Resolution Number : AC/II(23-24).3.RUS5

S. P. Mandali's
Ramnarain Ruia Autonomous College
(Affiliated to University of Mumbai)

Syllabus for
Program: B.Sc (Chemistry)
Program Code: RUSCHE

(Credit Based Semester and Grading System for academic year 2023-2024)

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.

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
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	

		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	

			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	

				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	

			Unit-II	Properties of coordination compounds	
			Unit-III	Organometallic chemistry	
			Unit-IV	Nanomaterials Bioinorganic chemistry	
		RUSCHE603	**Chemistry-III**		**2.5**
			Unit-I	Chemistry of carbohydrates Catalysts & reagents	
			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(23-24).2(II).RUS5

S.P. Mandali's

Ramnarain Ruia Autonomous College

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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 2023-2024)

Semester III
Course Code: RUSCHE301
Course Title : CHEMISTRY-I
Academic Year 2023-2024

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	

		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	

		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,	

		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)	

Course Code: RUSCHE302
Course Title : CHEMISTRY-II
Academic year 2023-2024.

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)**

		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)**

	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.	

	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.	

Course Code: RUSCHE303

Course Title : CHEMISTRY-III

Academic year 2023-2024

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.

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,	

		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 A**ccuracy 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)**

		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.	

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**

	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.

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 :

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

(B) 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**

(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)

Semester IV

Course Code: RUSCHE401

Course Title : CHEMISTRY-I

Academic year 2023-2024

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.

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)**

		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)**

		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)**

Course Code: RUSCHE402
Course Title : CHEMISTRY-II
Academic year 2023-2024.

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)**
		1.1 **Carboxylic 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)**

		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 bynucleophilic 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)**
		2.1 Amines: **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)**

		(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)**

		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), reagentsin organic synthesis etc. **3.1.3** Metal carbonyls: Bonding, general method of preparation and properties of $Ni(CO)_4$, $Fe(CO)_5$.	**(07L)**

Course Code: RUSCHE403

Course Title : CHEMISTRY-III

Academic year 2023-2024

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.

DETAILED SYLLABUS

RUSCHE403	CHEMISTRY-III		Credits-02
	Unit	**Unit Title**	**Lectures**
	I	**Methods of Separation**	**(15L)**
		1.1 Separation 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)**

		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)**

		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)**

		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	

		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.

	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.

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'

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**

(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)