S.P. Mandali's
Ramnarain Ruia Autonomous College

Syllabus for T.Y.B.Sc
Programme – B.Sc.
Course: Chemistry (RUSCHE)

(Credit Based Semester and Grading System with effect from the academic year 2019–2020)

SEMESTER V

Paper I : PHYSICAL CHEMISTRY

Course Code	UNIT	TOPICS	Credits	Lectures
RUSCHE501	**I**	Molecular spectroscopy	**2.5**	**15**
	II	Electrochemistry-III Classification of galvanic cells		**15**
	III	Colligative properties Chemical kinetics-II		**09** **06**
	IV	Surface chemistry & catalysis Colloids		**08** **07**

PAPER II: INORGANIC CHEMISTRY

Course Code	UNIT	TOPICS	Credits	Lectures
RUSCHE502	**I**	Chemical bonding: Molecular symmetry Molecular orbital theory for polyatomic species Metallic bonding	**2.5**	**07** **05** **03**
	II	Solid state chemistry		**15**
	III	Chemistry of elements: lanthanides & actinides		**15**
	IV	Chemistry of non aqueous solvents, inter-halogen compounds and xenon		**15**

PAPER III: ORGANIC CHEMISTRY

Course Code	UNIT	TOPICS	Credits	Lectures
RUSCHE503	I	Mechanism of organic reactions	2.5	15
	II	Stereochemistry		15
	III	IUPAC nomenclature Polymers		06 09
	IV	Synthesis of organic compounds		15

PAPER IV: ANALYTICAL CHEMISTRY

Course Code	UNIT	TOPICS	Credits	Lectures
RUSCHE504	I	Sampling Treatment of analytical data	2.5	15
	II	Titrimetric analysis: Redox titrations Precipitation titrations Complexometric titrations Non-aqueous titrations		15
	III	Atomic absorption spectroscopy Atomic emission methods Fluorescence and phosphorescence spectroscopy Nephelometry and turbidimetry		15
	IV	Thermal methods Radioanalytical techniques Mass spectrometry Method validation		15

PRACTICALS: SEMESTER V

Course Code	UNIT	TOPICS	Credits
RUSCHEP501	**I**	**PRACTICALS OF COURSE RUSCHE501 & RUSCHE502**	**3**
RUSCHEP502	**II**	**PRACTICALS OF COURSE RUSCHE503 & RUSCHE504**	**3**

SEMESTER VI

Paper I: PHYSICAL CHEMISTRY

Course Code	UNIT	TOPICS	Credits	Lectures
RUSCHE601	**I**	NMR spectroscopy Polymers	**2.5**	**08** **07**
	II	Electrochemistry-IV: decomposition potential, overvoltage and electroplating renewable sources		**08** **07**
	III	Nuclear chemistry-III		**15**
	IV	Basics of quantum chemistry		**15**

PAPER II : INORGANIC CHEMISTRY

Course Code	UNIT	TOPICS	Credits	Lectures
RUSCHE602	**I**	Coordination chemistry	**2.5**	**15**
	II	Properties of coordination compounds		**15**
	III	Organometallic chemistry		**15**
	IV	Nanomaterials Bioinorganic chemistry		**08** **07**

PAPER III: ORGANIC CHEMISTRY

Course Code	UNIT	TOPICS	Credits	Lectures
RUSCHE603	**I**	Chemistry of carbohydrates Catalysts & reagents	**2.5**	**09** **06**
	II	Chemistry of amino acids, proteins and nucleic acids Photochemistry		**08** **07**
	III	Spectroscopy –I		**15**
	IV	Spectroscopy -II		**08**
		Natural products		**07**

PAPER IV: ANALYTICAL CHEMISTRY

Course Code	UNIT	TOPICS	Credits	Lectures
RUSCHE604	**I**	Separation techniques (GC, HPLC,HPTLC, ion exchange chromatography)	**2.5**	**15**
	II	Electroanalytial techniques: Ion selective electrodes Polarography Amperometric titrations		**15**
	III	**Miscellaneous Methods** Potentiometric Titrations Bi-amperometric titrations Gel electrophoresis Size exclusion chromatography		**15**
	IV	**Applications to different fields**: Food analysis Cosmetic analysis Detergent analysis Water analysis Pharmaceutical analysis		**15**

PRACTICALS :SEMESTER VI

Course Code	UNIT	TOPICS	Credits
RUSCHEP601	**I**	**PRACTICALS OF COURSE RUSCHE601 & RUSCHE602**	**3**
RUSCHEP602	**II**	**PRACTICALS OF COURSE RUSCHE603 & RUSCHE604**	**3**

Detail Syllabus
Academic Year 2019-20

SEMESTER V
Paper-I: Physical Chemistry
Course Code: RUSCHE501
Credits: 2.5

Learning Objectives:

The learner is already introduced to the fundamental concepts of Physical Chemistry in his lower classes. In the current syllabi, he is introduced to the concept of Molecular Spectroscopy whereby he is introduced to the Rotational, Vibrational and Raman Spectra of Molecules. The subject of Electrochemistry is further explored on the basis of the concepts learnt in the lower classes. Advanced applications of Raoult's low to study colligative properties are also studied. The learner is finally introduced to Surface Chemistry and its applications to colloids.

Learning Outcome:

After studying the current syllabi, the student will have detailed knowledge of

- Rotational, Vibrational and Raman Spectra of Molecules.
- Galvanic Cells and Applications of Fundamentals of Electrochemistry
- Application of Raoult's Law and Clapeyron Equation to study Colligative Properties
- Advanced Kinetic Studies
- Surface Chemistry and its application to Colloids

Unit I	**1 MOLECULAR SPECTROSCOPY** 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. 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	**(15L)**

	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	
Unit II	**2 ELECTROCHEMISTRY- III: CLASSIFICATION OF GALVANIC CELLS** 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. 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.	**(15L)**
Unit III	**3.1 COLLIGATIVE PROPERTIES** 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.	**(9L)**
	3.2 CHEMICAL KINETICS-II 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. 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.	**(6L)**
Unit IV	**4.1 SURFACE CHEMISTRY AND CATALYSIS** 4.1.1 Adsorption: Physical and Chemical Adsorption, Types of adsorption isotherms, Langmuir's adsorption isotherm. B.E.T. equation for multilayer	**(8 L)**

	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 catalyzed reactions, effect of pH on acid and base catalyzed reactions. 4.1.2.2 Enzyme catalysis, mechanism and kinetics of reaction (Michaelis-Menten equation). **4.2 COLLOIDS** 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, electrokinetic 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.	**(7 L)**

SEMESTER V

Paper-II: Inorganic Chemistry

Course Code: RUSCHE502

Credits: 2.5

Learning Objectives:

Having studied the applications of the Molecular Orbital Theory for Homonuclear and heteronuclear diatomic molecules, it was essential to introduce the learner with heteronuclear polyatomic molecules. Also, the importance of symmetry elements, symmetry operations and concept of point group in chemistry is required to be understood by the learner which is quite important to understand the orientation of molecules in space. The structure of solids and defects in solids have a major application in the study of the physical parameters of compounds. The chemistry of inner transition elements is newly introduced at the TYBSc level which completes the discussion of all the four blocks of elements of the periodic table.

Learning outcome:

After a detailed study of this syllabus, the student will be able to undertand

- Importance of symmetry in chemistry.
- Concept of Point Group
- Correlation between Bond angle and Molecular Orbitals
- Band Theory and its application to metals
- Structure of Solids and their defects
- Comparison between Lanthanides and Actinides.
- Properties and Application of Uranium
- Properties of Xenon and other noble gases

Unit I	**Chemical Bonding** **1.1 Molecular Symmetry** **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 point groups: (i) $C_{\alpha v}$ (HCl), (ii) $D_{\alpha h}$ (H_2), (iii) C2v (H_2O), (iv) C_{3v} (NH_3), (v) C_{2h} (trans – trichloroethylene), and (vi) D_{3h} (BCl_3).	**(07L)**
	1.2 Molecular Orbital Theory for Polyatomic Species **1.2.1** Simple triatomic species: H_3^+ and H_3 (correlation between bond angle and Molecular orbitals). **1.2.2** Other molecules (considering only σ-bonding): i) BeH_2, ii) H_2O iii) CH_4	**(5L)**
	1.3 Metallic Bonding Band theory, explanation of electrical properties of conductors, insulators and semi conductors, intrinsic and extrinsic semiconductors.	**(3L)**
Unit II	**Solid State Chemistry** **2.1 Structures of Solids** **2.1.1** Explanation of terms viz.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 (discussion on Frenkel and Schottky defects)	**(11L)**
	2.2 Superconductivity **2.2.**1 Discovery of superconductivity **2.2.1** Superconductivity,transition temperature and Meissner effect. **2.2.2** Different types of superconductors viz, convential superconductors, , alkali metal fullerides (A3C60) and high temperature Superconductors. **2.2.3** Applications of superconducting materials.	**(04L)**
Unit III	**3 Chemistry of f-block elements** 3.1 Introduction Definition, position in periodic table and electronic configuration of lanthanides and actinides. 3.2 Chemistry of Lanthanides 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.	**(12L)**
	3.3 Chemistry of Actinides 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.	**(3L)**

Unit IV	**4.1 Chemistry of Non-aqueous Solvents** 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, dinitrogen tetraoxide as non-aqueous solvents with respect to i) acid base reactions and ii) redox reactions.	**(7 L)**
	4.2 **Chemistry of Interhalogens**: introduction, preparation, reactions and structures.	**(3L)**
	4.3 **Chemistry of pseudohalogens** : Intorduction, preparation, reaction and structures	**(3L)**
	4.4 **Chemistry of Xenon** : Introduction, Compounds of Xenon: Oxides, fluorides, oxyfluorides w.r.t. preparation , properties and bonding.	**(2L)**

SEMESTER V

Paper-III: Organic Chemistry

Course Code: RUSCHE503

Credits: 2.5

Learning Objectives:

The student at the TYBSc level is expected to apply the fundamentals of Organic Chemistry that he has learnt in the lower classes. The syllabi aims at incorporating these fundamentals to study the advanced concepts in Reaction Mechanism and stereochemistry. The IUPAC rules of nomenclature learnt in the lower classes are applied to Bicyclo and spiro compounds along with heterocycles. The need of the hour of having environmentally safe reactions is understood by the learner on studying the principles of Green Chemistry.

Learning Outcome

After studying this prescribed syllabi, the learner will have profound knowledge of

- Fundamentals of Organic Reaction Mechanisms
- Advanced Concepts in Stereochemistry
- Application of IUPAC nomenclature rules to spiro, bicyclo and heterocyclic compounds.
- Basic Idea of Polymer Chemistry
- Fundamentals of Green Chemistry and their applications to Organic Synthesis.

Unit I	**1 Mechanism of Organic Reactions** 1.1 Recapitulation: Curved arrows, intermediates, transition states, Electrophilicity vs acidity and nucleophilicity vs basicity. 1.2 Elimination Reactions: Mechanisms and stereochemistry.	**(15L)**

	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 ($B_{AC}2$). 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. 1.6 Name reactions: Michael, Wittig (mechanism and examples).	
Unit II	**2. Stereochemistry** 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, disubstituted cyclohexanes 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_N1, S_N2, S_Ni (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.	**(15L)**
Unit III	**3.1 IUPAC Nomenclature** 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.	**(6L)**

	3.1.3 Cummulenes upto three double bonds. **3.2 Polymers** 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 3.2.3 Condensation polymers: polyesters, polyamides, polyurethans, polycarbonates and phenol-formaldehyde resins. Uses 3.2.4 Mechanism of free radical addition polymerization. 3.2.5 Stereochemistry of polymers: Tacticity. Mechanism of 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).	**(9L)**
Unit IV	**Synthesis of Organic compounds** **4.1 Introduction**: Criteria for ideal organic synthesis. Calculaton of yields. Concept of selectivity with examples Linear and convergent synthesis with one example each Multi-component reactions: Mannich reaction, Hanztsch synthesis. 4**.2 Introduction to retrosynthesi**s: Analysis and synthesis, technical terms: target molecules (TM), retrosynthetic analysis, FGA, FGI, Disconnection, synthon and reagent. Retrosynthtic analysis of Limonene, Salbutamol and Proparacaine. **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 with examples. Atom economy and E-factor, calculations and their significance. Examples of reactions with low and high atom economy. 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.	**(15L)**

SEMESTER V
Paper-IV: Analytical Chemistry
Course Code: RUSCHE504
Credits: 2.5

Learning Objectives:

Learner in his lower classes, has encountered with classical techniques such as volumetric analysis and gravimetric analysis. He is familiar with Acid-Base titrations. At the TYBSc level, the learner should know the advanced titrimetric methods such as redox, precipitation, complexometric and non-aqueous titrations. Also, the need and importance of sampling and the different methods of sampling are elaborately introduced at this level. Concept of Quality and different standards and their utility is of utmost importance for them which will enable them to attain industrial readiness. Different optical methods, thermal methods, Radioanalytical techniques and Mass Spectrometry are the advanced instrumental methods which a learner should know prior to enrolling for higher studies or going ahead for industrial jobs.

Learning Outcome:

At the end of this course, the student will know

- Concept of Sampling and various methods of sampling.
- Importance of Quality Control
- Basic Principles of Redox, Precipitation, Complexometric and Non-Aqueous titrations.
- Applications of Advanced Instrumental methods

Unit I	**1.1 Sampling:** **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, sampling and equipment for sampling of powdered solids, sampling and equipment foe sampling of flowing solids, sampling of 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** **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. **1.2..6** Testing for significance, null hypothesis, variance ratio test.	**(15L)**

	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.	
Unit II	**Titrimetric analysis** **2.1 Redox Titrations** **2.1.1** General introduction, theory of redox indicators, **2.1.2** criterion for choosing an indicator for a redox titration, **2.1.3 C**onstruction of the titration curves in the case of i) Fe(II) vs Ce(IV), ii) Fe(II) vs CrO_7^{2-}, **2.1.4** Use of diphenyl amine and ferroin as redox indicator. **2.2 Precipitation titrations** **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** **2.3.1** General introduction of complexometric titrations **2.3.2** EDTA titrations **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 Nonaqueous titrations** **2.4.1** Need for nonaqueous titrations, **2.4.2** Types of solvents, choice of the solvent for the nonaqueous titrations, **2.4.3** Acid base titrations in nonaqueous media, **2.4.4** Use of glacial acetic acid as the solvent in nonaqueous titrations, nonaqueous titrations with a visual indicator using an instrument **2.4.5** Advantages and limitations	**(15L)**
Unit III	**Optical Methods** **3.1 Atomic Absorption Spectroscopy** **3.1.1** Atomic energy level diagram, basic principles, characteristic features of atomic spectra **3.1.2** Basic principles of atomic absorption spectroscopy, steps involved in the	**(6L)**

	process of atomization **3.1.3** Instrumentation: components-hollow cathode lamp, chopper, types of burners, premix and total consumption, electrothermal atomizers, **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** **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; comparison of atomic absorption and flame emission methods. **3.3 Fluorescence and phosphorescence spectroscopy** **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: 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. **3.4 Nephelometry and turbidimetry** **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	**(9L)**
Unit IV	**Miscellaneous Methods** **4.1 Thermal Methods** **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** **4.2.1** Neutron activation analysis, **4.2.1.1** Basic principles, characteristic features, operational procedure, **4.2.1.2** Applications. **4.2.1.3** Advantages and limitations	**(15L)**

	4.2.2 Isotope dilution analysis, **4.2.2.1** Basic principles, operational procedure, **4.2.2.2** Applications, advantages and limitations **4.3 Mass spectrometry** **4.3.1** Basic principles, **4.3.2** Instrumentation, components, sources, analysers, detectors **4.4 Method validation** **4.4.1** Need and significance of method validation **4.4.2** Parameters chosen for method validation **4.4.3** Procedure for method validation	

PRACTICALS

RUSCHEP501	**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 the amount of oxalic acid and its dissociation constants by pH-metry. 5. To determine the amount of oxalic acid by conductometric titration. 6. To determine the standard reduction potential of Cu^{2+}/Cu electrode at room temperature.
	Inorganic preparations 1. Potassium diaquo bis- (oxalate)cuprate(II)$K_2[Cu(C_2O_4)_2.(H_2O)]$ 2. Bis(ethylenediamine)iron(II)sulphate$[C_2H_4(NH_2)_2FeSO_4.4H_2O]$. **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 (Students are expected to standardize supplied EDTA solution using ZnSO4.7H20) 3. Estimation of copper(II) complexometrically using fast sulphon black-F indicator (Students are expected to standardize supplied EDTA solution using ZnSO4.7H20)
RUSCHEP502	**I) Binary Mixture Separation: Separation of mixture containing (VL + NVL) & (VL+ S) components.** 1. Minimum Six mixtures to be completed by the students. 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 student for 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 and ethylacetoacetate in presence of a base.
	Analytical Chemistry: 1. Determination of the amount of fluoride in the given solution colorimetrically. 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.

SEMESTER VI
Paper-I: Physical Chemistry
Course Code: RUSCHE601
Credits: 2.5

Learning Objectives:

As the student approaches the end of his Graduation studies, he needs to have the idea of applications of the fundamentals of physical chemistry. Hence this syllabi incorporates the understanding of Nuclear Magnetic Resonance for structure determination and Polymer chemistry. With basic understanding of fundamentals of Electrochemistry in lower classes, the learner is introduced to advanced applications of electrochemical phenomenon. Nuclear Chemistry is a major arena for research in the medical field and hence the learner is introduced to the basic concepts in Nuclear Chemistry. Basics of quantum chemistry are also introduced to the learner.

Learning Outcome:

After taking this course, the learner will have decent control on the following areas of Physical Chemistry:

- Nuclear Magnetic Resonance and Its applications
- Polymer Chemistry
- Renewable Energy Sources
- Basic Nuclear Chemistry
- Basics of Quantum Chemistry.

Unit I	**1.1 NUCLEAR MAGNETIC RESONANCE SPECTROSCOPY** 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 of protons, low resolution NMR spectrum, high resolution NMR spectrum.	**(08L)**
	1.2 POLYMERS 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 1.2.3 Methods of determining molar mass of polymers: 1) Ultracentrifugation method 2) Viscosity method of Viscosity average molar mass, Mark-Houwink equation.	**(07L)**

Unit II	**2.1 ELECTROCHEMISTRY- IV: DECOMPOSITION POTENTIAL, OVERVOLTAGE AND ELECTROPLATING** 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 RENEWABLE ENERGY SOURCES** 2.2.1 Lithium ion cell, 2.2.2 Hydrogen - fuel of future, Advantages and limitations of hydrogen as a universal energy medium, Production of hydrogen by electrolysis of water. 2.2.3 Fuel cells: Bacon's H_2 and O_2 fuel cell. 2.2.4 Solar energy: Photovoltaic effect, P-type and N- type of semiconductors, PN-Junction, Silicon solar cell.	**(08L)** **(7L)**
Unit III	**3. NUCLEAR CHEMISTRY** 3.1 Structure of Nucleus. 3.2 Nuclear disintegration/ Nuclear radioactivity, Types of nuclear radiations (α-ray, β-ray and γ-ray). 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; Differences 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	**(15L)**

	3.12 Detection and measurement of radioactivity – GM Counter and Scintillation Detector	
Unit IV	**4.0 BASICS OF QUANTUM MECHANICS** 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	**(15L)**

SEMESTER VI
Paper-II: Inorganic Chemistry
Course Code: RUSCHE602
Credits: 2.5

Learning objectives:

The student has learnt the applications of Valence Bond Theory and Molecular Orbital Theory so far. The Crystal Field theory and the important parameters associated with Crystal Field Theory were introduced to give the evidences of covalence in metal complexes. Also, the applications of MOT to octahedral complexes have been discussed in the current syllabi. With the same flow, the properties of the co-ordination compounds such as their spectral data and stability and reactivity of metal complexes is required to be understood by the learner. The principles of Organometallic chemistry have been further explored in Metallocenes. The learner is made familiar with industrially relevant topics such as Nanomaterials – their characterization and properties and medicinal chemistry.

Learning outcome:

Towards the end of the year, the learner will have good knowledge of

- Advantages of Crystal Field Theory over Valence Bond Theory
- Calculations of CFSE and its applications
- Applications of MOT to octahedral complexes
- Spectral Analysis of Inorganic Compounds- Determination of terms, term symbols and Orgel Diagrams
- Thermodynamic and Kinetic Stability of Complexes.
- Types of Reactions shown by Metal complexes.
- General Characteristics of Organometallic Compounds
- Synthesis of Nanomaterials and their properties

- Inorganic Compounds showing medicinal properties.

Unit I	**1. Coordination Chemistry** **1.1 Theories of metal-ligand bond** **1.1.1** Limitations of VBT **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 and 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. **1.1.7** Consequences of crystal field splitting on various properties such as inic 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 specftrum of $[IrCl_6]^{2-}$ iii) Nephelauxetic effect . **1.2 Molecular Orbital Theory (MOT) of Coordination Complexes** **1.2.1** Application to octahedral complexes in case of (i) $[Ti(H_2O)]^{3+}$, (ii) Fluoro complexes of Fe(II) and Fe (III) and (iii) Cyano complexes of Fe(II) and Fe (III).	**(11L)** **(4L)**
Unit II	**Properties of Co-ordination Compounds:** **2.1 Electronic Spectra** **2.1.1** Origin of electronic spectra **2.1.2** Types of electronic transitions in coordination co0mpounds: intra- ligand, charge transfer and intra-metal transitions. **2.1.3** Electronic configuration and electronic micro states, Term symbols, coupling of spin momenta (M_s),orbital momenta (M_l)and spin- orbit coupling or Russell-Saunders coupling. **2.1.4** Determination of Terms for *p2 and d2* electronic 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. d1 to d9 electronic configurations in octahedral crystal fields) **2.1.7** Selection rules for electronic transitions : Spin and orbital forbidden transitions (Laporte selection rules) **2.2 Stability of Metal Complexes** **2.2.1** Thermodynamic stability and kinetic stability of complexes with examples.	**(07L)**

	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 :** **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	**(04L)** **(04L)**
Unit III	**Organometallic Chemistry** 3.1 Organometallic Compounds of main group metals 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 (Transmetallation), (iii) Carbanion-Halide exchange, (iv) Metal Hydrogen exchange and (v) Methylene insertion reactions. **3.1.3** Chemical reactions: (i) Reactions with oxygen, (ii) Alkylation and arylation reactions (iii) Reactions with protic reagents and (iv) Complex formation reactions. **3.2 Metallocenes** Introduction, Ferrocene; Synthesis, properties, structure and bonding on the basis of VBT. ɗ- bonding in rhenium and molybdenum halide complexes.	**(9L)** **(06L)**
Unit IV	**Some Selected Topics** **4.1 Nanomaterials** 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** 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.	**(15L)**

SEMESTER VI
Paper-III: Organic Chemistry
Course Code: RUSCHE603
Credits: 2.5

Learning Objectives:

Along with basics of mechanism, the learner is expected to have basic understanding of biologically active molecules. This is introduced in the chapters of Carbohydrates, Amino Acids, Nucleic Acids and Natural Product Chemistry. So also, it is of utmost importance that the student has knowledge of structure determination using the advanced spectral techniques like UV-VIS spectroscopy, IR Spectroscopy, NMR Spectroscopy and Mass Spectrometry.

Learning Outcome:

At the end of the course, the student will have knowledge about

- Carbohydrates and their structures
- Reactions shown by Glucose
- General applications of various catalysts and Reagents
- Basic Fundamentals of Photochemistry
- Basics of Natural Product chemistry- Including Amino acids, nucleic acids etc
- Applications of Spectral techniques to Structure Determination

Unit I	**1.1 Chemistry of Carbohydrates:** 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 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).	**(09L)**
	1.2 Catalysts and Reagents : 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.	**(6L)**

	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, oxidation of CH_2 to CO (d) *m*-CPBA epoxidation of C=C. (e) NBS: allylic and benzylic bromination.	
II	**2.1 Chemistry of Amino acids, Proteins and Nucleic acids:** 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). **2.3 Photochemistry:** 2.3.1 Introduction: Difference between thermal and photochemical reactions. Jablonski diagram, singlet and triple states, allowed and forbidden transitions, fate of excited molecules, photosensitization. 2.3.2 Photochemical reactions of olefins: photoisomerisation, photochemical rearrangement of 1,4-dienes (di π methane) 2.3.3 Photochemistry of carbonyl compounds: Norrish I, Norrish II cleavages, photoreduction (e.g. benzophenone to benzpinacol).	**(08L)** **(07L)**
III	**3. Spectroscopy-I (UV-Visible, IR and ^{1}H NMR)** 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-Fischer Rule for conjugated polyenes. Applications of UV-Visible spectroscopy. 3.3 IR Spectrocopy: Basic theory, selection rule, nature of IR spectrum, characteristic vibrational frequencies of functional groups, fingerprint region. Applications IR Spectrocopy. 3.4 ^{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 exchange technique. Application of ^{1}H NMR in structure determination	**(15L)**
IV	**4.1 Spectroscopy-II** 4.1.1 Mass Spectrometry: Basic theory. Nature of mass spectrum. General rules of	**(8L)**

	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 : 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. (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.	**(07L)**

SEMESTER VI
Paper-IV: Analytical Chemistry
Course Code: RUSCHE604
Credits: 2.5

Learning Objectives:

Having introduced chromatographic techniques at the SYBSc level, the learner is exposed to sophisticated chromatographic methods such as GC, HPLC, HPTLC etc. Also, the electroanalytical techniques such as DC-Polarography and Amperometric and Bi-Amperometric Titrations are introduced. The importance of Size-Exclusion Chromatography, Gel Electrophoresis and Method Validation is stressed upon. The commercial applications of Analytical chemistry are also explored through food, cosmetic, detergent, water and pharmaceutical analysis.

Learning Outcome:

At the end of the course, the student will know:

- Basic Principles and Applications of Advanced sophisticated techniques.
- Advantages and limitations of these techniques.
- Industrial relevance of these techniques
- Basic Principles, Applications and comparison of Electroanalytical Methods
- Applications of Analytical methods to day-to-day life.

Unit I	**Separation Techniques.** **1.1 Gas Chromatography (05L)** **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 (03L)** **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 High Performance Thin Layer Chromatography (03)** **1.3.1** Introduction, Choice of stationary and mobile phases, sample application, **1.3.2** Development and recording in HPTLC, **1.3.3** Detectors used, single beam and double beam detectors, fluorometric detector, **1.3.4** Quantitative determination, **1.3.5** Applications of HPTLC	**(15L)**

	1.3.6 Advantages and limitations **1.3.7** Comparison between TLC and HPTLC **1.4 Ion Exchange Chromatography (04L)** **1.4.1** Introduction, types of ion exchangers, synthetic and natural, cation and anion, properties of resins **1.4.2** Ion exchange equilibria, selectivity coefficient, separation factors, factors affecting separation of ions **1.4.3** Ion exchange capacity and its determination **1.4.4** Applications of ion exchange chromatography, preparation of demineralized water, separation of amino acids, separation of lanthanides, preparation of exact concentration of acids or bases	
Unit II	**Electroanalytial Techniques** **2.1**: Introduction and classification of electroanalytical methods and specific features of each of the major category. **2.2 Ion Selective Electrodes:** **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** **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, **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** **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	**(15L)**

Unit III	**Miscellaneous Methods** **3.1 Potentiometric titrations** **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. **3.1.4** Advantages and limitations. **3.2 Biamperometric titrations,** **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** **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** **3.4.1** Introduction, principles, **3.4.2** Operational procedures, **3.4.3** Applications of size exclusion chromatography	**(15L)**
Unit IV	**Applications to different fields** **4.1 Food analysis** **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** **4.2.1** Talcum powder **4.2.2** Analysis of face powder **4.3 Detergent analysis** **4.3.1** Determination of active anionic matter	**(15L)**

	4.3.2 Determination of alkalinity **4.3.3** Determination of oxygen releasing capacity. **4.4 Water analysis** **4.4.1** Determination of dissolved oxygen **4.4.2** Determination of chemical oxygen demand **4.5 Pharmaceutical Analysis** **4.5.1** Determination of drugs by non-aqueous titration	

Semester-VI
Practicals

RUSCHEP601	**Physical Chemistry** 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.
	Inorganic preparations 1. Mercury tetrathiocyanato Cobaltate (II) $Hg[Co(SCN)_4]$ 2. Magnesium oxinate$[Mg(Ox)_2]$ 3. Tris-acetyl acetonato iron(III) $[Fe(AcAc)_3]$ 4. Tetrammine copper(II) sulphate. $[Cu(NH_3)_4]SO_4.H_2O$ **Inorganic estimations/ Analysis** 1. Estimation of copper iodometrically using sodium thiosulphate. 2. Estimation of lead by complexometrically using EDTA solution.
RUSCHEP602	**Binary Mixture Separation & identification (Solid + Solid)** (2.0 g mixture to be given) 1. Minimum six mixtures to be completed by the students. 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 students for detection of chemical type of mixture. After correct determination of the chemical type, the fixing reagent should be decided by the students 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**.**
	Analytical Chemistry: 1. Estimation of Chromium in water sample by using diphenylcarbazide spectrophotometrically. 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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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 3 out of 5	03	
Q.2)A)	Any 3 out of 5	12	Unit II
Q.2)B)	Any 3 out of 5	03	
Q.3)A)	Any 3 out of 5	12	Unit III
Q.3)B)	Any 3 out of 5	03	
Q.4)A)	Any 3 out of 5	12	Unit IV
Q.4)B)	Any 3 out of 5	03	

Practical Examination Pattern:

(A)Internal Examination: -				
	RUSCHEP501/601		RUSCHEP502/602	
	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

Semester V and VI:

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 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

Semester V

Course	501			502			503			504			Grand Total
	Internal	External	Total	Internal	External	Total	Internal	External	Total	Internal	External	Total	
Theory	40	60	100	40	60	100	40	60	100	40	60	100	400
Practicals	20	30	50	20	30	50	20	30	50	20	30	50	200

Semester VI

Course	601			602			603			604			Grand Total
	Internal	External	Total	Internal	External	Total	Internal	External	Total	Internal	External	Total	
Theory	40	60	100	40	60	100	40	60	100	40	60	100	400
Practicals	20	30	50	20	30	50	20	30	50	20	30	50	200

(Total: 1200 marks)