Resolution Number : AC/I(21-22).2(II).RUS5

S. P. Mandali's

Ramnarain Ruia Autonomous College

(Affiliated to University of Mumbai)

RUIA COLLEGE
Explore • Experience • Excel

Syllabus for

Program: B.Sc (Chemistry)

Program Code: RUSCHE

(Credit Based Semester and Grading
System for academic year 2022–2023)

Ramnarain Ruia Autonomous College

PROGRAM OUTCOMES

S. P. Mandali's Ramnarain Ruia Autonomous College has adopted the Outcome Based Education model to make its science graduates globally competent and capable of advancing in their careers. The Bachelors Program in Science also encourages students to reflect on the broader purpose of their education.

PO	Description
A student completing Bachelor's Degree in Science program will be able to:	
PO 1	Recall and explain acquired scientific knowledge in a comprehensive manner and apply the skills acquired in their chosen discipline. Interpret scientific ideas and relate its interconnectedness to various fields in science.
PO 2	Evaluate scientific ideas critically, analyse problems, explore options for practical demonstrations, illustrate work plans and execute them, organise data and draw inferences.
PO 3	Explore and evaluate digital information and use it for knowledge upgradation. Apply relevant information so gathered for analysis and communication using appropriate digital tools.
PO 4	Ask relevant questions, understand scientific relevance, hypothesize a scientific problem, construct and execute a project plan and analyse results.
PO 5	Take complex challenges, work responsibly and independently, as well as in cohesion with a team for completion of a task. Communicate effectively, convincingly and in an articulate manner.
PO 6	Apply scientific information with sensitivity to values of different cultural groups. Disseminate scientific knowledge effectively for upliftment of the society.
PO 7	Follow ethical practices at work place and be unbiased and critical in interpretation of scientific data. Understand the environmental issues and explore sustainable solutions for it.
PO 8	Keep abreast with current scientific developments in the specific discipline and adapt to technological advancements for better application of scientific knowledge as a lifelong learner.

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PROGRAM SPECIFIC OUTCOMES

PSO	Description
A student completing Bachelor's Degree in Science program in the subject of Chemistry will be able to:	
PSO 1	Acquire the fundamental knowledge of the main branches of chemistry viz. Physical, Inorganic, Organic and Analytical.
PSO 2	Identify and separate components of organic or inorganic origin and will also be able to analyse them by making use of the modern instrumental methods learned.
PSO 3	Communicate the results of the scientific work in oral as well as written format to both the scientists and the public at large.
PSO 4	Establish themselves as effective professionals and function as a member of an interdisciplinary problem solving team by demonstrating the critical thinking, problem solving & analytical reasoning skills while developing solutions or strategies for solving the real problems through the use of the chemistry knowledge gain during the course.
PSO 5	Appreciate the central role of chemistry in our society and use this as a basis for ethical behaviour in issues facing chemists including an understanding of safe handling of chemicals, environmental issues and key issues facing our society in terms of energy, health and medicine.
PSO 6	Develop skills that will prepare them not only for immediate employment but also for life-long learning in advanced areas of Chemistry and related fields.

PROGRAM OUTLINE

Year	Semester	Course Code	Course Title / Unit Title		Credits
F.Y.B.Sc	**I**	**RUSCHE101**	**Chemistry-I**		**2**
			Unit-I	Chemical Calculations	
			Unit-II	Atomic Structure, Periodic Table and Periodicity of Properties and Chemistry of s-block elements	
			Unit-III	Fundamentals of Organic Chemistry	
		RUSCHE102	**Chemistry-II**		**2**
			Unit-I	Gaseous and Liquid State	
			Unit-II	Oxidation Reduction Chemistry and Environmental impact of oxides of carbon, sulphur and nitrogen.	
			Unit-III	Stereochemistry	
		RUSCHEP101	**Practical**		**2**
	II	**RUSCHE201**	**Chemistry-I**		**2**
			Unit-I	Chemical Thermodynamics- I	
			Unit-II	Concepts of Qualitative Analysis and Acid-Base Theories	
			Unit-III	Chemistry of Aliphatic Hydrocarbons	
		RUSCHE202	**Chemistry-II**		**2**
			Unit-I	Chemical Kinetics-I and Photochemistry	
			Unit-II	Chemical Bond and Reactivity	
			Unit-III	Chemistry of Aromatic Hydrocarbons	
		RUSCHEP102	**Practical**		**2**
S.Y.B.Sc	**III**	**RUSCHE301**	**Chemistry-I**		**2**
			Unit-I	Chemical Thermodynamics-II	
			Unit-II	Electrochemistry-I : Electrolytic Conductance And Transport Number	
			Unit-III	Chemical Bonding	

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		RUSCHE302	**Chemistry-II**		2
			Unit-I	Reactivity and reactions of halogenated hydrocarbons, Organomagnesium and organolithium compounds, Alcohols, phenols and epoxides.	
			Unit-II	Chemistry of Carbonyl Compounds	
			Unit-III	Chemistry of p-block elements: (Group 13 and 14)	
		RUSCHE303	**Chemistry-III**		2
			Unit-I	Introduction to Analytical Chemistry	
			Unit-II	Classical methods of analysis Gravimetric Analysis Titrimetric Analysis	
			Unit-III	Environmental Chemistry: Chemistry of Water	
		RUSCHEP301	**Practical**		**2**
	IV	**RUSCHE401**	**Chemistry-I**		2
			Unit-I	Electrochemistry-II: Electromotive Force of Galvanic Cells. pH and Buffers	
			Unit-II	Solutions of Liquid In Liquid Phase Equilibria	
			Unit-III	Comparative Chemistry of the transition metal. Coordination Chemistry. Nature of the Metal-Ligand Bond.	
		RUSCHE402	**Chemistry-II**		2
			Unit-I	Carboxylic acids and their derivatives, Sulphonic acids.	
			Unit-II	Amines, Diazonium Salts, Heterocyclic Compounds	

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			Unit-III	Chemistry of Group 15 and 16 elements Organometallic Chemistry	
		RUSCHE403	**Chemistry-III**		**2**
			Unit-I	Separation Techniques Solvent Extraction Chromatography (PC , TLC, HPTLC)	
			Unit-II	UV- Visible Absorption spectroscopy Photometric titrations Conductometric titrations	
			Unit-III	Industrial Chemistry	
		RUSCHEP401	**Practical**		**2**
T.Y.B.Sc	**V**	**RUSCHE501**	**Chemistry-I**		**2.5**
			Unit-I	Molecular spectroscopy	
			Unit-II	Electrochemistry-III Classification of galvanic cells	
			Unit-III	Colligative properties Chemical kinetics-II	
			Unit-IV	Surface chemistry & catalysis Colloids	
		RUSCHE502	**Chemistry-II**		**2.5**
			Unit-I	Chemical bonding: Molecular symmetry Molecular orbital theory for polyatomic species Metallic bonding.	
			Unit-II	Solid state chemistry	
			Unit-III	Chemistry of elements: lanthanides & actinides	
			Unit-IV	Chemistry of non aqueous solvents, inter-halogen compounds and xenon	
		RUSCHE503	**Chemistry-III**		**2.5**
			Unit-I	Mechanism of organic reactions	
			Unit-II	Stereochemistry	
			Unit-III	IUPAC nomenclature	

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				Polymers	
			Unit-IV	Synthesis of organic compounds	
		RUSCHE504	**Chemistry-IV**		**2.5**
			Unit-I	Sampling Treatment of analytical data	
			Unit-II	Titrimetric analysis: Redox titrations Precipitation titrations Complexometric titrations Non-aqueous titrations	
			Unit-III	Atomic absorption spectroscopy. Atomic emission methods Fluorescence and phosphorescence spectroscopy. Nephelometry and turbidimetry.	
			Unit-IV	Thermal methods Radioanalytical techniques Mass spectrometry Method validation	
		RUSCHEP501	**Practical (RUSCHEP501 + RUSCHEP502)**		**3**
		RUSCHEP502	**Practical (RUSCHEP503 + RUSCHEP504)**		**3**
	VI	**RUSCHE601**	**Chemistry-I**		**2.5**
			Unit-I	NMR spectroscopy Polymers	
			Unit-II	Electrochemistry-IV: Decomposition potential, overvoltage and electroplating Crystalline State	
			Unit-III	Nuclear chemistry-III	
			Unit-IV	Basics of quantum chemistry	
		RUSCHE602	**Chemistry-II**		**2.5**
			Unit-I	Coordination chemistry	

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			Unit-II	Properties of coordination compounds	
			Unit-III	Organometallic chemistry	
			Unit-IV	Nanomaterials Bioinorganic chemistry	
		RUSCHE603	**Chemistry-III**		
			Unit-I	Chemistry of carbohydrates Catalysts & reagents	**2.5**
			Unit-II	Chemistry of amino acids, proteins and nucleic acids Photochemistry	
			Unit-III	Spectroscopy –I	
			Unit-IV	Spectroscopy –II Natural products	
		RUSCHE604	**Chemistry-IV**		**2.5**
			Unit-I	Separation techniques (GC, HPLC, ion exchange chromatography)	
			Unit-II	Electro-analytical techniques: Ion selective electrodes Polarography Amperometric titrations	
			Unit-III	Miscellaneous Methods Potentiometric Titrations Bi-amperometric titrations Gel electrophoresis Size exclusion chromatography	
			Unit-IV	Applications to different fields: Food analysis Cosmetic analysis Detergent analysis Water analysis Pharmaceutical analysis	
		RUSCHEP601	**Practical (RUSCHEP601 + RUSCHEP602)**		**3**
		RUSCHEP602	**Practical (RUSCHEP603 + RUSCHEP604)**		**3**

Resolution Number: AC/I(21-22).2(II).RUS5

S. P. Mandali's
Ramnarain Ruia Autonomous College
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Syllabus for Semester I & II
Program: F.Y.B.Sc
Program Code: RUSCHE

(Credit Based Semester and Grading System for academic year 2022–2023)

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SEMESTER I

Course Code: RUSCHE101

Unit	Content	No of Lectures
1	**Chemical Calculations:** 1.1 Mole concept, relation with molar mass, conversion of amount into mole and vice versa, relation with the number of particles present. 1.2 Amount and concentration, volume based units for concentration, molarity, normality, formality, mass based unit for concentration - molality and mole fraction, ppm and ppb, concept of millimoles and milliequivalents. 1.3 Problem solving based on various concentration units 1.4 Stoichiometry and calculations based on it, concept of limiting reactant and yield for a chemical reaction. 1.5 Calculations based on stoichiometry. 1.6 Primary standards, properties of primary standards, primary standards for different types of titrations, secondary standards, standardization, standard solutions.	15
2	**Atomic Structure and Periodic Table and Periodicity of Properties.** 2.1 Atomic Structure 2.1.1 Rutherford's Atomic Model; Bohr's Theory and its limitations, Somerfield extension to Bohr's theory Zeeman effect ; their relationship with quantum number; orbit and orbital. 2.1.2 Quantum Numbers of last electron; Hund's rule, Aufbau principle; Pauli exclusion Principle. 2.1.3 Wave function, Schrodinger wave equation (Mathematical expression not to be discussed), Radial and Angular forms of the wave function; Relationship between Radial function and probability; plots of probability for different orbitals; shapes of orbitals: s,p,d,f. . 2.2 Periodic Table and Periodicity of Properties. 2.2.1 Long form of the Periodic Table; Classification of elements as main group, transition, and inner transition elements;	15

	2.2.2 Periodicity in the following properties: Atomic and ionic size; electron gain enthalpy; ionization enthalpy, effective nuclear charge (Slater rule); Electronegativity: Pauling and Mulliken rules (Numerical problems expected, wherever applicable). **2.3 Chemistry of s- block elements** **2.3.1.** Chemical properties, Uses of alkali and alkaline earth metals, Diagonal relationship of Li and Mg. **2.3.2 Role of Na and K in biological systems.**	
3	**Fundamentals of Organic Chemistry** 3.1 Nomenclature of Organic Compounds: 3.1.1 IUPAC nomenclature of mono functional aliphatic compounds. 3.1.2 IUPAC nomenclature of bi-functional aliphatic compounds and their cyclic analogues. 3.2 Bonding and Structure of organic compounds: Concept of Hybridization (sp3, sp2and sp hybridization) Hybridization: sp3, sp2and sp hybridization of carbon and nitrogen; sp3 and sp2 hybridizations of oxygen in organic compounds and their geometry with suitable examples. 3.3 Basic concepts involved in organic reaction mechanism: 3.3.1 Electronic Effects: Inductive, electromeric, resonance effects, hyperconjugation. 3.3.2 Carbocations, Carbanions and Free radicals: Homolytic and heterolytic fission, examples of the same. Formation of carbocations, carbanions and free radicals. (primary, secondary, tertiary, allyl, benzyl), their relative stability. 3.3.4 Organic acids and bases; their relative strengths.	15

Course Code: RUSCHE102

Unit	Content	No of Lectures
1	**1. Gaseous Sate** 1.1.1 Postulates of kinetic theory of gases and Gas Laws. 1.1.2 Ideal and real gases, deviations from the gas laws, reasons for the deviations, compressibility factor, Boyle temperature. 1.1.3 Volume correction and pressure correction, van der Waals equation of state, use of the equation to explain the deviations from the gas laws. 1.1.4 Joule-Thomson effect, Joule-Thomson coefficient, inversion temperature, Linde's process of liquefaction of gases. 1.1.5 Maxwell - Boltzmann's distribution of velocities, the graphical presentation and its interpretation, average velocity, most probable velocity and R.M.S. velocity. **2. Liquid State** 1.2.1 Introduction to liquid state, characteristics of liquid state, physical properties of the liquids. 1.2.2 Determination of surface tension by drop number method using stalagmometer. 1.2.3 Surface active solutes and surface tension, applications of surface tension measurement. 1.2.4 Viscosity: Introduction, coefficient of viscosity. 1.2.5 Determination of coefficient of viscosity by Ostwald viscometer. 1.2.6 Applications of viscosity measurement.	15
2	**Oxidation Reduction Chemistry and Environmental impact of oxides of carbon, sulphur and nitrogen.** 2.1 Oxidation state, oxidation number, oxidation- reduction in terms of oxidation number 2.2 Balancing redox equations by i) oxidation number method and ii) ion- electron method. 2.3 Calculation of equivalent weight on the basis of chemical nature. 2.4 Study of oxides of carbon, sulphur and nitrogen with respect to their	15

	(a) Sources (b) Health Hazards (c) Environmental Impact (d) Control Techniques	
3	**Stereochemistry** 3.1.1 Optical Isomerism: optical activity, specific rotation, chirality, enantiomers, molecules with two similar and dissimilar chiral-centres, distereoisomers, mesostructures, racemic mixture. 3.1.2 Flying-wedge, Fischer, Newman and Sawhorse projection formulae (erythro, threo isomers) and their interconversion. 3.1.3 Relative and absolute configuration: D/L and R/S designations. 3.1.4 Geometrical isomerism in alkenes and cycloalkanes: cis–trans isomerism and E/Z notations with C.I.P rules. 3.1.5 Conformational analysis of alkanes (ethane, propane and n-butane) and their relative stability on the basis of energy diagrams.	15

Course Code: RUSCHEP101

	Experiments to Be Covered	
	i) Determination of the strength of the supplied sodium hydroxide solution, using solution of a primary standard for acid base titration. ii) Determination of the strength of the supplied sodium thiosulphate solution. iii) To determine value of ideal gas constant R in different units by eudiometer method. iv) To determine relative viscosity of a given polymer solution using Ostwald's viscometer. v) To determine the percentage composition of a mixture gravimetrically ($BaSO_4$ + NH_4Cl) vi) Semi-Micro Qualitative analysis of a binary mixture containing two cations and two anions (Only non-interfering radicals) vii) Purification of a given organic compound by crystallization with solvent/solvent-free. (Minimum three). ix) Characterization of solid organic compounds (Minimum three Compounds) x) To determine the individual strength of Sodium Carbonate and Sodium Bicarbonate in a mixture of the two using two indicators. xi) To Determine the Strength of commercially available sample of HCl.	

SEMESTER II

Course Code: RUSCHE201

Unit	Content	No of Lectures
1	**Chemical Thermodynamics-I** 1.1 Fundamental concepts in Thermodynamics: The macroscopic variables basic definitions needed to describe thermodynamic systems, equations of state and the ideal gas law. 1.2 First Law of Thermodynamics : Work, heat, and internal energy, Operational definitions, the molecular interpretation of heat, work and internal energy, the formulation of the First Law, state functions, and path functions 1.3 Work: The general expression for work, Expansion against constant pressure, Reversible expansion, Comparing Work for Reversible and Irreversible Processes 1.4 Heat transactions: Heat capacity, the definition of enthalpy, Enthalpy change and heat transfer, the variation of enthalpy with temperature. Heat capacity at constant pressure and volume, the relation between heat capacities. 1.5 Thermochemistry: Standard enthalpy changes, Hess's law, The temperature dependence of reaction enthalpies. Using Kirchhoff's law, application in biochemistry and materials science, experimental techniques i) Differential scanning calorimetry ii) Isothermal titration calorimetry	15
2	**Concept of Qualitative Analysis and Acid Base Theories:** 2.1.1 Macro, Semi-Micro, Micro, Ultra Micro, Trace Analysis 2.1.2 Reactions involving liberation of gases, Use of Papers impregnated with Reagents in qualitative analysis (With reference to papers impregnated with starch-iodide, potassium dichromate, lead acetate, dimethyl glyoxime, and oxine reagents) (balanced Chemical Reactions expected). 2.1.3 Precipitation equilibria: Factors affecting the solubility of an ionic compound viz. common ions, uncommon ions, temperature, nature of the solvent, pH, complexing agents (Balanced Chemical Equations and Numerical Problems Expected) 2.2 Acid-Base Theories	15

	2.2.1 Arrhenius; Lowry-Bronsted concept ; Classification of solvents, auto dissociation of amphiprotic solvents, Lewis concept ; Usanovich concept 2.2.2 Hard and Soft Acids and Bases-HSAB (with respect to occurrence and feasibility of chemical reaction);.	
3	**Chemistry of Aliphatic Hydrocarbons:** 3.1.1 Carbon-Carbon sigma bond: Chemistry of alkanes: Methods of Preparation of alkanes, Wurtz reaction, Wurtz-Fittig reaction, reactions of alkanes, free radical substitutions: Halogenation - relative reactivity and selectivity. 3.1.2 Carbon-Carbon pi bonds: alkenes and alkynes, methods of preparation of alkenes and alkynes by elimination reactions: mechanism of E1 andE2. Saytzeff and Hofmann eliminations. 3.1.3 Reactions of alkenes: electrophilic addition and mechanism (Markownikoff/ Anti Markownikoff addition). Mechanism of ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation (oxidation). 1, 2 and 1, 4-addition reactions in conjugated dienes, Diels-Alder reaction; Allylic and benzylicbromination using N-bromosuccinimide and its mechanism. 3.1.4 Methods of Preparation and reactions of alkynes: Acidity, electrophilic and nucleophilic additions. Hydration to form carbonyl compounds, alkylation of terminal alkynes.	15

Course Code: RUSCHE202

Unit	Content	No of Lectures
1	**1. Chemical Kinetics – I and Photochemistry** 1.1.1 Rate of a reaction, rate constant and measurement of reaction rates. 1.1.2 Order and molecularity of reaction. 1.1.3 Integrated rate equation for zero, first and second order reactions (with equal and unequal initial concentration of the reactants). 1.1.4 Kinetic characteristics of zero, first and second order reactions. 1.1.5 Numerical problems based on zero, first and second order reactions, Applications of kinetic study 1.1.6 Methods for the determination of the order of a reaction **2. Photochemistry** 1.2.1 Electromagnetic radiation, photochemical reactions, first and second law of photochemistry, photochemical and thermal reactions. 1.2.2 Quantum yield, measurement of quantum yield, actinometers.	15
2	**Chemical Bond and Reactivity** 2.1.1Types of chemical bonds; comparison between ionic and covalent bonds; polarizability and its effect on a bond, (Fajan's Rules). 2.1.2 Shapes of simple molecules: Lewis dot structures; Sidgwick-Powell theory; Basic VSEPR Theory for ABn type of molecules (neutral or charged species), with and without lone pair of electrons. 2.1.3 Isoelectronic species; applications and limitations of VSEPR Theory.	15
3	**Chemistry of Aromatic Hydrocarbons** **3**.1.1 Aromaticity: Benzene, Kekule's formulation of benzene structure (historical background), Hückel's rule, anti-aromaticity, aromatic character of arenes.	15

	3.1.2Aromaticity: cyclic carbocations/carbanions and heterocyclic compounds with suitable examples, aromaticity and acidity, relative stabilities. 3.1.3 Electrophilic aromatic substitution: sulphonation and Friedel-Craft alkylation/acylation and mechanisms for the same, mechanism of halogenation, nitration of benzene: 3.1.4 Directing effects of the substituents/groups on electrophilic aromatic substitution, reactions of mono substituted benzene derivatives (-CH_3, -NH_2, -OH, NO_2, -X) 3.1.5 Nucleophilic aromatic substitution of Aryl halides (replacement by –OH group and effect of nitro substituent).	

Course Code: RUSCHEP201

	Experiments to Be Covered	
	i) To determine the rate constant of the acid catalyzed hydrolysis of methyl acetate. ii) Determination of the strength of the supplied iodine solution using the sodium thiosulphate solution of known strength. iii) To study thermodynamic parameters of a simple chemical reactions. iv) To determine the valence factor of KMnO4 by titrating with oxalic acid. v) To determine the percentage composition of a mixture gravimetrically (ZnO + $ZnCO_3$) vi) Semi-Micro Qualitative analysis of a binary mixture containing two cations and two anions (Should also include interfering radicals) (Minimum three mixtures) vii) Chemical synthesis (one step) a) Preparation of Iodoform derivative of methyl ketone. b) Preparation of acetyl derivative of primary amine. c) Preparation of 2,4-DNP derivative of carbonyl compound viii) To determine the acid neutralising capacity of commercially available sample of antacid. ix) Characterisation of Liquid Organic Compounds containing C, H, (O), N, X elements. (Minimum three compounds)	

Modality of Assessment

Theory Examination Pattern:

A) Internal Assessment - 40% (40 Marks)

Sr No	Evaluation Type	Marks
1	Assignment	15
2	Class Test (MCQ / Objectives)	20
3	Active Participation in Class (Seminars/Presentations)	05
	Total	**40**

B) External Examination : 60 % (60 marks)
Semester End Theory Examination :

i. Duration - These examinations shall be of **two hours** duration.
ii. Theory question paper pattern :-

1. There shall be **three** questions each of **20** marks. On each unit there will be one question.
2. All questions shall be compulsory with internal choice within the questions.

Questions	Options	Marks	Questions based on
Q.1)	**Any 5 out of 7**	**20**	**Unit I**
Q.2)	**Any 5 out of 7**	**20**	**Unit II**
Q.3)	**Any 5 out of 7**	**20**	**Unit III**
	Total	**60**	

Practical Examination Pattern:

(A) Internal Examination:- 40 % (20 Marks)

Particulars	Paper I	Paper II
Journal	05	05
Experimental Work	10	10
Participation	05	05
Total	**20**	**20**

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B) External Examination : 60 % (30 Marks)

Semester End Practical Examination:

Particulars	**Paper I**	**Paper II**
Laboratory Work	25	25
Viva	05	05
Total	**30**	**30**

PRACTICAL BOOK/JOURNAL

- The students are required to present a duly certified journal for appearing at the practical examination, failing which they will not be allowed to appear for the examination.
- **In case of loss of Journal and/ or Report, a Lost Certificate should be obtained from Head/ Co-ordinator / In-charge of the department ; failing which the student will not be allowed to appear for the practical examination.**

Overall Examination and Marks Distribution Pattern:

Course	**101**			**102**			**Grand Total**
	Internal	**External**	**Total**	**Internal**	**External**	**Total**	
Theory	**40**	**60**	**100**	**40**	**60**	**100**	**200**
Practicals	**20**	**30**	**50**	**20**	**30**	**50**	**100**

(Total Marks : 300)

Resolution Number : AC/I(21-22).2(II).RUS5

S.P. Mandali's

Ramnarain Ruia Autonomous College

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RUIA COLLEGE
Explore ● Experience ● Excel

Syllabus for Semester III & IV
Program: S.Y.B.Sc.
Program Code : RUSCHE

(Credit Based Semester and Grading System with effect from the academic year 2022-2023)

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Semester III
Course Code: RUSCHE301
Course Title : CHEMISTRY-I
Academic Year 2022-2023

Course Outcomes :

After studying the course, the learner will be able to:	
CO 1	Understand significance of Gibb's and Helmholtz Free Energy and its applications.
CO 2	Apply Clapeyron equation to various phase transitions.
CO 3	Derive van't Hoff's Reaction Isochore and Isotherm.
CO 4	Derive various Maxwell relations.
CO 5	Give relationship between conductance, specific conductance, equivalent conductance and molar conductance.
CO 6	Describe the concept of Transport Number.
CO 7	Know the applications and Limitations of Valence Bond Theory
CO 8	Predict geometry of molecules based on Hybridization.
CO 9	Determine Bond Order, bond energy and magnetic behaviour of the compound based on Molecular Orbital Theory.

DETAILED SYLLABUS

RUSCHE301		**CHEMISTRY-I**	**Credits-02**
	Unit	**Unit Title**	**Lectures**
	I	**Chemical Thermodynamics-II**	**(15L)**
		1.0 Recapitulation **1.1** Variation of Gibb's free energy with Pressure and Temperature, Gibbs-Helmholtz equation. **1.2** Thermodynamics of open systems: partial molal properties, chemical potential and its variation with pressure	

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		and temperature, Gibb's Duhem equation. **1.3** Clapeyron equation and its application to phases in equilibria. Clausius-Clapeyron equation and its application to Liquid-Vapour equilibrium. **1.4** Concept of fugacity and activity **1.5** van't Hoff reaction isotherm and van't Hoff reaction isochore. **1.6** Maxwell's relations.	
	II	**Electrochemistry-I:** **Electrolytic Conductance And Transport Number**	**(15L)**
		2.1 Electronic and electrolytic Conductors: Conductance, cell constant, specific conductance, equivalent conductance and molar conductance and their relationships. Variation of Molar conductance with concentration, for weak and strong electrolytes. Concept of limiting molar conductance. (Numericals are expected). **2.2** Debye-Huckel theory for strong electrolytes: 1) Relaxation effect 2) Electrophoretic effect. **2.2** Kohlrausch's law of independent migration of ions. Limiting molar conductances for ions, determination of limiting molar conductance for weak electrolytes. **2.3** Measurement of conductance and determination of cell constant. **2.4** Applications of conductance measurements: 1) Determination of degree of dissociation	

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		and dissociation constant of weak electrolyte. 2) Determination of solubility and solubility product of sparingly soluble salts. **2.5** Transport number, relation between transport number and velocity of ions. Factors affecting transport number. **2.6** Hittorf's Rule and experimental determination of transport number using Hittorf's method **2.7** Experimental determination of transport number by moving boundary method. (Numericals are expected). **2.8** Absolute ionic mobility, relation between transport number, absolute ionic mobility and limiting molar conductance of ion.	
	III	**Chemical Bonding**	**(15L)**
		3.1. Valence Bond Theory	**(07L)**
		1.1.1 Valence bond theory: postulates of VBT, need for hybridisation, Orbitals involved in hybridisation sp, sp^2, sp^3, dsp^2, sp^3d, and sp^3d^2, sd), energetics of hybridisation, interaction between two hydrogen atoms and their Potential energy diagram, Bond energy of hydrogen molecule (experimental value), Theoretical improvements in bond energy of hydrogen molecule,	

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		1.1.2 Concept of resonance and Formal Charge; rules for resonance or canonical structures with examples.	
		3.2 Molecular Orbital Theory	**(08L)**
		3.2.1. Concept of orbital overlaps, types of orbital overlaps (s-s,s-p,p-p) **3.2.2.** Linear combination of atomic orbitals to form molecular orbitals (LCAO-MO approach). **3.2.3.** Application of MOT to Homonuclear diatomic molecules from He_2 molecule and for all the elements of second period, heteronuclear diatomic molecules (HCl, NO) **3.2.4** Molecular orbital Theory and determination of Bond Order and magnetic behaviour for O_2,O_2^+ O_2^-,O_2^{2-} (Problems are expected wherever applicable)	

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Course Code: RUSCHE302
Course Title : CHEMISTRY-II
Academic year 2022-2023.

Course Outcomes:

After studying the course, the learner will be able to:	
CO 1	Know the reactions of halogenated hydrocarbons.
CO 2	Assign Nomenclature to organometallic compounds, alcohols, phenols and epoxides.
CO 3	Compare the acidic strengths of alcohols and phenols.
CO 4	Write mechanisms of condensation reactions.
CO 5	Know the use of active methylene compounds in organic synthesis.
CO 6	Understand the concept of electron deficient compounds and its correlation with Lewis acidity.
CO 7	Draw the structure and bonding involved in diborane and tetraborane.
CO 8	Comprehend the chemistry of Silicon and its compounds.

DETAILED SYLLABUS

RUSCHE302		CHEMISTRY-II	Credits-02
	Unit	**Unit Title**	**Lectures**
	I	**Organic Chemistry – I**	**(15L)**
		1.1. Reactivity and reactions of halogenated hydrocarbons: **1.1.1. Alkyl halides:** Nucleophilic substitution reactions: S_N^1, S_N2 and S_Ni mechanisms with stereochemical aspects, factors affecting nucleophilic substitution reactions: nature of substrate, solvent, nucleophile and leaving group. **1.1.2. Aryl halides:** Reactivity of aryl halides towards nucleophilic substitution reactions.	**(04L)**

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		Nucleophilic aromatic substitution (S_NAr), addition-elimination and benzyne mechanism.	
		1.2 Organomagnesium and Organolithium compounds: Type, Nomenclature. Nature, and reactivity of carbon-metal bond. Method of preparation using alkyl / aryl halide. Structure, stability and reactions of these compounds with compounds containing, acidic hydrogen, carbonyl, cyanides group, epoxides and CO_2.	**(03L)**
		1.3.Alcohols, phenols and epoxides: **1.3.1. Alcohols:** Nomenclature, Methods of Preparation: 1. Hydration of alkenes 2.Hydrolysis of alkyl halides 3. Reduction of aldehydes and ketones 4. Using Grignard reagent. Properties: Hydrogen bonding, effect of hydrogen bonding on properties. Acidity of alcohols, Reactions of alcohols **1.3.2. Phenols:** methods of preparation, physical properties and acidic character, comparative acidic strengths of alcohols and phenols, resonance stabilization of phenoxide ion, reactions of phenols. **1.3.3**. **Epoxides:** Nomenclature, methods of preparation and reactivity of epoxides, reactions of epoxides, ring opening reactions by nucleophiles , acid hydrolysis, reaction with halogen halide, alcohol, hydrogen cyanide. Reactions with ammonia, amines, Grignard reagents, alkoxides.	**(08L)**

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	II	**Organic Chemistry II:** **Chemistry of Carbonyl Compounds**	**(15L)**
		2.1 Carbonyl Compounds: Nomenclature of aliphatic, alicyclic and aromatic carbonyl compounds, structure, reactivity of aldehydes and ketones . methods of preparation: oxidation of primary and secondary alcohols using PCC, hydration of alkynes, action of Grignard reagent on esters, Rosenmund reduction, Gattermann – Koch formylation and Friedel Craft acylation of arenes. **2.2** Mechanism of nucleophilic addition, and acid catalyzed nucleophilic addition reactions. **2.3** Reactions of aldehydes and ketones with $NaHSO_3$, HCN, RMgX, alcohol, amine, phenyl hydrazine, 2,4-Dinitrophenyl hydrazine, $LiAlH_4$ and $NaBH_4$. **2.4** Mechanism of the following reactions: Benzoin condensation, Knoevenagel condensation, Claisen-Schmidt and Cannizzaro reaction. **2.5** Keto-enol tautomerism: mechanism of acid and base catalysed enolization **2.6** Compounds with active methylene: Acetylacetone, ethyl acetoacetate diethyl malonate, stabilised enols. Reactions of Acetylacetone and ethyl acetoacetate: alkylation, conversion to ketone, mono- and dicarboxylic acid.	

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	III	**Chemistry of p block elements (Group 13 & 14)**	**(15L)**
		3.1 Chemistry of Group 13 elements 3.1.1 Electronic configuration, Trends in metallic characters: Oxidation states and Inert pair effect. 3.1.2 Electron deficient compounds – BH_3, BF_3, BCl_3 with respect to Lewis acidity and applications. 3.1.3 Preparation of simple boranes like diborane and tetraborane. 3.1.4 Structure and bonding in diborane and tetraborane (2e-3c bonds) 3.1.5 Borazine – Preparation, properties, Structure and bonding. **3.2 Chemistry of Group 14 elements** 3.2.1 Electronic configuration, Trends in metallic characters: Oxidation states and Inert pair effect. 3.2.1 Silica: Occurrence, Structure and inertness. 3.2.2 Methods of preparation of $SiCl_4$ and its structure. 3.2.3 Preparation of extra pure Silicon – Zone refining and Single Crystal method 3.2.4 Silicones – Preparation, classification, properties and uses.	

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Course Code: RUSCHE303
Course Title : CHEMISTRY-III
Academic year 2022-2023

Course Outcomes:

After studying this course, the learner will be able to:	
CO 1	Elaborate on the scope and importance of Analytical Chemistry.
CO 2	Describe and compare a range of classical and instrumental methods and will be able to explain their underlying theoretical principles.
CO 3	Enlist the advantages/disadvantages of classical & instrumental methods of analysis.
CO 4	Outline the steps involved in the analysis of a sample.
CO 5	Choose an appropriate analytical method to prepare , separate and quantify samples from various matrices.
CO 6	Classify different errors according to their sources
CO 7	Determine the different kinds of errors involved in chemical analysis.
CO 8	Suggest methods that can be adopted to minimize the different types of errors.
CO 9	Apply the scientific process , including statistical treatment of data, in the conduct and reporting of chemical analysis.
CO 10	Discuss the factors affecting the solubility of a precipitate.
CO 11	Enumerate the different steps involved in a precipitation gravimetry.
CO 12	Explain the effect of various experimental factors on the particle size of the precipitate.
CO 13	Define the various terms involved in titrimetric analysis.
CO 14	Explain the theory of acid-base indicators and choose a suitable indicator for a particular acid-base titration.
CO 15	Relate some of the properties of the water to its chemical makeup.
CO 16	Describe the composition of ground water.

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DETAILED SYLLABUS

RUSCHE303	CHEMISTRY-III		Credits-02
	Unit	**Unit Title**	**Lectures**
	I	**Introduction to analytical chemistry**	**(15L)**
		1.1 Scope and importance of analytical chemistry, difference between analytical chemistry and chemical analysis, qualitative and quantitative analysis, steps involved in analytical chemistry, types of analysis on the basis of sample size and the components estimated. Factors for choosing a method. **1.2** Classification of analytical methods, classical and instrumental, subdivision of classical and instrumental methods with the emphasis on the property measured, devices used and the nature of analysis. **1.3** Steps involved in chemical analysis from sampling to presentation of results and the conclusions. **1.4** Performance characteristics of an analytical method- qualitative and quantitative: LOD, LOQ, dynamic range, working range, sensitivity, selectivity. **1.5** Quantitative analysis using calibration curve method, standard addition method and internal standard method **1.6** LR and AR grade chemicals, MSDS of chemicals, glassware and its categories,	

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		calibration of volumetric glassware, burettes, pipettes and volumetric flasks. **1.7** Measurement, errors involved in the measurement, propagation of errors, random, gross and determinate errors, classification of determinate errors, instrumental, methodic, operational personal errors, minimization of errors. **1.8** Accuracy and precision, measures of accuracy: absolute error and relative error, constant error and proportionate error, measures of central tendency and dispersion: mean, mode, median, deviation, absolute, relative, average, standard deviation, range, review of data with respect to accuracy and precision. (Numericals are expected).	
	II	**Classical methods of analysis**	**(15L)**
		2.1 Gravimetric analysis: **2.1.1** Introduction to gravimetric analysis, types of gravimetric analysis, conditions for a reaction to be used in gravimetric analysis, solubility and solubility product, factors affecting solubility: temperature, common and diverse ion effect, pH, nature of the solvent, complexation. **2.1.2** Unit operations in gravimetric analysis, precipitation, homogenous and heterogeneous precipitation, relative super saturation, nucleation and crystal growth, their effect on particle size, Ostwald's ripening, impurities associated with precipitate formation, filtration,	**(07L)**

		washing of the precipitate, drying and incineration, use of thermal methods.	
		2.2 Titrimetric analysis **2.2.1** Introduction to titrimetric analysis, conditions for a reaction to be used in titrimetric analysis, terms involved: titrant, titrand, indicator, equivalence point, endpoint, titration error, types of titrations. **2.2.2 Acid –base titrations** **2.2.2.1** Acid base indicators, theory of acid base indicators, conditions for choosing an indicator. **2.2.2.2** Types of acid base titrations, titration curves. **2.2.2.3** Construction of the titration curves and the choosing of the indicator for A) strong acid –strong base B) strong acid –weak base C) weak acid – strong base D) weak acid –weak base **2.2.4** Titration of dibasic acid with a strong base, condition for obtaining two separate equivalence points, qualitative description of the titration curve, determination of the dissociation constant. **2.2.4** Titration of phosphoric acid with a strong base.	**(08L)**
	III	**Environmental Chemistry**	**(15L)**

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		3.1 Chemistry of water **3.1.1** Water as a natural resource : Physical and Chemical properties of water, significance of water as an universal solvent and its properties viz. pH , Dielectric constant ,boiling point. Anomalous behaviour of water. **3.1.2** Hydrological cycle. chemical composition of ground water. **3.1.3** Factors affecting solubility of gases in water . Solubility of CO_2 and O_2 in water **3.1.4** Water quality : Parameters for determining water quality i) Physical parameters: - pH, pE, conductivity, TS , TSS, TDS ii) Chemical Parameters- acidity, alkalinity, hardness, salinity , chlorine demand , DO, COD, iii) Biological parameter – BOD, MPN **3.1.5** Standards for Potable and industrial water.	

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Semester-III
Practical
Credits: 3

RUSCHEP301	**CHEMISTRY-I** 1. To study the kinetics of the reaction between $K_2S_2O_8$ and KI for equal concentration. 2. To determine conductance, specific conductance and molar conductance for given electrolyte solution. 3. To determine degree of dissociation and dissociation constant of weak electrolyte and hence to verity Ostwald's dilution law. 4. To determine solubility of a sparingly soluble salt conductometrically. 5. To determine the amount of strong acid in the given solution by conductometric titration. 6. To determine the amount of strong acid in the given solution by pH-metric titration.
RUSCHEP302	**CHEMISTRY-II** Qualitative determination of anion and molecular composition of the salts such as copper sulphate pentahydrate, nickel chloride hexahydrate, anhydrous cupric chloride using volumetric methods. (Learners will prepare EDTA solution). Minimum four salt samples will be given to every student. **Organic preparation and their purification:** Use 0.5-1.0g of the organic compound. Purify the product by recrystallization. Report theoretical yield, percentage yield and melting point of the purified product. **Preparation of:** 1. Cyclohexanoneoxime from cyclohexanone. 2. Tribromoaniline from aniline. 3. m-Dinitrobenzene from nitrobenzene 4. Phthalic anhydride from phthalic acid by sublimation 5. Preparation of 5-nitrosalicylic acid from salicylic acid. 6.Benzoic acid from benzamide. 7. Magneson – II from p-nitroaniline
RUSCHEP303	**CHEMISTRY-III**

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	1. Gravimetric estimation of Nickel (II) as Ni-DMG. 2. Gravimetric estimation of barium ions as $BaSO_4$. 3. To carry out the calibration ofpipette and burette. 4. To determine hardness of given water sample. 5. To determine Dissolved Oxygen of the given water sample. 6. To determine the COD of water sample.

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Modality of Assessment

Theory Examination Pattern:

A) Internal Assessment - 40% (40 Marks)

Sr No	Evaluation Type	Marks
1	Assignment	15
2	Class Test (MCQ / Objectives)	20
3	Active Participation in Class (Case studies/Seminars/Presentations)	05
	Total	**40**

B) External Examination : 60 % (60 marks)

Semester End Theory Examination :

(B) Duration - These examinations shall be of **two hours** duration.

(C) Theory question paper pattern :-

There shall be **three** questions each of **20** marks. On each unit there will be one question.

All questions shall be compulsory with internal choice within the questions.

Questions	Options	Marks	Questions based on
Q.1)	**Any 5 out of 7**	**20**	**Unit I**
Q.2)	**Any 5 out of 7**	**20**	**Unit II**
Q.3)	**Any 5 out of 7**	**20**	**Unit III**
	Total	**60**	

Practical Examination Pattern:

(A) Internal Examination:- 40 % (20 Marks)

Particulars	Paper I	Paper II	Paper-III
Journal	05	05	05
Experimental Work	10	10	10
Participation	05	05	05
Total	**20**	**20**	**20**

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(A) External Examination : 60 % (30 Marks)

Semester End Practical Examination:

Particulars	**Paper I**	**Paper II**	**Paper II**
Laboratory Work	25	25	25
Viva	05	05	05
Total	**30**	**30**	**30**

PRACTICAL BOOK/JOURNAL

- The students are required to present a duly certified journal for appearing at the practical examination, failing which they will not be allowed to appear for the examination.
- **In case of loss of Journal and/ or Report, a Lost Certificate should be obtained from Head/ Co-ordinator / In-charge of the department ; failing which the student will not be allowed to appear for the practical examination.**

Overall Examination and Marks Distribution Pattern:

Course	**301**			**302**			**303**			**Grand Total**
	Internal	**External**	**Total**	**Internal**	**External**	**Total**	**Internal**	**External**	**Total**	
Theory	**40**	**60**	**100**	**40**	**60**	**100**	**40**	**60**	**100**	**300**
Practicals	**20**	**30**	**50**	**20**	**30**	**50**	**20**	**30**	**50**	**150**

(Total: 450 marks)

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Semester IV
Course Code: RUSCHE401
Course Title : CHEMISTRY-I
Academic year 2022-2023

Course Outcomes :

After studying the course, the learner will be able to:	
CO 1	Apply the concepts of Gibbs' and Helmholtz Free Energy to EMF measurements.
CO 2	Understand the significance of Gibbs' and Helmholtz Free Energy and its applications to EMF measurements.
CO 3	Describe the types of Electrodes and Electrochemical Cells
CO 4	Derive Nernst Equation and can give its applications.
CO 5	Calculate the pH for strong and weak electrolytes and Buffer Action.
CO 6	Classify solutions on the basis of intermolecular forces.
CO 7	Determine molecular weight of a component in a given mixture by steam distillation.
CO 8	Apply phase rule to One-Component and Two-Component systems.
CO 9	Comprehend various Properties of Transition Metals.
CO 10	Define basic Terms involved in Co-ordination chemistry.
CO 11	Apply Werner's Theory to understand the model of co-ordination compounds.
CO 12	Know the significance of co-ordination compounds.
CO 13	Describe the nature of the Metal-Ligand Bond.

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DETAILED SYLLABUS

RUSCHE401		CHEMISTRY-I	Credits-02
	Unit	**Unit Title**	**Lectures**
	I	**Electrochemistry II and Concept of pH and Buffers**	**(15L)**
		1.1.Electromotive Force of Galvanic Cells **1.1.1** Electrochemical cells, galvanic cells, reversible cells and reversible electrodes, conventions to represent Galvanic cells. **1.1.2** Types of electrodes, standard electrode potential, electrochemical series. **1.1.3** Cell potential and standard cell potential. **1.1.4** Nernst equation and its importance. **1.1.5** Calculation of thermodynamic parameters: ΔG, ΔH, ΔS and equilibrium constant from EMF data. **1.1.6** Classification of galvanic cells: chemical cells and concentration cells **1.1.7** Determination of pH using glass electrode and quinhydrone electrode.	**(10L)**
		1.2 pH and Buffers **1.2.1** pH concept, calculation of pH for strong and weak electrolytes **1.2.2** Buffer, Henderson's equation for acidic and basic buffer **1.2.3** Buffer Capacity. (Numericals are expected).	**(05 L)**
	II	**Solutions of Liquid in Liquid and Phase Equilibria**	**(15L)**

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		2.1 Solutions of Liquid In Liquid **2.1.1** Thermodynamics of ideal solutions: ideal solutions and Raoult's law, deviations from Raoult's law. **2.1.2**Vapour pressure-composition and temperature –composition curves of ideal and non-ideal solutions. Distillation of liquids forming ideal and non-ideal solution, Azeotropes, steam distillation. **2.1.3** Partially miscible liquids: critical solution temperature; systems with upper critical solution temperature, lower critical solution temperature and having both. **2.1.4** Nernst distribution law and its applications to solvent extraction	**(08 L)**
		2.2 Phase Equilibria **2.2.1** Terms involved: Phases, components and degrees of freedom. Gibbs Phase Rule. **2.2.2** Phase diagrams of one-component systems (water, CO_2 and sulphur). **2.2.3** Two component systems involving eutectic (lead-silver system)	**(07L)**
	III	**Comparative Chemistry of transition metals and Co-Ordination Chemistry**	**(15L)**
		3.1: Chemistry of Transition Metals **3.1.1** Position in the periodic table, electronic configuration. **3.1.2** Significance of special stability of d^0, d^5 and d^{10}configurations, Variable oxidation states and their stabilities in aqueous solutions; ability to form	**(06 L)**

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		complexes, colour, magnetic property, catalytic property.	
		3.2 Coordination Chemistry: **3.2.1** Historical perspectives; **3.2.2** Molecular compounds – Double salts and Complex salts **3.2.3** Werner's theory **3.2.4** Basic terms viz complex ion, charge on the complex, ligands, coordination number, oxidation state, & Nomenclature **3.2.5** Sidgwick – Powel Theory of coordination compounds; Effective atomic number rule. **3.2.6** Stereoisomerism and optical isomerism of coordination compounds (C.N.= 4 and 6). **3.2.7** Evidence for the formation of coordination compounds. **3.2.8** Application of coordination compounds.	**(05 L)**
		3.3. Nature of the Metal-Ligand Bond: **3.3.1** Application of VBT to complexes with coordination number 4, 5 & 6, Inner and outer orbital complexes.	**(04L)**

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Course Code: RUSCHE402
Course Title : CHEMISTRY-II
Academic year 2022-2023.

Course Outcomes:

After studying this course, the learner will be able to:	
CO 1	Write reactions of Carboxylic and sulphonic acids and their derivatives
CO 2	Assign Nomenclature and explain the nature, type and reactivity of Amines and Diazonium Compounds
CO 3	Write reactions for the preparation of given heterocyclic Compounds.
CO 4	Classify Organometallic compounds and illustrate their catalytic applications.
CO 5	Comprehend the chemistry of metal carbonyls.

DETAILED SYLLABUS

RUSCHE402	**CHEMISTRY-II**		**Credits-02**
	Unit	**Unit Title**	**Lectures**
	I	**Chemistry of Carboxylic and Sulphonic Acids**	**(15L)**
		1.1Carboxylic Acids and their derivatives` **1.1.1**. Nomenclature, structure and physical properties, acidity of carboxylic acids, effects of substituents on acid strength of aliphatic and aromatic carboxylic acids. **1.1.2.** Preparation of carboxylic acids: oxidation of alcohols and alkyl benzene, carbonation of Grignard reagent and hydrolysis of nitriles. **1.1.3.** Reactions: Acidity, salt formation, decarboxylation, reduction of carboxylic acids with $LiAlH_4$, diborane, Hell-Volhard-Zelinsky reaction, conversion to acid chlorides, esters,	**(11L)**

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		amides and acid anhydrides and their relative reactivity. **1.1.4.** Mechanism of nucleophilic acyl and acid-catalysed nucleophilic acyl substitution. Interconversion of acid derivatives by nucleophilic acyl substitution. **1.1.5.** Mechanism of Claisen condensation and Dieckmann condensation.	
		1.2 Sulphonic acids: **1.2.1** Nomenclature, preparation of aromatic sulphonic acids by sulphonation of benzene (with mechanism), toluene and naphthalene. **1.2.2** Reactions: Acidity of arene sulfonic acid, comparative acidity of carboxylic acid and sulfonic acids reactions of arenesulphonic acid such as salt formation, desulphonation , phosphorous pentachloride, *ipso* substitution.	**(4L)**
	II	**Chemistry of Amines and Heterocyclic Chemistry**	**(15L)**
		2.1Amines: **2.1.1.**Nomenclature, effect of substituent on basicity of aliphatic and aromatic amines. **2.1.2.**Preparation: Reduction of aromatic nitro compounds using catalytic hydrogenation, chemical reduction using Fe-HCI, Sn-HCl, Zn-acetic acid. Reduction of nitriles, ammonolysis of halides, reductive amination, Hofmann bromamide reaction. **2.1.3.**Reactions: salt Formation, N-acylation, N-alkylation, Hofmann' exhaustive methylation	**(4L)**

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		(HEM), Hofmann-elimination, carbylamine reaction, reaction with nitrous acid, Electrophilic substitution in aromatic amines: bromination, nitration and sulphonation.	
		2.2 Diazonium Salts: **2.2.1** Preparation: - Sandmeyer reaction, Gattermann reaction, Gomberg reaction. Reactions: Replacement of diazo group by -H,-OH. Azo coupling with phenols, naphthols and aromatic amines, reduction of diazonium salt to aryl hydrazine and hydroazobenzene. Synthetic application.	**(3L)**
		2.3 Heterocyclic Compounds: **2.3.1.**Classification, nomenclature, electronic structure, aromaticity in 5-numbered and 6-membered rings containing one heteroatom. **2.3.2** Synthesis of Furan, Pyrrole (Paal-Knorr synthesis, Knorr pyrrole synthesis, and Hantzsch synthesis), Thiophene, Pyridine (Hantzsch synthesis). **2.3.3**. Reactivity of furan, pyrrole and thiophene towards electrophilic substitution reactions on the basis of stability of intermediate and of pyridine on the basis of electron distribution. Reactivity of pyridine towards nucleophilic substitution on the basis of electron distribution. **2.3.4.** Reactions of furan, pyrrole and thiophene: halogenation, nitration, sulphonation, Vilsmeier-Haack reaction, Friedel-Crafts reaction. Furan: Diels-Alder reaction, ring opening. Pyrrole:	**(8L)**

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		Acidity and basicity of pyrrole. Comparison of basicity of pyrrole and pyrrolidine. **2.3.5.** Pyridine: Basicity. Comparison of basicity of pyridine, pyrrole and piperidine. Reaction: sulphonation (with and without catalyst), Chichibabin reaction.	
	III	**Chemistry of Group 15 and Group 16 Elements and Basics of Organometallic Chemistry**	**(15L)**
		3.1 Chemistry of Group 15 and 16 Elements **3.1.1** Trends in physical and chemical properties of Group – 15 and Group – 16 Elements **3.1.2** Study of Compounds such as oxyacids of N and S with respect to preparation, properties and structure. **3.1.3** Physical properties of Hydrides of Group 15 and 16 Elements with respect to H- bonding.	**(08L)**
		3.2Organometallic Chemistry **3.1.1** Introduction, definition, classification based on hapticity and nature of metal-carbon bond. Eighteen electron rule and its applications, exceptions **3.1.2** Importance and few applications of organometallic compounds as catalysts (e.g. Ziegler-Natta catalyst, Wilkinson), reagents in organic synthesis etc. **3.1.3** Metal carbonyls: Bonding, general method of preparation and properties of $Ni(CO)_4$, $Fe(CO)_5$.	**(07L)**

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Course Code: RUSCHE403
Course Title : CHEMISTRY-III
Academic year 2022-2023

Course Outcomes:

After completing this course, the learner will be able to:	
CO 1	Categorize the different types of separation methods under physical , chemical , mechanical methods.
CO 2	Explain the basic principle of the solvent extraction and chromatography techniques.
CO 3	Define the terms partition coefficient & distribution ratio.
CO 4	Know the factors that affect extraction efficiency.
CO 5	Describe the different types of solvent extraction and will be able to enlist the advantages and limitation of each type.
CO 6	Illustrate the role of chelating agents in solvent extraction.
CO 7	Develop simple separation schemes and determine the optimal conditions for isolating and separating analyte, based on distribution ratios.
CO 8	Choose an appropriate mobile phase for the effective separation of different components present in a sample.
CO 9	Develop the chromatogram skilfully and will be able the apply the most suitable method for the detection of the resolved components.
CO 10	Apply the theoretical principles of chromatography learned to separate and quantify different components present in a sample.
CO 11	Explain the basic principle involved in quantitative analysis using UV-Vis spectroscopy.
CO 12	Derive the mathematical expression of Beer-Lambert's law.
CO 13	Describe the function of the different components of a colorimeter and spectrophotometer.
CO 14	Distinguish between colorimeters & spectrophotometers.
CO 15	Recognize the limitations of UV-Vis spectroscopy.
CO 16	Explain the basic principle involved in different types of conductometric titrations.
CO 17	Enlist the advantages and limitations of conductometric titrations.

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DETAILED SYLLABUS

RUSCHE403	CHEMISTRY-III		Credits-02
	Unit	**Unit Title**	**Lectures**
	I	**Methods of Separation**	**(15L)**
		1.1Separation Techniques in analytical Chemistry **1.1.1 Introduction to separation Techniques** **1.1.2** Separation and its importance in analytical chemistry, estimation without separation. **1.1.3** Classification of separation methods physical and chemical **1.1.4** Chemical methods, precipitation, complex formation. **1.1.5** Physical methods of separation, precipitation, fractional precipitation, volatilization, distillation, fractional distillation, vacuum distillation.	**(04L)**
		1.2 Solvent Extraction **1.2.1** Nernst's distribution law, partition coefficient, distribution ratio, **1.2.2** Percentage extraction, extraction efficiency, percentage extraction for single step and multistep process with the same total volume of the extracting solvent **1.2.3**. Modes of extraction: Chelation, ion-pair formation and solvation. **1.2.4** Batch and continuous extraction, Counter current extraction	**(04L)**

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		1.3 Chromatography **1.3.1** Introduction, Stationary and mobile phase, common features of all chromatographic techniques, classification of chromatographic methods on the basis of physical state of the two phases. **1.3.2 Paper chromatography** **1.3.2.1** Introduction and basic principles. **1.3.2.2** Stationary phase, transfer of the sample, mobile phase. **1.3.2.3** Methods of developing the chromatogram, methods of detection, physical, chemical and enzymatic. **1.3.2.4** Applications. **1.3.2.5** Comparison of the paper and thin layer techniques. **1.3.3 Thin layer chromatography** **1.3.3.1** Introduction, mechanism of separation, retardation factor, basic principles. **1.3.3.2** Stationary phase, preparation and transfer of the sample, mobile phases and their nature. **1.3.3.3** Methods of development of the chromatogram, detection methods, physical and chemical. **1.3.3.4** Applications, for determination of purity, following the course of a chemical reaction.	**(05L)**

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		1.4 High Performance Thin Layer Chromatography **1.4.1** Introduction, Choice of stationary and mobile phases, sample application, **1.4.2** Development and recording in HPTLC, **1.4.3** Detectors used, single beam and double beam detectors, fluorometric detector, **1.4.4** Quantitative determination, **1.4.5** Applications of HPTLC **1.4.6** Advantages and limitations **1.4.7** Comparison between TLC and HPTLC	**(02L)**
	II	**UV-VIS Spectroscopy and Conductometric Titrations**	**(15L)**
		2.1 UV- Visible Absorption spectroscopy: **2.1.1** Recapitulation of basic concept of spectroscopy. **2.1.2** Terms involved in absorption spectroscopy, monochromatic and polychromatic radiation, radiant power, absorbance, transmittance, absorptivity, molar extinction coefficient, wavelength of maximum absorption. **2.1.3** Statement of Beer's law & Lamberts' law combined mathematical expression for Beer-Lambert's Law, deviations from Beer-Lambert's law, types of deviations. **2.1.4** Components of an optical instrument and their functions, photometers and spectrophotometers.	**(12L)**

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		2.1.5 Photometers: Sources, monochromators, sample containers and detectors, block diagram for a single and double beam photometer. (Numerical problems expected.) **2.1.6 Photometric titrations** **2.1.6.1** Basic principles, experimental set up and operational procedures, **2.1.6.2** Requirements for a photometric titration, types of photometric titration curves, and determination of equivalence point. **2.1.6.3** Advantages and limitations	
		2.2 Conductometric titrations **2.2.1**Conductometry and conductometric titrations, basic principles, operational procedure, determination of the equivalence point., **2.2.2**Conductometric titration curves for the titration of 1] Acid –base titrations of all types 2] Displacement titration 3] Precipitation titrations 4] Complexometric titrations **2.2.3** Advantages and limitations.	**(03L)**
	III	**Industrial Chemistry**	**(15L)**
		3.1 Concept of quality, Quality assurance, Product Development (Formulation), Stability Study, Quality control . **3.2** International Standards and their significance	

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		3.3 Unit Operations- Filtration, Distillation, Fractional distillation, Crystallisation	

Semester IV
Practicals

RUSCHEP401	**CHEMISTRY-I** **Credits: 3**
	1. To determine order of the reaction between $K_2S_2O_8$ and KI for unequal concentrations. 2. To determine dissociation constant of weak acid by incomplete titration method using pH meter. 3. To determine dissociation constant of weak acid by pH metric titration. 4. To determine the amount of strong acid in the given solution by potentiometric titration 5. To determine standard cell potential (E^{o}_{cell}), standard free energy change (ΔG^{o}) and equilibrium constant (K) for a given galvanic cell. 6. To determine the amount of weak acid in the given solution by conductometric titration.
	CHEMISTRY-II 1. Qualitative Analysis of bi-functional organic compounds (minimum four) on the basis of i. Preliminary examination ii. Solubility profile iii. Detection of elements C, H, (O), N, S and X. iv. Detection of functional groups v. Determination of physical constants (M.P/B.P) Solid or liquid Compounds containing not more than two functional groups from among the following classes may be given for analysis to be given: Carboxylic acids, phenol, carbohydrates, aldehydes, ketones, ester, amides, nitro, anilides, amines, alkyl and aryl halides.

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	2. Separation of binary organic mixture (solid+solid) and (solid+liquid) on the basis of type and nature. (Nature and physical constant expected). Minimum four binary mixtures will be given to every student. **3. Inorganic preparation –** 1.*Tris*(ethylene diamine) nickel (II) thiosulphate. 2. preparation of Copper DMSO 3. Preparation of magnesium oxalate.
	CHEMISTRY-III 1. Chromatography: Separation of cations Fe(III), Ni(II) and Cu(II) in a sample by paper chromatography 2. To determine partition coefficient of iodine between water and CCl_4 3. Estimation of Fe(II) in the given solution by titrating against Ce(IV)potentiometrically. 4. Determination of amount of Fe (III) in the given solution by photometric titration using salicylic acid. 5. To verify Beer Lamberts law. 6. Determination of Calcium and Magnesium in the given sample of Dolomite ore. 7. To determine the purity of the given commercial sample of aspirin using phenol red indicator.

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Reference Books for Physical Chemistry:

1) The Elements of Physical Chemistry, P.W. Atkins, Oxford University Press, Oxford.

2) Principles of Physical Chemistry. By Maron and Pruton 4th Ed. Oxford and IBH publication.

3) Physical Chemistry, G.M. Barrow, Tata McGraw Hill Publishing Co.Ltd. New Delhi.

4) Modern Electrochemistry, J.O'M. Bockris& A.K.N. Reddy, Maria. Gamboa – Aldeco. Springer.

5) Khosla B.D., Garg V.C. and Gulati A., Senior Practical Physical Chemistry, R. Chand and Co., New Delhi (2011).

6) Athawale V.D. and Mathur P., Experimental Physical Chemistry, New Age International, New Delhi (2001)

References for Organic Chemistry:

1. Organic Chemistry, F. A. Carey, Tata McGraw-Hill Publishing company Ltd.
2. Paula Y. Bruice, Organic Chemistry, Pearson Education.
3. Organic Chemistry, Finar, I. L. (Volume 1), Dorling Kindersley (India) Pvt. Ltd.
4. Heterocyclic Chemistry, Synthesis reactions and Mechanisms, R.K Bansal, Wiley Eastern Ltd.
5. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
6. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996

Reference Books for Inorganic Chemistry:

1. A.I. Vogel. "Textbook of Quantitative Inorganic Analysis," Longman, London (1961).
2. J. D. Lee, 4thEdn., Concise Inorganic Chemistry, ELBS, The group III elements Pg. 359- 648.
3. D. F. Shriver and P. W. Atkins, Inorganic chemistry, 3rd edition, Oxford University Press (1999) page 325-446.

4. Puri, Sharma and Kalia, Milestone publishers, Principles of Inorganic Chemistry, page 416-628.
5. Concepts of Inorganic Chemistry by James Huheey
6. Inorganic Chemistry by R.L. Madan

References for Analytical Chemistry:

1. D. A. Skoog, D. M. West, F. J. Holler, and S. R. Crouch, Analytical Chemistry: An Introduction, 7th ed., Chapter 15, pp. 345-381.
2. A.I. Vogel. “Textbook of Quantitative Inorganic Analysis,” Longman, London (1961).
3. R.V. Dilts. “Analytical Chemistry. Methods of Separation,” van Nostrand, N.Y. (1974).
4. Asim K. Das, ‘Environmental Chemistry with Green Chemistry’ Books & Allied (P) Ltd.
5. K.A. Gavhane, ‘Unit operations-I and II’

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Modality of Assessment

Theory Examination Pattern:

A) Internal Assessment - 40% (40 Marks)

Sr No	Evaluation Type	Marks
1	Assignment	15
2	Class Test (MCQ / Objectives)	20
3	Active Participation in Class (Case studies/Seminars/Presentations)	05
	Total	**40**

B) External Examination : 60 % (60 marks)

Semester End Theory Examination :

(B) Duration - These examinations shall be of **two hours** duration.

(C) Theory question paper pattern :-

3. There shall be **three** questions each of **20** marks. On each unit there will be one question.
4. All questions shall be compulsory with internal choice within the questions.

Questions	Options	Marks	Questions based on
Q.1)	**Any 5 out of 7**	**20**	**Unit I**
Q.2)	**Any 5 out of 7**	**20**	**Unit II**
Q.3)	**Any 5 out of 7**	**20**	**Unit III**
	Total	**60**	

Practical Examination Pattern:

A) Internal Examination:- 40 % (20 Marks)

Particulars	**Paper I**	**Paper II**	**Paper-III**
Journal	05	05	05
Experimental Work	10	10	10
Participation	05	05	05
Total	**20**	**20**	**20**

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(B) External Examination : 60 % (30 Marks)

Semester End Practical Examination:

Particulars	**Paper I**	**Paper II**	**Paper II**
Laboratory Work	25	25	25
Viva	05	05	05
Total	**30**	**30**	**30**

PRACTICAL BOOK/JOURNAL

- The students are required to present a duly certified journal for appearing at the practical examination, failing which they will not be allowed to appear for the examination.
- **In case of loss of Journal and/ or Report, a Lost Certificate should be obtained from Head/ Co-ordinator / In-charge of the department ; failing which the student will not be allowed to appear for the practical examination.**

Overall Examination and Marks Distribution Pattern:

Course	**401**			**402**			**403**			**Grand Total**
	Internal	**External**	**Total**	**Internal**	**External**	**Total**	**Internal**	**External**	**Total**	
Theory	**40**	**60**	**100**	**40**	**60**	**100**	**40**	**60**	**100**	**300**
Practicals	**20**	**30**	**50**	**20**	**30**	**50**	**20**	**30**	**50**	**150**

(Total: 450 marks)

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Resolution Number : AC/I(21-22).2(II).RUS5

S.P. Mandali's

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(Affiliated to University of Mumbai)

Syllabus for SEMESTER V & VI
Program : T.Y.B.Sc.
Program Code : RUSCHE

(Credit Based Semester and Grading System with effect from the academic year 2022-2023)

Ramnarain Ruia Autonomous College

Semester V
Course Code:RUSCHE501
Course Title : CHEMISTRY-I
Academic Year 2022-2023

Course Outcomes:

After studying this course, the learner will be able to:	
CO 1	Comprehend the fundamentals of rotational, vibrational and Raman spectra of molecules.
CO 2	Outline the applications of Galvanic Cells.
CO 3	Apply Raoult's Law and Clapeyron Equation to study Colligative Properties
CO 4	Understand reaction dynamics.
CO 5	Apply principles of Surface Chemistry to Colloids

DETAILED SYLLABUS

RUSCHE501		**CHEMISTRY-I**	**Credits-2.5**
	Unit	**Unit Title**	**Lectures**
	I	**MOLECULAR SPECTROSCOPY**	**(15L)**
		1.1. 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. **1.2.**Vibrational 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.	

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		1.3. Vibrational-Rotational (IR) spectrum of diatomic molecule: vibrating rotor, energy levels, selection rule, nature of spectrum, P and R branch lines, anharmonic oscillator, energy levels, selection rule, fundamental band, overtones. Applications of vibrational-rotational spectrum in determining force constant and its significance infrared spectra of simple molecules like H_2O and CO_2 **1.4** Raman Spectroscopy: Scattering of electromagnetic radiation, Rayleigh scattering, Raman scattering, nature of Raman spectrum (Stoke's lines and anti Stoke's lines), Raman shift, quantum theory of Raman spectrum, comparative study of IR and Raman spectra, rule of mutual exclusion (example of CO_2 molecule). Number of modes of vibrations for linear and non-linear molecules.	
	II	**ELECTROCHEMISTRY- III: CLASSIFICATION OF GALVANIC CELLS**	**(15L)**
		2.1 Lewis concept of Activity and Activity coefficient, Mean ionic activity and mean ionic activity coefficient of an electrolyte, ionic strength of a solution, Debye-Huckel limiting law. **2.2.** Classification of galvanic cells: Chemical Cells and concentration cells, Cells with transference and without transference, Expression for EMF of each type of cell. **2.3** Origin of liquid junction potential and its elimination.	

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		2.4. Determination of solubility product and solubility of a sparingly soluble salt by Chemical cell and by Concentration cell. **2.5** Determination of liquid junction potential.	
	III	**COLLIGATIVE PROPERTIES AND CHEMICAL KINETICS – II**	**(15L)**
		3.1 COLLIGATIVE PROPERTIES	**(09L)**
		3.1.1 Colligative properties, Raoult's law. **3.1.2** Relative lowering of vapour pressure. **3.1.3** Elevation of boiling point – Thermodynamic derivation for relation between elevation of boiling point and molality. **3.1.4** Depression in freezing point- Thermodynamic derivation for relation between depression in freezing point and molality **3.1.5** Osmosis and Osmotic Pressure – Determination of molar mass form Osmotic pressure. Abnormal molar masses of solute, van't Hoff factor (Degree of dissociation and degree of association). Reverse osmosis.	
		3.2 CHEMICAL KINETICS-II	**(06L)**
		3.2.1 Recapitulation, Collision theory of reaction rates, applications of collision theory to bimolecular reaction and unimolecular reaction (Lindemann's theory), Merits and demerits of Collision theory. Steric factor and Probability factor.	

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		3.2.2 Activated complex theory of bimolecular reactions. Merits of Activated complex theory. **3.2.3** Classification of reactions- slow, fast and ultra fast, study of kinetics of fast reactions by Stop Flow method.	
	IV	**SURFACE CHEMISTRY, CATALYSIS AND CHEMISTRY OF COLLOIDS**	**(15L)**
		4.1: Surface Chemistry and Catalysis	**(08L)**
		4.1.1 Adsorption: Physical and Chemical Adsorption, Types of adsorption isotherms, Langmuir's adsorption isotherm. B.E.T. equation for multilayer adsorption, determination of surface area of an adsorbent using B.E.T. equation. **4.1.2.** Catalysis: Homogeneous and heterogeneous catalysis, catalytic activity and selectivity, promoters, inhibitors, catalyst poisoning and deactivation. **4.1.2.1** Acid catalysis and Base catalysis, mechanism and kinetics of acid and base catalysed reactions, effect of pH on acid and base catalysed reactions. **4.1.2.2** Enzyme catalysis, mechanism and kinetics of reaction (Michaelis-Menten equation).	
		4.2 COLLOIDS	**(07L)**
		4.2.1 Introduction to colloidal state of matter. **4.2.2** Origin of charge on colloidal particles. Concept of electrical double layer, zeta potential, Helmholtz and Stern model, electro kinetic phenomena: electrophoresis,	

		electro-osmosis, streaming potential and sedimentation potential. **4.2.3** Colloidal electrolytes. **4.2.4** Donnan Membrane Equilibrium. **4.2.5** Surfactants, Micelle formation, application of surfactants in detergents, food industry and pesticide formulations.	

Course Code: RUSCHE502
Course Title : CHEMISTRY-II
Academic year 2022-2023
Credits:2.5

Course outcomes:

After studying this course, the learner will be able to:	
CO 1	Identify the elements of symmetry.
CO 2	Assign point groups to molecules.
CO 3	Correlate between bond angle and molecular orbitals.
CO 4	Understand band theory and its application to metals.
CO 5	Depict structure of solids and their defects.
CO 6	Compare various aspects of lanthanides and actinides.
CO 7	Describe properties and application of Uranium.
CO 8	Distinguish between properties of Xenon and other noble gases.

DETAILED SYLLABUS

RUSCHE502	**CHEMISTRY-II**		**Credits-2.5**
	Unit	**Unit Title**	**Lectures**
	I	**Molecular Symmetry and Chemical Bonding**	**(15L)**
		1.1 Molecular Symmetry	**(07L)**

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		1.1.1 Introduction and Importance of symmetry in chemistry. **1.1.2** Symmetry elements and symmetry operations. **1.1.3** Concept of a Point Group with illustrations using the following pointgroups: (i) $C_{\alpha v}$ (HCl), (ii) $D_{\alpha h}$ (H_2),(iii) C_2v (H_2O), (iv) C_{3v} (NH_3), (v) C_{2h}(trans – trichloroethylene), and (vi) D_{3h}(BCl_3).	
		1.2 Molecular Orbital Theory for Polyatomic Species	**(05L)**
		1.2.1 Simple triatomic species: H_3^+ andH_3 (correlation between bond angle andMolecular orbitals). **1.2.2** Other molecules (consideringonly σ-bonding): i) BeH_2, ii) H_2O iii) CH_4	
		1.3 Metallic Bonding	**(03L)**
		Band theory, explanation of electrical properties of conductors, insulators and semi conductors, intrinsic and extrinsic semiconductors.	
	II	**Solid State Chemistry and Superconductivity**	**(15L)**
		2.1 Structures of Solids	**(11L)**
		2.1.1 Terms involved: crystal lattice, lattice points, unit cells and lattice constants. **2.1.2** Closest packing of rigid spheres (hcp, ccp), packing density in simple cubic, bcc, fcc and hcp lattices (numerical problems expected). **2.1.3** Stoichiometric point defects in solids: Frenkel and Schottky defects.	
		2.2 Superconductivity	**(04L)**

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		2.2.1 Discovery of superconductivity. **2.2.1** Superconductivity, transition temperature and Meissner effect. **2.2.2** Different types of superconductors viz, conventional superconductors, alkali metal fullerides (A_3C_{60}) and high temperature Superconductors. **2.2.3** Applications of superconducting materials.	
	III	**Chemistry of *f*-block elements**	**(12L)**
		3.1 Introduction: Definition, position in periodic table and electronic configuration of lanthanides and actinides.	**(01L)**
		3.2 Chemistry of Lanthanides	**(11L)**
		3.2.1 Lanthanide contraction and its consequences. 3.2.2 Oxidation states. 3.2.3 Magnetic and spectral properties. 3.2.4 Occurrence, extraction and separation of lanthanides by Solvent extraction. 3.2.5 Applications of lanthanides.	
		3.3 Chemistry of Actinides	**(03L)**
		3.3.1 Comparison between lanthanides and actinides. 3.3.2 Chemistry of Uranium and with reference to occurrence and isolation (solvent extraction method) 3.3.2 Properties and applications of Uranium.	
	IV	**Non Aqueous Solvents and Chemistry of Pseudohalogens, Interhalogens and Xenon**	**(15L)**
		4.1 Chemistry of Non-aqueous Solvents	**(07L)**
		Classification of solvents and importance of non-aqueous solvents.	

		4.1.1 Super critical carbon dioxide and ionic liquids as solvents 4.1.2 Characteristics and study of liquid ammonia, dinitrogentetraoxide as non-aqueous solvents with respect to i) acid base reactions and ii) redox reactions.	
		4.2 Chemistry of Interhalogens:	**(03L)**
		Introduction, preparation, reactions and structures.	
		4.3 **Chemistry of pseudohalogens:**	**(03L)**
		Introduction, preparation, reaction and structures	
		4.4 Chemistry of Xenon:	**(02L)**
		Introduction, Compounds of Xenon: Oxides, fluorides, oxyfluorides w.r.t. preparation , properties and bonding.	

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Course Code: RUSCHE503
Course Title : CHEMISTRY-III
Academic year 2022-2023

Course Outcomes:

After studying this course, the learner will be able to:	
CO 1	Apply fundamentals of Organic Reaction Mechanism to various reactions.
CO 2	Compare various conformations of some organic compounds
CO 3	Apply the concepts of stereochemistry to Organic reactions.

CO 4	Assign IUPAC names to spiro, bicyclo and heterocyclic compounds.
CO 5	Understand Basics of Polymer Chemistry.
CO 6	Illustrate basics of Green Chemistry to Organic Synthesis.

DETAILED SYLLABUS

RUSCHE503	**CHEMISTRY-III**		**Credits-02**
	Unit	**Unit Title**	**Lectures**
	I	**Mechanism of Organic Reactions**	**(15L)**
		1.1 Recapitulation: Curved arrows, intermediates, transition states, Electrophilicity vs acidity and nucleophilicity vs basicity. 1.2 Elimination Reactions: Mechanisms and stereochemistry. 1.2.1 E_1 and E_2 Mechanisms, factors influencing the mechanism: nature of substrate, leaving group, structure of base, solvent; Saytzeff and Hofmann elimination; elimination *vs* substitution. 1.2.2 E_1CB mechanism 1.2.3 Pyrolytic elimination: Cope, Chugaev, pyrolysis of acetates. 1.3 Neighbouring group participation in nucleophilic substitution reactions: partcipation of lone pair of electrons, kinetics and stereochemical outcome. 1.4 Acyl nucleophilic substitution (Tetrahedral mechanism): Acid catalysed esterification of carboxylic acids and base promoted hydrolysis of esters ($B_{AC}2$).	

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		1.5 Mechanism of following rearrangements with examples and stereochemistry wherever applicable. 1.5.1 Migration to electron deficient carbon: Pinacol, Benzylic acid. 1.5.2 Migration to electron deficient nitrogen: Beckmann, Hofmann. 1.5.3 Migration involving a carbanion: Favorski. 2.3 Name reactions: Michael, Wittig (mechanism and examples).	
	II	**Stereochemistry**	**(15L)**
		2.1 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. 2.2 Conformations of cyclohexane, mono, disubstitutedcyclohexanes and their relative stabilities 2.3 Stereo selectivity and Stereo specificity: Idea of enantioselectivity (ee) and diastereoselectivity (de). Topicity- enantiotopic and diastereotopic atoms, groups and faces. 2.4 Stereochemistry of: 2.4.1 Substitution reactions- S_N^1, S_N^2, S_N^i (reaction of alcohol with thionyl chloride). 2.4.2 Elimination reactions: E_2-Base induced dehydrohalogenation of 1-bromo-1,2-diphenylpropane. 2.4.3 Addition reactions to olefins- i) catalytic hydrogenation ii) bromination (electrophilic anti	

		addition) (iii) synhydroxylation with OsO_4 and $KMnO_4$. iv) epoxidation followed by hydrolysis.	
	III	**IUPAC Nomenclature and Chemistry of Polymers**	**(15L)**
		3.1 IUPAC Nomenclature	**(06L)**
		IUPAC systematic nomenclature of the following classes of compounds (including substituted ones up to two substituents/ functional groups): 3.1.1 Bicyclic compounds- spiro, fused, and bridged (upto 11carbon atoms) - saturated and unsaturated compounds. 3.1.2 Biphenyls. 3.1.3 Cummulenesupto three double bonds.	
		3.2 Polymers	**(09L)**
		3.2.1 Introduction: Review of terms: monomer, polymer, homopolymer, copolymer, thermoplastics and thermosets. 3.2.2 Addition polymers: polyethylene, polypropylene, Teflon, PVC and polystyrene. Uses, recycling	

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		3.2.3 Condensation polymers: polyesters, polyamides, polyurethanes, polycarbonates and phenol-formaldehyde resins. Uses 3.2.4 Mechanism of free radical addition polymerization. 3.2.5 Stereochemistry of polymers: Tacticity. Mechanism and stereochemical control of polymerization using Ziegler-Natta catalyst 3.2.6 Natural and synthetic rubbers: polymerization of isoprene: 1,2- and 1,4- addition (*cis*and *trans*), styrene- butadiene copolymer. 3.2.7 Additives to polymers: Plasticizers, stabilizers and fillers. 3.2.8 Biodegradable polymers: Classification and uses. Polylactic acid- structure, properties and use for packaging and medical purposes. (Note: Identification of monomer in a given polymer and the structure of a polymer from given monomer(s) is expected. Conditions for isomerisation not expected).	
	IV	**Synthesis of Organic compounds**	**(15L)**
		4.1 Introduction: Criteria for ideal organic synthesis. Calculation of yields. Concept of selectivity: Linear and convergent synthesis, Multi-component reactions: Mannich reaction, Hanztsch synthesis. 4.2 Introduction to retrosynthesis: Analysis and synthesis, technical terms: target molecules (TM), retrosynthetic analysis, FGA, FGI, Disconnection, synthon and reagent. Retrosynthtic analysis of Limonene, Salbutamol and Proparacaine.	

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		4.3 Green chemistry and synthesis: 4.3.1 Introduction to green chemistry: definition, need for and importance of green synthesis, Twelve principles of green chemistry, Atom economy and E-factor calculations and their significance. 4.3.2 Green synthesis in industry: Green starting materials: D-glucose to adipic acid. Green reagents: Selective methylation of active methylene using dimethyl carbonate. Green solvent: Supercritical CO_2, deep eutectic solvents (DES). Green catalyst: Heterogeneous catalysis using tellurium, biocatalysis. Green synthesis of paracetamol. 4.4 Other methods of organic synthesis Microwave assisted organic synthesis (Using organic solvents and in solid state). Ultrasound in organic synthesis, Phase transfer catalysis. Polymer supported synthesis: Merrifield polypeptide synthesis.	

Course Code: RUSCHE504

<u>Course Title: CHEMISTRY-IV</u>

Academic year 2022-2023

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Course Outcomes:

After completing this course, the learner will be able to:	
CO 1	Elaborate on the need and importance of sampling and the various methods used for sampling of solid, liquids and gases.
CO 2	Evaluate the analytical data in terms of statistics.
CO 3	Interpret the sources of random errors and their effect on analytical results.
CO 4	State the significance of confidence limits in the error analysis.
CO 5	Specify the standard deviation of calculated results.
CO 6	Explain the Q-test for rejection of data.
CO 7	Outline a procedure for the application of null hypothesis to the data.
CO 8	Discuss the importance of graphical representation of data.
CO 9	Describe the different methods used for locating endpoints in precipitation titrations.
CO 10	Classify the different types of solvents used for non-aqueous titrations with respect to their acid base properties.
CO 11	Illustrate the effect of dielectric constant and nature of solvent on solute behaviour in non aqueous titrations.
CO 12	Explain the basic principle involved in AAS, AES, fluorescence, phosphorescence, turbidimetry and nephelometry.
CO 13	Describe the function of different components of AAS,flame photometer ,Fluorimeter, Phosphorimeter, Turbidimeter and nephelometer.
CO 14	List the factors affecting fluorescence and phosphorescence and also the factors affecting scattering of light in turbidimetry and nephelometry.
CO 15	Relate fluorescence intensity with concentration

DETAILED SYLLABUS

RUSCHE504	**CHEMISTRY-IV**		**Credits-2.5**
	Unit	**Unit Title**	**Lectures**

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	I	**Sampling and Treatment of Analytical Data**	**(15L)**
		1.1 Sampling:	**(07L)**
		1.1.1 Sampling, need and importance, terms involved, sampling techniques, non-random and random sampling, sequential sampling, 1.1.2 Sampling of gases, precautions, methods used, pressure and temperature sampling 1.1.3 Sampling of liquids, sample thief, homogeneous and heterogeneous liquids, stationary and flowing liquids, 1.1.4 Sampling of solids, bulk ratio, size to weight ratio, 1.1.5 Sampling and equipment for sampling of compact solids, powdered solids, flowing solids and particulate solids. 1.1.6 Methods of reduction of the size of the sample 1.1.7 Preservation of sample, dissolution of the samples, use of fluxes	
		1.2 Treatment of analytical data	**(08L)**
		1.2.1 Collection and processing of data, concept of classes, and class frequencies, histogram and frequency polygon. 1.2.3 Distribution of random errors, Gaussian distribution curve and its salient features. 1.2..4 Concept of confidence limits and confidence interval, computation of both by using range, student's t and population standard deviation. 1.2.5 Criterion for the rejection of a result, empirical methods like 2.5 d and 4.0 d rule, statistical approach.	

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		1.2.6 Testing for significance, null hypothesis, variance ratio test. 1.2.7 Graphical presentation of results, scatter diagram, regression analysis, method of averages, least square method for line of the type y = mx + c and y = mx 1.2.8 Significant figures and their use in data treatment.	
	II	**Titrimetric analysis**	**(15L)**
		2.1 Redox Titrations	**(04L)**
		2.1.1 General introduction, theory of redox indicators, 2.1.2 criterion for choosing an indicator for a redox titration, 2.1.3 Construction of the titration curves in the case of i) Fe(II) vsCe(IV) ii) Fe(II) vs $Cr_2O_7^{2-}$ 2.1.4 Use of diphenyl amine and ferroin as redox indicator.	
		2.2 Precipitation titrations	**(04L)**
		2.2.1 Basic principles of precipitation titrations 2.2.2 Argentimetric titrations, construction of the titration curve for the titration of sodium chloride with silver nitrate. 2.2.3 Mohr’s method 2.2.4 Volhard’s method 2.2.5 Adsorption indicators, examples and uses.	
		2.3 Complexometric titrations	**(04L)**
		2.3.1 General introduction of complexometric titrations 2.3.2 EDTA titrations	

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		2.3.2.1 EDTA as a chelating agent, structure of the chelate, characteristic features of the metal EDTA complexes. 2.3.2.2 Stability constant of the EDTA complexes, conditional stability constants, construction of the titration curve in the titration of a metal ion with EDTA with the example of Ca^{2+}. 2.3.2.3 Types of EDTA titrations. 2.3.2.4 Methods of improving the selectivity of EDTA titrations. 2.3.2.5 Metallochromic indicators	
		2.4 Non-aqueous titrations	**(03L)**
		2.4.1 Need for non-aqueous titrations, 2.4.2 Types of solvents, choice of the solvent for the non-aqueous titrations, 2.4.3 Acid base titrations in non-aqueous media, 2.4.4 Use of glacial acetic acid as the solvent in non-aqueous titrations, non-aqueous titrations with a visual indicator using an instrument **2.4.5** Advantages and limitations.	
	III	**Optical Methods**	**(15L)**
		3.1 Atomic Absorption Spectroscopy (AAS)	**(05L)**
		3.1.1 Atomic energy level diagram, characteristic features of atomic spectra. 3.1.2 Basic principles of Atomic Absorption Spectroscopy, steps involved in the process of atomization. 3.1.3 Instrumentation: Components-hollow cathode lamp, chopper, types of atomizers: (i) premix burner (ii) total consumption burner (iii) electrothermal atomizers.	

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		3.1.4 Qualitative and quantitative analysis, calibration curve and standard addition method. 3.1.5 Applications of Atomic Absorption Spectroscopy.	
		3.2 Atomic Emission Methods	**(04L)**
		3.2.1 Flame emission: basic principles of flame photometry 3.2.2 Instrumentation, flames and burners, detectors, 3.2.3 Qualitative and quantitative analysis, calibration curve, standard addition and internal standard method 3.2.4 Applications of flame photometry. 3.2.5 Comparison of atomic absorption and atomic emission methods	
		3.3 Fluorescence and phosphorescence spectroscopy	**(03L)**
		3.3.1 Basic principles of fluorescence and phosphorescence, Jablonski diagram and its utility, factors affecting fluorescence and phosphorescence 3.3.2 Relation between fluorescence intensity and concentration 3.3.3 Instrumentation of fluorimetry and phosphorimetry 3.3.4 Applications of fluorimetry and phosphorimetry 3.3.5 Comparison of fluorimetry and phosphorimetry 3.3.6 Comparison of absorption and fluorimetric techniques.	

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		3.4 Nephelometry and turbidimetry	**(03L)**
		3.4.1 Scattering of radiation, basic principles of nephelometry and turbidimetry, 3.4.2 Factors affecting scattering of radiation, particle size, wavelength, concentration, refractive index. 3.4.3 Instrumentation in nephelometry and turbidimetry. 3.4.4 Applications of both techniques.	
	IV	**Miscellaneous Methods**	**(15L)**
		4.1 Thermal Methods	**(04L)**
		4.1.1 Introduction to thermal methods, classification of thermal methods, 4.1.2 Thermo gravimetric analysis, thermogram, factors affecting the thermogravimetric curve 4.1.3 Instrumentation, components, thermo balance, furnace, sample holder, recorder, measurement of temperature 4.1.4 Applications, limitations.	
		4.2 Radioanalytical techniques	**(04L)**
		4.2.1 Neutron Activation Analysis (NAA) 4.2.1.1 Basic principles, characteristic features, operational procedure 4.2.1.2 Advantages, limitations and application of NAA. 4.2.2 Isotope Dilution Analysis (IDA) 4.2.2.1 Basic principles, operational procedure 4.2.2.2 Applications, advantages and limitations of IDA	
		4.3 Mass spectrometry	**(04L)**
		4.3.1 Basic principles 4.3.2 Instrumentation, components, sources, analysers, detectors.	

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		4.4 Method validation	**(03L)**
		4.4.1 Need and significance of method validation 4.4.2 Parameters chosen for method validation 4.4.3 Procedure for method validation	

Semester V
Practicals

RUSCHEP501	**Credits-03**
	CHEMISTRY-I **Physical Chemistry** 1. To study the effect of ionic strength on the rate of reaction between $K_2S_2O_8$ and KI using KCl. 2. To study the rate of adsorption of acetic acid on activated charcoal. 3. To study the relative strength of acetic acid and monochloroacetic acid. 4. To determine pK_1 and $pK_2$of phosphoric acid by pH-metry. **5.** To determine the amount of weak dibasic by conductometric titration. **6.** To determine the standard reduction potential of Cu^{2+}/Cu electrode at room temperature.
	CHEMISTRY-II **Inorganic preparations** 1. Potassium diaquobis- (oxalate)cuprate(II)K2[Cu(C2O4)2.(H2O] 2. Bis(ethylenediamine)iron(II)sulphate[C2H4(NH2)2FeSO4.4H2O]. **Volumetric analysis** 1. Determination of magnesium from the supplied commercial sample of Milk of magnesia tablet 2. Estimation of Nickel(II) complexometrically using murexide indicator (Learners are expected to standardize supplied EDTA solution using ZnSO4.7H20)

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	3. Estimation of copper(II) complexometrically using fast sulphon black-F indicator (Learners are expected to standardize supplied EDTA solution using ZnSO4.7H20)
RUSCHEP502	**CHEMISTRY-III** **I) Binary Mixture Separation: Separation of mixture containing (VL + NVL) & (VL+ S) components.** 1. Minimum Six mixtures to be completed by the learners. 2. Components of the liq-liq mixture should include volatile liquids like acetone, methylacetate, ethylacetate, isopropylalcohol, methyl alcohol, ethyl alcohol, chloroform and non- volatile liquids like chlorobenzene, bromobenzene, aniline, N,N-dimethylaniline, acetophenone, nitrobenzene, ethyl benzoate. 3. Components of the liq- solid mixture should include volatile liquids like acetone, methylacetate, ethylacetate, ethyl alcohol, methyl alcohol, isopropylalcohol, chloroform and solids such as water insoluble acids, phenols, bases, neutral. 4. A sample of the mixture one ml to be given to the learnerfor detection of the physical type of the mixture. 5. After correct determination of physical type, separation of the binary mixture to be carried out by distillation method using microscale technique. 6. After separation into component A and component B, the physical constants and the yield of the separated components is to be determined. **II) Organic Preparations:** 1. Acetylation of hydroquinone. 2. Bromination of acetanilide. 3. Hydrolysis of ethyl benzoate. 4. Nitration of acetanilide. 5. Microwave assisted synthesis of Schiff's base from aniline and p-anisaldehyde. 6. Microwave assisted synthesis of coumarin by Knoevenagel reaction from salicylaldehyde andethylacetoacetate in presence of a base.
	CHEMISTRY-IV: 1. Determination of the amount of fluoride in the given solution colorimetrically.

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	2. Estimation of Vitamin C content of a given tablet by titration with sodium hydroxide pH metrically 3. To determine potassium content of a commercial salt sample by flame photometry. 4. To determine the amount of chloride in the given sample using Mohr's method. **5.** To determine the amount of persulphate in the given sample by back titration with standard Fe(II) ammonium sulphate solution. **6.** To estimate Fe(II) in a tablet using diphenylamine as an indicator.

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Modality of Assessment

Theory Examination Pattern:

A) Internal Assessment - 40% of total marks:

(40 marks)

Sr No	**Evaluation type**	**Marks**
1	One Assignment	10
2	One class Test (multiple choice questions / objective)	20
3	Active participation in routine class instructional deliveries (seminars//presentation)	05
4	Overall conduct, participation in co-curricular activities of the department.	05

B) External examination – 60 %

Semester End Theory Assessment - 60% **60 marks**

These examinations shall be of **two hours** duration.
There shall be **Four** questions each of **15** marks. On each unit there will be one question.
All questions shall be compulsory with internal choice within the questions.
Theory question paper pattern is as follows :-

Questions	Options	Marks	Questions on
Q.1)A)	Any 3 out of 5	12	Unit I
Q.1)B)	Any 1 out of 2	03	
Q.2)A)	Any 3 out of 5	12	Unit II
Q.2)B)	Any 1 out of 2	03	
Q.3)A)	Any 3 out of 5	12	Unit III
Q.3)B)	Any 1 out of 2	03	
Q.4)A)	Any 3 out of 5	12	Unit IV
Q.4)B)	Any 1 out of 2	03	

Practical Examination Pattern:

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(A)Internal Examination: -				
	RUSCHEP501		RUSCHEP502	
	Paper I	Paper II	Paper III	Paper IV
Journal	05	05	05	05
Tests	10	10	10	10
Active Participation	05	05	05	05
Total	20	20	20	20
(B) External (Semester end practical examination):-				
Laboratory work	25	25	25	25
Viva	05	05	05	05
Total	30	30	30	30
Grand Total	100		100	

PRACTICAL JOURNAL

The students are required to present a duly certified journal for appearing at the practical examination, failing which they will not be allowed to appear for the examination.

In case of loss of Journal, Certificate from Head/ Co-ordinator should be submitted, failing which the student will not be allowed to appear for the practical examination.

Overall Examination and Marks Distribution Pattern

Course	501			502			Grand Total
	Internal	External	Total	Internal	External	Total	
Theory	40	60	100	40	60	100	200
Practical	20	30	50	20	30	50	100
Course	503			504			
	Internal	External	Total	Internal	External	Total	
Theory	40	60	100	40	60	100	200
Practical	20	30	50	20	30	50	100
(Total Marks : 600)							

SEMESTER VI
Course Code: RUSCHE601
Course Title: CHEMISTRY-I
Academic year 2022-2023

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Course Outcomes:

After studying this course, the learner will be able to:	
CO 1	Understand the basic principles of Nuclear Magnetic Resonance spectroscopy
CO 2	Classify polymers based on various parameters
CO 3	Determine overvoltage and decomposition potential
CO 4	Illustrate the use of X-rays in the study of solid state
CO 5	Differentiate between nuclear fission and nuclear fusion processes
CO 6	Understand the basic operations used in Quantum Chemistry.

DETAILED SYLLABUS

RUSCHE601	**CHEMISTRY-I**		**Credits-2.5**
	Unit	**Unit Title**	**Lectures**
	I	**Nuclear Magnetic Resonance Spectroscopy and Polymer Chemistry**	**(15L)**
		1.1: Nuclear Magnetic Resonance Spectroscopy	**(08L)**
		1.1.1. Nuclear spin, magnetic moment, criteria for nuclei to be NMR active, energy levels,Larmor precession, Relaxation processes in NMR (spin-spin relaxation and spin-lattice relaxation). 1.1.2. NMR Spectrometer, chemical shift, shielding and deshielding ofprotons, low resolution NMR spectrum, high resolution NMR spectrum.	
		1.2 Polymers	**(07L)**
		1.2.1 Classification of polymers based on 1) source, 2) structure, 3)thermal response, 4) Physical properties 1.2.2 Molar mass of polymers: 1) Number average molar mass, 2) Weight average molar mass, 3) Viscosity average molar mass, monodispersity, polydispersity, polydisperity index	

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		1.2.3 Methods of determining molar mass of polymers: 1) Ultracentrifugation method 2) Viscosity method of Viscosity average molar mass, Mark-Houwink equation.	
	II	**Electrochemistry – IV And Crystalline State**	**(15L)**
		2.1electrochemistry-IV:Decomposition Potential, Overvoltage And Electroplating	**(08L)**
		2.1.1 Polarization, concentration polarization and its elimination. 2.1.2 Decomposition potential and its experimental determination, factors affecting decomposition potential. 2.1.3 Over voltage and its experimental determination, factors affecting overvoltage. 2.1.4 Tafel's equation for hydrogen overvoltage 2.1.5 Electroplating – Objectives and process	
		2.2 Crystalline State	**(07L)**
		2.2.1. Recapitulation: Laws of Crystallography 2.2.2. Characteristics of simple cubic, face centered and body centered cubic system, inter planar distance in cubic lattices. 2.2.3 Use of X- rays in the study of crystal structure, Bragg's equation, X- ray diffraction method of studying crystal lattices, structure of NaCl, Determination of Avogadro number.	
	III	**Nuclear Chemistry**	**(15L)**
		3.1 Structure of Nucleus. 3.2 Nuclear disintegration/ Nuclear radioactivity, Types of nuclear radiations (α-ray, β-ray and γ-ray).	

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		3.3 Nuclear transmutation and Artificial radioactivity, Nuclear transmutation with different types of projectiles. 3.4 Kinetics of radioactivity: units of radioactivity, expression of decay constant and its units, half life of nuclear reactions. 3.5 Radioactive Equilibrium- 1) Secular 2) Transient; Difference between chemical and radioactive equilibrium. 3.6 Mode of decay of radioactive elements: 1) emission of positrons 2) emission of electrons 3) K-electron capture. 3.7 Energy involved in Nuclear reactions: Q-value and Threshold energy. 3.8 Nuclear Fission process and its Characteristics features of nuclear fission process, Factors affecting Nuclear Fission: 1) Multiplication Factor 2) Critical Mass 3.9 Fertile and fissile materials, conversion of fertile material to fissile material. 3.10 Basic components of Nuclear Reactors, Types of Nuclear Reactors: 1) Power Reactor 2)Breeder Reactor. 3.11 Nuclear Fusion - Characteristics; Mechanism of nuclear fusion: 1) Carbon cycle 2) Proton cycle 3.12 Detection and measurement of radioactivity – GM Counter andScintillation Detector 3.13: Applications of Radiochemistry: Carbon dating, isotopic labelling.	
	IV	**Basics of Quantum Mechanics**	**(15L)**

		4.1 Classical mechanics: limitations of classical mechanics: 1) Black body radiation 2) photoelectric effect 3) Compton Effect. 4.2 Introduction to quantum mechanics, Planck's theory of quantization, wave particle duality, de-Broglie equation, Heisenberg's uncertainty principle. 4.3 The Schrodinger wave equation 4.3 Postulates of quantum mechanics 1) State function and its significance 2) Concept of operators: definition, addition, subtraction and multiplication of operators, commutative and non-commutative operators, linear operator, Hermitian operator 3) Eigen function and eigen value, eigen value equation. 4) Wave mechanical operator for evaluating various classical properties. 5) Expectation value. 4.4 Solution of the Schrodinger wave equation for a simple system: Particle in one dimensional box.	

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Course Code: RUSCHE602
Course Title : CHEMISTRY-II
Academic year 2022-2023

Course outcomes:

After studying this course, the learner will be able to:	
CO 1	Compare and contrast between Crystal Field Theory and Valence Bond Theory

CO 2	Calculate CFSE of complexes, and thus predict stability
CO 3	Apply MOT to octahedral complexes
CO 4	Carry out Spectral Analysis of Inorganic Compound: determine terms, term symbols and Orgel Diagrams
CO 5	Study Thermodynamic and Kinetic Stability of Complexes.
CO 6	Differentiate between complexes based on their lability.
CO 7	Describe general characteristics of Organometallic Compounds
CO 8	Study Nanomaterials with respect to their synthesis and properties

DETAILED SYLLABUS

RUSCHE602	**CHEMISTRY-II**		**Credits-2.5**
	Unit	**Unit Title**	**Lectures**
	I	**Coordination Chemistry**	
		1.1 Theories of metal-ligand bond	**(11L)**
		1.1.1 Recapitulation of VBT and its limitations. **1.1.2** Crystal field theory and effect of crystal field on central metal valence orbitals in various geometries, **1.1.3** Splitting of *d* orbitals in octahedral, square planar and tetrahedral crystal fields **1.1.4** Distortions from the octahedral geometry : i) Effect of ligand field ii) Jahn- Teller distortions **1.1.5** Crystal field splitting parameter, its calculation and factors affecting it in octahedral complexes, Spectrochemical series. **1.1.6** Crystal field stabilization energy (CFSE), calculation of CFSE, for octahedral and tetrahedral complexes with *d1* to *d10* metal ion configurations.	

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		1.1.7 Consequences of crystal field splitting on various properties such as ionic radii, hydration, energy, lattice energy, enthalpies of formation, colour and magnetic properties. **1.1.8** Limitations of CFT **1.1.9:** Evidences for covalence in metal complexes: i) intensities of d-d transitions, ii) ESR spectrum of $[IrCl_6]^{2-}$ iii) Nephelauxetic effect	
		1.2 Molecular Orbital Theory (MOT) of Coordination Complexes:	**(04L)**
		Application to octahedral complexes in case of (i) [Ti(H2O)]3+, (ii) Fluoro complexes of Fe(II) and Fe (III) and (iii) Cyano complexes of Fe(II) and Fe (III).	
	II	**Properties of Co-ordination Compounds**	**(15L)**
		2.1 Electronic Spectra	**(07L)**
		2.1.1 Origin of electronic spectra **2.1.2** Types of electronic transitions in coordination compounds: intra- ligand, charge transfer and intra-metal transitions. **2.1.3** Electronic configuration and electronic micro states, Term symbols, coupling of spin momenta (Ms),orbital momenta (Ml)and spin-orbit coupling or Russell-Saunders coupling. **2.1.4** Determination of Terms for p^2 *and* d^2electronic configuration **2.1.5** Terms and micro-states for transition metal atoms/ions. **2.1.6**Orgel diagrams for D and F terms (i.e. d^1 to d^9 electronic configurations in octahedral crystal fields)	

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		2.1.7 Selection rules for electronic transitions : Spin and orbital forbidden transitions (Laporte selection rules)	
		2.2 Stability of Metal Complexes	**(04L)**
		2.2.1 Thermodynamic stability and kinetic stability of complexes with examples. **2.2.2** Stability constants: Stepwise and overall constants and their interrelationship. **2.2.3** Factors affecting thermodynamic stability (Factors related to nature of central metal atom, nature of ligand, chelate effect to be discussed)	
		2.3 : Reactivity of Metal Complexes :	**(04L)**
		2.3.1 Comparison between inorganic and organic reactions **2.3.**2 Types of reactions in metal complexes **2.3.3** Inert and labile complexes: Correlation between electronic configuration and lability of Complexes **2.3.4** Ligand substitution reactions: Associative and Dissociative mechanisms **2.3.5** Acid hydrolysis, base hydrolysis and anation reaction	
	III	**Organometallic Chemistry**	**(15L)**
		3.1 Organometallic Compounds of main group metals	**(09L)**
		3.1.1 General characteristics of various types of Organometallic compounds, viz., ionic, sigma bonded and electron deficient compounds 3.1.2 General synthetic methods: (i) Oxidative addition (ii) Metal-Metal exchange	

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		(Transmetallation) (iii) Carbanion-Halide exchange (iv) Metal Hydrogen exchange (v) Methylene insertion reactions. 3.1.3Chemical reactions: (i) Reactions with oxygen (ii) Alkylation and arylation reactions (iii) Reactions with protic reagents (iv) Complex formation reactions.	
		3.2 Metallocenes	**(04L)**
		Introduction, Ferrocene; Synthesis, properties, structure and bonding on the basis of VBT	
		3.3 ɗ- bonding in rhenium and molybdenum halide complexes.	**(02L)**
	IV	**Some Selected Topics**	**(15L)**
		4.1 Nanomaterials	**(08L)**
		4.1.1Introduction and importance of nanomaterials 4.1.2 Chemical methods of synthesis of nanomaterials 4.1.3 Characterisation of Nanomaterials (UV and XRD techniques) 4.1.4 Dimensions and forms of Nanomaterials : Nano films , nano layers , nano tubes , nanowires and nano particles. 4.1.5 Properties (comparison between bulk and nano materials) : 1. Optical 2. Electrical and 3. Mechanical properties	
		4.2.Bio-inorganic and Medicinal Chemistry	**(07L)**
		4.2.1 Metal Co-ordination in biological system: Enzymes, apoenzymes and Coenzymes . 4.2.2 Metal complexes in medicine: cis- platin and gold complexes 4.2.3 Inorganic pharmaceuticals.	

Course Code: RUSCHE603
Course Title: CHEMISTRY-III
Academic year 2022-2023.

Course Outcomes:

After studying this course, the learner will be able to:	
CO 1	Classify carbohydrates.
CO 2	Study reactions shown by Glucose
CO 3	Illustrate general applications of various catalysts and Reagents
CO 4	Understand basic principles of Photochemistry
CO 5	Know basics of Natural Product chemistry- Including Amino acids, nucleic acids etc
CO 6	Apply Spectral techniques to Structure Determination

DETAILED SYLLABUS

RUSCHE603	**CHEMISTRY-III**		**Credits-2.5**
	Unit	**Unit Title**	**Lectures**
	I	**Chemistry of Carbohydrates and Catalysts and Reagents**	**(15L)**
		1.1 Chemistry of Carbohydrates	**(09L)**
		1.1.1 Introduction: Classification, reducing and non-reducing sugars, DL notation. 1.1.2 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	

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		and 6 carbons. Chair conformation with stereochemistry of D-glucose. Stability of chair forms of D- glucose. 1.1.3 Stereoisomers of D-glucose: Enantiomers and diastereomers, anomers and epimers. 1.1.4 Mutarotation in D-glucose with mechanism. 1.1.5 Chain lengthening and shortening reactions: Modified Kiliani-Fischer synthesis (D- arabinose to D-glucose and D-mannose), Wohl method (D-glucose to D-arabinose). 1.1.6 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) acetylation e) methylation (d and e with cyclic pyranose forms). 1.1.7 Glycosides: general structure, formation of alkyl glycosides and anomeric effect. 1.1.8 Disaccharides: Structures of sucrose and maltose (cyclic forms: Haworth/chair).	
		1.2 Catalysts and Reagents :	**(06L)**
		Study of the following catalysts and reagents with respect to functional group transformations and selectivity (no mechanism) 1.2.1 **Catalysts:** Catalysts for hydrogenation: Raney Ni, Pt and PtO_2: C=C, CN, NO_2, aromatic ring; Pd/C: C=C, COCl→ CHO (Rosenmund); Lindlar catalyst: alkynes; Wilkinson's catalyst: olefins. 1.2.2 **Reagents**: (a) LiAlH4 and Red-Al: reduction of CO, COOR, CN, and NO_2. (b) $NaBH_4$: reduction of CO (c) SeO_2: hydroxylation of allylic and benzylic positions,	

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		oxidation of CH_2 to CO (d) *m*-CPBA epoxidation of C=C (e) NBS: allylic and benzylicbromination.	
	II	**Chemistry of Amino Acids, Proteins and Nucleic Acids and Photochemistry**	**(15L)**
		2.1 Chemistry of Amino acids, Proteins and Nucleic acids:	**(08L)**
		2.1.1 α-Amino acids: General structure, configuration, essential (valine, leucine, phenylalanine), neutral (glycine, alanine), acidic (glutamic acid) and basic (lysine) amino acids (systematic names with abbreviations). pH dependency of ionic structure and isoelectric point. 2.1.2 Polypeptides and Proteins: Nature of Peptide bond. Nomenclature and representation of peptides (di and tripeptides) 2.1.3 Proteins: general idea of primary, secondary, tertiary and quartenary structures. 2.1.4 Nucleic acids: Controlled 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 including base pairing).	
		2.2 Photochemistry:	**(07L)**
		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. 2.2.2 Photochemical reactions of olefins: photoisomerisation, photochemical rearrangement of 1,4-dienes (di π methane)	

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		2.2.3 Photochemistry of carbonyl compounds: Norrish I, Norrish II cleavages, photoreduction (e.g. benzophenone to benzpinacol).	
	III	**Spectroscopy-I (UV-Visible, IR and ^{1}H NMR)**	**(15L)**
		3.1 Introduction: Electromagnetic spectrum, units of wavelength and frequency. 3.2 UV- Visible spectroscopy: Basic theory, solvents, nature of UV-VIS spectrum, concept of Chromophore, auxochrome,bathochromic shift, Hypsochromic shift, hyperchromic and hypochromic effects, chromophore-chromophore and chromophore -auxochrome interactions. Calculation of absorption maxima by Woodward-Fieser Rule for conjugated polyenes. Applications of UV-Visible spectroscopy. 3.3 IR Spectroscopy: Basic theory, selection rule, nature of IR spectrum, characteristic vibrational frequencies of functional groups, fingerprint region. Applications IR Spectroscopy. 1.2 ^{1}H NMR Spectroscopy: Basic theory of ^{1}H NMR, nature of ^{1}H NMR spectrum, chemical shift (∂ unit), standard for ^{1}H NMR, solvents used. Factors affecting chemical shift: inductive effect and anisotropic effect (with reference to C=C, C≡C, C=O and benzene ring). Spin- spin coupling and coupling constant. Application of deuterium	

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		exchange technique. Application of ^{1}H NMR in structure determination.	
	IV	**Spectroscopy-II and Natural Products**	**(15L)**
		4.1 Spectroscopy-II	**(08L)**
		4.1.1 Mass Spectrometry: Basic theory. Nature of mass spectrum. General rules of fragmentation. Importance of molecular ion peak, isotopic peaks, base peak, Nitrogen rule. Fragmentation of alkanes and aliphatic carbonyl compounds including Mclafferty rearrangement. 4.1.2 Spectral characteristics of following classes of organic compounds, including benzene and monosubstituted benzenes with respect to UV-VIS, IR, ^{1}H NMR: (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). 4.1.3 Problems of structure elucidation of simple organic compounds using individual or combined use of the UV-VIS, IR, ^{1}H NMR and Mass spectroscopic techniques. (index of hydrogen deficiency expected).	
		4.2 Natural Products :	**(07L)**
		4.2.1 Introduction, sources, classification and functions to the following natural products (Structures of the compounds specified are expected) (a) Terpenoids: (isoprene rule). citral, α-terpeniol, camphor and α-pinene. (b) Alkaloids: nicotine, atropine.	

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		(c) Vitamins: vitamin A and vitamin C. (d) Hormones: adrenaline, thyroxine. (e) Steroids: cholesterol, progesterone. 4.2.2 Structure determination of natural products: (a) Ozonolysis in terpenoids: Examples of open chain and monocyclic monoterpenoids. (b) Hofmann exhaustive methylation and degradation in alkaloids: simple open chain and monocyclic amines. 4.2.3 Commercial synthesis: (a) camphor from α-pinene (b) α- and β- ionones from citral. 4.2.4 Introduction to primary and secondary metabolites and broad classification of natural products based on biosynthesis.	

Course Code: RUSCHE604
Course Title: CHEMISTRY-IV
Academic year 2022-2023

Course Outcomes:

After studying this course, the learner will be able to:	
CO 1	Outline the basic principles, instrumentation of these advanced separation techniques and electroanalytical methods.
CO 2	Assess advantages and limitations of these techniques.
CO 3	Correlate these techniques with industrial applications.
CO 4	Relate the applications of analytical methods in day-to-day life.

DETAILED SYLLABUS

RUSCHE604	**CHEMISTRY-IV**		**Credits-2.5**
	Unit	**Unit Title**	**Lectures**

	I	**Separation Techniques.**	**(15L)**
		1.1 Gas Chromatography	**(06L)**
		1.1.1 Introduction, basic principles, terms involved, **1.1.2** Rate theory and plate theory of chromatography **1.1.3** Instrumentation, components of the instruments, Types of columns, packing materials. **1.1.4**Types of detectors, TCD, FID, ECD, their relative advantages and imitations **1.1.5** Qualitative and quantitative analysis, **1.1.6** Applications of GC	
		1.2 High Pressure Liquid Chromatography	**(05L)**
		1.2.1 Introduction, basic principles. **1.2.2** Instrumentation and its components. **1.2.3**Solvent reservoirs, degassing system, **1.2.4**Types of pumps, pneumatic, reciprocating, syringe type, their advantages and limitations, **1.2.5**Pre-column, types of columns, packed and capillary, sample injection systems **1.2.6** Detectors, UV-Visible, refractive index, **1.2.7** Applications of HPLC	
		1.3 Ion Exchange Chromatography	**(04L)**
		1.3.1 Introduction, types of ion exchangers, synthetic and natural, cation and anion, properties of resins **1.3.2** Ion exchange equilibria, selectivity coefficient, separation factors, factors affecting separation of ions **1.3.3** Ion exchange capacity and its determination	

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		1.3.4 Applications of ion exchange chromatography, preparation of demineralized water, separation of amino acids, separation of lanthanides, preparation of exact concentration of acids or bases	
	II	**Electroanalytical Methods**	**(15L)**
		2.1: Introduction and classification of electroanalytical methods and specific features of each of the major category.	**(01L)**
		2.2 Ion Selective Electrodes:	**(04L)**
		2.2.1 Ion selective and ion specific electrodes, components of ion selective electrode, properties of membrane in ion selective electrode, classification of ion selective electrodes **2.2.2** Solid membrane electrodes: Fluoride ion selective electrode, Glass membrane electrode, Glass electrode. **2.2.3** Liquid membrane electrode: Calcium ion electrode	
		2.3 Polarography	**(07L)**
		2.3.1 Basic principles, polarizable and nonpolarizable electrodes, supporting electrolyte, its function, selection of supporting electrolyte **2.3.2** The polarogram, terms involved, residual current, limiting current, diffusion current, half wave potential. **2.3.3** Oxygen interference and its removal, polarographic maxima and use of maxima suppressors.	

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		2.3.4 Equation of polarographic wave, determination of half wave potential and diffusion current from the polarogram **2.3.5**Ilkovic equation, terms involved and their explanation **2.3.6** DME, Construction, working, advantages and limitations; **2.3.7** Instrumentation, H- shaped polarographic cell , Qualitative and quantitative analysis, calibration curve method, standard addition method. **2.3.8** Applications of polarography.	
		2.4 Amperometric titrations	**(03L)**
		2.4.1 Basic principles: construction of the titration curve, Different types of amperometric titration curves, **2.4.2** Rotating platinum electrode, construction, working, advantages and limitations. **2.4.3** Applications of amperometric titrations, **2.4.4** Comparison of amperometry and polarography	
	III	**Miscellaneous Methods**	**(15L)**
		3.1 Potentiometric titrations	**(04L)**
		3.1.1 Potentiometry and potentiometric titrations, basic principles, indicator and reference electrode, types of titrations and indicator electrodes used for each type. **3.1.2** Experimental set up & procedures for the potentiometric titrations, **3.1.3** Determination of equivalence point in potentiometric titrations, use of E vs.V, first and second derivative plots vs. V for the determination of the equivalence point.	

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		3.1.4 Advantages and limitations.	
		3.2 Biamperometric titrations,	**(02L)**
		3.2.1 Basic principles, experimental set up, **3.2.2** Biamperometric titration curves, determination of the equivalence point **3.2.3** Determination of water content by Karl Fischer method.	
		3.3 Gel electrophoresis	**(06L)**
		3.3.1 Basic principle, **3.3.2** Factors affecting migration rate, supporting media, SDS page, Isoelectric focussing **3.3.3** 2D gel support, application of the sample, procedure. **3.3.4** Separation and identification methods **3.3.5** Applications	
		3.4 Size exclusion Chromatography	**(03L)**
		3.4.1 Introduction, principles, **3.4.2** Operational procedures, **3.4.3** Applications of size exclusion chromatography	
	IV	**Selected Industrial Applications of Analytical Chemistry**	**(15L)**
		4.1 Food analysis	**(05L)**
		4.1 .1 Milk powder **4.1.1.1** Determination of lactose **4.1.1.2** Determination of calcium and iron **4.1.2 Honey** **4.1.2.1** Total reducing sugars in honey	
		4.2 Cosmetic analysis	**(02L)**

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		4.2.1 Talcum powder **4.2.2** Analysis of face powder	
		4.3 Detergent analysis	**(03L)**
		4.3.1 Determination of active anionic matter **4.3.2** Determination of alkalinity **4.3.3** Determination of oxygen releasing capacity.	
		4.4 Water analysis	**(03L)**
		4.4.1 Determination of dissolved oxygen **4.4.2** Determination of chemical oxygen demand	
		4.5 Pharmaceutical Analysis	**(02L)**
		4.5.1 Determination of drugs by non-aqueous titration	

Semester-VI

Practicals

RUSCHEP601	**Credits-3**
	CHEMISTRY-I 1. To determine the energy of activation for the acid catalyzed hydrolysis of methyl acetate. 2. To determine the molecular weight of high polymer polyvinyl alcohol (PVA) by viscosity measurement. 3. To determine acidic and basic dissociation constant of amino acid and hence calculate isoelectric point. 4. To determine the amount of weak acid and strong acid in the given mixture by conductometric titration. 5. To determine the solubility and solubility product of AgCl potentiometrically using chemical cell. **6.** To determine Critical Micelle Concentration (CMC) using conductometer.

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	CHEMISTRY-II **Inorganic preparations** 1. Mercury tetrathiocyanatoCobaltate (II) Hg[Co(SCN)4] 2. Magnesium oxinate[Mg(Ox)2] 3. Tris-acetyl acetonato iron(III) [Fe(AcAc)3] 4. Tetramminecopper(II) sulphate. [Cu(NH3)4]SO4.H2O **Inorganic estimations/ Analysis** 1. Estimation of copper iodometrically using sodium thiosulphate. 2. Estimation of lead by complexometrically using EDTA solution.
RUSCHEP602	**CHEMISTRY-III** **Binary Mixture Separation & identification (Solid + Solid)** (2.0 g mixture to be given) 1. Minimum six mixtures to be completed by the learners. 2. Components of the mixture should include water soluble and water insoluble acids (carboxylic acid), water insoluble phenols (α-naphthol, β-naphthol), water insoluble bases (nitroanilines), water soluble (urea and thiourea) and water insoluble neutrals (Aromatic hydrocarbons, m-dinitrobenzene, anilides, amides) 3. A sample of binary mixture to be given (<1.0 gram) to the learners for detection of chemical type of mixture. After correct determination of the chemical type, the fixing reagent should be decided by the learners for separation. 4. Follow separation scheme with the bulk sample of the binary mixture. 5. After separation of the components into independent components A and B, a. One component (decided by the examiner) is to be analyzed and identified by chemical method with melting point and also by IR spectroscopy. (This component is not to be weighed). b. The other component is to be purified, dried, weighed and melting point is to be determined.
	CHEMISTRY-IV: 1. Estimation of Chromium in water sample by using diphenylcarbazide spectrophotometrically.

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	2. Determination of acetic acid content in vinegar sample by using quinhydrone electrode potentiometrically. 3. Determination of phosphoric acid in cola sample pH metrically. 4. Estimation of calcium and magnesium content in Talcum powder. 5. Estimation of reducing sugar in honey by Wilstatter method. 6. Separation and estimation of Mg(II) and Zn(II) from given sample solution using an anion exchanger.

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1. Physical Chemistry, Ira Levine, 5th Edition, 2002 Tata McGraw Hill Publishing Co.Ltd.
2. The Elements of Physical Chemistry, P.W. Atkins, Oxford University Press, Oxford..
3. Modern Electrochemistry, J.O.M Bockris& A.K.N. Reddy, Maria Gamboa – Aldeco 2nd Edition, 1st Indian reprint,2006 Springer
4. Physical Chemistry, G.M. Barrow, 6th Edition, Tata McGraw Hill Publishing Co. Ltd. New Delhi.
5. The Elements of Physical Chemistry, P.W. Atkins, 2nd Edition, Oxford UniverstityPress Oxford
6. Physical Chemistry, G.K. Vemullapallie, 1997, Prentice Hall of India, Pvt.Ltd. New Delhi.

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1. D. Banerjea, *Coordination chemistry,* Tata McGraw Hill, New Delhi, (1993).
2. D. F. Shriver and P. W. Atkins, *Inorganic chemistry,* 3rd Ed., Oxford University Press, (1999).
3. N. N. Greenwood and E. Earnshaw, *Chemistry of elements,*Pergamon Press, Singapore, (1989).
4. W. L. Jolly, *Modern inorganic chemistry,* 2nd Ed. McGraw Hill Book Co., (1991).
5. B. E. Douglas and H. McDaniel, *Concepts and models in inorganic chemistry,* 3rd Ed., John Wiley & Sons, Inc., New York, (1994).
6. G. N. Mukherjee and A. Das, *Elements of bioinorganic chemistry,* Dhuri and Sons, Calcutta, (1988).
7. R. W. Hay, *Bioinorganic chemistry,* Ellis Harwood, England, (1984).
8. R. C. Mehrotra and A. Singh, *Organometallic chemistry: A unified approach,* Wiley Eastern, New Delhi, (1991).

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9. Practical Inorganic Chemistry by G. Marr and B. W. Rockett,VanNostrand Reinhold Company London1972. P 34. (For synthesis of iron ethylenediamine sulphate)
10. Microscale Inorganic Chemistry by Z. Szafran, Ronald M. Pike and Mono M. Singh. Pub.John Wiley and Sons1991.p.218.(For preparation of $CuCl_2$.2DMSO.

Organic Chemistry

1. Organic Chemistry, Francis A Carey, Pearson Education, 6th Edition, Special Indian Edition 2008.
2. Organic Chemistry, R.T. Morrison and R.N. Boyd, 6th Edition, Pearson Edition.
3. Organic Chemistry, T.W.G. Solomon and C.B. Fryhle, 8th Edition, John Wiley & Sons, 2004.
4. Organic Chemistry Baula Y. Bruice, Pearson Edition, 2008.
5. Organic Chemistry, J.G. Smith, 2nd Editionm Special Indian Edition, Tata. McGraw Hill.
6. Stereochemistry, P.S. Kalsi, New Age International Ltd. 4th Edition,2006
7. Organic Spectroscopy by Jag Mohan
8. Furniss, B. S.; Hannaford, A. J.; Rogers, V.; Smith, P. W. G.; Tatchell, A. R. Vogel's Textbook of Practical Organic Chemistry, ELBS.

Analytical Chemistry

1. D. Harvey, Modern Analytical Chemistry, The McGraw-Hill Pub. 1st Edition (2000)
2. H.S. Ray, R Sridhar and K.P. Abraham, Extraction of Nonferrous Metals, AffiliatedEast-West Press Pvt. Ltd. New Delhi (1985) reprint 2007.
3. G.H. Jeffery, J. Bassett, J. Mendham and R.C. Denney , Vogel's Textbook of Qunatitative Chemical Analysis, Fifth edition, ELBS Publication (1996)
4. D.A. Skoog D.M. West and F.J. Holler, Fundametals of Analytical Chemistry, 7thEdition (printed in India in 2001) ISBN Publication.
5. Analytical Chemistry, J.G. Dick,1973 Tata McGraw Hill Publishing Co. Ltd. New Delhi.
6. Quantitative analysis, Dey& Underwood, Prentice Hall of India, Pvt. Ltd. New Delhi
7. Fundamentals of Analytical Chemistry, Skoog 8th edition, Saunders college publishing.

Modality of Assessment

Theory Examination Pattern:

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A) Internal Assessment - 40% of total marks:

(40 marks)

Sr No	Evaluation type	Marks
1	One Assignment	10
2	One class Test (multiple choice questions / objective)	20
3	Active participation in routine class instructional deliveries (seminars//presentation)	05
4	Overall conduct, participation in co-curricular activities of the department.	05

B) External examination – 60 %

Semester End Theory Assessment - 60% **60 marks**

These examinations shall be of **two hours** duration.

There shall be **Four** questions each of **15** marks. On each unit there will be one question.

All questions shall be compulsory with internal choice within the questions.

Theory question paper pattern is as follows :-

Questions	Options	Marks	Questions on
Q.1)A)	Any 3 out of 5	12	Unit I
Q.1)B)	Any 1 out of 2	03	
Q.2)A)	Any 3 out of 5	12	Unit II
Q.2)B)	Any 1 out of 2	03	
Q.3)A)	Any 3 out of 5	12	Unit III
Q.3)B)	Any 1 out of 2	03	
Q.4)A)	Any 3 out of 5	12	Unit IV
Q.4)B)	Any 1 out of 2	03	

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Practical Examination Pattern:

(A)Internal Examination: -				
	RUSCHEP601		**RUSCHEP602**	
	Paper I	**Paper II**	**Paper III**	**Paper IV**
Journal	**05**	**05**	**05**	**05**
Tests	**10**	**10**	**10**	**10**
Active Participation	**05**	**05**	**05**	**05**
Total	**20**	**20**	**20**	**20**
(B) External (Semester end practical examination):-				
Laboratory work	**25**	**25**	**25**	**25**
Viva	**05**	**05**	**05**	**05**
Total	**30**	**30**	**30**	**30**
Grand Total	**100**		**100**	

PRACTICAL JOURNAL

The students are required to present a duly certified journal for appearing at the practical examination, failing which they will not be allowed to appear for the examination.

In case of loss of Journal, Certificate from Head/ Co-ordinator should be submitted, failing which the student will not be allowed to appear for the practical examination.

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Overall Examination and Marks Distribution Pattern

Course	**601**	**602**	**Grand Total**

	Internal	External	Total	Internal	External	Total	
Theory	**40**	**60**	**100**	**40**	**60**	**100**	**200**
Practical	**20**	**30**	**50**	**20**	**30**	**50**	**100**
Course	**603**			**604**			
	Internal	**External**	**Total**	**Internal**	**External**	**Total**	
Theory	**40**	**60**	**100**	**40**	**60**	**100**	**200**
Practical	**20**	**30**	**50**	**20**	**30**	**50**	**100**
(Total Marks : 600)							