Hindi Vidya Prachar Samiti's

Ramniranjan Jhunjhunwala College

of Arts, Science & Commerce

(Autonomous College)

Affiliated to

UNIVERSITY OF MUMBAI

Syllabus for the S.Y. B.Sc.

Program: B.Sc. (Chemistry)

Course Code: RJSUCHE

CBCS: 2020 - 2021

DISTRIBUTION OF TOPICS AND CREDITS

S.Y. B.Sc. CHEMISTRY SEMESTER III

Course	Nomenclature	Credits	Topics
RJSUCHE301	Paper I	2	1. Physical 2. Inorganic 3. Organic
RJSUCHE302	Paper II	2	1. Physical 2. Inorganic 3. Organic
RJSUCHE303	Paper III	2	1. Analytical 2. Analytical 3. Industrial and Environmental Chemistry
RJSUCHEPR301 RJSUCHEPR302 RJSUCHEPR303	Paper I Paper II Paper III	3	

S.Y.B.Sc CHEMISTRY SEMESTER IV

Course	Nomenclature	Credits	Topics
RJSUCHE401	Paper I	2	1. Physical 2. Inorganic 3. Organic
RJSUCHE402	Paper II	2	1. Physical 2. Inorganic 3. Organic
RJSUCHE403	Paper III	2	1. Analytical 2. Analytical 3. Industrial and Environmental Chemistry
RJSUCHEPR401 RJSUCHEPR402 RJSUCHEPR403	Paper I Paper II Paper III	3	

SEMESTER I (THEORY)	L	Cr

Paper-I	**Paper Code: RJSUCHE301**	45	2
UNIT I		15	
Physical Chemistry			
1	**CHEMICAL THERMODYNAMICS-II** 1.1Free Energy Functions: Helmholtz Free Energy, Gibb's Free Energy, Variation of Gibb's free energy with Pressure and Temperature, Gibbs-Helmholtz equation. (Numericals expected). 1.2 Thermodynamics of Open System: Partial Molal Properties, Chemical Potential and its variation with Pressure and Temperature, Gibb's Duhem equation. 1.3 Concept of Fugacity and Activity 1.4 Chemical Equilibrium and Equilibrium Constant: Equilibrium constant, Kp and Kc and their inter-relation, Van't Hoff reaction isotherm, Van't Hoff reaction isochore. (Numericals expected).		
2	**ELECTROCHEMISTRY-II** 2.1U- tube experiment, Hittorf's rule. 2.2 Migration of ions, velocity of ions and change in concentration around electrodes(unattackable). 2.3 Transport number definition and determination by Moving Boundary Method. 2.4 Factors affecting transport number of ions. 2.5 Relation between transport number and ionic conductance. 2.6 Nernst's equation		
UNIT II		15	
Inorganic Chemistry			
2	**Chemical Bonding** **2.1 Non-Directional Bonding** 2.1.1 Ionic Bond: Conditions for the Formation of the Ionic bond. 2.1.2 Lattice Energy, Born-Lande Equation 2.1.3 Kapustinskii Equation 2.1.4 Born-Haber Cycle and its Application (Numerical problems are expected wherever possible)		
	2.2 Directional Bonding: Orbital Approach. 2.2.1 Covalent Bonding: The Valence Bond Theory- Introduction and basic postulates. 2.2.2 Interaction between two hydrogen atoms and the Potential energy		

	diagram of the resultant system. 2.2.3 Corrections applied to the system of two hydrogen atoms- Formation of H_2 2.2.4 Resonance, rules for resonating or canonical structure, the concept for formal charges. 2.2.5 Bonding in Polyatomic Species: The role of Hybridization and types of hybrid orbitals- sp, sp^2, sp^3,sp^3d^1, sp^3d^2		
3	**Molecular Orbital Theory** 3.1 Linear combination of atomic orbitals to give molecular orbitals LCAO-MO approach. 3.2 Application of LCAO –MO 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) with respect to B_2,C_2 and N_2 molecular orbital diagram, molecular configuration, bond order, bond energy and magnetic properties of all the homo-nuclear diatomic molecules mentioned. b) Heteronuclear diatomic molecules; CO, NO, and HCl. (Discussion should include a comparison with homo-nuclear diatomic molecules. Molecular orbital diagram with molecular configuration, bond order, stability, magnetic behavior, and polarity.		
UNIT III		15	
Organic Chemistry			
1	**IUPAC nomenclature of aromatic system and cycloalkanes**: Polysubstituted benzene, trisubstituted naphthalenes, disubstituted anthracenes, cycloalkanes and derivatives (up to 6 membered rings).		
2	**Aromaticity:** a. Monosubstituted benzene; activation and deactivation of rings, writing resonating structure. b. Directive influence at groups in aromatic electrophilic substitutions. i. o/p directing (activating) e.g.-OH ii. o/p directing (deactivating) e.g., Halogen iii. m- directing group (deactivating) e.g.-NO_2 based on electron density distribution and stability of intermediates.		

3	**Haloarenes and phenols:** **Haloarenes:** Reactivity of aryl halides towards nucleophilic substitution reaction. Nucleophilic aromatic substitution (S_NA_r). Addition-elimination mechanism and benzyne mechanism, cine substitution. **Phenols:** Preparation methods: from haloarenes, sulphonic acids (phenol, resorcinol, naphthols), acidic characters of phenols; steam volatility of o-nitrophenol. **The reaction of phenols:** Nitration, Bromination, O-acylation, Williamson synthesis, Fries rearrangement, Claisen rearrangement.		

S.Y.BSc.	Semester III Theory
RJSUCHE301	**Course Outcomes:**

Paper I	➢ To give exposure to various aspects of Gibbs free energy and partial molal properties. ➢ To impart insights into Nernst's equation and Hittorf's method ➢ To make students aware of different types of bonding and molecular orbital theory to diatomic molecules. **Learning outcomes:** *On successful completion of this course, students will be able to* ➢ calculate the Gibbs free energy change and partial molal properties of a system. ➢ understand Van't-Hoff reaction isotherm and isochore. ➢ determine the transport number of an ion by Hittorf's method ➢ apply the Nernst equation to calculate the emf of a cell ➢ understand lattice energy, Bond-Lande equation, Kapustinski equation, Born-Haber cycle and its applications. ➢ acquire knowledge on valence bond theory and different types of hybridization. ➢ understand the molecular orbital theory of homonuclear and heteronuclear diatomic molecules and its applications. ➢ learn the method of naming aromatic compounds. ➢ understand the concept of aromaticity. ➢ learn the reaction of haloarenes and their mechanism. ➢ know the reaction of phenols.

SEMESTER III (THEORY)	**L**	**Cr**

Paper-II	**Paper Code: RJSUCHE302**	45	2
UNIT I		15	
Physical Chemistry			
1	**Chemical kinetics-II** 1.1 Types of complex chemical reactions: Reversible or opposing, Consecutive and parallel reactions (No derivations, only example expected). Thermal chain reactions: H_2 & Br_2 Reaction (only steps involved, no kinetic expression expected). 1.2 Effect of temperature on the rate of reaction. Arrhenius equation, the concept of energy of activation (Ea). (Numericals expected). 1.3 Theories of Reaction Rates: Collision theory and activated complex theory of bimolecular reactions. Comparison between the two theories (Qualitative treatment only).		
2	**Solutions** 2.1 Liquid-liquid Mixtures (Binary mixtures) 2.2 Completely Miscible Liquids: Raoult's Law and Ideal and Non-ideal Solutions (Positive and Negative Deviations). 2.3 Partially Miscible Liquids: Partially Miscible Liquids with Upper Critical Solution Temperature (Example: Phenol-Water System), Partially Miscible Liquids with Lower Critical Solution Temperature (Example: Triethylamine-Water System), Partially Miscible Liquids with Upper and Lower Critical Solution Temperature (Example: Nicotine-Water System) 2.4 Distillation technique- Fractional distillation, Lever rule, Azeotropes, Steam distillation. 2.5 Nernst distribution law and its application in solvent extraction.		
UNIT II		15	
Inorganic Chemistry			
1	**Selected topics on p block elements** **1 Chemistry of Boron compounds** 1.1 Introduction to group 13 elements, Periodicity in properties, Electron deficient compounds – BH_3, BF_3, BCl_3 with respect to Lewis acidity and applications. 1.2 Preparation of simple boranes like diborane and tetraborane. 1.3 Structure and bonding in diborane and tetraborane (2e-3c bonds) 1.4 Synthesis of Borax.		

2	**Chemistry of Silicon and Germanium** 2.1 Silicon compounds: Occurrence, Structure and inertness of SiO_2 2.2 Preparation and structure of $SiCl_4$. 2.3 Occurrence and extraction of Germanium. 2.4 Preparation of extra pure Silicon and Germanium.		
3	**Chemistry of Nitrogen family** 3.1 Trends in chemical reactivity - Formation of hydrides, halides, oxides with special reference to oxides of nitrogen. 3.2 Oxides of nitrogen with respect to preparation and structure of NO, NO_2, N_2O, and N_2O_4.		
	UNIT III	15	
	Organic chemistry		
1	**Stereochemistry –III** 1.1 Absolute configuration: E-Z, R-S nomenclature (molecules having maximum of two asymmetric centers) 1.2 Resolution of racemates; Chemical method with illustrative examples. 1.3 Conformation of n-butane: syn-anti nomenclature, relative stabilities, energy diagram		
2	**Chemistry of carbonyl compounds** 2.1 Preparation of aliphatic, acyclic and aromatic compounds- oxidation of alcohols, Rosenmund reduction, Gattermann Koch formylation, Friedel Crafts acylation. 2.2 General mechanism of nucleophilic addition across >C=O. Reactions of >C=O with HCN, $NaHSO_3$, alcohol, amines, hydroxylamine, phenyl hydrazine, $LiAlH_4$, and $NaBH_4$. 2.3 Keto-enol tautomerism: Mechanism of acid and base catalyzed enolization. 2.4 Name reactions (Mechanism). Knoevenagel reaction, Benzoic condensation, Cannizzaro reaction.		

S.Y. BSc.	Semester III Theory
RJSUCHE302 Paper II	**Course Outcomes**: ➢ To analyze different reactions on the basis of steps undergone. ➢ To study temperature dependence on reaction rate through Arrhenius equation. ➢ Identify factors necessary to vary the reaction rate through Collision and Transition state theories. ➢ Investigate the interaction between two liquids when mixed together. ➢ To study the miscibility of liquids and preferential separation of solute through the distribution process. ➢ To study in detail some important elements of Group 13, 14 1nd 15. ➢ to study the difference between absolute and relative configurations. ➢ to identify absolute configuration around asymmetric carbon. ➢ to study different methods of preparation of carbonyl compounds. ➢ to study reactivity and reactions of carbonyl compounds. **Learning outcomes:** **Unit I (Physical Chemistry)** ➢ to suggest the pathway of reaction. ➢ determine the energy of activation by varying the temperature. ➢ develop the ideas to alter reaction rate. ➢ develop strategies to homogenize, heterogenize and separate the liquids in mixture. ➢ achieve isolation of selective components of mixture through the distribution process. **Unit II (Inorganic Chemistry)**

	➢ the preparation, structure, and bonding in compounds of boron. ➢ the preparation of extra pure silicon and germanium, the structure of SiO_2 and $SiCl_4$. ➢ the preparation and structure of oxides of nitrogen.. **Unit III (Organic chemistry)** ➢ learn the absolute configuration of stereoisomers. ➢ know the reasons for reactivity of carbonyl compounds & to study the mechanism of some name reactions involving >C=O group.

SEMESTER III (THEORY)		**L**	**Cr**
Paper-11I	**Paper Code: RJSUCHE303**	45	2

	UNIT I	15	
	Analytical Chemistry		
1	**Introduction, Classical Methods of Analysis & Statistical Treatment of Analytical Data-I** **1.1 Introduction to Analytical Chemistry** Analytical Chemistry & chemical analysis, Analysis Based on (i) the nature of information required: (Proximate, Partial, Trace, Complete Analysis) and (ii) the size of the sample used (Macro, semi-micro and micro analysis), Classical and Non-Classical methods of analysis with emphasis on the property being measured **1.2 Classical Methods of Analysis- Titrimetric Methods** Terms used in titrimetric analysis**:** titrant, titrand, titration, equivalence point, end point, titration error, indicator, Standard solutions: Primary and secondary standards **1.3 Neutralization Titrations** Concept of pH and its importance in neutralization titrations Construction of titration curve (on the basis of change in pH) and choice of indicators in the following titrations: Strong acid v/s strong base Weak acid v/s Strong base **1.4 Statistical Treatment of Analytical Data-I** Types of errors: Determinate & Indeterminate errors, source wise classification of determinate errors, constant and proportionate errors Accuracy & precision, Measures of central tendency: mean, median, mode Measures of dispersion: absolute deviation, relative deviation, range, average deviation, relative average deviation, standard deviation, variance and coefficient of variation. ***(Numerical problems wherever possible expected)***		
	UNIT II	15	
	Analytical Chemistry		
1	**Types of Analytical Instrumental methods based on**		

	i. Optical properties (e.g., UV-Visible spectrometry, Polarimetry) ii. Electrochemical properties (e.g., Potentiometry, Conductometry,) iii. Thermal effects (e.g., Thermogravimetry)		
2	**Spectrometry** Interaction of electromagnetic radiation with matter: Absorption and Emission spectroscopy Basic Terms: Radiant Power, Absorbance, Transmittance, Monochromatic light, Polychromatic light, Wavelength of maximum absorbance, Absorptivity and Molar Absorptivity. Statement and derivation of Beer's Law and Lambert's Law, Combined Mathematical Expression of Beer –Lambert's Law, Validity of Beer-Lambert's Law, Deviations from Beer-Lambert's Law ((Real deviations, Instrumental deviations and Chemical deviations) ***(Numerical problems expected)*** Instrumentation for absorption spectroscopy: Block diagrams for Single beam colorimeter and spectrophotometer (principle, construction & working) Applications of UV-Visible Spectrophotometry. Qualitative analysis, & Quantitative analysis by Calibration curve method.		
3	**Photometric Titrations** Principle and Instrumentation of Photometric titration, Types of Photometric titration Curves with examples.		
	UNIT III	15	
	Industrial & Environmental Chemistry - I		
1	**1 Sources of Organic Compounds** **1.1 Introduction** (a) Non-renewable: Coal, Petroleum, Natural gas. (b) Renewable: Biomass **1.2 Coal:** Structure & types of coal, destructive distillation of coal, coal tar refining, coal liquefaction, coal gasification. **1.3 Petroleum**: Characteristics, composition & origin of petroleum , Refining of petroleum: Fractional distillation, chemical methods of Refining, Cracking, Reforming. **1.4 Natural gas:** Composition, conversion to methane, higher alkanes, Aromatic compounds. **1.5 Synthetic gas composition:** Production of syn-gas from coal, natural gas, biomass. Synthetic uses of syn-gas, production of methanol, hydroformylation of olefins. **1.6 Biomass:** Transforming biomass into chemicals. **1.7 Biofuels** : Methanol, ethanol, biodiesel.		

2	**Environmental Studies** 2.1 Characterization of waste: biochemical oxygen demand (BOD), chemical oxygen demand (COD), total organic carbon (TOC), aerobic and anaerobic processes. 2.2 Removing of solid contaminants, physical and chemical principles such as coagulation, flocculation and sedimentation. 2.3 Primary, secondary and tertiary treatment of liquid effluents.		

S.Y. BSc.	Theory Semester III
RJSUCHE303	**Course Outcomes:** ➢ Study of basics of analytical chemistry, classification of analytical methods, classical method like titrimetry and also study use of statistics in analytical chemistry ➢ Study of Analytical Instrumental methods based on electrical properties, optical properties. ➢ study of visible spectrometry, Beer-Lambert's law, single beam colorimeter, spectrometer, photometric titrations ➢ study of renewable and nonrenewable sources and their uses. ➢ study of BOD, COD of effluent water and primary, secondary and tertiary treatment on liquid effluents. **Learning outcomes:** ***On successful completion of this course students will be able to*** **Unit I And II (Analytical Chemistry)** ➢ Understand wide range of techniques that are useful in Quantitative analysis ➢ Provide background of numerous analytical methods. ➢ Teach Laboratory skills and consequently enhance the confidence of students catered from various fields of science, in their ability to obtain high quality analytical data. ➢ Understand Principle and Instrumentation of Photometric titration

	➢ understand Instrumentation for absorption spectroscopy and application **Unit III (Industrial & Environmental Chemistry)** ➢ Understand non-renewable & renewable sources, their origin and uses ➢ learn characterization of waste & removing contaminants from waste by different methods.

SEMESTER IV (THEORY)		**L**	**Cr**
Paper-I	**Paper Code: RJSUCHE401**	45	2
UNIT I		15	
Physical Chemistry			
1	**1. Photochemistry** a) Introduction. Difference between Thermal and Photochemical reactions. Laws of Photochemistry: Grotthus-Draper Law, Stark-Einstein law. Einstein of energy. (Numericals expected). b) Quantum efficiency, determination using actinometer. (Numericals expected). c) Photochemical reactions and Primary and secondary processes. Reactions with High and Low quantum efficiency (explain with examples). Reasons for high and low quantum efficiency. d) **Photochemical Phenomenon:** Fluorescence, Phosphorescence, Chemiluminescence, Ozone formation/ depletion.		
2	**Nuclear chemistry-I** **Nuclear Stability & Radioactivity:** Factors affecting stability of nucleus: Mass defect of Nucleus, binding energy, binding energy per nucleon, binding energy curve, N/P ratio, Odd-Even number rule, Magic numbers. (Problems on mass defect, binding energy, binding energy per nucleon is expected)		
3	**Basics of quantum chemistry** Concept of quantization, atomic spectra (no derivation), wave particle duality, uncertainty principle, wave function and its interpretation, well-behaved function.		

	UNIT II	15	
	Inorganic Chemistry		
1	**Transition elements** 1 Position in the periodic table and electronic configuration. 2 Chemistry of 3 d transition elements with reference to oxidation states. Unusual oxidation states and their stabilities in aqueous solutions (with special reference to vanadium and chromium). Colour, magnetic property, ability to form complexes. 3 Study of oxides and chlorides of Titanium and Vanadium w.r.t. physical and chemical properties. 4 Qualitative tests for transition metal ions: General considerations in devising test (with reference to Chromium, Manganese, Iron, Cobalt, Nickel and Copper).		
2	**Coordination Chemistry:** **2.1 Introduction to chemistry of coordination compounds** 1. Historical perspectives: Early ideas on coordination compounds. 2. Basic terms and nomenclature. 3. Types of ligands. 4. Isomerism; General types with special reference to stereoisomerism of coordination compounds (C.N.=6). 5. Evidence for the formation of coordination compounds. 6. Application of coordination compounds. **2.2 Theories of co-ordination compounds** 1. Werner's theory of co-ordination compounds. 2. Effective atomic number rule. 3. Eighteen electron rule. **2.3 Nature of the Metal-Ligand Bond.** 1. Valance bond theory: Hybridization of the central metal orbitals- sp^3, dsp^2, sp^2d, sp^3d^1, d^2sp^3 (Inner orbital complexes), sp^3d^2 (outer orbital complexes). Discussion should include the ions: Mn (II), Fe (II), Fe (III), Co (II), Co(III), Ni(II), Cu(II), Zn(II) complexes with ligands like aqua, ammonia, CN^- and Halides. 2. Limitations of V.B.T.		
	UNIT III	15	
	Organic Chemistry		
1	**Aromatic amino compounds:** 1.1 Preparation: Reduction of aromatic nitro compounds using catalytic hydrogenation, Fe-HCl and Zn/ HOAc, reduction of nitriles, ammonolysis		

	of halides, Hoffmann bromamide reaction. 1.2 Effect of substituents on basicity of amines. 1.3 Reactions: salt formation, N-alkylation, N-acylation, carbylamine reaction, Electrophilic substitution in aromatic amines: bromination , nitration and sulphonation. 1.4 Diazonium salts: preparation of diazonium salt, mechanism of diazotization, synthetic applications: Sandmeyer, Gattermann and Gomberg reactions, replacement of diazo group by -H, -OH, reduction to aryl hydrazines.		
2	**Heterocyclic Chemistry** **2.1 Introduction:** Electronic structure and aromaticity of furan, thiophene, pyrrole and pyridine. 2.2 **Synthesis:** Synthesis of furan, thiophene, pyrrole by Paal-Knorr synthesis, pyridine by Hantzsch synthesis 2.3 **Reactivity:** Reactivity towards electrophilic substitution in furan, thiophene, pyrrole on the basis of stability of intermediate, nucleophilic substitution in pyridine on the basis of electron distribution. 2.4 **Reactions:** the following reactions of furan, thiophene and pyrrole: Nitration, Sulphonation, Halogenation, Friedel-Crafts reactions, Vilsmeier-Haack formylation. Sulphonation of pyridine with and without catalyst, catalytic hydrogenation of pyridine, Chichibabin reaction		

S.Y. BSc.	Theory Semester IV
RJSUCHE401 Paper I	**Course Outcomes:** ➢ To expose the students to the concepts and terminologies involved in photochemistry as well as quantum chemistry. ➢ To give the students an idea about the stability and instability of the nucleus of an atom. ➢ To study the properties of transition elements. ➢ To understand the chemistry of coordination compounds. **Learning outcomes:** After completing this course, the learner will be able to **Unit I (Physical Chemistry)** ➢ explain the concepts and terminologies of photochemistry & calculate the quantum yield of a photochemical reaction. ➢ understand and predict the stability of the nucleus of an atom ➢ comprehend the basics of quantum chemistry. **Unit II (Inorganic Chemistry)** ➢ understand the properties of 3d transition elements and ions.

	➢ understand the terminologies of coordination chemistry as well as theories associated with coordination compounds. **Unit III (Organic chemistry)** ➢ Understand the reactions of aromatic amino compounds. ➢ synthesize the variety of organic compounds from diazonium salt. ➢ understand heterocyclic chemistry.

SEMESTER IV (THEORY)		L	Cr
Paper-II	**Paper Code: RJSUCHE402**	45	2
UNIT I		15	
Physical Chemistry			
1	**Solid State** i. Recapitulation of laws of crystallography and types of crystals. ii. Characteristics of simple cubic, Face centered cubic and body centered cubic systems, interplanar distance in simple cubic lattice & expression for ratio for all three types. iii. Use of X-rays in the study of crystal structure, Bragg's equation (Derivation expected), X-rays diffraction method of studying crystal lattice structure, structure of NaCl and KCl. Determination of Avogadro's number (Numericals expected).		
2	**Catalysis** i. Types of catalysis, Catalytic activity, Specificity and selectivity, Inhibitors, Catalyst poisoning and Deactivation. ii. Mechanism and kinetics of acid -base catalyzed reactions, effect of pH. iii. Mechanism and kinetics of enzyme catalyzed reactions (Michaelis-Menten equation). iv. Effect of particle size and efficiency of nano particles as catalyst.		
UNIT II		15	
Inorganic Chemistry			
1	**Ions in aqueous medium** **Acidity of Cations and Basicity of Anions** i. Hydration of Cations: Hydrolysis of Cations predicting degree of hydrolysis of Cations- effect of Charge and Radius. ii. Latimer Equation, Relationship between pK_a, acidity and z^2/r ratios of metal ions, graphical presentation. iii. Classification of cations on the basis of acidity category:non-acidic, moderately acidic, strongly acidic, very strongly acidic with pK_a values range and examples. iv. Hydration of anions: effect of charge and radius, hydration of anions and classification on the basis of basicity.		

2	**Chemistry of Volatile Oxides and Oxo-acids.** i. Physical properties of concentrated oxo-acids like Sulphuric, Nitric and Phosphoric acid. **ii.** Application of these acids.		
	UNIT III	15	
	Organic Chemistry		
1	**Aromatic carboxylic acids & its derivatives:** i. Preparation of carboxylic acids (with reference to benzoic acid, salicylic acid & phthalic acid) oxidation of alcohols & alkyl benzene, carbonation of Grignard reagent and hydrolysis of Nitriles. Kolbe-Schmidt synthesis (mechanism). ii. Effects of substitution on strength of aromatic carboxylic acids. iii. Reactions: salt formation, decarboxylation reduction with $LiAlH_4$,Hell-Volard-Zelinsky reaction, conversion of acid to acid chloride, amide, anhydride & ester (mechanism of esterification). iv. Name Reaction (Mechanism): Claisen condensation and Dieckmann condensation.		
2	**Aromatic sulfonic acids:** i. Preparation of aromatic sulfonic acids: Commonly used sulfonating agents. Sulfonation of benzene (with mechanism), mono-substituted benzenes and naphthalene. ii. Comparative study of acidity of Ar-COOH and Ar-SO_3H. iii. Reaction: salt formation, reaction with alcohol, PCl_5, IPSO, substitution, desulphonation.		

S.Y. BSc.	Theory Semester IV
RJSUCHE402 Paper II	**Course Outcomes:** ➢ recollect the basic concepts, laws in solid state and study how X-rays play pivotal roles in their understanding. ➢ to take an insight to the structures of common substances and predict their densities. ➢ study catalysis, its types and obtain the kinetic relations. ➢ to know about nano-particles ➢ to study the principle involved in the hydrolysis and hydration of cations and anions in aqueous solution, types of anions and cations with their predominance diagrams.

	➢ to study different methods of preparation of aromatic carboxylic and sulphonic acids. ➢ to learn the effects of different substituents on acidity of carboxylic acids. ➢ to study reactivity and reactions of aromatic carboxylic and sulphonic acids. **Learning outcomes:** **Unit I (Physical Chemistry)** ➢ able to determine the interplanar spacing between different imaginary planes, atoms per unit cell in SC, BCC and FCC crystal systems. ➢ understand the Bragg's relation and various factors determining the intensity of X- ray peaks. ➢ realize the key role of catalyst in tuning reaction rate with special attention to Enzyme and Acid catalyzed reactions. ➢ develop the innovative ideas possible from nano-particles. **Unit II (Inorganic Chemistry)** ➢ To understand the acidity of cations and basicity of anions in aqueous medium. ➢ To learn the properties and applications of oxoacids of N, P & S. **Unit III (Organic chemistry)** ➢ compare reactivities of aromatic carboxylic acids & sulphonic acids. ➢ learn reactions of aromatic acids.

SEMESTER IV (THEORY)		**L**	**Cr**
Paper-III	**Paper Code: RJSUCHE403**	45	2
UNIT I		15	
Analytical Chemistry			
1	**Statistical Treatment of Analytical Data–II** i.Gaussian distribution curve, Equation and salient features of Gaussian		

	distribution curve ii. Concept of confidence limits and confidence interval and its computation using (i) Population standard deviation (ii) Student's *t* test (iii) Range iii. Criteria for rejection of doubtful result (i) 2.5 d rule (ii) 4.0 d rule (iii) Q test iv. Test of Significance (i) Null hypothesis (ii) F-test (variance ratio test) v. Graphical representation of data and obtaining best fitting straight line by using method of averages (i) For line passing through origin (ii) For line not passing through origin. (***Numerical problems wherever possible expected)***		
2	**Separation Technique-Chromatography** i. Introduction to Chromatography ii. Classification of chromatographic methods based on stationary and mobile phase iii. Paper Chromatography: Principle, Techniques and Applications. iv. Thin layer Chromatography: Principle, Technique and Applications.		
	UNIT II	15	
	Analytical Chemistry		
1	**Instrumental Methods-II** **1. Instruments based on electrochemical properties of analyte** **1.1 Potentiometry** Principle, role of reference and indicator electrodes, applications in neutralization reactions with reference to the titration of a strong acid against a strong base using quinhydrone electrode, Graphical methods for detection of end points, Advantages & limitations of potentiometric titrations. **1.2 Conductometry** Basic principle, conductivity cell: construction & care, Applications in neutralization titration w.r.t. Strong acid v/s strong base Weak acid v/s Strong base Weak base v/s strong acid Weak acid v/s weak base Advantages & limitations of conductometric titrations		
2	**1. Separation techniques-Solvent Extraction** 1.1 Introduction, Nernst distribution Law, Partition Coefficient, Distribution Ratio. 1.2 Conditions of extraction: Equilibration time, Solvent volumes, temperature,		

	pH. 1.3 Single step and multistep extractions (derivation expected), Percentage extraction for single step and multistep extractions (derivation expected), Separation factor. 1.4 Batch and continuous extractions.		
	UNIT III	15	
	Industrial & Environmental Chemistry		
1	**1. Industrial & Environmental Chemistry - II:** 1.1 **General principles of metallurgy** 1.2 Extraction and purification of: i. Copper (from pyrites) by pyrometallurgy and electrolysis. ii. Silver by hydrometallurgy. iii. Aluminium by electrometallurgy.		
2	**1. Environmental Aspects of Chemical Industry** i. Volatile organic compounds (VOC) ii. Hydrocarbons as air pollutants iii. Carbon emission-carbon credit, carbon neutrality, carbon offsetting. iv. Material Safety Data Sheet (MSDS) **2. Toxicology** i. Concept and important terms ii. Common environmental toxicants. iii. Organic toxicants: Chlorinated hydrocarbon, Polyaromic hydrocarbon (PAH) & their toxic effects. iv. Toxic effects of pesticides. v. Case study: Bhopal gas tragedy.		

S.Y. BSc.	Theory Semester IV
RJSUCHE403 Paper III	**Course Outcomes** ➢ To study Basics Principle, and applications of potentiometric titrations. ➢ To study Basics principle, conductivity cell: construction & care, of conductometric titrations. ➢ To study Basics principle of Separation Techniques-Solvent Extraction ➢ To study statistical treatment of analytical data, chromatographic methods like paper chromatography and TLC.

	➢ To study different metallurgical processes used for copper, silver and aluminium. ➢ To study different environmental aspects of the chemical industry. **Learning outcomes:** After completing this course, the learner will be able to **Unit I And II (Analytical Chemistry)** ➢ understand a wide range of techniques that are useful in Quantitative analysis, and gain knowledge on numerous analytical methods. ➢ Learn Laboratory skills and consequently enhance their ability to obtain high quality analytical data. ➢ understand Principle and applications of potentiometric titrations and conductometric titrations. ➢ gain knowledge of statistical treatment and apply it for quantitative analysis. ➢ understand the basic techniques to be used in paper chromatography & TLC. **Unit III (Industrial & Environmental Chemistry)** ➢ learn the metallurgical operations used for the extraction of copper, silver and aluminium. ➢ understand various environmental aspects of the chemical industry .

Semester III (PRACTICALS)		**L**	**Cr**
Practical-I	**Paper Code: RJSUCHEPR301**		1
1	**Physical** 1. To verify Oswald's dilution law for a weak acid conductometrically. 2. To investigate the reaction between $K_2S_2O_8$ (potassium persulphate) and KI (potassium iodide) with equal in initial concentration. 3. To determine the amount of HCl in the given sample potentiometrically. 4. To determine the critical solution temperature (CST) of Phenol-water system and comment on CST.		

2	**Analytical** **1.** Assay and calculation of % error in the neutralization titration of given commercial sample of aspirin by using I.P. **2.** Estimation & calculation of % error in the conductometric titration of given acid with strong base **3.** Calculation of % error in the colorimetric estimation of copper ions in the given solution by using calibration curve method 4. Determination of λ and molar absorptivity (∑) of manganese in $KMnO_4$ by using spectrophotometer .		
Practical-II	**Paper Code: RJSUCHEPR302**		1
1	**Inorganic** **1. Qualitative analysis: (at least 6 mixtures to be performed)** Semi-micro inorganic qualitative analysis of a sample containing two cations and two anions. Dry test and wet tests to be performed. Cations (from amongst): Ba^{2+}, Ca^{2+}, Sr^{2+}, Cu^{2+}, Co^{2+}, Fe^{3+}, Ni^{2+}, Zn^{2+}, Mg^{2+}, Al^{3+}, K^{+}, NH_4^{+} Anions (From amongst): CO_3^{2-}, SO_3^{2-}, NO_2^{-}, NO_3^{-}, Cl^{-}, Br^{-}, SO_4^{2-}, PO_4^{3-} **2. Volumetric Estimation:** i) Estimation of iron present in the given ferric alum solution using diphenylamine indicator. ii) Estimation of lead by complexometric method.(Standardization of EDTA to be done)		
Practical-III	**Paper Code: RJSUCHEPR303**		1
1	**Organic** a) Identification of organic compounds (solid/liquid) containing bifunctional groups with C, H, (O), N, S, halogen (Minimum 6 compounds) b) Derivatization of an organic compound with a given functional group. Preparation of suitable derivative, purification drying and MP determination. i) Iodoform from acetone ii) Cyclohexanone oxime from cyclohexanone. iii) Phthalic anhydride from phthalic acid by sublimation		

S.Y.B. Sc.	Semester III, Practical
RJSUCHEPR301 **RJSUCHEPR302** **RJSUCHEPR303**	**Course Outcomes:** ➢ To study Basics Principle and use of instruments like potentiometer, pH meter, conductometer and colorimeter. ➢ To study basics of kinetic experiments, measurement of critical solution temperature. ➢ To study the qualitative analysis of inorganic salts. ➢ To understand the estimation of Fe and Pb by volumetric analysis. **Learning outcomes:** After completing this course, the learner will be able to ➢ learn how to use and how to take care of various instruments used in physical-analytical laboratories. ➢ learn to standardize various instruments used in physical-analytical laboratories. ➢ learn to use various techniques in kinetics experiments. ➢ understand S.O.P of electrical instruments. ➢ develop skills in analysis of water insoluble inorganic mixture following S.M. techniques. ➢ learn organic identification. ➢ learn one step organic derivatization. ➢ find out the cations and anions present in the given inorganic mixture. ➢ estimate the metal ions present in the given solution by titration.

Semester IV (PRACTICALS)		**L**	**Cr**
Practical-I:	**Paper Code: RJSUCHEPR401**		1
1	**Physical** 1. To determine standard E.M.F. of Daniel cell and the standard Gibbs free energy change for the cell reaction potentiometrically.		

	2. To compare the strengths of HCl and H_2SO_4 by studying kinetics of acid hydrolysis of methyl acetate. 3. To prepare acidic buffer and basic buffer and determine their buffer capacity. 4. To verify Henderson's equation. **Analytical** 1. Paper chromatography: Separation of cations like Fe(III), Ni(II) and Cu(II) in a sample. 2. To investigate the partition of Ferric ions between organic (Ethyl acetate) and aqueous phase and thereby to determine the (i) partition Coefficient of Fe (III) between ethyl acetate and water (ii) extraction efficiency of ethyl acetate as the solvent of extraction. 3. pH metry : Estimation of vitamin C content in a given sample by titration with NaOH pH metrically and calculation of % error . 4. Potentiometry : Estimation of Fe(II) in the given solution by titrating against $K_2Cr_2O_7$ potentiometrically and calculation of % error.		
Practical-II:	**Paper Code: RJSUCHEPR402**		1
	a) Volumetric Estimation: 1. Estimation of Na_2CO_3 & $NaHCO_3$ using double indicator. 2. Estimation of boric acid for its percentage purity. 3. Estimation of KIO_3 for its percentage purity. 4. Commercial analysis of organic acid (Vinegar). 5. Estimation of total hardness of water.		
2	**b) Inorganic Preparation:** 1. Copper acetylacetonate. 2. Hexamine Nickel (II) chloride 3. $CuCl_2$.2DMSO		
Practical-II:	**Paper Code: RJSUCHEPR403**		1
1	**a) Organic Estimation:** i) Determination of equivalent weight of organic acid by alkalimetry. ii) Estimation of amide by hydrolysis. iii) Estimation of aniline by bromination.		

2	**b) Organic preparation:** i) Acetanilide from aniline. ii) m-dinitrobenzene from Nitrobenzene. iii) p-bromoacetanilide from acetanilide. iv) Tribromoaniline from aniline.		

S.Y. B.Sc.	Practicals Semester IV
RJSUCHEPR401 **RJSUCHEPR402** **RJSUCHEPR403**	**Course Outcomes:** ➢ To study Electroanalytical methods and chromatographic techniques ➢ to impart knowledge to estimate the composition of mixtures and commercial samples. ➢ to prepare inorganic complexes. **Learning outcomes:** ➢ understand chromatographic techniques of separations of metals. ➢ learn to estimate different inorganic compounds using volumetric technique. ➢ understand organic synthesis with respect to calculation of yield. ➢ will be able to estimate the composition, percentage purity and assay of commercial samples. ➢ will able to prepare transition metal complexes.

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2. Unit operations and processes – P.H. Groggins.
3. Coal and combustion: Dr. Kale.
4. Industrial Chemistry-B. K. Sharma, Goyal publishing house.
5. Renewable sources of energy and environment: E. Hinnawi and A.K.Biswas
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B.Sc. (Chemistry) Semester – III & IV

Exam Pattern

Internal exam
Internal 1: MCQ (20 marks)
Internal 2: Short answer questions (20 marks)

Term end exam paper pattern
Total marks: 60
Each question paper will have 4 questions of 15 marks each. All questions will be compulsory.
The nature of Q.1 (from unit 1), Q.2 (from unit 2), Q.3 (from unit 3) will be as follows:

Learners to answer any **3** questions out of 5 (each of 5 marks)

Q.4 will be of type:

A or A	from unit 1 of 5 marks
B or B	from unit 2 of 5 marks
C or C	from unit 3 of 5 marks

Semester end practical exam pattern
50 marks per course
Journal: 5 marks
Written test / viva voce based on theory behind all the experiments conducted per course: 10 marks
Experiment: 35 marks