Resolution Number: AC/I(21-22).2(II).RPS5

S. P. Mandali's

Ramnarain Ruia Autonomous College

(Affiliated to University of Mumbai)

SYLLABUS

Program: M.Sc.

Program Code: (RPSCHE)

(Credit based semester and grading system with effect from the academic year 2022-2023).

PROGRAM OUTCOME

GA	Description
A student after completing Master's in Science program will be able to	
GA 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.
GA 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.
GA 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.
GA 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.
GA 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.
GA 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.
GA 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.
GA 8	Understand cross disciplinary relevance of scientific developments and relearn and reskill so as to adapt to technological advancements.

PROGRAM OUTCOMES

PO	Description
A student completing Master's degree in Science Program in the subject of chemistry will be able to :	
PO 1	Acquire in-depth knowledge of the advance concepts in the branch of specialization viz, Physical , Inorganic , Organic & Analytical.
PO 2	Design and carry out analysis as well as accurately record and analyse the results.
PO 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.
PO 4	Apply the skills to do specialized research in the core and applied areas of chemical sciences.
PO 5	Explore new areas of research in chemistry and allied fields of science and technology.
PO 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.
PO 7	Explain why chemistry plays an integral role in addressing social , economic and environmental problems.
PO 8	Become professionally skilled for higher studies in research institutions and to work in industries.

PROGRAM OUTLINE

Year	Semester	Course Code	Course Title	Credits
M.Sc-I	I	RPSCHE101	Physical Chemistry	**4**
		RPSCHE102	Inorganic Chemistry	**4**
		RPSCHE103	Organic Chemistry	**4**
		RPSCHE104	Analytical Chemistry	**4**
		RPSCHE1P1	Physical Chemistry	**2**
		RPSCHE1P2	Inorganic Chemistry	**2**
		RPSCHE1P3	Organic Chemistry	**2**
		RPSCHE1P4	Analytical Chemistry	**2**
	II	RPSCHE201	Physical Chemistry	**4**
		RPSCHE202	Inorganic Chemistry	**4**
		RPSCHE203	Organic Chemistry	**4**
		RPSCHE204	Analytical Chemistry	**4**
		RPSCHE2P1	Physical Chemistry	**2**
		RPSCHE2P2	Inorganic Chemistry	**2**
		RPSCHE2P3	Organic Chemistry	**2**
		RPSCHE2P4	Analytical Chemistry	**2**

Resolution Number:

S. P. Mandali's

Ramnarain Ruia Autonomous College

(Affiliated to University of Mumbai)

Syllabus for SEMESTER I and II

Program: M.Sc.

Program Code: (RPSCHE)

(Credit based semester and grading system with effect from the academic year 2022-2023)

SEMESTER-I			
Course Code	**Unit**	**Course Title / Unit Title**	**Credits**
RPSCHE101		**PHYSICAL CHEMISTRY**	**4**
	I	Thermodynamics-I	
	II	Quantum Chemistry– I	
	III	Chemical Dynamics-I	
	IV	Electrochemistry	
RPSCHE102		**INORGANIC CHEMISTRY**	**4**
	I	Chemical Bonding	
	II	Molecular Symmetry and Group Theory	
	III	Materials Chemistry and Nanomaterials	
	IV	Characterisation of Coordination compounds	
RPSCHE103		**ORGANIC CHEMISTRY**	**4**
	I	Physical Organic Chemistry	
	II	Nucleophilic substitution reactions and Aromaticity	
	III	Stereochemistry	
	IV	Oxidation and Reduction	
RPSCHE104		**ANALYTICAL CHEMISTRY**	**4**
	I	Language of Analytical Chemistry & Quality in Analytical Chemistry.	
	II	Calculations based on Chemical Principles	
	III	Optical Methods	
	IV	Thermal Methods& Automation in chemical analysis	
RPSCHE1P1		**Practical**	**8**
RPSCHE1P2			
RPSCHE1P3			
RPSCHE1P4			

SEMESTER II			
Course Code	**Unit**	**Course Title / Unit Title**	**Credits**
RPSCHE201		**PHYSICAL CHEMISTRY**	**4**
	I	Chemical Thermodynamics –II	
	II	Quantum Chemistry–II	
	III	Chemical Dynamics–II	
	IV	Solid State Chemistry and Phase Equilibria	
RPSCHE202		**INORGANIC CHEMISTRY**	**4**
	I	Inorganic Reaction Mechanism	
	II	Organometallic Chemistry of Transition metals	
	III	Environmental Chemistry	
	IV	Bioinorganic Chemistry	
RPSCHE203		**ORGANIC CHEMISTRY**	**4**
	I	Alkylation of Nucleophilic Carbon Intermediates	
	II	Reactions and Rearrangements	
	III	Introduction to Molecular Orbital Theory for Organic Chemistry	
	IV	NMR spectroscopy and Mass spectrometry	
RPSCHE204		**ANALYTICAL CHEMISTRY**	**4**
	I	Chromatography	
	II	X-ray spectroscopy & Mass spectrometry	
	III	Surface Analytical Techniques &Atomic Spectroscopy	
	IV	Electroanalytical Methods	
RPSCHE2P1		**Practical**	**8**
RPSCHE2P2			
RPSCHE2P3			
RPSCHE2P4			

Course Code: RPSCHE101
Course Title : PHYSICAL CHEMISTRY
Academic year 2019-20.

Course Outcomes:

After completion of this Course, the learner will be able to:	
CO 1	Derive Maxwell equations and understand their significance.
CO 2	Connect quantum mechanical operators to observables.
CO 3	Calculate probabilities, amplitudes, averages values of the observables.
CO 4	Derive rate laws of different types of the reactions.

DETAILED SYLLABUS

Course Code	Unit	Course title / Unit Title	Credits/ Lectures
RPSCHE101	**PHYSICAL CHEMISTRY**		**04**
	I	**Thermodynamics–I**	**(15)**
		1.1 State function and exact differentials. Maxwell equations, Maxwell thermodynamic Relations; it's significance and applications to ideal gases, Joule Thomson experiment, Joule Thomson coefficient, inversion temperature, Joule Thomson coefficient in terms of van der Waals constants. **1.2** Third law of Thermodynamics, Entropy change for a phase transition, absolute entropies, determination of absolute entropies in terms of heat capacity, standard molar entropies and their dependence on molecular mass and molecular Structure, residual entropy.	
	II	**Quantum Chemistry –I**	**(15)**

		2.1 Classical Mechanics, failure of classical mechanics: Need for Quantum Mechanics. **2.2** Particle waves and Schrödinger wave equation, wave functions, properties of wave functions,	

		Normalization of wave functions, orthogonality of wave functions. **2.3** 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. **2.4 Application of quantum mechanics to the following systems:** **2.4.1** Free particle, wave function and energy of a free particle. **2.4.2** Particle in a one, two- and three-dimensional box, separation of variables, Expression for the wave function of the system, expression for the energy of the system, concept of quantization, introduction of quantum number, degeneracy of the energy levels. **2.4.3** Harmonic oscillator, approximate solution of the equation, Hermite polynomials, expression for wave function, expression for energy, use of the recursion formula.	
	III	**Chemical Dynamics–I**	**(15)**
		3.1 Rate 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. **3.2** 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. **3.3** Some 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. **3.4** Polymerization reactions: Kinetics of stepwise polymerization, Calculation of degree of polymerization for stepwise reaction. Kinetics of free radical chain polymerization, Kinetic chain length and estimation of average no. of monomer units in the polymer produced by chain polymerization.	
	IV	**Electrochemistry**	**(15)**
		4.1 Debye-Huckel theory of activity coefficient, Debye-Huckel limiting law and its extension to higher concentration (derivations are expected). **4.2** Electrolytic conductance and ionic interaction, relaxation effect, Debye-Hückel- Onsager equation (derivation expected). Validity of this	

		equation for aqueous and non- aqueous solution, deviations from Onsager equation, Debye - Falkenhagen effect (dispersion of conductance at high frequencies), Wien effect. **4.3 Batteries:** Alkaline fuel cells, Phosphoric acid fuel cells, High temperature fuel cells [Solid – Oxide Fuel Cells (SOFC) and Molten Carbonate Fuel Cells] **4.4 Bio-electrochemistry:** Introduction, cells and membranes, membrane potentials, theory of membrane potentials, interfacial electron transfer in biological systems, adsorption of proteins onto metals from solution, electron transfer from modified metals to dissolved protein in solution, enzymes as electrodes, electrochemical enzyme-catalysed oxidation of styrene. Goldmann equation. **(Derivations are expected)**	

References:

1. Peter Atkins and Julio de Paula, Atkins Physical Chemistry, 7th Edition, Oxford University Press, 2002.
2. K.J. Laidler and J.H. Meiser, Physical Chemistry, 2nd Edition, CBS Publishers and Distributors, New Delhi, 1999.
3. S. Glasstone, Text Book of Physical Chemistry, 2ndEdition, McMillan and Co. Ltd., London, 1962.
4. R.K. Prasad, Quantum Chemistry, 2nd Edition, New Age International Publishers, 2000.
5. Thomas Engel and Philip Reid, Physical Chemistry, 3rd Edition, Pearson Education Limited, 2013.
6. D.N. Bajpai, Advanced Physical Chemistry, S. Chand 1st Edition, 1992.
7. Bockris, John O'M., Reddy, Amulya K.N., Gamboa-Aldeco, Maria E., Modern Electrochemistry, 2A, Plenum Publishers, 1998.

Semester-I
Practical

RPSCHE1P1	Physical Chemistry		Credits - 02
	Non – Instrumental		
	1.	To determine the heat of solution (ΔH) of a sparingly soluble acid (benzoic /salicylic acid) from solubility measurement at three different temperature.	
	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.	To investigate the reaction between acetone and iodine.	
	4.	To study the variation in the solubility of $Ca(OH)_2$ in presence of NaOH and hence to determine the solubility product of $Ca(OH)_2$ at room temperature.	
	Instrumental		
	1.	To determine the mean ionic activity coefficient of an electrolyte by e.m.f. measurement.	
	2	To study the effect of substituent on the dissociation constant of acetic acid conductometrically.	
	3.	To determine pKa values of phosphoric acid by potentiometric titration with sodium hydroxide using glass electrode.	
	4.	To verify Ostwald's dilution law and to determine the dissociation constant of a weak mono-basic acid conductometrically.	

Course Code : RPSCHE102

Course Title : INORGANIC CHEMISTRY

Academic year 2020-21

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	Know how the physical properties like melting and boiling points of molecules get affected by chemical forces present in it.
CO 4	Understand Symmetry operations and Symmetry elements.
CO 5	Differentiate Abelian and Non-abelian point groups.
CO 6	Use of Great Orthogonality Theorem for construction of character table.
CO 7	Examine chemical bonding, visualizing molecular orbitals, behaviour of atoms, molecules and solids using group theory.
CO 8	Know the importance of Material Chemistry and its potential in developing applications, either by compositional control to optimize properties or by fabrication into desired forms, shapes or products.
CO 9	Recognize the importance of Stability as we all seek to achieve stability including molecules.
CO 10	Aware of the various methods/ techniques used to detect complex formation between metal and ligand.
CO 11	Interpret the electronic spectra of octahedral and square planar complexes.
CO 12	Calculate the various spectral parameters using correlation diagram and spectra.

DETAILED SYLLABUS

Course Code	Unit	Course Title / Unit Title	Credits/ Lectures
RPSCHE102		**INORGANIC CHEMISTRY**	**4**
	I	**Chemical Bonding**	**(15)**
		1.1 Recapitulation of hybridization, Derivation of wave functions for *sp*, sp^2, *sp3*orbital hybridization types considering only sigma bonding. **1.2** Discussion of involvement of *d*-orbitals in various types of hybridizations. Concept of resonance, resonance energy, Formal charge with examples. **1.3** Critical analysis of VBT. **1.4** Molecular Orbital Theory for diatomic species of First transition Series. **1.5** Molecular Orbital Theory for Polyatomic species considering σ bonding for SF_6, CO_2, B_2H_6 molecular species. **1.6** Chemical Forces: 1.6.1 Hydrogen bonding – Concept, Types, Properties, Methods of Detection and Importance. 1.6.2 Intermolecular Forces: Dipole-Dipole Interaction, Induced dipole-Induced dipole Interaction 1.6.3 Effects of Chemical Forces: Melting and Boiling Points, Solubility	
	II	**Molecular Symmetry and Group Theory**	**(15)**
		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** Reduction of reducible representations using reduction formula. **2.4.5** Group-subgroup relationships. **2.4.6** Descent and ascent in symmetry correlation diagrams showing relationship between different groups.	
	III	**Materials Chemistry and Nanomaterials**	**(15)**
		3.1 Solid State Chemistry: **3.1.1** Electronic structure of solids and band theory, Fermi level, K Space and Brillouin Zones. **3.1.2** Structures of Compounds of the type: AB (nickel arsenide (NiAs)), AB_2 (fluorite (CaF_2) and anti-fluorite structures, rutile (TiO_2) structure and layer structure (cadmium chloride and iodide ($CdCl_2$, CdI_2)).	

		3.1.3 Methods of preparation for inorganic solids: Ceramic method, precursor method, sol-gel method (applications in Biosensors), microwave synthesis (discussion on principles, examples, merits and demerits are expected). **3.2 Nanomaterials:** **3.2.1** Preparative methods: Chemical methods, Solvothermal, Combustion synthesis, Microwave, Co-precipitation, Langmuir Blodgett (L-B) method, Biological methods: Synthesis using microorganisms. **3.2.2** Applications in the field of semiconductors and solar cells.	
	IV	**Characterisation of Coordination compounds**	**(15)**
		4.1 Thermodynamic and Kinetic Stability, Stepwise and Overall Stability Constant, Relationship between Stepwise and Overall Formation constant.**(Numerical Problem expected).** **4.2** Detection of Complex Formation: Formation of precipitate, Conductivity measurements, Spectral method (Colour Change in Solution), pH method, magnetic measurements. **4.3** 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. **4.4** Interpretation of electronic spectra for octahedral and square planar complexes. **4.5** 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

RPSCHE1P2	Inorganic Chemistry		Credits – 02
		Non Instrumental **Inorganic Preparations (Synthesis and Characterization):**	
	1.	Hexammine nickel (II) sulphate	
	2.	Bis (ethylenediammine) Copper (II) Sulphate	
	3.	Tris-thiourea copper(I) sulphate	
		Instrumental	
	1.	Determination of equilibrium constant by Slope intercept method for Fe^{+3}/ SCN^- system	
	2.	Determination of Electrolytic nature of inorganic compounds by Conductance measurement.	
	3.	Determination of Copper (II) using EDTA spectrophotometrically	
	4.	Determination of titanium (IV) colorimetrically.	

References:

1. G H Jeffery, J Bassett, J Mendhem, R C Denney, Vogel's Textbook Of Quantitative Chemical Analysis, 3rd Edition, Longman Scientific & Technical,1989.
2. R Gopalan, V Ramalingam, Concise Coordination Chemistry, Vikas Publishing House Pvt. Ltd. 2001.
3. H N Patel, S P Turakhia, S S Kelkar, S R Puniyani, Post Graduate Practical Chemistry Part I, Himalaya Publishing House, 5th Edition, 2008.

Course Code : RPSCHE103

Course Title : ORGANIC CHEMISTRY

Academic year 2020-21

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/ Lectures
RPSCHE103		**ORGANIC CHEMISTRY**	**04**
	I	**Physical Organic Chemistry**	**(15)**
		1.1 Thermodynamic and Kinetic requirements of a reaction: rate and equilibrium constants, reaction coordinate diagram, transition state (activated complex), nature of activated complex, Hammond postulate, Reactivity *vs* selectivity, Curtin-Hammett Principle, Microscopic reversibility, Kinetic *vs* thermodynamic control of organic reactions. **1.2 Determining Mechanism of a Reaction:** Product analysis, kinetic studies, use of isotopes (Kinetic isotope effect – primary and secondary kinetic isotope effect). Detection and trapping of	

		intermediates, crossover experiments and stereochemical evidence. **1.3 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.	
	II	**Nucleophilic Substitution Reactions and Aromaticity**	**(15)**
		2.1 Nucleophilic Substitution Reactions **2.1.1 Aliphatic nucleophilic substitution:** S_N1, S_N2, S_N^i reactions, mixed S_N1 and S_N2 and SET mechanisms. S_N reactions involving NGP - participation by aryl rings, α-and pi-bonds. Factors affecting these reactions: substrate, nucleophilicity, solvent, steric effect, hard-soft interaction, leaving group. Ambident nucleophiles. S_NcA, S_N1' and S_N2 reactions. S_N at sp^2 (vinylic) carbon. **2.1.2 Aromatic nucleophilic substitution:** S_NAr, S_N1, 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** Structural, 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. **2.2.3** Aromatic and antiaromatic compounds up-to 18 carbon atoms. Homoaromatic compounds. Aromaticity of all benzenoid systems, heterocycles, metallocenes, azulenes, annulenes, aromatic ions and Fullerene (C_{60}).	
	III	**Stereochemistry**	**(15)**
		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 number of chiral centers: enantiomeric and meso forms, concept of stereogenic, chirotopic, and pseudoasymmetric centres. R-S nomenclature for chiral centres 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, trans-cyclooctenes. **3.5. Prochirality:** Chiral and prochiral centres; prochiral axis and prochiral plane. Homotopic, heterotopic (enantiotopic and diastereotopic) ligands and faces. Identification using substitution and symmetry criteria. Nomenclature of stereoheterotopic ligands and faces. Symbols for stereoheterotopic ligands in molecules with i) one or more prochiral centres ii) a chiral as well as a prochiral centre, iii) a prochiral axis iv) a prochiral plane v) pro-pseudoasymmetric centre. Symbols for enantiotopic and diastereotopic faces.	
	IV	**Oxidation and Reduction**	**(15)**
		4.1. Oxidation: General mechanism, selectivity, and important applications of the following: **4.1.1. Dehydrogenation:** Dehydrogenation of C-C bonds including aromatization of six membered rings using chloranil and DDQ. **4.1.2. Oxidation of alcohols to aldehydes and ketones:** Chromium reagents such as $K_2Cr_2O_7/H_2SO_4$ (Jones reagent), CrO_3-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. **4.1.3. 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 $NaIO_4$. **4.1.4. 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). **4.1.5. Oxidation of aldehydes and ketones:** with H_2O_2 (Dakin reaction), with peroxy acid (Baeyer-Villiger oxidation) **4.2. Reduction:** General mechanism, selectivity, and important applications of the following reducing reagents: **4.2.1. Reduction of CO to CH_2 in aldehydes and ketones-**Clemmensen reduction, Wolff-Kishner reduction and Huang-Minlon modification. **4.2.2. 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). **4.2.3.** NH_2NH_2 (diimide reduction) and other non-metal based agents including organic reducing agents (Hantzsch dihydropyridine). **4.2.4. Dissolving metal reductions:** using Zn, Li, Na, and Mg under neutral and acidic conditions, Li/Na-liquid NH_3 mediated reduction (Birch reduction) of aromatic compounds and acetylenes.	

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

RPSCHE1P3	**Organic Chemistry**	**(Credits – 02)**
	One step preparations (1.0 g scale):	
	1.	Bromobenzene to p-nitrobromobenzene
	2.	Anthracene to anthraquinone
	3.	Benzoin to benzil
	4.	Anthracene to Anthracene maleic anhydride adduct
	5.	2-Naphthol to BINOL
	6.	p-Benzoquinone to 1,2,4-triacetoxybenzene
	7.	*o*-Phenylenediamine to 2-methylbenzimidazole
	8.	*o*-Phenylenediamine to 2,3-diphenylquinoxaline

Course Code : RPSCHE104

Course Title : ANALYTICAL CHEMISTRY

Academic year 2020-21

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	Determine the different types of errors in chemical analysis.
CO 3	Make use of calibration curve and standard addition method to carry out quantitative analysis of sample.
CO 4	Outline the role and importance of total quality management, safety, accreditations and GLP in industries.
CO 5	Apply the knowledge learned to all scientific data analyses during their studies and future career-related activities.
CO 6	Explain the working principle and Enlist the applications of UV visible and IR spectroscopy.
CO 7	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 8	Compare the technique of DTA with DSC.
CO 9	Comprehend the utility of automation in chemical analysis.
CO 10	Outline the Objectives of automation in chemical analysis.
CO 11	Enlist the advantages and disadvantages of Automatic Analysis.

DETAILED SYLLABUS

Course Code	Unit	Course Title / Unit Title	Credits/ Lectures
RPSCHE104		**ANALYTICAL CHEMISTRY**	**04**
	I	**Language of Analytical Chemistry & Quality in Analytical Chemistry**	**(15)**
		1.1 Language of Analytical Chemistry: **1.1.1** Analytical perspective, Common analytical problems, terms involved in analytical chemistry (analysis, determination, measurement, techniques, methods, procedures and protocol). **1.1.2** An overview of analytical methods, types of instrumental methods, instruments for analysis, data domains, electrical and non-electrical domains, detectors, transducers and sensors, selection of an analytical method, accuracy, precision, selectivity, sensitivity, detection limit and dynamic range. **1.1.3** Errors, determinate and indeterminate errors. Types of determinate errors, tackling of errors. **1.1.4** Quantitative methods of analysis: calibration curve, standard addition and internal standard method. **1.2 Quality in Analytical Chemistry:** **1.2.1 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. **1.2.2** **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). **1.2.3** **Accreditations:** Accreditation of Laboratories, Introduction to ISO series, Indian Government Standards (ISI, Hallmark, Agmark). **1.2.4** **Good Laboratory Practices (GLP):** Principle, Objective, OECD guidelines, The US FDA 21CFR58, Klimisch score.	
	II	**Calculations based on Chemical Principles**	**(15)**
		2.1 Concentration of a solution based on volume and mass units. **2.2** Calculations of ppm, ppb and dilution of the solutions, concept of mmol. **2.3** Stoichiometry of chemical reactions, concept of kg mol, limiting reactant, theoretical and Practical yield. **2.4** Solubility and solubility equilibria, effect of presence of common ion. **2.4.1** Calculations of pH of acids, bases, acidic and basic buffers. **2.4.2** Concept of formation constants, stability and instability constants, stepwise formation constants. **2.5** 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).	
	III	**Optical Methods**	**(15)**
		3.1 Recapitulation and FT Technique: **3.1.1** Recapitulation of basic concepts, Electromagnetic spectrum, Sources, Detectors, sample containers. **3.1.2** Laser as a source of radiation, Fibre optics **3.1.3** Introduction of Fourier Transform **3.2 Molecular Ultraviolet and Visible Spectroscopy** **3.2.1** 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. **3.2.2** Applications of Ultraviolet and Visible spectroscopy: 1. On charge transfer absorption 2. Simultaneous spectroscopy 3. Derivative Spectroscopy **3.2.3** Dual spectrometry – Introduction, Principle, Instrumentation and Applications. (NUMERICALS ARE EXPECTED) **3.3 Infrared Absorption Spectroscopy:** **3.3.1** Instrumentation: Sources, Sample handling, Transducers, Dispersive, non-dispersive instrument **3.3.2** FTIR and its advantages **3.3.3** Applications of IR (Mid IR, Near IR, Far IR): Qualitative with emphasis on "Finger print"	

		region, Quantitative analysis, Advantages and Limitations of IR **3.3.4** Introduction and basic principles of diffuse reflectance spectroscopy.	
	IV	**Thermal Methods and Automation in Chemical Analysis**	**(15)**
		4.1 Thermal Methods: **4.1.1. Introduction :** Recapitulation of types of thermal methods, comparison between TGA and DTA. **4.1.2. Differential Scanning Calorimetry-** Principle, comparison of DTA and DSC, Instrumentation, Block diagram, Nature of DSC Curve, Factors affecting curves (sample size, sample shape, pressure). **4.1.3. Applications –** Heat of reaction, Specific heat, Safety screening, Polymers, liquid crystals, Percentage cystallinity, oxidative stability, Drug analysis, Magnetic transition. E.g. Analysis of Polyethylene for its crystallinity. **4.2. 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 equipments, 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

RPSCHE1P4	**ANALYTICAL CHEMISTRY**	**(CREDITS – 02)**
	1.	To carry out assay of the sodium chloride injection by Volhard's method. (Statistical method)
	2.	To determine (a) the ion exchange capacity (b) exchange efficiency of the given cation exchange resin.
	3.	To determine amount of Cr(III) and Fe(II) individually in a mixture of the two by titration with EDTA.
	4.	To determine the breakthrough capacity of a cation exchange resin.
	5.	To determine the lead and tin content of a solder alloy by titration with EDTA.
	6.	To determine amount of Cu(II) present in the given solution containing a mixture of Cu(II) and Fe(II).
	7.	To determine number of nitro groups in the given compound using $TiCl_3$.

Reference:

G H Jeffery, J Bassett, J Mendhem, R C Denney, Vogel's Textbook Of Quantitative Chemical Analysis, 3rd Edition, Longman Scientific & Technical,1989.

MODALITY OF ASSESSMENT

Theory Examination Pattern:

A) Internal Assessment - 40% - 40 Marks

Presentation: 20 Marks

Continuous Internal Assessment (CIA): 20 Marks

For each paper, learners are evaluated from their presentation based on the topic selected from syllabus. The assessment of presentation is as follows:

Sr. No	Evaluation type	Marks
1	Presentation content	10
2	Presentation skills	05
3	Viva	05
4	Continuous Internal Assessment (CIA) e.g. Test, Group discussion, assignment, open-book tests etc.	20
	Total	40

B) External examination - 60 % - 60 Marks

Semester End Theory Examination - 60 marks

Duration - These examinations shall be of **2.5 hours** duration.

Paper Pattern:

1. There shall be **04** questions each of **15** marks. On each unit, there will be one question.
2. questions shall be compulsory with internal choice within the questions.

Questions	Options	Marks	Questions based on
Q.1) A)	Any 3 out of 5	12	Unit I
Q.1) B)	Any 1 out of 2	3	
Q.2) A)	Any 3 out of 5	12	Unit II
Q.2) B)	Any 1 out of 2	3	
Q.3) A)	Any 3 out of 5	12	Unit III
Q.3) B)	Any 1 out of 2	3	
Q.4) A)	Any 3 out of 5	12	Unit IV
Q.4) B)	Any 1 out of 2	3	
	Total	**60**	

Practical Examination Pattern:

Semester End Practical Examination: 50 marks

Experimental work	**40**
Viva	**05**
Journal	**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, a Lost Certificate should be obtained from Head/ Coordinator / In-charge of the department; failing which the student will not be allowed to appear for the practical examination.

Overall Examination and Marks Distribution Pattern

Course	**101**			**102**			**Grand Total**
	Internal	**External**	**Total**	**Internal**	**External**	**Total**	
Theory	**40**	**60**	**100**	**40**	**60**	**100**	**200**
Practical			**50**			**50**	**100**
Course	**103**			**104**			**Grand Total**
	Internal	**External**	**Total**	**Internal**	**External**	**Total**	
Theory	**40**	**60**	**100**	**40**	**60**	**100**	**200**
Practical			**50**			**50**	**100**

Total: 600 marks

Course Code : RPSCHE201
Course Title : PHYSICAL CHEMISTRY
Academic year 2020-21

Course Outcomes:

After completion of this Course, the learner will be able to:	
CO 1	Distinguish between physical and chemical adsorption.
CO 2	Predict spontaneous nature of thermodynamic mixing.
CO 3	Calculate energy of hydrogen atom.
CO 4	Draw the atomic orbital and locate radial and angular nodes.
CO 5	Derive rate laws for the solid-state reaction.
CO 6	Analyse the effect of inhibitor on enzyme catalysed reaction.
CO 7	Draw phase diagram for two and three component system.

DETAILED SYLLABUS

Course Code	Unit	Course Title / Unit Title	Credits/ Lectures
RPSCHE201	**PHYSICAL CHEMISTRY**		**04**
	I	**Chemical Thermodynamics –II**	**(15)**
		1.1 Fugacity of real gases, Determination of fugacity of real gases using graphical method and from equation of state. Equilibrium constant for real gases in terms of fugacity. Gibbs energy of mixing, entropy and enthalpy of mixing. **1.2** Real solutions: Chemical potential in non-ideal solutions excess functions of non-ideal solutions calculation of partial molar volume and partial molar enthalpy, Gibbs Duhem Margules equation. **1.3** Thermodynamics of surfaces, Pressure difference across curved surface (Laplace equation), vapour pressure of droplets (Kelvin equation), Gibbs adsorption isotherm, BET isotherm (derivations expected).	

		1.4 Bioenergetics: standard free energy change in biochemical reactions, exergonic, endergonic. Hydrolysis of ATP, synthesis of ATP from ADP.	
	II	**Quantum Chemistry –II**	**(15)**
		2.1 Rigid rotor, spherical coordinates Schrödinger wave equation in spherical coordinates, separation of the variables, the phi equation, wave-function, quantum number, the theta equation, wave function, quantization of rotational energy, spherical harmonics. **2.2** 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, introduction of the four quantum numbers and their interdependence on the basis of the solutions of the three equations, total wave function, 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. **2.3** Application of the Schrödinger equation to two electron system, limitations of the equation, need for the approximate solutions, methods of obtaining the approximate solution of the Schrödinger wave equation.	
	III	**Chemical Dynamics– II**	**(15)**
		3.1 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	

		3.2 Steady state and pre-equilibrium approximations, Lindemann mechanism for the unimolecular reaction. Enzyme catalysis – Michaelis-Menten Mechanism, Lineweaver and Eadie-Hofstee plots, **3.3** Inhibition of Enzyme action: Competitive, Non-competitive and Uncompetitive Inhibition. Effect of pH, Enzyme activation by metal ions, Regulatory enzymes. **3.4** Kinetics of reactions in the Solid State: - Factors affecting reactions in solids Rate laws for reactions in solid: The parabolic rate law, the first order rate Law, the contracting sphere rate law, Contracting area rate law, some examples of kinetic studies.	
	IV	**Solid State Chemistry and Phase Equilibria**	**(15)**
		4.1 Solid State Chemistry: Recapitulation: Structures and Defects in solids. Types of Defects and Stoichiometry **4.1.1** Zero dimensional (point) Defects **4.1.2** One dimensional (line) Defects **4.1.3** Two dimensional (Planar) Defects **4.1.4** Thermodynamics of formation of defects (Mathematical derivation to find concentration of defects and numerical problems based on it) **4.2 Phase equilibria:** Recapitulation: Introduction and definition of terms involved in phase rule. Thermodynamic derivation of Gibbs Phase rule. Two component system: **4.2.1** Solid –Gas System: Hydrate formation, Amino compound formation	

		4.2.2 Solid – Liquid System: Formation of a compound with congruent melting point, Formation of a compound with incongruent melting point. (with suitable examples) **4.2.3** Three component system Type-I: Formation of one pair of partially miscible liquids Type-II: Formation of two pairs of partially miscible liquids Type-III: Formation of three pairs of partially miscible liquids	

References:

1. K.J. Laidler and J.H. Meiser, Physical Chemistry, 2nd Edition, CBS Publishers and Distributors, New Delhi, 1999.
2. Ira R. Levine, Physical Chemistry, 5th Edition, Tata McGraw-Hill New Delhi, 2002.
3. Principles of the Solid State, H.V. Keer, New Age International Publishers, 2011.
4. Solid State Chemistry, D.K. Chakrabarty, New Age International Publishers, 1996.
5. S. Glasstone, Thermodynamics for Chemists, Affiliated East-West Press, New Delhi, 1964.
6. Robert J. Silby and Robert A. Alberty, Physical Chemistry, 3rdEdition, John Wiley and Sons (Asia) Pvt. Ltd., 2002.
7. Principles of Chemical Kinetics, 2ndEdition, James E. House, Elsevier, 2007.

Semester II
Practical

RPSCHE2P1	Physical Chemistry		Credits
	Non – Instrumental		**2**
	1.	Polar plots of atomic orbitals such as 1*s*, $2p_z$ and $3d_{z2}$ orbitals by using angular part of hydrogen atom wave functions.	
	2.	To study the influence of ionic strength on the base catalysed hydrolysis of ethyl acetate.	
	3.	To study phase diagram of three component system water – chloroform /toluene - acetic acid.	
	4.	To determine the rate constant of decomposition reaction of diacetone alcohol by dialtometric method.	
	Instrumental:		
	1.	To determine the formula of silver ammonia complex by potentiometric method.	
	2.	To determine CMC of sodium Lauryl Sulphate from measurement of conductivities at different concentrations.	
	3.	To determine Hammett constant of *m*- and *p*- amino benzoic acid/nitro benzoic acid by pH measurement.	
	4.	To determine the Michaelis – Menten's constant value (K_m) of the enzyme Beta Amylase spectrophotometrically.	

Course Code : RPSCHE202

Course Title : INORGANIC CHEMISTRY

Academic year 2020-21

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/ Lecture
RPSCHE202	**INORGANIC CHEMISTRY**		**04**
	I	**Inorganic Reaction Mechanism**	**(15)**
		1.1 Rate of reactions, factors affecting the rate of reactions, techniques for determination of rate of reaction (Direct chemical analysis, spectrophotometric method, electrochemical and flow methods). **1.2** 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 racemisation 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**	**(15)**
		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** ReactionsInvolving 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 **2.2.3** Metathesis and Polymerization Reactions **2.2.3.1** π Bond Metathesis **2.2.3.2** σ Bond Metathesis **2.2.3.3** Alkyne Metathesis **2.3** Transition Metal–Carbene and –Carbyne Complexes: Structure, Preparation, and Chemistry: **2.3.1** Structure of Metal Carbene **2.3.2** Synthesis of Metal Carbene Complexes **2.3.3** Reactions of Metal–Carbene Complexes	

		2.3.4 Metal–Carbyne Complexes **2.4** Preparation and properties of the following compounds: Sandwich compounds of Fe, Cr and Half Sandwich compounds of Cr, Mo. **2.5** 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**	**(15)**
		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 Interaction of radiation in context with the environment:** Sources and biological implication of radioactive materials. Effect of low level radiation on cells- Its applications in diagnosis and treatment, Effect of radiation on cell proliferation and cancer.	
	IV	**Bioinorganic Chemistry**	**(15)**
		4.1. 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. **4.2.** Activation of oxygen in biological system with examples of mono-oxygenases, and oxidases-structure of the metal center and mechanism of oxygen activation by these enzymes. **4.3.** Copper containing enzymes- superoxide dismutase, tyrosinase and laccase: catalytic reactions and the structures of the metal binding site **4.4.** Nitrogen fixation-nitrogenase, hydrogenases. **4.5.** Metal ion transport and storage:Ionophores, transferrin, ferritin and metallothionins **4.6.** Medicinal applications of cis-platin and related compounds .	

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.
7. Gary O. Spessard, Gary L. Miessler, Organometallic Chemistry, 2nd Edition, Oxford University Press 2010.
8. R.H Crabtree, The Organometallic Chemistry of the Transition Metals, 5th Edition, Wiley International Pvt., Ltd 2000.
9. Stanley E. Manahan, Environmental Chemistry, 9th Edition, CRC Press Publishers, 2010
10. Stanley E. Manahan, Fundamentals of Environmental and Toxicological Chemistry, 4th edition, CRC Press Taylor & Francis Group, 2013.
11. Jerrold B. Leikin, Frank P. Paloucek, Poisoning and Toxicology Handbook, 4th Edition, Informa Healthcare USA, Inc. 2008

12. I. Bertini, H.B.Gray, S. J. Lippard and J.S. Valentine, Bioinorganic Chemistry, First South Indian Edition, Viva Books, New Delhi, 1998.
13. Robert R.Crichton, Biological Inorganic Chemistry – An Introduction, 1st Edition, Elsevier, 2008.
14. Wolfgang Kaim, Brigitte Schwederski, Axel Klein, Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life, Second Edition, John Wiley & Sons, Ltd, 2013.

Semester II
Practical

RPSCHE2P2		Inorganic Chemistry	Credits
	1.	**Ores and Alloys (Non-instrumental)**	**2**
	2.	Analysis of Devarda's alloy	
	3.	Analysis of Cu – Ni alloy	
	4.	Analysis of Tin Solder alloy	
	5.	Analysis of Limestone.	
		Instrumental	
	1.	Estimation of Copper using Iodometric method Potentiometrically.	
	2.	Estimation of Fe^{+3} solution using Ce(IV) ions Potentiometrically	

References:

1. G H Jeffery, J Bassett, J Mendhem, R C Denney, Vogel's Textbook Of Quantitative Chemical Analysis, 3rd Edition, Longman Scientific & Technical,1989.
2. G. N. Mukherjee, Advanced experiments in Inorganic Chemistry, 1st Edition, U.N.Dhur & Sons Pvt. Ltd.2010.
3. H N Patel, S P Turakhia, S S Kelkar, S R Puniyani, Post Graduate Practical Chemistry Part I, Himalaya Publishing House, 5th Edition, 2008.

Course Code : RPSCHE203
Course Title : ORGANIC CHEMISTRY
Academic year 2020-21

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/ Lecture
RPSCHE203		**ORGANIC CHEMISTRY**	**4**
	I	**Alkylation of Nucleophilic Carbon Intermediates**	**(15)**
		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. **1.2.4** Acylation of carbanions.	
	II	**Reactions and Rearrangements**	**(15)**
		Mechanisms, stereochemistry (if applicable) and applications of the following: **2.1 Reactions:** Baylis-Hilman reaction, McMurry Coupling, Corey-Fuchs reaction, Nef reaction, Passerini reaction. **2.2 Concerted 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	**Introduction to Molecular Orbital Theory for Organic Chemistry**	**(15)**
		3.1 Introduction to Molecular Orbital Theory for Organic Chemistry: **3.1.1 Molecular orbitals:** Formation of σ- and π-MOs by using LCAO method. Formation of π MOs of ethylene, butadiene, 1, 3, 5-hexatriene, allyl cation, anion and radical. Concept of nodal planes and energies of π-MOs **3.1.2 Introduction to FMOs:** HOMO and LUMO and significance of HOMO-LUMO gap in absorption spectra as well as chemical reactions. MOs of formaldehyde: The effect of electronegativity perturbation and orbital polarization in formaldehyde. HOMO and LUMO (π and π* orbitals) of formaldehyde. A brief description of MOs of nucleophiles and electrophiles. Concept of 'donor-acceptor' interactions in nucleophilic addition reactions on formaldehyde. Connection of this HOMO-LUMO interaction with 'curved arrows' used in reaction mechanisms. The concept of hardness and softness and its application to electrophiles and nucleophiles. Examples of hard and soft nucleophiles/ electrophiles. Identification of hard and soft reactive sites on the basis of MOs. **3.1.3** Application of FMO concepts in (a) S_N2 reaction, (b) Lewis acid base adducts (BF_3-NH_3 complex), (c) ethylene dimerization to butadiene, (d) Diels-Alder cycloaddition, (e) regioselective reaction of allyl cation with	

		allyl anion (f) addition of hydride to formaldehyde. **3.2 Applications of UV and IR spectroscopy:** **3.2.1 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). **3.2.2 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.	
	IV	**NMR Spectroscopy and Mass Spectrometry**	**(15)**
		4.1.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. **4.2.^{13}C NMR Spectroscopy:** Theory and comparison with proton NMR, proton coupled and decoupled spectra, off-resonance decoupling. Factors influencing carbon shifts, correlation of chemical shifts of aliphatic, olefin, alkyne, aromatic and carbonyl carbons. **4.3.Mass Spectrometry:** Molecular ion peak, base peak, isotopic abundance, metastable ions. Nitrogen rule, Determination of molecular formula of organic compounds based on isotopic abundance and HRMS. Fragmentation pattern in various classes of organic compounds (including compounds containing hetero atoms), McLafferty rearrangement, Retro-Diels-Alder reaction, ortho effect. **4.4.**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

RPSCHE2P3	Organic Chemistry	Credits
	Separation of Binary mixture using Micro-Scale technique 1.Separation of binary mixture using physical and chemical methods. 2.Characterization of one of the components with the help of chemical analysis and confirmation of the structure with the help of derivative preparation and its physical constant. 3.Purification and determination of mass and physical constant of the second component. The following types are expected: (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. **Minimum three mixtures from each type and a total of ten mixtures are expected.**	**2**

References:

1. Systematic Qualitative organic analysis, H. Middleton (Orient Longman)
2. A Handbook of Organic Analysis, H.T. Clark (Orient Longman)
3. Systematic Identification of organic compounds, R.L. Shriner (John Wiley, New York)
4. Practical Organic Chemistry by Mann and Saunders.
5. Advance Practical Organic Chemistry, N.K. Vishnoi, Vikas Publication.

Course Code : RPSCHE204
Course Title : ANALYTICAL CHEMISTRY
Academic year 2020-21

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	Elaborate on the methods of electrogravimetry and coulometry.
CO 5	Compare the advantages/disadvantages of electrogravimetry and coulometry.
CO 6	Describe the functioning of different types of ion selective electrodes.
CO 7	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/ Lectures**
RPSCHE204	**ANALYTICAL CHEMISTRY**		**4**
	I	**Chromatography**	**(15)**
		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	**X-ray Spectroscopy & Mass Spectrometry**	**(15)**
		2.1 X-ray spectroscopy: principle, instrumentation and applications of X-ray fluorescence, absorption and diffraction spectroscopy. (6L) **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. (9L)	
	III	**Surface Analytical Techniques & Atomic Spectroscopy**	**(15)**
		3.1. Surface Analytical Techniques: Introduction, Principle, Instrumentation and Applications of: **3.1.1** Scanning Electron Microscopy (SEM) **3.1.2.**Scanning Tunneling Microscopy (STM)	

		3.1.3. Transmission Electron Microscopy (TEM) **3.1.4.**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.	
	IV	**Electroanalytical Methods**	**(15)**
		4.1. Ion selective potentiometry and Polarography: Ion selective electrodes and their applications (solid state, precipitate, liquid –liquid, enzyme and gas sensing electrodes), ion selective field effect transistors, biocatalytic membrane electrodes and enzyme based biosensors. **4.2. Polarography:** Ilkovic equation, derivation starting with Cottrell equation, effect of complex formation on the polarographic waves. **4.3. Electrogravimetry**: Introduction, principle, instrumentation, factors affecting the nature of the deposit, applications. **4.4. Coulometry:** Introduction, principle, instrumentation, coulometry at controlled potential and controlled current. **(Numericals are Expected)**	

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.

Semester II

Practical

RPSCHE2P4		Analytical Chemistry	Credits
	1.	To determine percentage purity of sodium carbonate in washing soda pH metrically.	**2**
	2.	To determine amount of Ti(III) and Fe(II) in a mixture by titration with Ce(IV) potentiometrically.	
	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 glass calomel system potentiometrically.	
	4.	To determine the amount of nitrite present in the given water sample colorimetrically.	
	5.	To determine the amount of Fe(II) and Fe(III) in a mixture using 1,10-phenanthroline spectrophotometrically.	
	6.	Simultaneous determination of Cr(VI) and Mn(VII) in a mixture spectrophotometrically.	
	7.	To determine the percentage composition of HCl and H_2SO_4 on weight basis in a mixture of two by conductometric titration with NaOH and $BaCl_2$.	
	8.	To determine amount of potassium in the given sample of fertilizers using flame photometer by standard addition method.	

Reference:

G H Jeffery, J Bassett, J Mendhem, R C Denney, Vogel's Textbook Of Quantitative Chemical Analysis, 3rd Edition, Longman Scientific & Technical,1989.

MODALITY OF ASSESSMENT

Theory Examination Pattern:

C) Internal Assessment - 40% - 40 Marks

Presentation: 20 Marks

Continuous Internal Assessment (CIA): 20 Marks

For each paper, learners are evaluated from their presentation based on the topic selected from syllabus. The assessment of presentation is as follows:

Sr. No	Evaluation type	Marks
1	Presentation content	10
2	Presentation skills	05
3	Viva	05
4	Continuous Internal Assessment (CIA) e.g. Test, Group discussion, assignment, open-book tests etc.	20
	Total	40

D) External examination - 60 % - 60 Marks

Semester End Theory Examination - 60 marks

Duration - These examinations shall be of **2.5 hours** duration.

Paper Pattern:

1. There shall be **04** questions each of **15** marks. On each unit, there will be one question.
2. Questions shall be compulsory with internal choice within the questions.

Questions	Options	Marks	Questions based on
Q.1) A)	Any 3 out of 5	12	Unit I
Q.1) B)	Any 1 out of 2	3	
Q.2) A)	Any 3 out of 5	12	Unit II
Q.2) B)	Any 1 out of 2	3	
Q.3) A)	Any 3 out of 5	12	Unit III
Q.3) B)	Any 1 out of 2	3	
Q.4) A)	Any 3 out of 5	12	Unit IV
Q.4) B)	Any 1 out of 2	3	
	Total	**60**	

Practical Examination Pattern:

Semester End Practical Examination: 50 marks

Experimental work	**40**
Viva	**05**
Journal	**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, a Lost Certificate should be obtained from Head/ Coordinator / In-charge of the department; failing which the student will not be allowed to appear for the practical examination.

Overall Examination and Marks Distribution Pattern

Course	**201**			**202**			**Grand Total**
	Internal	**External**	**Total**	**Internal**	**External**	**Total**	
Theory	**40**	**60**	**100**	**40**	**60**	**100**	**200**
Practical			**50**			**50**	**100**
Course	**203**			**204**			**Grand Total**
	Internal	**External**	**Total**	**Internal**	**External**	**Total**	
Theory	**40**	**60**	**100**	**40**	**60**	**100**	**200**
Practical			**50**			**50**	**100**

Total: 600 marks

st Certificate should be obtained from Head/ Coordinator / In-charge of the department; failing which the student will not be allowed to appear for the practical examination.

Overall Examination and Marks Distribution Pattern

Course	**401**			**402** _			**Grand Total**
	Internal	**External**	**Total**	**Internal**	**External**	**Total**	
Theory	**40**	**60**	**100**	**40**	**60**	**100**	**200**
Practical			**50**			**50**	**100**
Course	**403**			**404**			**Grand Total**
	Internal	**External**	**Total**	**Internal**	**External**	**Total**	
Theory	**40**	**60**	**100**	**40**	**60**	**100**	**200**
Practical			**50**			**50**	**100**