coal to liquid), coal gasification – synthesis gas (syn gas), hydropyrolysis 1.3 Petroleum : Charactrisitics, composition and origin of petroleum Refining of petroleum. Catalytic cracking and reforming, hydrocracking, thermal cracking, steam cracking. 1.4 Natural gas : Composition, Conversion of methane to-higher alkanes , synthetic diesel (gas to liquid) methanol, aromatic compounds, Natural gas hydrates: occurrence, structuture.		**1**

		1.5 Synthesis gas (syn gas) : Production of syn gas from – coal, natural gas, biomass, Composition, Synthetic use of syn gas- Separation of H2 Production of – methanol, alkanes, hydroformylation of olefins, synthesis diesel (biomass to liquid) 1.6 Oligomerisation and metathesis of olefins. 1.7 Biomass : Trasforming biomass into chemicals (pyrolysis) and synthesis gas. 1.8 Biofuels: Ethanol, biodiesel, synthetic diesel, methanol 2. **Chemical Industry** **4L** Idea of chemical plant, different units, block digrams and flow digrams. Flow diagrams : Principle, importance, typical elements. Typical flow diagram of single unit process. Idea of flow diagrams of multiple process units. Continous vs batch operations. Raw materials, intermediates, end products, by-products, waste. Unit processes – nitration as an example. **3. Environmental aspects of Chemical Industry** Volatile Organic Compounds (VOC), Greehouse effect : Ozone depletion, important greenhouse gases and their sourses. Hydrocarbons as air pollutants, Harmful effects of industrial effluents. Carbon emission – carbon credit, carbon neutrality, carbon offsetting. Material safely Data Sheet (MSDS).		
USCH P3		Practicals based on both courses in theory	**3**	**9**

SEMESTER IV

Course Code	UNIT	TOPICS	Credits	L / Week
USCH401	I	**Phases in Equilibra: (15L)** 1) Introduction to the terms: phase, component, degrees of freedom, Gibbs phase rule. 2) Two component systems: A) Liquid-liquid mixture, completely miscible liquids, phase diagrams, pressure composition and temperature diagrams, Raoult's law, ideal solutions, distillation of mixtures forming ideal solution, fractional distillation, distillation under reduced pressure, deviations from the Raoult's law, positive and negative deviations, nonideal solutions, azeotropes distillation of azeotropic mixtures, breaking of azeotropoes. B) Liquid-liquid mixtures, partially miscible liquids, partially miscible liquid pairs exhibiting lower critical solution temperature, upper critical solution temperature and both lower and upper critical solution temperature. C) Liquid-liquid mixtures, completely immiscible liquids, steam distillation. 3) Nernst's distribution law, partition coefficient distribution ratio, solutes undergoing association and dissociation (Qualitative explanation only)	2	1
	II	**Electrochemical Cells and Ionic Equilibria (15L)** Electrochemical Cells 1) Galvanic and electrolytic cells, types of electrodes, ion specific and ion selective, comparison, types of ion specific electrodes, (iv) redox electrodes. 2) Cell representation and cell reaction, (Students are expected to write the cell reaction for a given cell and vice versa. 3) Reversible and irreversible cells, chemical and concentration cells, primary and secondary cells. 4) Thermodynamic parameters (G, H and S) for the cell reaction taking place ion a cell. 5) Nernst's equation for cell emf and hence for a single electrode potential (Derivation expected.)		1

		6) Determination of equilibrium constant from emf measurements. Ionic equilibria: 1) Concept of PH, POH, calculations of PH of solution of acids and bases. 2) Buffer, buffer capacity, Henderson's equation for acidic and basic buffers (derivation expected).		
	III	**Introduction to Titrimetric Analysis and Use of Instrumental Methods Ion (15L)**Titrimetric Analysis Introduction to Titrimetic Methods of Analysis 1) Requirements for a reaction to be used in titrimetric analysis, classification of titrimetric analysis, terms: titration, titrand, titrant, titre value, indicator, endpoint, equivalence point, titration error. 2) Calibration of the volumetric glassware, burettes, pipettes and volumetric flasks. 3) Theory of acid base indicators, choice of an indicator for the titration dependence on the PH at the equivalence point. Use of Instrumental Methods in Titrimetric Analysis 1) Conductometric Titrations: Basic principles, experimental set up titration curves in the titration of (i) strong acid vs, strong base, (ii) weak acid vs, strong base, (iii) weak acid vs, weak base, (iv) Mixture of strong and weak acid/strong weak base vs, strong base/weak base or strong acid/weak acid, (v) sodium chloride vs, silver nitrate (vi) barium hydroxide vs, magnesium sulphate advantages and limitations. **2)** Potentiometric Titrations: Basic principles, concept of indicator electrode, indicator electrodes for different types of titration, determination of end point from the graphs of E vs V, E/ E vs, mean volume, 2E/ V vs, mean volume, advantage and limitations. (3) Photometric titrations: Basic principles, titration curves, advantages and limitations. (4) Use of computes, use of spread sheets.		**1**

USCH402	**I**	**Acids and Bases, Chemistry of Elements and Organometallic Compounds 15L** 1. Acids and Bases: **5L** (i) Appreciation of various concepts due to: (a) Arrhenius (b) Lowry-Bronstead (c) Lux-Flood (d) Lewis (e) Solvent-System (f) Usanovich (ii) Pearson's classification of acids and bases and his principle of HSAB. 2. Chemistry of Group 15 and Group 16 elements: **5L** General discussion of trends in their physical and chemical properties, Physical properties of hydrides of Group 15 and Group 16 elements with respect to hydrogen bonding. 3. Organometallic Componds: **5L** (i) Introduction, definition, classification on the basis of: (a) Hapticity, and (b) Nature of metal-carbon (M-C) bond (ii) Eighteen Electron Rule with respect to applications and exceptions: (iii) Metal carbonyls with respect to: (a) Classification and bonding (b) General methods of preparation, and (c) Properties. (iv) Applications of organometallic compounds		**1**
	II	1. Chemistry of Group 17 and Group 18 elements: **6L** (i) General trends in physical and chemical properties (ii) Chemistry of pseudo-halogens with respect to: (a) Comparison with halogens (b) Preparation and uses. **2.** Chemistry of Group – 18 elements with respect to: **4L** i) History, and ii) Preparation and structures of xenon		**1**

		fluorides and oxy fluorides 3. Bio-Inorganic Chemistry: **5L** (i) Metaloporphyrins (ii) Chlorophy II (iii) Cytochromes (iv) Hemoglobin and myoglobin: oxygen transport and storage.		
	III	**1.** Corrosion and Methods of Protection of Metals **7L** (i) Introduction (to include economics and importance of corrosion) (ii) Types of corrosion (iii) Electrochemical theory of corrosion (iv) Methods of Protection (a) Coating (b) Electroplating (c) Cathode protection (d) Anodizing (e) Sacrificial Coating. 2. Environmental Studies: **8L** (i) Multidisciplinary nature of environmental studies: Definition, scope and importance **2L** (ii) Environmental Pollution: Definition, Causes, Effects and Control measures of: **3L** (a) Water pollution (b) Soil pollution (iii) Role of an individual in prevention of pollution and Pollution case studies with reference to water and soil pollution. **1L** (iv) Environment Protection Act: **2L** (a) Air (Prevention and Control of Pollution) Act (b) Water (Prevention and Control of Pollution) Act (c) Public awareness		**1**

USCH403	**I**	1. **Aromatic Nitrogen compounds 8L** **1.1 Aromatic nitrocompounds** 1.1.1 Preparation : Nitration using mixed acid, Preparation of mononitro and dinitro-compounds through nitration of benzene (mechanism), nitrobenzene, toluene, chlorobenzene, naphthalene, anisole. 1.1.2 Reactions : Reduction of nitro-compounds under different conditions. 1.1.3 Applications of nitro compounds : In the preparion of amines and explosives. 11.2. **Aromatic amino compounds** 11.2.1 Preparation : Reduction of aromatic nitro compounds using catalytic hydrogenation, dissolving metal reduction using – Fe-HCI, Sn-HCI, Zn-HOAc, NaHS, Animation of halobenzenes, Chemoselective reduction of dinitrobenzene, Hoffmann bromanide reaction. 11.2.2. Reactions : Basicity of aromatic amines – effect of substituents on basicity of aniline, salt formation, N-alkylation, N-acylation, halogenations, reductive alkaylation, diazotization of aromatic primary amines (mechanism) Reactions of aryl diazonium salts-Sandmeyer and Gattermann reactions, Replacemet of diazo group by H – OH- CN Gomberg reaction. Azo-coupling reaction with phenols/naphthols and aromatic amines. Reducation of diazonium salt to aryl hydrazine. Formation of azo-and hydrazo-benzenes. 4. Chromophore – auzochrome concept, azo group as a chromophore, azo dyes. **Aromatic Aldehydes and Ketones 7L** 4.1 Preparation of aromatic aldehydes : Preparation using CO (Gettermann-Koch reaction) HCN (Gattermann reaction) DMG/POCI, (Vilsmerier – Haack reaction) Reimer-Tiemann reaction (mechanism) Oxidation of methularenes.		**1**

		Rosenmund reaction. 4.2 Preparation of aromatic ketones: Friedel-Crafts acylation using acid chloride and acid anhydirge (mechanism) 4.3 General reaction : Reactions with - Ammonia and amines, hydroxylamine, phenylhydrazine, hydrogen cyanide, sodium bisulphate 4.4 Reactions with mechanism : Knoevengel reaction, claisen-Schmidt reaction, benzoin reaction, Cannizzaro reaction. 4.5 Application of aromatic aldehydes and ketones.		
	II	**Aromatic acids 6L** 13.1 **Aromatic carboxylic acids :** 13.1.1 Preparation of mono-and-di-carboxylic acids : Preparation by side chain oxidation of alkyl benzenes, reaction of Grignard reagents with solid carbon dioxide, hydrolysis of aryl nitriles, Kolbe-Schmidt reaction (mechanism) 13.1.2. Reactions of aromatic carboxylic acids : Acidity, Effect ofsubstituent on the acidity of benzoic acid, Acid catalyzed esterification, esterification, Reduction and decarboxylation. 13.1.3. Applications of aromatic catboxlic acid 13.2 **Aromatic sulfonic acids** 13.2.1 Preparation of aromatic sulfonic acids : Commonly used sulfonating agents. Sulfonation of benzene (with mechanism) mono-substituted benznene and naphthalene. 13.2.2 Reaction : acidity of arene sulfonic acids. Comparative acidity of carboxylic acid and sulfonic acids. Salt formation, desulfonation IPSO substitutuion. – SO3 H as a solubilizing and blocking group preparation of sulfonic esters. 13.2.3 Uses of pTSA, sulfonated		**1**

		polystyrene naphthalene monosulfinic acids. 13.2.4 Aromatic chlorosulfonyl compounds : Aromatic chlorosulfnation using chlorosulfonic acid. Reaction of arulsulfonyl chlorides with water, ammonia an damines. Preparation of saccharin Chloramine – T, sulfanilamide.		
	III	14 **Stereochemistry 5L** 14.1 Assigning stercodescriptors to chiral centres : Cahn-Ingold-Prelog (CIP) Rules of assigning absolute configuration (R and S) to a stereogenic centre. Assigning absolute configuration to molecules having maximum two chiral carbon atoms E and Z stereodescriptors to geometrical isomers. 14.2 Diastereomers of disubstituted cycloalkanes (3 and 4 member rings) 14.3 Resolution of enantiomers : chemical and chromatographic resolution. 14.4 Conformational analysis of – propane, 2-methylpropane, 2,2-dimethulpropane, n-butane. 15. **Sturcture Determination and Multistep Synthesis 4L** Based on the reactions of aromatic compounds discussed above the following aspects should be highlighted: 15.1 Sturcture determination through a series of reactions. 15.2 Planning multistep synthesis of polysubstituted benzenes (upto 4 steps) **15L** **16. Green Chemistry** 16.1 Green chemistry: Definition, need, importance. 12 principles of green chemistry with relevant examples. Concepts and simple		**1**

		calculations on – Yield and Selectivity, E-factor, Atom economy. 16.2 Examples of green chemistry in industry. a) Green starting materials-commodity chemicals from glucose. b) Green reactions-halide free synthesis of aromatic amines. c) Green reagents-selective methylation using dimethyl carbonate. d) Green chemical solvants-use of supercritical carbon dioxide. e) Green chemical products-synthesis of thermal polyaspartates. f) Green chemistry and catalysis-novel homogenous, heterogenous and enzymatic catalysts in industry. i) catalytic liquid phase selective hydrogenation of nitrobenzene to p-aminophenol. ii) liquid phase air oxidation of p-cresol to p-hydroxybenzaldehyde. 16.3 Further trends in green chemistry 17. **Manufacture of Some bulk Chemicals Including flow diagrams.** Phenol, methanol(from syn gas),dodecylbenzene sulphonate,styrene,ethylene oxide.		
USCHP4		Practicals based on both courses in theory	**3**	**9**

Reference Books

Physical and Analytical chemistry

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2. Physical Chemistry, P.C. Rakshit, 6th Edition, 2001, Sarat Book Distributors, Kolkota. [Chapters VII, IX, XVIII].
3. Physical Chemistry, R.J. Silbey, & R.A. Alberty, 3rd edition , John Wiley & Sons, Inc [part 1]
4. Physical Chemistry, G. Castellan, 3rd esition, 5th rReprint, 1995 Narosa Publishing House [Chapter, 10,11,12,15,17].
5. Modern Electrochemistry, J.O.M Bockris & A.K.N. Reddy, Maria Gamboa – Aldeco 2nd Edition, 1st Indian reprint,2006 Springer [Chapter 1,2,3]
6. Visible & U.V. Spectroscopy, Analytical Chemsitry by Open Learing R. Demny & R. Sinclairm 1991 John Wiley & Sons
7. Classical Methods , Vol 1 Analytical Chemistry by Open Learning D. Cooper & C. Devan,1991 John Wiley & Sons {Chapter 5,6,7]
8. Physical Chemistry, G.M. Barrow, 6th Edition, Tata McGraw Hill Publishing Co. Ltd. New Delhi.
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10. Physical Chemistry, G.K. Vemullapallie, 1997, Prentice Hall of India, Pvt.Ltd. New Delhi.
11. Analytical Chemistry, J.G. Dick,1973 Tata McGraw Hill Publishing Co. Ltd. New Delhi.
12. Quantitative analysis, Dey & Underwood, Prentice Hall of India, Pvt. Ltd. New Delhi
13. Fundamentals of Analytical Chemistry, Skoog etal 8th edition, Saunders college publishing.

INORGANIC AND INDUSTRIAL CHEMISTRY

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4. B. Douglas, D. McDaniel and J.Alexanderm Concepts and Models of Inorganic Chemistry, 3rd Edition, J. Wiley and Sons Inc. (1994)

5. F.A. Cotton, G. Wilkinson and P.L. Gauss, Basic Inorganic Chemistry, 3rd Edition, J. Wiley and Sons, Inc (1195)
6. A.G. Shape, Inorganic Chemistry, 3rd Edition, Pearson Education Pub. New Delhi (1192)
7. N.N. Greenwood and A. Earnshaw, Chemistry of Elements Pergammen Press Oxford (1984)
8. Bernard Moody, Comparitive Inorganic Chemistry, 3rd Edition CBS Punlication, New Delhi (1996)
9. D. Banerjea, Coordination Chemistry, 2nd Editionm Asian Books Pvt. Ltd. New Delhi (2007)
10. RC. Meherotra and A. Singh Organometallic Chemistry Unified Approach 2nd Edition New Age International Pvt. Ltd. (2000)
11. Gary O. Spessard and L. Miessler, Organometallic Chemistry, Prentice Hall(1997)
12. P.R. Jenkins Organometallic Reagents in Synthesis, Oxford University press First Indian Edition (2005)
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