Resolution Number: AC/II(23-24).2.RPS5

S. P. Mandali's

Ramnarain Ruia Autonomous College

(Affiliated to University of Mumbai)

Syllabus for SEMESTER I and II

Program: M.Sc. Organic /Physical/Inorganic Chemistry

Program Code: (RPSCHE)

(Credit based semester and grading system with effect from the academic year 2023-2024)

PROGRAM OUTCOME

PO	Description
A student after completing Master's in Science program will be able to	
PO 1	Demonstrate in depth understanding in the relevant science discipline. Recall, explain, extrapolate and organize conceptual scientific knowledge for execution and application and also to evaluate its relevance.
PO 2	Critically evaluate, analyse and comprehend a scientific problem. Think creatively, experiment and generate a solution independently, check and validate it and modify if necessary.
PO 3	Access, evaluate, understand and compare digital information from various sources and apply it for scientific knowledge acquisition as well as scientific data analysis and presentation.
PO 4	Articulate scientific ideas, put forth a hypothesis, design and execute testing tools and draw relevant inferences. Communicate the research work in appropriate scientific language.
PO 5	Demonstrate initiative, competence and tenacity at the workplace. Successfully plan and execute tasks independently as well as with team members. Effectively communicate and present complex information accurately and appropriately to different groups.
PO 6	Use an objective, unbiased and non-manipulative approach in collection and interpretation of scientific data and avoid plagiarism and violation of Intellectual Property Rights. Appreciate and be sensitive to environmental and sustainability issues and understand its scientific significance and global relevance.
PO 7	Translate academic research into innovation and creatively design scientific solutions to problems. Exemplify project plans, use management skills and lead a team for planning and execution of a task.
PO 8	Understand cross disciplinary relevance of scientific developments and relearn and reskill so as to adapt to technological advancements.

PROGRAM SPECIFIC OUTCOMES

PSO	Description
A student completing Master's degree in Science Program in the subject of chemistry will be able to :	
PSO 1	Acquire in-depth knowledge of the advance concepts in the branch of specialization viz, Physical , Inorganic , Organic & Analytical.
PSO 2	Design and carry out analysis as well as accurately record and analyse the results.
PSO 3	Explain the findings and share the results with scientists and non scientist with the help of the written and oral communication skills acquire during the course.
PSO 4	Apply the skills to do specialized research in the core and applied areas of chemical sciences.
PSO 5	Explore new areas of research in chemistry and allied fields of science and technology.
PSO 6	Demonstrating the developed skills such as problem solving approach , critical thinking , analytical reasoning ,team work and effective communication for solving the applied research problems related to their field.
PSO 7	Explain why chemistry plays an integral role in addressing social , economic and environmental problems.
PSO 8	Become professionally skilled for higher studies in research institutions and to work in industries.

PROGRAM OUTLINE

YEAR	SEM	COURSE CODE	Type of Course	COURSE TITLE	CREDITS
M.Sc. I	**I**	**RPSCHE.O 501**	Discipline Specific Core I	**Physical Chemistry**	3
		RPSCHEP .O501	Practical DSC I	**Physical Chemistry Practicals I**	1
		RPSCHE.O 502	Discipline Specific Core II	**Inorganic Chemistry**	3
		RPSCHEP .O502	Practical DSC II	**Inorganic Chemistry Practicals I**	1
		RPSCHE.O 503	Discipline Specific Core III	**Organic Chemistry**	3
		RPSCHEP .O503	Practical DSC III	**Organic Chemistry Practicals I**	1
		RPSCHE.O 504	Discipline Specific Core IV	**Quality Control In Chemical Industries I**	2
		RPSRMC HE.O505	RM	**RESEARCH METHODOLOGY**	4
		RPSCHEA. O507	Discipline Specific Elective	**Fundamentals Of Analytical Chemistry**	3
		RPSCHE AP.O507	Practical on DSE	**Practicals on Fundamentals of Analytical Chemistry**	1
.	II	**RPSCHE.E 511**	Discipline Specific Core I	**Physical Chemistry**	3
		RPSCHEP .E511	Practical DSC I	**Physical Chemistry Practicals II**	1
		RPSCHE.E 512	Discipline Specific Core II	**Inorganic Chemistry**	3
		RPSCHEP .E512	Practical DSC II	**Inorganic Chemistry Practicals II**	1
		RPSCHE.E 513	Discipline Specific Core III	**Organic Chemistry**	3
		RPSCHEP .E513	Practical DSC III	**Organic Chemistry Practicals II**	1
		RPSCHE.E 514	Discipline Specific Core IV	**Quality Control In Chemical Industries II**	2

		RPSCHEA.E517	Discipline Specific Elective	**Fundamentals Of Analytical Chemistry**	3
		RPSCHEAP.E517	Practical on DSE	**Fundamentals Of Analytical Chemistry Practicals II**	1
		RPSCHERP.E519	Research project		4

Course Code: RPSCHE.O501

Course Title: PHYSICAL CHEMISTRY

Academic year 2023-24.

Course Outcomes:

After completion of this Course, the learner will be able to:	
CO1	Derive Maxwell equations and understand their significance.
CO2	Connect quantum mechanical operators to observables.
CO3	Calculate probabilities, amplitudes, averages values of the observables.
CO3	Derive rate laws of different types of the reactions.

DETAILED SYLLABUS

Course Code	Unit	Course title / Unit Title	Credits/Hours 3/45
		PHYSICAL CHEMISTRY	**3**
RPSCHE.O501	**I**	**Thermodynamics I** 1.1 Recapitulation :- Heat, Work, & Conservation of energy – The basic concepts, the first law, infinitesimal changes, mechanical work, work of compression & expansion, free expansion, Expansion against constant pressure, reversible expansion, Heat :- heat capacity, enthalpy. State functions & differentials – state functions, Exact & Inexact differential, changes in internal energy, the temperature dependence of the internal energy, Temperature dependence of the enthalpy. Work of adiabatic expansion Irreversible adiabatic expansion, reversible adiabatic expansion. 1.2 The Second law of Thermodynamics Measuring the dispersal the entropy, The second law, the definition of entropy, the entropy changes in the system, natural events. Entropy changes in the universe – The enthalpy change when a system is heated, Entropy changes in surroundings, the entropy of phase transition, the entropy of irreversible changes. Concentrating	

		on the system – The Helmoltz & Gibbs function, some remarks on the Helmholtz function, Maximum work, some remarks to Gibbs function Evaluating the entropy & Gibbs function, The Third law of Thermodynamics, Third law entropies standard molar Gibbs function. 1.3 Combining First & Second Law – One way of developing the fundamental equations Properties of the Gibbs function, the temperature dependence of the Gibbs functions, the pressure dependence of the Gibbs functions, The Chemical potential of a perfect gas, the open system & changes of composition.	
	II	**Chemical Kinetics–I** 2.1Rate laws for complex reactions, parallel reaction with example of nuclear reactions and fluorescence decay, opposing reactions, rate constants by temperature jump method, consecutive reactions, rate determining step and steady state approximation. 2.2 Collision theory of reaction rates, collision cross-sections, rate coefficient, steric factor, Straight chain reactions. Theory of absolute reaction rates activated complex theory, potential energy surface, and thermodynamic interpretation, comparison of results with Eyring and Arrhenius equations. 2.3Some inorganic mechanisms: formation and decomposition of phosgene, decomposition of ozone, Reaction between Hydrogen and Bromine and some general examples Organic Decompositions: Decomposition of ethane, decomposition of acetaldehyde Gas phase combustion: Reaction between hydrogen and oxygen, Semenov – Hinshelwood and Thompson mechanism, Explosion limits and factors affecting explosion limits. 2.4 Elementary Reactions in Solution: - Solvent Effects on reaction rates, Reactions between ions- influence of solvent Dielectric constant, influence of ionic strength, Linear free energy relationships.	

		2.5 Steady state and pre-equilibrium approximations, Lindemann mechanism for the unimolecular reaction. Enzyme catalysis – Michaelis-Menten Mechanism, Lineweaver and Eadie plots.	
	III	**Quantum Chemistry I** 3.1 Classical Mechanics, failure of classical mechanics: Need for Quantum Mechanics. 3.2 Particle waves and Schrödinger wave equation, wave functions, properties of wave functions, 3.3 Normalization of wave functions, orthogonality of wave functions. 3.4 Operators and their algebra, linear and Hermitian operators, operators for the dynamic variables of a system such as position, linear momentum, angular momentum, total energy, eigen functions, eigen values and eigen value equation, Schrödinger wave equation as the eigen value equation of the Hamiltonian operator, average value and the expectation value of a dynamic variable of the system, Postulates of Quantum Mechanics, Schrödinger's Time independent wave equation from Schrödinger's time dependent wave equation. 3.5 Application of quantum mechanics to the following systems: 3.5.1 Free particle, 3.5.2 Particle in a box one, two- and three-dimensional box, separation of variables, Expression for the system's wave function, the expression for the system's energy, the concept of quantization, introduction of quantum number, degeneracy of the energy levels. 3.5.3 Harmonic oscillator, approximate solution of the equation, Hermite polynomials, the expression for wave function, the expression for energy, use of the recursion formula.	
		References: 1. Atkins' Physical Chemistry by Julio De Paula, Peter Atkins, James Keeler.	

		2. Physical Chemistry by Thomas Engel and Philip Reid. 3. Chemical Kinetics, 3rd Edition by Laidler. 4. Principles of Chemical Kinetics by James House's. 5. Quantum Chemistry by R.K. Prasad 6. Quantum Chemistry-Including Spectroscopy Sen B.K.	

Semester-I Practical

Course Code	**Physical Chemistry Practicals I**		**Credits/Hours 1/30**
RPSCHEP. O501	**Non – Instrumental**		**1**
	1.	To determine the heat of solution (ΔH) of a sparingly soluble acid (benzoic /salicylic acid) from solubility measurement at three different temperatures.	
	2.	To study acid-catalyzed iodination of acetone by titration method.	
	3.	To study the influence of ionic strength on the rate of ionic reactions.	
	Instrumental		
	1.	To determine pKa values of phosphoric acid by potentiometric titration with sodium hydroxide using a glass electrode.	
	2	To determine Hammett constant of m- and p- amino benzoic acid/nitro benzoic acid by pH measurement.	
	3.	To determine the CMC of sodium Lauryl Sulphate from the measurement of conductivities at different concentrations.	
		References: 1. Practical Physical Chemistry, B. Viswanathan and P.S.Raghavan, Viva Books Private Limited, 2005. 2. Experimental Physical Chemistry, V.D. Athawale and P. Mathur, New Age. 3. S.W. Rajbhoj and T.K. Chondhekar, Systematic Experimental Physical Chemistry, Anjali Publication, 2013.	

		4. Garland C.W., Nifler J.W. and Schoemaber D.P., "Experiments in Physical Chemistry", 7th Ed., McGraw-Hill International. 2002.	

Course Code: RPSCHE.O502

Course Title: INORGANIC CHEMISTRY

Academic year 2023-24

Course Outcomes:

After completion of this Course, the learner will be able to:	
CO 1	Comprehend the derivation of different hybridizations such as *sp*, sp^2, *sp3* using sigma bonding concept.
CO 2	Recognize the concept of MOT and how MOT is constructed for polyatomic molecules.
CO 3	Understand Symmetry operations and Symmetry elements.
CO 4	Differentiate Abelian and Non-abelian point groups.
CO 5	Use of Great Orthogonality Theorem for construction of character table.
CO 6	Examine chemical bonding, visualizing molecular orbitals, behaviour of atoms, molecules and solids using group theory.
CO 7	Aware of the various methods/ techniques used to detect complex formation between metal and ligand
CO 8	Interpret the electronic spectra of octahedral and square planar complexes.

DETAILED SYLLABUS

Course Code	Unit	Course title / Unit Title	Credits/Hours 3/45
		INORGANIC CHEMISTRY	
RPSCHE.O502	**I**	**Chemical Bonding** 1.1 Discussion of involvement of *d*-orbitals in various types of hybridizations. Concept of resonance, resonance energy, Formal charge with examples. 1.2 Critical analysis of VBT. 1.3 Molecular Orbital Theory for diatomic species of First transition Series.	

		1.4 Molecular Orbital Theory for Polyatomic species considering σ bonding for SF_6, CO_2, B_2H_6 molecular species. 1.5 Chemical Forces: 1.5.1 Hydrogen bonding – Concept, Types, Properties, Methods of Detection, and Importance. 1.5.2 Intermolecular Forces: Dipole-Dipole Interaction, Induced dipole-Induced dipole Interaction 1.5.3 Effects of Chemical Forces: Melting and Boiling Points, Solubility	
	II	**Molecular Symmetry and Group Theory** 2.1 Symmetry criterion of optical activity, symmetry restrictions on dipole moment. A systematic procedure for symmetry classification of molecules. 2.2 Concepts of Groups, Sub-groups, Classes of Symmetry operations, Group Multiplication Tables. Abelian and non-Abelian point groups. 2.3 Representation of Groups: Matrix representation of symmetry operations, reducible and irreducible representations. The Great Orthogonality Theorem and its application in construction of character tables for point groups C_2v, C_3v and D_{2h}, structure of character tables. 2.4 Applications of Group Theory: 2.4.1 Symmetry adapted linear combinations (SALC), symmetry aspects of MO theory, sigma bonding in AB_n (Ammonia, CH_4) molecule. 2.4.2 Determination of symmetry species for translations and rotations. 2.4.3 Mulliken's notations for irreducible representations. 2.4.4 Group-subgroup relationships.	
	III	**Characterisation of Coordination compounds** 3.1 Detection of Complex Formation: Formation of precipitate, Conductivity measurements, Spectral method (Colour Change in Solution), pH method, magnetic measurements. 3.2 Determination of formation constants of metal complexes: Spectroscopic methods viz., Job's method, mole-ratio and slope-ratio	

		methods for determination of stepwise formation constants of metal complexes. 3.3 Interpretation of electronic spectra for octahedral and square planar complexes. 3.4 Spectral calculations using Orgel and Tanabe-Sugano diagram, calculation of electronic parameters such as Δ, B, C, Nephelauxetic ratio. **(Numerical Problem expected).**	
		References: 1. Wai-Kee Li, Gong-Du Zhou and Thomas Chungwai Mak, Advanced Structural Inorganic Chemistry, Oxford University Press, 2008. 2. B. R. Puri, L. R. Sharma and K. C. Kalia, Principles of Inorganic Chemistry, 33rd Edition, Vishal Publishing CO., 2017-2018. 3. P.W. Atkins, T. Overton, J. Rourke, M. Weller and F. Armstrong; Shriver & Atkins: Inorganic Chemistry, 6th ed. Oxford University Press, 2014. 4. K. V. Reddy. Symmetry and Spectroscopy of Molecules, 2nd Edition, New Age International Publishers, New Delhi, 2009. 5. S. Swarnalakshmi, T. Saroja and R. M. Ezhilarasi, A Simple Approach to Group Theory in Chemistry, Universities Press, 2008. 6. G. Miessler and D. Tarr, Inorganic Chemistry, 3rd Ed., Pearson Education, 2004. 7. Lesley E. Smart, Elaine A. Moore, Solid State Chemistry Introduction,	

		3rd Edition, Taylor & Francis Group, LLC, 2005. 8. C. E. Housecroft and A. G. Sharpe, Inorganic Chemistry, Pearson Education Limited,2nd Edition, 2005. 9. F. A. Cotton, Chemical Applications of Group Theory, 2nd Edition, Wiley Eastern Ltd., 1989. 10. R Gopalan, V Ramalingam, Concise Coordination Chemistry, Vikas Publishing House Pvt. Ltd. 2001. J. E. Huheey, E. A. Keiter and R. L. Keiter; Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Education, 2006.	

Semester I

Practical

Course Code	**Inorganic Chemistry Practicals I**		**Credits/Hours 1/30**
RPSCHEP. O502		**Non Instrumental** **Inorganic Preparations (Synthesis and Characterization):**	**1**
	1.	Hexammine nickel (II) sulphate	
	2.	Bis(ethylenediammine) Copper (II) Sulphate	
		Instrumental	
	1.	Determination of titanium (IV) colorimetrically.	
	2.	Determination of Electrolytic nature of inorganic compounds by Conductance measurement.	

	3.	Determination of Copper (II) using EDTA spectrophotometrically	

Course Code: RPSCHE.O503

Course Title: ORGANIC CHEMISTRY

Academic year 2023-24

Course Outcomes:

After completion of this course, the learner will be able to:	
CO 1	Know the kinetic and thermodynamic requirements of organic reactions and a few methods to determine the reaction mechanisms.
CO 2	Recognize the factors affecting acidity and basicity.
CO 3	Understand advanced nucleophilic substitutions with special emphasis on Neighbouring Group Participations (NGP) and factors affecting the NGP.
CO 4	Identify structural, thermochemical, and magnetic criteria for aromaticity, including NMR characteristics of aromatic systems.
CO 5	Comprehend the concept of chirality, Molecules with tri- and tetra-coordinate centres, Axial and planar chirality and prochirality.
CO 6	Explore the applications of different oxidizing and reducing agents in organic reactions.

DETAILED SYLLABUS

Course Code	**Unit**	**Course title / Unit Title**	**Credits/Hours 3/45**
		ORGANIC CHEMISTRY	
RPSCHE.O503	**I**	1.1. Oxidation: General mechanism, selectivity, and important applications of the following: 1.1.1. Dehydrogenation: Dehydrogenation of C-C bonds including aromatization of six membered rings using chloranil and DDQ. 1.1.2. Oxidation of alcohols to aldehydes and ketones: Chromium reagents such as K2Cr2O7/H2SO4 (Jones reagent), CrO3-pyridine (Collin's reagent), PCC (Corey's reagent) and PDC (Cornforth reagent),	

		hypervalent iodine reagents (IBX, Dess- Martin periodinane). DMSO based reagents (Swern oxidation), Corey-Kim oxidation - advantages over Swern and limitations; and Pfitzner-Moffatt oxidation-DCC and DMSO and Oppenauer oxidation. 1.1.3. Oxidation involving C-C bonds cleavage: Glycols using HIO_4; cycloalkanones using CrO_3; carbon-carbon double bond using CrO_3, $NaIO_4$ and OsO_4; aromatic rings using RuO_4 and $NaIO_4$. 1.1.4. Oxidation involving replacement of hydrogen by oxygen: oxidation of CH_2 to CO by SeO_2, oxidation of aryl methanes by CrO_2Cl_2 (Etard oxidation). 1.1.5. Oxidation of aldehydes and ketones: with H_2O_2 (Dakin reaction), with peroxy acid (Baeyer-Villiger oxidation) 1.2. Reduction: General mechanism, selectivity, and important applications of the following reducing reagents: 1.2.2. Metal hydride reduction: Boron reagents ($NaBH_4$, $NaCNBH_3$, diborane, 9-BBN, $Na(OAc)_3BH$, aluminium reagents ($LiAlH_4$, DIBAL-H, Red Al, L and K- selectrides).	
	II	2.1 Nucleophilic Substitution Reactions 2.1.1 Aliphatic nucleophilic substitution: SN1, SN2, SN reactions, mixed SN1 and SN2 and SET mechanisms. SN reactions involving NGP - participation by aryl rings, α-and pi-bonds. Factors affecting these reactions: substrate, nucleophilicity, solvent, steric effect, hard-soft interaction, and leaving group. Ambident nucleophiles. SNcA, SN1', and SN2 reactions. SN at sp^2 (vinylic) carbon. 2.1.2 Aromatic nucleophilic substitution: SNAr, SN1, benzyne mechanisms. Ipso, cine, tele, and vicarious substitution. 2.1.3 Ester hydrolysis: Classification, nomenclature, and study of all eight mechanisms of acid and base-catalyzed hydrolysis with suitable examples. 2.2 Aromaticity:	

		2.2.1 Structure, thermochemical, and magnetic criteria for aromaticity, including NMR characteristics of aromatic systems. Delocalization and aromaticity. 2.2.2 Application of HMO theory to monocyclic conjugated systems. Frost-Musulin diagrams. Huckel's (4n+2) and 4n rules. Aromatic and antiaromatic compounds up-to 18 carbon atoms. Homoaromatic compounds. Aromaticity of all benzenoid systems, heterocycles, metallocenes, azulenes, annulenes, aromatic ions and Fullerene (C60).	
	III	3.1. Concept of Chirality: Recognition of symmetry elements. 3.2. Molecules with tri- and tetra-coordinate centers: Compounds with carbon, silicon, nitrogen, phosphorous and sulphur chiral centers, relative configurational stabilities. 3.3. Molecules with two or more chiral centers: Constitutionally unsymmetrical molecules: erythro-threo and syn-anti systems of nomenclature. Interconversion of Fischer, Sawhorse, Newman, and Flying wedge projections. Constitutionally symmetrical molecules with odd and even numbers of chiral centers: enantiomeric and meso forms, the concept of stereogenic, chirotopic, and pseudoasymmetric centers. R-S nomenclature for chiral centers in acyclic and cyclic compounds. 3.4. Axial and Planar chirality: Principles of axial and planar chirality. Stereochemical features and configurational descriptors (R,S) for the following classes of compounds: allenes, alkylidene cycloalkanes, spirans, biaryls (buttressing effect) (including BINOLs and BINAPs), ansa compounds**,** cyclophanes, and trans-cyclooctenes. 3.5 Acids and Bases: Factors affecting acidity and basicity: Electronegativity and inductive effect, resonance, bond strength, electrostatic effects, hybridization, aromaticity, and solvation. Comparative study of acidity and	

		basicity of organic compounds on the basis of pKa values, Leveling effect, and non-aqueous solvents. Acid and base catalysis – general and specific catalysis with examples.	
		References: 1. Advanced Organic Chemistry: Reactions, Mechanisms and Structure, Michael B. Smith, Jerry March, Wiley. 2. Molecular Orbital and Organic chemical reactions, Ian Fleming Reference Edition, Wiley 3. Stereochemistry of Organic Compounds-Principles and Applications, D. Nasipuri. New International Publishers Ltd. 4. Stereochemistry: Conformation and mechamism, P.S. Kalsi, New Age International, New Delhi. 5. Organic Reaction Mechanisms, V.K. Ahluwalia, R.K. Parasher, Alpha Science International, 2011.	

Semester I
Practical

Course Code	**Organic Chemistry Practicals I**	**Credits/Hours 1/30**
RPSCHEP.O503	**One-step preparations (1.0 g scale):**	
	1. Bromobenzene to p-nitrobromobenzene 2. Benzoin to benzil 3. 2-Naphthol to BINOL 4. Benzoquinone to 1,2,4-triacetoxybenzene 5. o-Phenylenediamine to 2,3-diphenylquinoxaline 6. Anthracene to anthraquinone	

Course Code: RPSCHE.O504

Course Title:

Academic year 2023-24

Course Outcomes:

After completion of this Course, the learner will be able to:	
CO 1	Outline the role and importance of Quality control, quality assurance, TQM and QMS.
CO 2	Apply the knowledge learned to all scientific data analyses during their studies and future career-related activities.

DETAILED SYLLABUS

Course Code	Unit	Course Title / Unit Title	Credits/ Hours 2/30
		Quality Control in Chemical Industries I	
RPSCHE.O504	**I**	**1.1 Statistical Quality Control Techniques:** Statistical treatment of data. Control charts, Performance Evaluation uncertainties in measurement. Validation of analytical methods. **1.2 Quality control and Quality Assurance:** Definitions, Focus, Goals, Parameters, and Responsibility of QA and QC	**2**
	II	**2.1 Quality Management System (QMS):** Evolution and significance of Quality Management, types of quality standards for laboratories, total quality management (TQM),philosophy implementation of TQM (reference of Kaizen, Six Sigma approach & 5S), quality audits and quality reviews, responsibility of laboratory staff for quality and problems, QBD	
		References: 1. Fundamentals of Analytical Chemistry, By Douglas A. Skoog, Donald M. West, F. James Holler, Stanley R. Crouch, 9th Edition, 2004. 2. ISO 9000 Quality Systems Handbook, Fourth Edition, David Hoyle. (Free download). 3. Quality in the Analytical Laboratory, Elizabeth Pichard, Wiley India, 2007.	

		4. Safety and Hazards Management in Chemical Industries, M N Vyas, Atlantic Publisher.	

Discipline Specific Elective (DSE)
Course Code: RPSCHEAN.O507
Course Title: Fundamentals of Analytical Chemistry
Academic year 2023-24

Course Outcomes:

After completion of this Course, the learner will be able to:	
CO 1	Identify the relationships among the different instrument components and the flow of information from the characteristics of the analyte through the components to the numerical or graphical output produced by the instrument.
CO 2	Explain the working principle and Enlist the applications of UV visible and IR spectroscopy.
CO 3	Elaborate on the basic principle underlying the different types of thermal methods and will understand how these methods are employed in industries and research for characterization of sample.
CO 4	Compare the technique of DTA with DSC.
CO 5	Comprehend the utility of automation in chemical analysis.
CO 6	Outline the Objectives of automation in chemical analysis.
CO 7	Enlist the advantages and disadvantages of Automatic Analysis.

DETAILED SYLLABUS

Course Code	Unit	Course Title / Unit Title	Credits/Hours 3/45
		ANALYTICAL CHEMISTRY	
RPSCHEAN.O507	**I**	1.1 Concentration of a solution based on volume and mass units. 1.2 Calculations of ppm, ppb and dilution of the solutions, concept of mmol. 1.3 Stoichiometry of chemical reactions, concept of kg mol, limiting reactant, theoretical and Practical yield. Solubility and	

		solubility equilibria, effect of the presence of common ion. 1.3.1 Calculations of pH of acids, bases, acidic and basic buffers. 1.3.2 Concept of formation constants, stability and instability constants, stepwise formation constants. 1.4 Oxidation number, rules for assigning oxidation number, redox reaction in term of oxidation number, oxidizing and reducing agents, equivalent weight of oxidizing and reducing agents, stoichiometry of redox titration (Normality of a solution of a oxidizing / reducing agent and its relationship with molarity)	
	II	2.1 Recapitulation and FT Technique: 2.1.1 Recapitulation of basic concepts, Electromagnetic spectrum, Sources, Detectors, sample containers. 2.1.2 Laser as a source of radiation, Fibre optics 2.1.3 Introduction of Fourier Transform 2.2 Molecular Ultraviolet and Visible Spectroscopy 2.2.1 Derivation of Beer- Lambert's Law and its limitations, factors affecting molecular absorption, types of transitions (emphasis on charge transfer absorption), pH, temperature, solvent and effect of substituents. 2.2.2 Applications of Ultraviolet and Visible spectroscopy: On charge transfer absorption Simultaneous spectroscopy Derivative Spectroscopy 2.2.3 Dual spectrometry – Introduction, Principle, Instrumentation and Applications. (NUMERICALS ARE EXPECTED) 2.3 Infrared Absorption Spectroscopy: 2.3.1 Instrumentation: Sources, Sample handling, Transducers, Dispersive, non-dispersive instrument 2.3.2 FTIR and its advantages	

		2.3.3 Applications of IR (Mid IR, Near IR, Far IR): Qualitative with emphasis on "Finger print" region, Quantitative analysis, Advantages and Limitations of IR 2.3.4 Introduction and basic principles of diffuse reflectance spectroscopy.	
	III	3.1 Thermal Methods: 3.1.1 Introduction : Recapitulation of types of thermal methods, comparison between TGA and DTA. 3.1.2 Differential Scanning Calorimetry- Principle, comparison of DTA and DSC, Instrumentation, Block diagram, Nature of DSC Curve, Factors affecting curves (sample size, sample shape, pressure). 3.1.3 Applications – The heat of reaction, Specific heat, Safety screening, Polymers, liquid crystals, Percentage crystallinity, oxidative stability, Drug analysis, Magnetic transition. E.g. Analysis of Polyethylene for its crystallinity. 3.2 Automation in Chemical Analysis: Need for automation, Objectives of automation, An overview of automated instruments and instrumentation, process control analysis, flow injection analysis, discrete automated systems, automatic analysis based on multilayered films, gas monitoring equipment, Automatic titrators.	
		References: 1. Modern Analytical Chemistry, David Harvey, McGraw-Hill Higher Education, 2000. 2. Principles of Instrumental Analysis - Skoog, Holler and Nieman, 6th Edition, 2017 3. Fundamentals of Analytical Chemistry, By Douglas A. Skoog,	

		Donald M. West, F. James Holler, Stanley R. Crouch, 9th Edition, 2004. 4. ISO 9000 Quality Systems Handbook, Fourth Edition, David Hoyle. (Free download). 5. Quality in the Analytical Laboratory, Elizabeth Pichard, Wiley India, 2007. 6. Safety and Hazards Management in Chemical Industries, M N Vyas, Atlantic Publisher. 7. Analytical chemistry: Problems & Solutions by S.M. Khopkar New Delhi, New Age International (P) Ltd., 2002. 8. H. H. Willard, L. L. Merritt, J. A. Dean, F. A. Settle, Instrumental Methods of Analysis,6thEdition, CBS Publisher, 1988. 9. R. D. Braun, Introduction to Instrumental Analysis, McGraw Hill Publisher, 1985 10. G. W. Ewing, Instrumental Methods of Chemical Analysis, 5thEdition, McGraw Hill Publisher, 1960. 11. Vogel Quantitative Chemical Analysis, Pearson, 6thEdition, 2009. 12. Analytical Chemistry by Open Course: Thermal Methods by James W. Dodd & Kenneth H. Tonge.	

Semester I

Practical

Code	Practicals on Fundamentals of Analytical Chemistry		CREDITS/Hours 1/30
RPSCHEANP. O507	**1.**	Simultaneous determination of Cr(VI) and Mn(VII) in a mixture spectrophotometrically.	
	2.	To determine the amount of nitrite present in the given water sample colorimetrically.	
	3.	To determine the percentage purity of a sample (glycine/sodium benzoate/primary amine) by titration with perchloric acid in a non-aqueous medium using a glass calomel system potentiometrically.	
	4.	To carry out an assay of the sodium chloride injection by Volhard's method. (Statistical method)	
	5.	To determine the amount of Cr(III) and Fe(II) individually in a mixture of the two by titration with EDTA.	
	6.	To determine (a) the ion exchange capacity (b) the exchange efficiency of the given cation exchange resin.	

Course Code: RPSRMCHE.O505

Course Title:RESEARCH METHODOLOGY

Academic year 2023-24

Course Outcomes:

After completion of this Course, the learner will be able to:	
CO 1	Understand basics of research methodology
CO 2	Get the technical know-how of research from developing a problem.
CO 3	Be able to write a research paper, study formats of existing research papers and review papers
CO 4	Be aware about importance of lab-safety and the safety protocols in R&D laboratories.

DETAILED SYLLABUS

Course Code	**Unit**	**Course Title / Unit Title**	**Credits/ Hours 4/60**
RPSRMCHE.O505	**I**	1.1 Print: Primary, Secondary and Tertiary sources Review of Literature 1.2 Journals: 1.3 Journal abbreviations, abstracts, current titles, reviews, monographs, dictionaries, text-books, current contents, Introduction to Chemical Abstracts and Beilstein, Subject Index, Substance Index, Author Index, Formula Index, and other Indices with examples. 1.4 Digital: 1.5 Web sources, E-journals, Journal access, TOC alerts, Hot articles, Citation Index, Impact factor, H-index, E-consortium, UGC infonet, E-books, Internet discussion groups and communities, Blogs, preprint servers, Search engines, Scirus, Google Scholar, ChemIndustry, Wiki-databases, ChemSpider, Science Direct, SciFinder, Scopus. 1.6 Information Technology and Library Resources: 1.7 The Internet and World wide web, Internet resources for Chemistry, finding and citing published information.	

	II	**Data Analysis** 2.1 The Investigative Approach: Making and recording Measurements, SI units and their use, Scientific methods and design of experiments 2.2 Analysis and Presentation of Data: Descriptive statistics, choosing and using statistical tests, Chemometrics, Analysis of Variance (ANOVA), Correlation and regression, curve fitting, fitting of linear equations, simple linear cases, weighted linear case, analysis of residuals, general polynomial fitting, linearizing transformations, exponential function fit, r and its abuse, basic aspects of multiple linear regression analysis	
	III	**Methods of Scientific Research and Writing Scientific Papers** 3.1 Reporting practical and project work, writing literature surveys and reviews, organizing a poster display, giving an oral presentation. 3.2 Writing Scientific Papers: Justification for scientific contributions, bibliography, description of methods, conclusions, the need for illustration, style, publications of scientific work, writing ethics, avoiding plagiarism.	
	IV	**Chemical Safety & Ethical Handling of Chemicals** 4.1 Safe working procedure and protective environment, protective apparel, emergency procedure, first aid, laboratory ventilation, safe storage and use of hazardous chemicals, procedure for working with substances that pose hazards, flammable or explosive hazards, procedures for working with gases at pressures above or below atmospheric pressure 4.2 Safe storage and disposal of waste chemicals, recovery, recycling and reuse of laboratory chemicals, procedure for laboratory disposal of explosives, identification, verification and segregation of laboratory waste, disposal of chemicals in the sanitary sewer system, incineration and transportation of hazardous chemicals.	
		Reference: 1. Reasearch methodology, New age publication By R.C.Kothari,Gaurav Garg 2. Research Methodology By Dr. Baidyanath Mishra	

Course Code: RPSCHE.O511

Course Title: PHYSICAL CHEMISTRY

Academic year 2023-24

Course Outcomes:

After completion of this Course, the learner will be able to:	
CO 1	Predict spontaneous nature of thermodynamic mixing.
CO 2	Calculate energy of hydrogen atom.
CO 3	Draw the atomic orbital and locate radial and angular nodes.
CO 4	Understand construction and working of various types of Batteries

DETAILED SYLLABUS

Course Code	Unit	Course Title / Unit Title	Credits/ Hours 3/45
		PHYSICAL CHEMISTRY	
RPSCHE.O511	**I**	**Thermodynamics II** 1.1 Fugacity of real gases, Determination of fugacity of real gases using the graphical method and from the equation of state. The equilibrium constant for real gases in terms of fugacity. 1.2 Physical Transformation of pure materials. The stability of phases, Phase equilibrium & phase diagrams, the solid–liquid boundary, the liquid-vapour boundary, the solid- vapour boundary, and the solid-liquid-vapour equilibrium. Three-component system formation of one, two, and three pair of partially miscible liquids. 1.3 Real solutions: Chemical potential in non-ideal solutions excess functions of non-ideal solutions Gibbs Duhem Margules equation. 1.4 The physical transformation of simple mixtures, Partial molar quantities Partial molar volume, Partial molar Gibbs function, the thermodynamics of mixing – the Gibbs function of mixing after thermodynamics mixing functions. 1.5 Bioenergetics: standard free energy change in biochemical reactions, exergonic, endergonic.	
	II	**Electrochemistry** 2.1 Debye-Hückel theory of activity coefficient, Debye-Hückel limiting law and its extension to higher concentration	

		(derivations are expected).Electrolytic conductance and ionic interaction, relaxation effect, Debye-Hückel- Onsager equation (derivation expected). Validity of this equation for an aqueous and non-aqueous solution, deviations from Onsager equation, 2.2 Batteries: Alkaline fuel cells, Phosphoric acid fuel cells, High-temperature fuel cells [Solid –Oxide Fuel Cells (SOFC) and Molten Carbonate Fuel Cells] 2.3 Bio-electrochemistry: Introduction, cells and membranes, membrane potentials, theory of membrane potentials, interfacial electron transfer in biological systems, and adsorption of proteins onto metals from solution, electron transfer from modified metals to dissolved protein in solution, enzymes as electrodes.	
	III	**Quantum Chemistry II** 3.1 Rigid rotor, spherical coordinates Schrödinger wave equation in spherical coordinates, separation of the variables, the phi equation, wave-function, quantum number, theta equation, wave function, quantization of rotational energy, spherical harmonics. 3.2 Hydrogen atom, the two-particle problem, separation of the energy as translational and potential, separation of variables, the R the Θ and the ϕ equations, solution of the equation, the introduction of the four quantum numbers and their interdependence on the basis of the solutions of the three equations, total wave function, the expression for the energy, probability density function, distances, and energies in atomic units, radial and angular plots., points of maximum probability, expressions for the total wave function for 1s,2s, 2p and 3d orbitals of hydrogen.	
		References: 1. Ira R. Levine, Physical Chemistry, 5th Edn., Tata McGraw-Hill New Delhi, 2002. 2. Ira N. Levine, Quantum Chemistry, 5th Edn., Pearson Education (Singapore) Pte. Ltd., Indian Branch, New Delhi, 2000. 3. Bockris, John O'M., Reddy, Amulya K.N., Gamboa-Aldeco, Maria E., Modern Electrochemistry, 2A, Plenum Publishers, 1998. 4. A Textbook of Physical Chemistry by K L Kapoor Vol 1 to 5. 5. A.K. Chandra, Introductory Quantum Chemistry, Tata McGraw – Hill, 1994.	

Semester II
Practical

Course Code	Physical Chemistry Practicals II		Credits /Hours 1/30
RPSCHEP.O 511	**Non – Instrumental**		**1**
	1.	Determine the densities of a series of solutions and calculate the partial molar volume of the component.	
	2.	To study the variation of calcium sulphate with ionic strength and hence determine the thermodynamic solubility product of $CaSO_4$ at room temperature.	
	3.	Polar plots of atomic orbitals such as 1s, $2p_z$, and $3d_z^2$orbitals by using the angular part of hydrogen atom wave functions.	
	Instrumental		
	4.	To verify Ostwald's dilution law and to determine the dissociation constant of a weak monobasic acid conductometrically.	
	5.	To study the effect of substituent on the dissociation constant of acetic acid conductometrically.	
	6.	To determine the mean ionic activity coefficient of an electrolyte by e.m.f. measurement.	
		References: 1. Practical Physical Chemistry, B. Viswanathan and P.S.Raghavan, Viva Books Private Limited, 2005. 2. Experimental Physical Chemistry, V.D. Athawale and P. Mathur, New Age. 3. S.W. Rajbhoj and T.K. Chondhekar, Systematic Experimental Physical Chemistry, Anjali Publication, 2013. 4. Garland C.W., Nifler J.W. and Schoemaber D.P., "Experiments in Physical Chemistry", 7th Ed., McGraw-Hill International. 2002.	

Course Code: RPSCHE.O512

Course Title: INORGANIC CHEMISTRY

Academic year 2023-24

Course Outcomes:

After completion of this Course, the learner will be able to:	
CO 1	Analyse the reaction pathways of metal complexes and to develop a deeper understanding of their mechanisms.
CO 2	Know the rate behaviour of the reaction using reaction mechanism.
CO 3	Recognize the general shape of the transition state using trans effect, steric effect and stereochemistry of the coordination complexes.
CO 4	Illustrate the importance of 18 and 16 electron rules.
CO 5	Understand the structure and bonding involved in d block Organometallic compounds on the basis of VBT and MOT.
CO 6	Critically review environmental issues as a matter of widespread public concern.
CO 7	Know the toxicology of certain elements through case studies.
CO 8	Identify the importance of essential elements for the organisms.
CO 9	Evaluate the role of metal ions in biological systems.

DETAILED SYLLABUS

Course Code	**Unit**	**Course Title / Unit Title**	**Credits/ Hours 3/45**
		INORGANIC CHEMISTRY	
RPSCHE.O512	**I**	**Inorganic Reaction Mechanism** Rate of reactions, factors affecting the rate of reactions, techniques for determination of the rate of reaction (Direct chemical analysis, spectrophotometric method, electrochemical and flow methods). Ligand substitution reactions of: 1.2.1 Octahedral complexes without breaking of metal-ligand bond (Use of isotopic labelling method) 1.2.2 Square planar complexes, trans-effect, its theories, and applications. Mechanism and factors affecting these substitution reactions.	

		1.3 Stereochemistry of substitution reactions of octahedral complexes. (Isomerisation and racemization reactions and applications.) 1.4 Electron-transfer processes: 1.4.1 Inner-sphere mechanism 1.4.2 Outer-sphere mechanism 1.4.3 Complimentary and non-complimentary reactions.	
	II	**Organometallic Chemistry of Transition metals** **2.1** Eighteen and sixteen electron rule and electron counting with examples. **2.2** Types of organometallic reactions; **2.2.1** Reactions That Occur at the Metal **2.2.1.1** Ligand substitution **2.2.1.2** Oxidative addition **2.2.1.3** Reductive elimination **2.2.2** Reactions Involving Modification of Ligands **2.2.2.1** Insertion and Deinsertion (Elimination) **2.2.2.2** Nucleophilic Addition to the Ligand **2.2.2.3** Nucleophilic Abstraction **2.2.2.4** Electrophilic Reactions **2.3** Metathesis and Polymerization Reactions **2.3.1** π Bond Metathesis **2.3.2** σ Bond Metathesis **2.3.3** Alkyne Metathesis 2.4 Transition Metal–Carbene and –Carbyne Complexes: Structure, Preparation, and Chemistry: 2.4.1 Structure of Metal Carbene 2.4.2 Synthesis of Metal Carbene Complexes 2.4.3 Reactions of Metal–Carbene Complexes 2.4.4 Metal–Carbyne Complexes 2.5 Preparation and properties of the following compounds: Sandwich compounds of Fe, Cr and Half Sandwich compounds of Cr, Mo. 2.6 Structure and bonding on the basis of VBT and MOT in the following Organometallic compounds: Zeise's salt, ferrocene and bis(arene)chromium(0).	
	III	**Environmental Chemistry** 3.1 Conception of Heavy Metals: Critical discussion on heavy metals. 3.2 Toxicity of metallic species: Mercury, lead, cadmium, arsenic, copper and chromium, with respect to their sources, distribution, speciation, biochemical effects and toxicology, control and treatment. 3.3 Case Studies: (a) Itai-itai disease for Cadmium toxicity, (b) Arsenic Poisoning in the Indo-Bangladesh region. 3.4 Biological oxygen carriers; hemoglobin, hemerythrene and hemocyanine- structure of metal active center and	

		differences in mechanism of oxygen binding, Differences between hemoglobin and myoglobin: Cooperativity of oxygen binding in hemoglobin and Hill equation, pH dependence of oxygen affinity in hemoglobin and myoglobin and its implications. 3.5 Metal ion transport and storage: Ionophores, transferrin, ferritin and metallothionins 3.6 Medicinal applications of cis-platin and related compound	
		References: 1. P. Atkins, T. Overton, J. Rourke, M. Weller and F. Armstrong, Inorganic Chemistry, 5thEdition, Oxford University Press, 2010. 2. Gurdeep Raj, Advanced Inorganic Chemistry-Vol.II, 12th Edition, Goel publishing house, 2012. 3. B. R. Puri, L. R. Sharma and K. C. Kalia, Principles of Inorganic Chemistry, Milestone Publishers, 2013-2014. 4. R. Gopalan and V. Ramlingam, Concise Coordination chemistry, Vikas Publishing house Pvt. Ltd., 2001. 5. Robert B. Jordan, Reaction Mechanisms of Inorganic and Organometallic Systems, 3rdEdition, Oxford University Press 2008. 6. Catherine E. Housecroft and Alan G. Sharpe, Inorganic Chemistry, 2nd Edition, Pearson Education Limited, 2005.	

Semester II
Practical

Course Code		**Inorganic Chemistry Practicals II**	**Credits /Hours 1/30**
RPSCHEP.O512		**Ores and Alloys (Non-instrumental)**	
	1.	Analysis of Devarda's alloy	
	2.	Analysis of Cu – Ni alloy	
	3.	Analysis of Limestone.	
		Instrumental	
	1.	Estimation of Copper using Iodometric method Potentiometrically.	
	2.	Estimation of Fe^{+3} solution using Ce(IV) ions Potentiometrically	

Course Code: RPSCHE.O513

Course Title: ORGANIC CHEMISTRY

Academic year 2023-24

Course Outcomes:

After completion of this Course, the learner will be able to:	
CO 1	Correlate between kinetically and thermodynamically formed enolates and the factors affecting their formation.
CO 2	Understand the interaction of carbon nucleophiles with carbonyl groups and its reaction mechanism.
CO 3	Draw the mechanism and stereochemistry (if applicable) of various rearrangement reactions.
CO 4	Apply Molecular orbital theory to organic molecules with special emphasis on the FMO theory
CO 5	Make use of advanced application of UV, IR and NMR spectroscopy techniques in structural elucidation of molecules.
CO 6	Know the concept of McLafferty Rearrangement and its implications on Fragmentation pattern of molecules.

DETAILED SYLLABUS

Course Code	**Unit**	**Course Title / Unit Title**	**Credits/ Hours 3/45**
	ORGANIC CHEMISTRY		

RPSCHE.O513	**I**	**Alkylation of Nucleophilic Carbon Intermediates** 1.1 Alkylation of Nucleophilic Carbon Intermediates: 1.1.1 Generation of carbanion, kinetic and thermodynamic enolate formation, Regioselectivity in enolate formation, alkylation of enolates. 1.1.2 Generation and alkylation of dianion, medium effects in the alkylation of enolates, oxygen versus carbon as the site of alkylation. 1.1.3 Alkylation of aldehydes, ketones, esters, amides and nitriles. 1.1.4 Nitrogen analogs of enols and enolates-Enamines and Imines anions, alkylation of enamines and imines. 1.1.5 Alkylation of carbon nucleophiles by conjugate addition (Michael reaction). 1.2 Reaction of carbon nucleophiles with carbonyl groups: 1.2.1 Mechanism of Acid and base catalysed Aldol condensation, Mixed Aldol condensation with aromatic aldehydes, regiochemistry in mixed reactions of aliphatic aldehydes and ketones, intramolecular Aldol reaction and Robinson annulation. 1.2.2 Addition reactions with amines and iminium ions; Mannich reaction. 1.2.3 Amine catalyzed condensation reaction: Knoevenagel reaction. Acylation of carbanions.	
	II	**Reactions and Rearrangements** Mechanisms, stereochemistry (if applicable) and applications of the following: 2.1 Reactions: Baylis-Hilman reaction, McMurry Coupling, Corey-Fuchs reaction, Nef reaction, Passerini reaction.	

		2.2Concerted rearrangements: Hofmann, Curtius, Lossen, Schmidt, Wolff, Boulton-Katritzky. 2.3 Cationic rearrangements: Tiffeneau-Demjanov, Pummerer, Dienone-phenol, Rupe, Wagner-Meerwein. 2.4 Anionic rearrangements: Brook, Neber, Von Richter, Wittig, Gabriel–Colman, Payne.	
	III	**Spectrometry** 3.1 Ultraviolet spectroscopy: Recapitulation, UV spectra of dienes, conjugated polyenes (cyclic and acyclic), carbonyl and unsaturated carbonyl compounds, substituted aromatic compounds. Factors affecting the position and intensity of UV bands – effect of conjugation, steric factor, pH, and solvent polarity. Calculation of absorption maxima for above classes of compounds by Woodward-Fieser rules (using Woodward-Fieser tables for values for substituents). 3.2 Infrared spectroscopy: Fundamental, overtone and combination bands, vibrational coupling, factors affecting vibrational frequency (atomic weight, conjugation, ring size, solvent and hydrogen bonding). Characteristic vibrational frequencies for alkanes, alkenes, alkynes, aromatics, alcohols, ethers, phenols, amines, nitriles and nitro compounds. Detailed study of vibrational frequencies of carbonyl compounds, aldehydes, ketones, esters, amides, acids, acid halides, anhydrides, lactones, lactams and conjugated carbonyl compounds. 3.3 .Proton Magnetic Resonance Spectroscopy: Principle, Chemical shift, Factors affecting chemical shift (Electronegativity, H-bonding, Anisotropy effects). Chemical and magnetic equivalence,	

		Chemical shift values and correlation for protons bonded to carbon and other nuclei as in alcohols, phenols, enols, carboxylic acids, amines, amides. Spin-spin coupling, Coupling constant (J), Factors affecting J, geminal, vicinal and long range coupling (allylic and aromatic). First order spectra, Karplus equation. 3.4. Structure determination involving individual or combined use of the above spectral techniques.	
		References: 1. Advanced Organic Chemistry Part B: Reactions and Synthesis, F. A Carey and R.J Sundberg, 4th Edition. 2. Organic Chemistry, J. Claydens, N. Greeves, S. Warren and P. Wothers, Oxford University Press. 3. Advanced Organic Chemistry: Reactions, Mechanisms and Structure, Michael B. Smith, Jerry March, Wiley. 4. Organic Synthesis, Jagdamba Singh, L.D.S. Yadav, Pragati Prakashan. 5. Organic Spectroscopy-Principles and Applications, Jagmohan, Narosa Publication.	

Semester II
Practical

Course Code	Organic Chemistry Practicals II	Credits/ Hours 1/30
RPSCHEP.O513	Separation of binary mixture using physical and chemical methods. (Characterization and identification of one of the components) The following types are expected:	**1**

	(i) Water soluble/water insoluble solid and water insoluble solid, (ii) Non-volatile liquid-Non-volatile liquid (chemical separation) (iii) Water-insoluble solid-Non-volatile liquid. (Total six mixtures)	

Course Code: RPSCHE.O514

Course Title:

Academic year 2023-24

Course Outcomes:

After completion of this Course, the learner will be able to:	
CO 1	Outline the role and importance of safety, accreditations and GLP in industries.
CO 2	Apply the knowledge learned to all scientific data analyses during their studies and future career-related activities.

DETAILED SYLLABUS

Course Code	**Unit**	**Course Title / Unit Title**	**Credits/ Hours 2/30**
		Quality Control in Chemical Industries II	
RPSCHE.O514	**I**	**1.1 Accreditations:** Accreditation of Laboratories, Introduction to ISO series, Indian Government Standards (ISI, Hallmark, Agmark). **1.2 Safety in Laboratories**: Basic concepts of Safety in Laboratories, Personal Protection Equipment (PPE), OSHA, Toxic Hazard (TH) classifications, Hazardous Chemical Processes (including process calorimetry / thermal build up concepts). (30L)	**2**
	II	**2.1 Good Laboratory Practices (GLP):** Principle, Objective, OECD guidelines, The US FDA 21CFR58, Klimisch score, GMP in Drugs and Pharmaceutical Industries Accreditation of QC laboratories: Tools and Mechanisms ICH Guidelines on Drug substances and Products.	

		References: **References:** 1. Fundamentals of Analytical Chemistry, By Douglas A. Skoog, Donald M. West, F. James Holler, Stanley R. Crouch, 9th Edition, 2004. 2. ISO 9000 Quality Systems Handbook, Fourth Edition, David Hoyle. (Free download). 3. Quality in the Analytical Laboratory, Elizabeth Pichard, Wiley India, 2007. **4.** Safety and Hazards Management in Chemical Industries, M N Vyas, Atlantic Publisher.	

Course Code: RPSCHEAN.E517

Course Title: ANALYTICAL CHEMISTRY

Academic year 2023-24

Course Outcomes:

After completion of this Course, the learner will be able to:	
CO 1	Utilize GC & HPLC techniques for separation of the different components present in a sample.
CO 2	Make use of X-ray spectroscopy for qualitative and quantitative analysis of elements.
CO 3	Describe the function of different components of a mass spectrometer.
CO 4	Select the best method from among those covered in these units while carrying out analysis of a sample and will be able to justify their choice.

DETAILED SYLLABUS

Course Code	**Unit**	**Course Title / Unit Title**	**Credits/ Hours 3/45**
		ANALYTICAL CHEMISTRY	**3**
RPSCHEAN.E 517	**I**	**1.1** Recapitulation of basic concepts in chromatography: Classification of chromatographic methods, requirements of an ideal detector, types of detectors in LC and GC, comparative account of detectors with reference to	

		their applications (LC and GC respectively), qualitative and quantitative analysis**.** **1.2** Concept of plate and rate theories in chromatography: efficiency, resolution, selectivity and separation capability. Van Deemter equation and broadening of chromatographic peaks. Optimization of chromatographic conditions**.** **1.3** Gas Chromatography: Instrumentation of GC with special reference to sample injection systems – split/splitless, column types, solid/ liquid stationary phases, column switching techniques, temperature programming, Thermionic and mass spectrometric detector, Applications. **1.4** High Performance Liquid Chromatography (HPLC): Normal phase and reversed phase with special reference to types of commercially available columns (Use of C8 and C18 columns). Diode array type and fluorescence detector, Applications of HPLC. Chiral and ion chromatography.	
	II	**2.1 X-ray spectroscopy**: principle, instrumentation and applications of X-ray fluorescence, absorption and diffraction spectroscopy. **2.2 Mass spectrometry**: recapitulation, instrumentation, ion sources for molecular studies, electron impact, field ionization, field desorption, chemical ionization and fast atom bombardment, Electro spray ionization (ESI) and Matrix-assisted desorption-ionization (MALDI) sources. Mass analyzers: Quadrupole, time of flight, ion trap, Magnetic Sector and Hybrid. Applications.	
	III	**3.1Surface Analytical Techniques:**	

		3.1.1 Introduction, Principle, Instrumentation and Applications of: **3.1.2** Scanning Electron Microscopy (SEM) **3.1.3** .Scanning Tunneling Microscopy (STM) **3.1.4** Transmission Electron Microscopy (TEM) **3.1.5** Electron Spectroscopy**:** principles, instrumentation and applications of the following ESCA (XPS), AUGER and UPS. **3.2 Atomic Spectroscopy:** **3.2.1** Advantages and Limitations of AAS **3.2.2** Atomic Spectroscopy based on plasma sources – Introduction, Principle, Instrumentation and Applications.	
		References: 1. Principles of Instrumental Analysis - Skoog, Holler and Nieman, 5th Edition. 2. Analytical Chemistry Principles – John H Kennedy, 2nd edition, Saunders College Publishing 1990. 3. Modern Analytical Chemistry David Harvey; McGraw Hill Higher education publishers, 2000. 4. Vogel's Text book of quantitative chemical analysis, 6th edition, Pearson Education Limited, 2007. 5. Electrochemical Methods Fundamentals and Applications, Allen J Bard and Larry R Faulkner, John Wiley and Sons, 1980. 6. Instrumental Methods of Analysis Willard, Merrit, Dean and Settle, 7thedition, CBS publishers. 7. Analytical chemistry by Garry D Christian,6th edition, John Wiley & Sons.	

		8. R. D. Braun, Introduction to Instrumental Analysis, McGraw Hill Publisher. 9. Fundamentals of Analytical Chemistry, By Douglas A. Skoog, Donald M. West, F. James Holler, Stanley R. Crouch, 9th Edition, 2004.	

Practical

Course Code		**Analytical Chemistry Practicals II**	**Credits/ Hours 1/30**
RPSCHEAN.E 517	**1.**	To determine amount of potassium in the given sample of fertilizers using flame photometer by standard addition method.	**1**
	2.	To determine amount of Ti(III) and Fe(II) in a mixture by titration with Ce(IV) potentiometrically.	
	3.	To determine the amount of Fe(II) and Fe(III) in a mixture using 1,10-phenanthroline spectrophotometrically.	
	4.	To determine the lead and tin content of a solder alloy by titration with EDTA.	
	5.	To determine amount of Cu(II) present in the given solution containing a mixture of Cu(II) and Fe(II).	
	6.	To determine the breakthrough capacity of a cation exchange resin.	
Course Code		**Research Project**	**Credits/ Hours 4/60**

Discipline Specific Course I,II and III

Modality of Assessment

Theory Examination Pattern:

A) Internal Assessment - 40% (30 Marks)

Sr. No.	Evaluation Type	Marks
1	Presentations	15
2	Class Test (MCQ / Objectives)	15
	Total	30

B) External Examination : 60 % (45 marks) Semester End Theory Examination :

1. Duration - These examinations shall be of 1 Hr 30 Mins duration.

Theory question paper pattern :-

2. There shall be three questions each of 15 marks. All questions shall be compulsory with internal choice within the questions.

Questions	Options	Marks	Questions based on
Q.1)	Any 3 out of 5	15	Unit I
Q.2)	Any 3 out of 5	15	Unit II
Q.3)	Any 3 out of 5	15	Unit III
	Total	45	

Practical Examination Pattern:

(A) External Examination : 100 % (50 Marks)Semester End Practical Examination:

Particulars	**Discipline Specific Course I,II and III Practicals**
Laboratory Work	40
Journal	05
Viva	05
Total	50

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.

Discipline Specific Course IV

Modality of Assessment

Theory Examination Pattern:

External Examination : 100 % (50 marks)

Semester End Theory Examination :

1. Duration - These examinations shall be of 2 Hr duration.

Theory question paper pattern :-

2. There shall be two questions each of 25 marks.All questions shall be compulsory with internal choice within the questions.

Questions	Options	Marks	Questions based on
Q.1)	Any 5 out of 7	25	Unit I
Q.2)	Any 5 out of 7	25	Unit II
	Total	50	

Modality of Assessment

Discipline Specific Elective

Theory Examination Pattern:

A) Internal Assessment - 40% (30 Marks)

Sr. No.	Evaluation Type	Marks
1	Presentations	15
2	Class Test (MCQ / Objectives)	15
	Total	30

B) External Examination : 60 % (45 marks) Semester End Theory Examination :

1. Duration - These examinations shall be of 1 Hr 30 Mins duration.

Theory question paper pattern :-

2. There shall be three questions each of 15 marks. All questions shall be compulsory with internal choice within the questions.

Questions	Options	Marks	Questions based on
Q.1)	Any 3 out of 5	15	Unit I
Q.2)	Any 3 out of 5	15	Unit II
Q.3)	Any 3 out of 5	15	Unit III
	Total	45	

Practical Examination Pattern:

(B) External Examination : 100 % (50 Marks)Semester End Practical Examination:

Particulars	**Discipline Specific Elective Practicals**
Laboratory Work	40
Journal	05
Viva	05
Total	50

Modality of Assessment
Research Methodology

Theory Examination Pattern:

A) Internal Assessment - 40% (40 Marks)

Sr. No.	Evaluation Type	Marks
1	Presentations /Assignment / Class Test / Open Book Test	40
	Total	40

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

1. Duration - These examinations shall be of 2 Hr 30 min duration.

Theory question paper pattern :-

2. There shall be three questions each of 15 marks. All questions shall be compulsory with internal choice within the questions.

Questions	Options	Marks	Questions based on
Q.1)	Any 3 out of 5	15	Unit I
Q.2)	Any 3 out of 5	15	Unit II
Q.3)	Any 3 out of 5	15	Unit III
Q.4)	Any 3 out of 5	15	Unit IV

	Total	60	

Modality of Assessment
Research Project

Sr.No.	Criteria	Marks
1.	**Project Proposal/ Selection**	**10**
2.	**Literature Survey**	**10**
3.	**Project Work including Monthly Report**	**60**
4.	**Final Dissertation**	**20**
		Total = 100 M