Resolution Number: AB/II (20-21).2.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 2020-2021).

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	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**
M.Sc-II (Physical Chemistry)	III	RPSCHEP301	Polymer, Surface & Photochemistry	**4**
		RPSCHEP302	Advanced Instrumental Techniques	**4**
		RPSCHEP303	Atomic and Molecular: Structure and Spectroscopy	**4**
		RPSCHEPEC-I 304	Nano-chemistry, Applied Electrochemistry, Statistical Mechanics & Nuclear Chemistry	**4**
		RPSCHEPEC-II 304	Modern Methods in Instrumental Analysis	**4**
		RPSCHEP3P1	Practical	**2**
		RPSCHEP3P2		**2**
		RPSCHEP3P3		**2**
		RPSCHEP3P4		**2**
	IV	RPSCHEP401	Chemistry: Polymer,Green , Biophysical & Applied	**4**

		RPSCHEP402	Material Sciences and Non-equilibrium Thermodynamics	**4**
		RPSCHEP403	Symmetry, Spectroscopy and Catalysis	**4**
		RPSCHEPOC-I 404	Intellectual Property Rights & Cheminformatics	**4**
		RPSCHEPOC-II 404	Research Methodology	**4**
		RPSCHEP4P1	Practical	**2**
		RPSCHEP4P2		**2**
		RPSCHEP4P3		**2**
		RPSCHEP4P4	Project Evaluation	**2**
M.Sc-II (Inorganic Chemistry)	III	RPSCHEI301	Solid State Chemistry	**4**
		RPSCHEI302	Advanced Instrumental Techniques	**4**
		RPSCHEI303	Bioinorganic and Coordination Chemistry	**4**
		RPSCHEPEC-I 304	Applied Chemistry-I	**4**
		RPSCHEPEC-II 304	Applied Chemistry-II	**4**
		RPSCHEI3P1	Practical	**2**
		RPSCHEI3P2		**2**
		RPSCHEI3P3		**2**
		RPSCHEI3P4		**2**
	IV	RPSCHEI401	Solid state chemistry & Molecular spectroscopy	**4**
		RPSCHEI402	Organometallic & Main group chemistry	**4**
		RPSCHEI403	Symmetry , Spectroscopy techniques & Catalysis	**4**
		RPSCHEIOC-I 404	Intellectual Property Rights & Cheminformatics	**4**
		RPSCHEIOC-II 404	Research Methodology	**4**
		RPSCHEI4P1	Practical	**2**
		RPSCHEI4P2		**2**
		RPSCHEI4P3		**2**
		RPSCHEI4P4	Project Evaluation	**2**
M.Sc-II (Organic Chemistry)	III	RPSCHEO301	Theoretical Organic Chemistry-I	**4**

		RPSCHEO302	Synthetic Organic Chemistry-I	**4**
		RPSCHEO303	Natural Products & Spectroscopy	**4**
		RPSCHEOEC-I 304	Medicinal , Enzymes & Green Chemistry	**4**
		RPSCHEOEC-II 304	Bioorganic Chemistry	**4**
		RPSCHEO3P1	Practical	**2**
		RPSCHEO3P2		**2**
		RPSCHEO3P3		**2**
		RPSCHEO3P4		**2**
	IV	RPSCHEO401	Theoretical Organic Chemistry -II	**4**
		RPSCHEO402	Synthetic Organic Chemistry-II	**4**
		RPSCHEO403	Natural Products & heterocyclic Chemistry	**4**
		RPSCHEOOC-I 404	Intellectual Property Rights & Cheminformatics	**4**
		RPSCHEOOC-II 404	Research Methodology	**4**
		RPSCHEO4P1	Practical	**2**
		RPSCHEO4P2		**2**
		RPSCHEO4P3		**2**
		RPSCHEO4P4	Project Evaluation	**2**
M.Sc-II (Analytical Chemistry)	III	RPSCHEA301	Quality in Analytical Chemistry	**4**
		RPSCHEA302	Advanced Instrumental Techniques	**4**
		RPSCHEA303	Bioanalytical Chemistry & Food Analysis	**4**
		RPSCHEAEC-I 304	Environmental & Certain Industrially Important Materials	**4**
		RPSCHEAEC-II 304	Pharmaceutical & Organic Analysis	**4**
		RPSCHEA3P1	Practical	**2**
		RPSCHEA3P2		**2**
		RPSCHEA3P3		**2**
		RPSCHEA3P4		**2**

	IV	RPSCHEA401	Separation Techniques & Industrial Materials	**4**
		RPSCHEA402	Advanced Instrumental Techniques	**4**
		RPSCHEA403	Environmental & Certain Industrially Important Materials	**4**
		RPSCHEAOC-I 404	Intellectual Property Rights & Cheminformatics	**4**
		RPSCHEAOC-II 404	Research Methodology	**4**
		RPSCHEA4P1	Practical	**2**
		RPSCHEA4P2		**2**
		RPSCHEA4P3		**2**
		RPSCHEA4P4	Project Evaluation	**2**

Resolution Number: AB/II (20-21).2.RPS5

S. P. Mandali's

Ramnarain Ruia Autonomous College

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Syllabus for SEMESTER I and II

Program: M.Sc.

Program Code: (RPSCHE)

(Credit based semester and grading system with effect from the academic year 2020-2021)

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 2020-21.

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, *sp*3orbital 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 $3d_{Z^2}$ 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_N^2 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

Resolution Number: AB/II (20-21).2.RPS5

S.P.Mandali's

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RUIA COLLEGE
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Syllabus for Semester III & IV

Program: M.Sc. (Physical Chemistry)

Program code: RPSCHEP

(Credit Based Semester and Grading System from the academic year 2020–2021)

SEMESTER III			
Course Code	**Unit**	**Course Title / Unit Title**	**Credits**
RPSCHEP301	**Polymer, Surface & Photochemistry**		**4**
	I	Polymer Chemistry-I	
	II	Modern Applications of Surface Chemistry	
	III	Photo Chemistry-I	
	IV	Applications of Fluorescence Phenomena	
RPSCHEP302	**Advanced Instrumental Techniques**		**4**
	I	Spectral Methods-I	
	II	Hyphenated Techniques	
	III	Thermal and Radioanalytical Methods	
	IV	Electroanalytical methods	
RPSCHEP303	**Atomic and Molecular: Structure and Spectroscopy**		**4**
	I	Atomic structure	
	II	Atomic spectroscopy	
	III	Molecular Structure	
	IV	Molecular spectroscopy	
RPSCHEPEC-I304	**Nano-chemistry, Applied Electrochemistry, Statistical Mechanics & Nuclear Chemistry**		**4**
	I	Advances in Nanomaterials	
	II	Advanced electrochemistry	
	III	Statistical Mechanics	
	IV	Nuclear Chemistry	
RPSCHEPEC-II304	**Modern Methods in Instrumental Analysis**		**4**
	I	Miscellaneous spectral methods	
	II	Advanced electro-analytical chemistry -I	
	III	Advanced electro-analytical chemistry -II	
	IV	Mass Spectrometry and Raman Spectroscopy	
RPSCHEP3P1	**Practical**		**8**
RPSCHEP3P2			
RPSCHEP3P3			
RPSCHEP3P4			

SEMESTER IV			
Course Code	**Unit**	**Course Title / Unit Title**	**Credits**
RPSCHEP401		**Chemistry: Polymer, Green, Biophysical and Applied.**	**4**
	I	Polymer Chemistry-II	
	II	Computational Chemistry	
	III	Bio-physical Chemistry and Green Chemistry	
	IV	Photochemistry-II: Kinetics and Applications	
RPSCHEP402		**Material Sciences and Non-equilibrium Thermodynamics**	**4**
	I	Solid State Chemistry	
	II	Instrumental Methods	
	III	Lasers and super conductors	
	IV	Non-equilibrium thermodynamics	
RPSCHEP403		**Symmetry, Spectroscopy and Catalysis**	**4**
	I	Symmetry in Chemistry	
	II	N.M.R. Spectroscopy	
	III	ESR and Mossbauer Spectroscopy	
	IV	Catalysis	
RPSCHEPOC-I404		**Intellectual Property Rights & Cheminformatics**	**4**
	I	Intellectual Property Right -I	
	II	Intellectual Property Right -II	
	III	Cheminformatics-I	
	IV	Cheminformatics-II	
RPSCHEPOC-II404		**Research Methodology**	**4**
	I	Review of Literature	
	II	Data Analysis	
	III	Methods of Scientific Research and Writing Scientific Papers	
	IV	Chemical Safety & Ethical Handling of Chemicals	
RPSCHEP4P1		**Practical**	**8**
RPSCHEP4P2			
RPSCHEP4P3			
RPSCHEP4P4			

SEMESTER III
Course Code: RPSCHEP301
Course Title: POLYMER, SURFACE & PHOTOCHEMISTRY
Academic year 2020-21

Course Outcomes:

After completing this course, the learner will be able to:	
CO 1	Determine molar mass of polymers using different methods.
CO 2	Distinguish the various types of polymers.
CO 3	Classify the surfactants by their process of formation.
CO 4	List the various applications of surfactant in different fields.
CO 5	Illustrate the various deactivation processes of molecular excited states.
CO 6	Describe the photochemical reactivity of ethenes and carbonyl compounds.
CO 7	Explain the application of Fluorescence Phenomena.

DETAILED SYLLABUS

Course Code	Unit	Course Title / Unit Title	Credits/ Lectures
RPSCHEP301		**POLYMER, SURFACE & PHOTOCHEMISTRY**	**4**
	I	**Polymer Chemistry-I**	**(15L)**
		1.1 Introduction: Polymer Science, fundamental terms, historical outline, classification based on: the origin (natural, semi-synthetic, synthetic etc.),the structure(linear, branched, network, hyper branched, dendrimer, ladder, cross linked, IPN),the type of atom in the main chain (homochain, heterochain),the formation(condensation, addition), homo polymers, co polymers(random, alternate, block, graft),the behaviour on application of heat (thermoplastic and (thermosetting),the form and application (plastics, fibre, elastomers and resins).	

		1.2 Molar Mass: Molecular weight averages, fractionation, molecular weight determination by GPC/SEC, end group analysis, viscometry, vapour phase osmometry gradient elution, and molecular weight distribution curve. **1.3 Types of polymerization**: Condensation, addition (cationic and anionic) and copolymerization (with kinetics), chain transfer reactions.	
	II	**Modern Applications of Surface Chemistry.**	**(15 L)**
		2.1 Surface active agents and micelle: **Surface-active agents** and their classification, hydrophile-lipophile balance. **Micellization**: shape and structure of micelles, hydrophobic interaction, critical Micelles concentration (cmc), factors affecting CMC of surfactants, counter ion binding to micelles, micelle catalysis, and reverse micelles. **Emulsions**: Solubilisation, micro emulsions, characterization of microemulsions, **2.2 Hydrogen storage by Adsorption:** **Hydrogen storage**: fundamentals physisorption, temperature and pressure influence, chemisorption, adsorption energy, 'Electrochemical' adsorption. **Practical adsorption**: storage of hydrogen with carbon materials, activated carbon, graphite graphene, carbon Nano structures, fullerene. Carbon Nano fibres (CNF) and graphite Nano fibres electrochemical storage of hydrogen in carbon materials.	
	III	**Photo Chemistry-I**	**(15L)**

		3.1 Photo chemical principles: Environmental effect on absorption and emission spectra, properties of excited states, excited state acidity constants, dipole moments and redox properties, Importance of photochemistry, origin of life. **3.2 Photo physical processes in electronically excited molecules:** Types of photo physical pathways, types of radiation less transitions, fluorescence emission, fluorescence and structure. Triplet state and phosphorescence emission, delayed fluorescence–e type and p-type delayed fluorescence. **3.3 Photo chemical reactions**: ketones, olefins conjugated olefins and aromatic compounds, photosynthesis.	
	IV	**Applications of Fluorescence Phenomena**	**(15L)**
		4.1 Fluorescence sensing: Mechanism of sensing; sensing techniques based on coalitional quenching, energy transfer, electron transfer; examples of pH sensors glucose sensors and protein sensors. **4.2 Novel fluorophores**: Quantum dots, lanthanides and long-lifetime Metal- ligand complexes. **4.3 Radiative decay engineering**: metal enhanced fluorescence **4.4 DNA technology** sequencing.	

Reference Books:

1. P. Bahadur and N.V. Sastry, Principles of Polymer Science, 2nd Edition, Narosa Publishing House, 2005.
2. C.E. Carraher, Jr., Carraher's Polymer Chemistry, 8th Edition, CRC Press, New York, 2010.
3. Joel R. Fried, Polymer Science and Technology, Prentice –Hall of India Pvt. Ltd., 2000
4. V.R. Gowarikar, H.V. Vishwanathan and J. Shreedhar, Polymer Science, New Age International Pvt. Ltd., New Delhi, 1990.
5. M.J. Rosen, Surfactants and Interfacial Phenomena, 3rd Edition, John Wiley, 2004.
6. Y. Moroi, Micelles: Theoretical and Applied Aspects, Plenum Press, New York, 1992.
7. Tushar K. Ghosh, Energy Resources and Systems: Volume 2, Springer Link: Bucher, Springer, 2011.
8. R. Strobel, J. Garche, P.T. Mosely, L.J'orrisen, G. Wolfd, "Review Hydrogen Storage by Carbon Materials", Journal of Power Sources, June 2006
9. C.H. De Puy, O.L.Chapman, Molecular reactions and photochemistry, Prentice Hall of India Pvt. Ltd., 1988.
10. K.K. Rohatgi- Mukherjee, Fundamentals of Photochemistry, Reprint 2002, New Age International Publisher, 1978.
11. B. Valeur, Molecular Fluorescence: Principles and Applications, Wiley –VCH, 2001.
12. J.R. Lakowicz, Principles of Fluorescence Spectroscopy, Springer Publications, 2006.

Course Code: RPSCHEP302
Course Title: ADVANCED INSTRUMENTAL TECHNIQUES
Academic year 2020-21

Course Outcomes:

After studying this course, the learner will be able to-	
CO 1	Make use of the basic working principles of surface analytical techniques (such as SIMS, PIXE) electron spectroscopy and Nuclear Quadrupole Resonance for different applications.
CO 2	Assess hyphenated techniques and the different types of interfaces that are used to achieve this hyphenation.
CO 3	Apply principles of the thermal methods and radiochemical methods for different applications.
CO 4	Develop a working knowledge of various methods used in Voltammetry.
CO 5	Explain anodic, cathodic and adsorptive stripping methods in voltammetry.
CO 6	Select a suitable method of voltammetry for the analysis of a particular sample.

DETAILED SYLLABUS

Course Code	Unit	Course Title / Unit Title	Credits/ Lectures
RPSCHEP302		**ADVANCED INSTRUMENTAL TECHNIQUES**	**4**
	I	**Spectral Methods-I**	**(15L)**
		1.1 Surface Analytical Techniques: Preparation of the surface, difficulties involved in the surface analysis. (1L) **1.2** Principle, instrumentation and applications of the following: **a.** ATR-FTIR spectroscopy (2L) **b.** Secondary Ion mass spectroscopy. (SIMS) (2L) **c.** X-Ray Photoelectron Spectroscopy (XPS) (2L) **d.** Low-Energy Ion Scattering Spectroscopy (LEIS) and Rutherford Backscattering (2L)	

		e. Scanning Probe Microscopy including AFM, CFM (3L) **1.3** Nuclear Quadrupole Resonance (NQR), ENDOR, ELDOR. (3L)	
	II	**Hyphenated techniques**	**(15 L)**
		2.1 Concept of hyphenation, need for hyphenation, possible hyphenations. (1L) **2.2**. Interfacing devices, instrumentation and applications of GC – MS, (Head space GC , Pyrolysis GC), GC -FTIR, (3L) **2.3** LC-MS: Interface and Ionization techniques for LC-MS, Thermospray, Particle beam, FAB, and Atmospheric Pressure Ionization (API) Techniques. (3L) **2.4** Different Mass Analysers, Magnetic Sector, Quadrupole, Ion Trap, Time of Flight, FTICR (3L) **2.5** LC-MS/MS: Tandem MS, Triple Quad MS, Collision Induced Dissociation Cell, Different scan events, MRM transitions. Hybrid MS/MS. Applications of Tandem MS. (3L) **2.6** Radio chromatography (2L)	
	III	**Thermal and Radioanalytical methods**	**(15L)**
		3.1 Enthalpimetric methods and thermometric titrations. **3.2** Thermal analysis- Principle, Interfacing, instrumentation and Applications of **(a)** Simultaneous Thermal Analysis- TG-DTA and TG-DSC **3.3** Evolved gas analysis- TG-MS and TG-FTIR (8L) **3.4** Activation analysis- NAA, radiometric titrations and radio-release methods, isotope dilution method, introduction, principle, single	

		dilution method, double dilution method and applications. **3.5** Auto, X-ray and Gamma Radiography (7L)	
	IV	**Electroanalytical Methods**	**(15L)**
		4.1 Current Sampled (TAST) Polarography, Normal and Differential Pulse Polarography, Differential double Pulse Polarography (2L) **4.2** Potential Sweep methods- Linear Sweep Voltammetry and Cyclic voltammetry. Potential Step method- Chronoamperomertry (2L) **4.3** Controlled potential technique- Chronopotentiometry (2L) **4.4** Stripping Voltammetry- anodic, cathodic, and adsorption (2L) **4.5**.Chemically and electrolytically modified electrodes and ultra- microelectrodes in voltammetry, Biosensor (2L) **4.6** Corrosion and electrochemistry, Use of Galvano stat and potentiostat (3L) **4.7** Spectro-electrochemistry (2L)	

Reference Books:

1. Principles of Instrumental Analysis, D. A. Skoog, F. J. Holler and J.A. Niemann, 5th Edition (1998).
2. Instrumental Methods of Analysis, H. H. Willard, L. L. Merritt Jr, J. A. Dean and F. A. Settle Jr 7th Ed CBS (1986).
3. Introduction to Instrumental Analysis, R. D. Braun, Mc Graw Hill (1987).
4. Analytical Chemistry, G. D. Christian, 4th Ed. John Wiley, New York (1986).
5. Fundamentals of Analytical Chemistry, D .A. Skoog, D. M. West, and F. J. Holler Holt-Saunders 6th Edition (1992).
6. Electroanalytical Chemistry, Ed A. J. Bard and Marcel Dekker, New York, (A series of volumes).
7. Electroanalytical Chemistry, J.J. Lingane, 2nd Ed Interscience, New York (1958).
8. Modern Polarographic Methods in Analytical Chemistry, A. M. Bond, Marcel Dekker, New York, (1980).
9. Introduction to polarography and allied techniques by Kamla Zutski (2006).
10. Surface Analysis –The Principal Techniques, 2nd Edition Edited by John C. Vickerman and

Ian S. Gilmore 2009 John Wiley & Sons, Ltd. ISBN: 978-0-470-01763-0.

11. NMR, NQR, EPR, and Mössbauer Spectroscopy in Inorganic Chemistry *R. V. Parish*. Ellis Horwood, Chichester.

Course Code: RPSCHEP303

Course Title: ATOMIC AND MOLECULAR: STRUCTURE AND SPECTROSCOPY

Academic year 2020-21

Course Outcomes:

After completing this course, the learner will be able to:	
CO 1	Solve the Schrodinger equation for complex system.
CO 2	Compare different theories of Molecule formation
CO 3	Discuss the general principles and theory of spectroscopy
CO 4	Summarize applications of various types of spectroscopic methods.

DETAILED SYLLABUS

Course Code	Unit	Course Title / Unit Title	Credits/ Lectures
RPSCHEP303	**ATOMIC AND MOLECULAR: STRUCTURE AND SPECTROSCOPY**		**4**
	I	**Atomic structure**	**(15L)**
		Introduction to approximate methods in Quantum Mechanics- **1.1 Variation Method**: Variation Theorem, extension of the variation method, determinants, simultaneous linear equations, linear variation functions. **1.2 Perturbation Theory**: Nondegenerate Perturbation Theory, first order wave function correction, first order and second order energy correction. Perturbation treatment of the Helium atom ground state, Variation treatment	

		of the Helium atom ground state, Perturbation Theory for a degenerate energy level **1.3 Multielectron atoms**: Independent electron approximation, electron spin, spin statistic theorem, symmetric and antisymmetric wave function, the Pauli exclusion principle, slater determinants. **1.4 Hartree's method:** Hartree Folk method, Slater type orbitals, orbital energies.	
	II	**Atomic spectroscopy**	**(15 L)**
		2.1 Angular momentum, orbital and spin, total angular momentum, total angular momentum (J) of many electron atoms, Russell Saunders (L-S) coupling and J-J coupling **2.2** Term symbols, term symbols for multi electron atoms like He, Li, Be, B etc. **2.3** Exchange of interactions and multiplicity of states. **2.4** Anomalous Zeeman Effect and Paschen Back effect. **2.5** Atomic spectra and selection rules, energy level diagram of atomic sodium.	
	III	**Molecular Structure**	**(15L)**
		3.1 Chemical Bonding: The Born–Oppenheimer approximation, LCAO method-molecular orbital formation **3.2 Molecular Orbital theory:** MO theory of bonding in hydrogen molecule ion and hydrogen molecule, physical interpretation of bonding and antibonding molecular orbital, calculation of ground state energy, excited state of H_2 singlet and triplet state.	

		3.3Valence bond theory: Heitler-London treatment to hydrogen molecule, resonance, antisymmetric wave function and nature of bonding. Heitler-London Slater Pauling theory. **3.4 Principle of hybridisation:** Directed valence & hybridization in simple polyatomic molecules. (sp, sp^2 and sp^3 hybridisation). **3.5 Huckel theory:** Huckel molecular orbital's Theory for–ethylene, Allyl system, cyclopropenyl, linear butadiene, cyclobutadiene and benzene system.	
	IV	**Molecular Spectroscopy**	**(15L)**
		4.1 Rotational Spectroscopy: Classification of poly atomic Molecules spherical top, symmetric top and asymmetric top molecules, intensity of spectral lines, non-rigid rotor, spectrum of non-rigid rotor, rotational Spectra of polyatomic molecules, Stark effect, Information derived from the rotational spectra. **4.2 Raman Spectroscopy:** Theory of Raman scattering, quantum theory classical theory of molecular polarizability, pure Rotational Raman spectra, Vibrational Raman spectra, polarization and depolarization of Raman lines, structure determination using IR and Raman spectroscopy (example: XY_2, XY_3 and XY_4), instrumentation. **4.3 Electronic Spectra of molecules:** Introduction, vibrational course structure, progressions and sequences, Frank Condon principle, intensity of vibrational electronic spectra, term symbols for linear molecules, selection rules,	

		dissociation and Predissociation, types of electronic transitions-d-d, vibronic, charge transfer, π-π^*, n-π^*transitions, fate of electronically excited states.	

Reference Books:

1. Atkins P.W, Physical Chemistry, Oxford University Press,6th edition,(1998).
2. R. K. Prasad, Quantum Chemistry,3rd Ed., New Age International Publishers,(2006).
3. A. McQuarrie, Quantum Chemistry, Viva Books Private Limited, New Delhi, first Indian ed., (2003).
4. M. L. Gupta, Atomic and Molecular Spectroscopy, New Age International Publishers, (2001).
5. A.K.Chandra, Introductory QuantumChemistry,4McGrawH edition(1994),Tata McGraw-Hill, New Delhi.
6. I.N. Levine, Quantum Chemistry, 5th Edition (2000), Pearson Educ. Inc., New Delhi.
7. James E. House, Fundamentals of Quantum Chemistry, Second Ed., Academic Press,(2005)
8. C.N. Banwell and E.M. Mc Cash, Fundamentals of Molecular Spectroscopy, 4thEd., Tata-McGraw-Hill,(1994).
9. H.S. Randhawa, Modern Molecular Spectroscopy, McMillan India Ltd.,(2003).
10. G.Aruldas, Molecular Structure and Spectroscopy, Prentice-HallofIndia, (2001).
11. Donald L. Pavia, Gary M. Lampman and George S. Kriz, Introduction to Spectroscopy, 3rd Ed., Thomson, Brooks/Cole, (2001).

Course Code: RPSCHEPEC-I304

Course Title : Nano-chemistry, Applied Electrochemistry, Statistical Mechanics & Nuclear Chemistry

Academic year 2020-21

Course Outcomes:

After completing this course, the learner will be able to:	
CO 1	Perceive the concept of nanomaterials and preparation of various nanomaterials for the research in material science
CO 2	Develop the concept of electrochemistry in energy creation which is need of new age by fuel cells, batteries
CO 3	Apply the concept of probability to the thermodynamic properties at micro level
CO 4	Prove derivation of Maxwell-Boltzmann, Fermi-Dirac statistics.
CO 5	Build knowledge of particle accelerators work viz. Linear, cyclotron.
CO 6	Comprehend the concept of nuclear model's Liquid drop, Fermi gas, Shell, Optical etc.
CO 7	Apply knowledge of nuclear radiations in pharma, geology, industry for various applications

DETAILED SYLLABUS

Course Code	Unit	Course Title / Unit Title	Credits/ Lectures
RPSCHEPEC-I 304	**Nano-chemistry, Applied Electrochemistry, Statistical Mechanics & Nuclear Chemistry**		**4**
	I	**Advantages in nanomaterials**	**(15L)**
		1.1 Types of nanomaterials e.g. nanotubes, nanorods, solid spheres, core-shell nanoparticles, mesoporous materials, General preparative methods for various nanomaterials **1.2 Important properties on nanomaterials:** Optical properties of metal and semiconductor nanomaterials, magnetic properties	

		1.3Some special nanomaterials: **Carbon nanotubes-** Types, synthesis using various methods, growth mechanism, electronic structure. **Porous Silicon-** Preparation and mechanism of porous silicon formation, factors affecting porous structure, properties of porous silicon. **Aerogels-** types of aerogels, properties and applications of aerogels **1.5 Application of nanomaterials** in electronics, energy, automobiles, sports and toys, textile, cosmetics, medicine, space and defence. **1.5 Environmental effects of nanotechnology**	
	II	**Advanced Electrochemistry**	**(15L)**
		2.1 Kinetics of Electrode reactions (Electrodics): Essentials of electrode reactions, Butler-Volmmer Model for electrode kinetics, One step, one electron process through potential energy diagram, standard rate constants and transfer coefficients, equilibrium condition and exchange current, current over potential equation, Tafel behaviour. Mass transfer by migration and diffusion, Fick's Law **2.2 Electrochemical device**s: Batteries, Fuel cells, photo electrochemical and dye sensitized solar cells, electrochemical super capacitors, and ion-selective electrodes. **2.3 Corrosion:** Mechanism, Potential – pH diagram, Measurement of corrosion rates, corrosion	

		inhibition-anodic and cathodic protection, passivation.	
	III	**Statistical Mechanics**	**(15L)**
		3.1 Thermodynamic probability: Combinatorial problems, Stirling approximation**,** Lagrange's method, macro and microstates, ensembles, Boltzmann distribution law. **3.2 Partition functions**: Translational, rotational, vibrational, electronic and nuclear partition functions, Expressions for the thermodynamic functions in terms of partition function -Internal energy, heat capacity, the Helmholtz and Gibbs functions, Enthalpy, entropy and equilibrium constants. Sackur – Tetrode equation for the entropy of a mono atomic gas. Molecular partition function. **3.3** Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics. **3.4** Debye and Einstein theory of specific heats of solids.	
	IV	**Nuclear Chemistry**	**(15L)**
		4.1 Charged particle accelerator- linear accelerator, cyclotron, Betatron, Synchro-cyclotron, synchrotron **4.2 Nuclear forces-** characteristics and Meson field theory of nuclear forces **4.3 Nuclear Models-** Liquid drop model**,** Fermi Gas Model, Shell Model, Collective Model, Optical Model. **4.4 Applications of Nuclear radiations-** Geological applications of radioactivity, age of minerals and rocks, age of earth and solar system, medical, industrial and Agricultural applications	

		of radiochemistry, positron emission tomography, Radio immune assay.	

Reference Books:

1. Sulabha K. Kulkarni, Nanotechnology: Principles and Practices, Capital publishing company (2007)
2. Lesley E. Smart and Elaine A. Moore, Solid State Chemistry- An introduction, 3rd Ed., Taylor and Francis, (2005), Chapter 11
3. Atkins P. W, Physical Chemistry, Oxford University Press,6th edition,(1998).
4. Laidler K.J. and Meiser J.H., Physical Chemistry, 2nd edition, CBS publishers & distributors,(1999).
5. John M. Seddon & Julian D. Gale, Thermodynamics and Statistical mechanics, Tutorial Chemistry Texts series,Vol.10,Royal Society of Chemistry,(2001).
6. D. A. McQuarrie, Statistical Mechanics, (1976) Harper and Row Publishers, New York.
7. Silbey RJ & Alberty RA, Physical Chemistry,3rd edition, John Wiley and sons, Inc.(2002).
8. B. K. Agarwal and M. Eisner, Statistical Mechanics,(1988)Wiley Eastern, New Delhi.
9. G. Friedlander, J. W. Kennedy, Nuclear and Radio Chemistry.Third. John Wiley and sons,(1981).
10. H. J. Arnikar, Essentials of Nuclear Chemistry. Wiley Eastern Ltd.,(1989).

Course Code: RPSCHEPEC-II304
Course Title: MODERN METHODS IN INSTRUMENTAL ANALYSIS
Academic year 2020-21

Course Outcomes:

After studying this course, the learner will be able to-	
CO 1	Make use of principles of reflectance methods, photoacoustic spectroscopy, Chemiluminescence methods, and polarimetry for various applications.
CO 2	Discuss advantages of modified electrodes over the classical polarographic methods.
CO 3	Develop a working knowledge of various methods used in modern voltammetry.
CO 4	Outline enhanced Raman spectroscopy techniques, namely Surface Enhanced Raman and Resonance Raman Spectroscopy.
CO 5	Interpret mass spectra of molecules, recognize metastable ion peaks, and correlate peak presence with possible fragmentation mechanisms to arrive at the structure.

DETAILED SYLLABUS

Course Code	Unit	Course Title / Unit Title	Credits/ Lectures
RPSCHEPEC-II304		**MODERN METHODS IN INSTRUMENTAL ANALYSIS**	**4**
	I	**Miscellaneous Spectral Methods**	**(15L)**
		Principle, Instrumentation and Applications of: **1.1.** Reflectance spectroscopy **1.2** Photoacoustic spectroscopy **1.3**Polarimetry: ORD, CD **1.4** Chemiluminescence methods	
	II	**Advanced Electroanalytical Chemistry – I**	**(15 L)**
		2.1 Overview of electrode processes electrocapillary curve and electro-capillary maximum potential	

		2.2 Microelectrodes: mercury electrodes, stationary mercury drop electrodes (SMDE), hanging mercury drop electrodes (HMDE), mercury film electrodes (MFE), carbon paste electrodes and chemically modified electrodes. **2.3:** Three electrode systems in modern Polarography, necessity for and development of new voltammetric techniques and their comparison with classical DC Polarography.	
	III	**Advanced Electroanalytical Chemistry – II**	**(15L)**
		3.1 Voltammetric methods: Sampled DC Polarography, Linear Sweep voltammetry, cyclic voltammetry, diagnostic criteria of cyclic voltammetry. **3.2** Pulsed techniques in Polarography: Normal pulse Polarography, differential pulse Polarography, double differential pulse Polarography. **3.3** Sinusoidal AC polarography, Square wave Polarography **3.4** Applications of electrochemical methods in Organic synthesis.	
	IV	**Mass Spectrometry and Raman Spectroscopy**	**(15L)**
		4.1 Mass spectroscopy: Recapitulation, correlation of mass spectra with molecular structure- interpretation of mass spectra, analytical information derived from mass spectra- molecular identification, meta stable peaks, Fragmentation Reactions **4.2 Raman spectroscopy:**	

		Principle Theory Instrumentation techniques (SERS and Resonance Raman) and Applications of Raman spectroscopy.	

Reference books:

1. Principles of Instrumental Analysis, D. A. Skoog, F. J. Holler and J.A. Niemann, 5th Edition (1998).
2. Instrumental Methods of Analysis, H. H. Willard, L. L. Merritt Jr, J. A. Dean and F. A. Settle Jr 7th Ed CBS (1986).
3. Introduction to Instrumental Analysis, R. D. Braun, Mc Graw Hill (1987).
4. Analytical Chemistry, G. D. Christian, 4th Ed. John Wiley, New York (1986).
5. Fundamentals of Analytical Chemistry, D .A. Skoog, D. M. West, and F. J. Holler Holt-Saunders 6th Edition (1992).
6. Electroanalytical Chemistry, Ed A. J. Bard and Marcel Dekker, New York, (A series of volumes).
7. Electroanalytical Chemistry, J.J. Lingane, 2nd Ed Interscience, New York (1958).
8. Modern Polarographic Methods in Analytical Chemistry, A. M. Bond, Marcel Dekker, New York, (1980).
9. Introduction to polarography and allied techniques by Kamla Zutski (2006).

SEMESTER-III
Practical
Credits: 8

RPSCHEP3P1
1. To estimate the amount of hydrochloric acid and acetic acid in a mixture by titration with an alkali using a pH meter. 2. To determine ΔG, ΔHand ΔS of dissolution of a sparingly soluble salt by conductometry. 3. To titrate potassium ferrocyanide with zinc sulphate and hence to determine the formula of the complex. (Potentiometrically) 4. Dissociation constant of an acid- base indicator by spectrophotometry. 5. Thermodynamic data of electrochemical cell by e.m.f. measurements. 6. Simulations determination of $KMnO_4$ and $K_2Cr_2O_7$ by spectrophotometry.
RPSCHEP3P2
1. To determine the formula of the copper (**II**) ammonia complex by partition method. 2. Molecular weight of a polymer by end group estimation. 3. Determination of the energy of activation and other thermodynamic parameters of activation for the acid catalysed hydrolysis of methyl acetate. 4. To study the order of the reaction between bromate and bromide. 5. To estimate the amount of a salt of an organic acid/ sparingly soluble salt like magnesium carbonate by ion exchange chromatography. 6. To measure the radius of glycerol molecule.
RPSCHEP3P3
1. To determine K_1 and K_2 of a dibasic acid by titration with a base. 2. To determine the composition of a mixture of hydrochloric acid, potassium chloride and ammonium chloride by titration with sodium hydroxide and silver nitrate. 3. To determine the E^0 of the quinhydrone electrode. 4. To determine the ionization constant of bromophenol blue. 5. To determine dissociation constant of p-nitro phenol. 6. To determine the proton ligand stability constant of an organic acid and metal ligand stability constant of its complex by pH measurement.
RPSCHEP3P4
1. To determine the isoelectric point of gelatine by viscosity measurement.

2. Hydrolysis constant of aniline hydrochloride by distribution coefficient method.
3. Effect of salt on the distribution of acetic acid between water ethyl acetate.
4. To determine the effect of ionic strength of a solution on the reaction between potassium persulphate and potassium iodide.
5. To investigate reaction between H_2O_2 and KI.
6. To study the effect of the extended conjugation on the λmax of p-nitro phenol by recording spectrum in acidic and alkaline medium

Reference books:

1. Practical Physical Chemistry, A. Findary, T.A. Kitchner (Longmans, Green and Co)
2. Experiments in Physical Chemistry, J.M. Wilson, K.J. Newcombe, A.R. Denko, R.M.W. Richett (Pergamon Press)
3. Senior Practical Physical Chemistry, B.D. Khosla and V.S. Garg (R. Chand and Co., Delhi.

MODALITY OF ASSESSMENT

Theory Examination Pattern:

E) 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 %

Semester End Theory Assessment - 60 marks

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

ii. Paper Pattern:

a. There shall be **04** questions each of **15** marks. On each unit, there will be one question.

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

Questions	Options	Marks	Questions 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	

Practical Examination Pattern:

Semester End Practical Examination: 50 marks

Experimental work	**40**
Viva	**05**
Journal	**05**

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	**301**			**302**			**Grand Total**
	Internal	**External**	**Total**	**Internal**	**External**	**Total**	
Theory	**40**	**60**	**100**	**40**	**60**	**100**	**200**
Practical			**50**			**50**	**100**
Course	**303**			**304**			**Grand Total**
	Internal	**External**	**Total**	**Internal**	**External**	**Total**	
Theory	**40**	**60**	**100**	**40**	**60**	**100**	**200**
Practical			**50**			**50**	**100**

Total: 600 marks

SEMESTER –IV
Course Code: RPSCHEP401
Course Title : CHEMISTRY: POLYMER, GREEN, BIOPHYSICAL AND APPLIED.
Academic year 2020-21

Course Outcomes:

After completing this course, the learner will be able to:	
CO 1	Elaborate Macromolecule, their properties and its characterization.
CO 2	Account for the fundamental background of Density Functional Theory
CO 3	Prove Hohenberg-Kohn theorems and their application.
CO 4	Apply photo physical kinetics of unimolecular and bimolecular processes using Stern-Volmer kinetics.
CO 5	Appraise physical chemistry involved in biological process.
CO 6	Measure thermodynamic parameters for different interactions that are important for the formation of structures in biological systems.
CO 7	Compare the different techniques of electrophoresis
CO 8	Discuss important uses of the solar cell.

DETAILED SYLLABUS

Course Code	Unit	Course Title / Unit Title	Credits/ Lectures
RPSCHEP401		**CHEMISTRY: POLYMER, GREEN, BIOPHYSICAL AND APPLIED.**	**4**
	I	**Polymer Chemistry-II**	**(15L)**
		1.1 Polymers in solid state – Transitions (glass transition and crystalline melting temperature), crystalline behaviour, factors affecting crystallinity, polymer blends and alloys. **1.2 Identification and characterization of polymers**: Chemical analysis- End group analysis; Physical analysis by Spectral methods: IR, UV, Raman, NMR, X-ray Diffraction analysis, Microscopic	

		methods: SEM, TEM, Thermal analysis-TGA, DTA, DSC. **1.3 Properties of polymers**: Thermal (glass transition temperature, and its determination), mechanical (deformation and fracture) effects in polymers, viscoelasticity surface (surface tension, hardness, friction, abrasion), physical (Impact strength, Tensile strength, solubility) of polymers, weather ability, rheology and mechanical models, mechanical behaviour, Rubber elasticity, **1.4 Polymer degradation and stabilization**: Oxidative, thermal, radiation, Biodegradation	
	II	**Computational Chemistry**	**(15 L)**
		2.1 Semi-empirical Theories: Recapitulation of Hückel method, extended Hückel method, ZDO approximation, CNDO/INDO methods, Molecular Properties, Computational aspects, **2.2 Density Functional Theory:** Introduction, Hohenberg-Kohn Theorem, N and V representability, Levy Functional, Kohn Sham equations, Functional derivatives and local potentials, Thomas Fermi theory, The Kohn-Sham construction, Fractional occupation numbers, Janak's theorem.	
	III	**Biophysical Chemistry and Green Chemistry**	**(15L)**
		3.1 Biophysical Chemistry **Introduction to Complex Biomolecules:** Proteins, enzymes, DNA, RNA, polysaccharides and lipids. chirality and pH dependence of biomolecules. **Biosensors:** Enzyme based, Electrochemical,	

		immunosensor, fluorescence, optical, Piezoelectric Biosensors. **Electrophoresis (Technique for bio-molecular study):** Principle and factors affecting electro-phoretic mobility, zone electrophoresis–Paper electrophoresis, cellules acetate electrophoresis, Gel electrophoresis. Capillary Electrophoresis, Application of electrophoresis. **3.2 Green Chemistry:** Recapitulation of principles of green chemistry, Waste minimization techniques. Catalysis and Green Chemistry: Phase transfer catalysts, biocatalyst, photo catalysis. Organic solvents, solvent free system, supercritical fluid, ionic liquid, their characteristics, use as catalyst and solvents. Alternative energy sources for initiation and execution of chemical reaction: Microwave and sonochemistry.	
	IV	**Photochemistry-II: Kinetics and Applications**	**(15L)**
		4.1 Photophysical Kinetics of bimolecular processes. Mechanism of fluorescence quenching, Collisions in solutions, Kinetics of collisional quenching and Stern-Volmer equation and deviations from Stern Volmer equation, Concentration dependence of quenching and excimer formation, quenching by added substances–charge transfer mechanism and energy transfer mechanism. **4.2 Solar Cells:** Photovoltaic and photo galvanic cells; photoelectron chemistry; prospects of solar energy conversion and storage, organic solar cells.	

Reference Books:

1. P. Bahadur and N. V. Sastry, Principles of Polymer Science, second edition, Narosa Publishing House,(2005).
2. C. E. Carraher, Jr., Carraher's Polymer Chemistry, 8thedition, CRC Press, New York,(2010).
3. Joel R. Fried, Polymer Science and Technology, Prentice-Hall of India Pvt. Ltd.,(2000).
4. V.R. Gowarikar, H.V. Viswanathan and J. Sreedhar, Polymer Science. New Age International Pvt. Ltd., New Delhi, (1990).
5. U.N Dash,. A Text Book of Biophysical Chemistry, Macmillan India Ltd.
6. Gurtu and Gurtu, Biophysical Chemistry, Pragati Prakashan.
7. Mike Lancaster, Green Chemistry an Introductory Text, Royal Society of Chemistry.
8. K.K.Rohatgi- Mukherjee. Fundamentals of Photochemistry. Reprint 2002. New Age International Publisher, (1978).
9. Approximate Molecular Orbital Theory, J. A. Pople and D. L. Beveridge, McGraw Hill, New York (1971)
10. Molecular Modelling, A. Leach, Longman, Landon (1996).

Course Code: RPSCHEP402

Course Title : Material Sciences and Non-equilibrium Thermodynamics

Academic year 2020-21

Course Outcomes:

After completing this course, the learner will be able to:	
CO 1	Relate concept of bonding for structure of crystalline solids.
CO 2	Explain different types of lattices, unit cells and defects in crystal in detail.
CO 3	Assess structure determination by powder diffraction and single crystal X-ray diffraction.
CO 4	Develop concept of lasers in chemistry, its generation, characteristics and types of lasers.
CO 5	Describe applications of lasers in chemistry such as spectroscopy, isotope separation, and kinetics of fast reactions.
CO 6	Make use of Band theory for working of superconductors and magnetic properties.
CO 7	Explain second law of thermodynamics at non-equilibrium i.e. entropy production and rate. Also, comprehend principle of microscopic reversibility and transport phenomena across membranes.

DETAILED SYLLABUS

Course Code	Unit	Course Title / Unit Title	Credits/ Lectures
RPSCHEP402	**Material Sciences and Non-equilibrium Thermodynamics**		**4**
	I	**Solid State Chemistry**	**(15L)**
		1.1. Bonding and Structure: Classification of solids based on nature of force.(ionic, metallic, van der Waal's, hydrogen bonded), crystal structures. **1.2.**Symmetry and choice of unit cell, Bravais lattice, Miller indices, Point groups and space groups, Close packing, Lattices and unit cells. **1.3.** Crystalline solids, ionic radii, radius ratio rule, lattice energy, lattice energy, crystal structure	

		determination by powder diffraction, and single crystal X-ray diffraction. **1.4.** Defects and non-stoichiometry: point defects, plane defects, line defects. Solid solutions Diffusion in solids: Mechanisms, Steady state and non-steady state diffusion, factors affecting diffusion.	
	II	**Instrumental Methods**	**(15 L)**
		2.1 X-Ray Diffraction: Introduction to XRD, Diffraction of waves by crystal, particle and solid. Generation of X Rays (K shell knockout), Bragg condition, Bragg method, Miller indices, Methods of diffraction, Laue method, Debye-Scherrer method of X ray structural analysis of crystals, Advantages of these methods, Index reflections, Identification of unit cells from systematic absences in diffraction pattern, Uses of powder XRD. **2.2 Electron and Neutron Diffraction** **2.2.1 Electron diffraction**: Diffraction patterns for single crystal, polycrystalline and amorphous material. Difference between X-ray and electrons, experimental technique. Applications of electron diffraction **2.2.2 Neutron diffraction**: Properties of neutron, Principle of neutron scattering, comparison with X-rays. Advantages of neutron scattering, scattering of neutrons by solids and liquids.	
	III	**Lasers and Super conductors**	**(15L)**
		3.1 Lasers in chemistry **General principles of LASER action**-Population Inversion, cavity and mode characteristics, Q-switching, Mode locking.	

		Practical lasers- Solid state lasers-Ruby, neodymium, gas lasers-He- Ne, Ar, Kr, Carbon dioxide, Chemical and exciplex Lasers, Dye lasers LED and Semiconductor Lasers**.** **Applications of Lasers in chemistry:** Spectroscopy at high photon fluxes, collimated beams, Precision specified transitions, Isotope separation, Study of fast reactions using pulsed techniques**.** **3.2 Super conducting solid materials** Band theory of electrical conductivity, Bardeen-Cooper-Schriffer Theory of super conductivity, the superconducting state, High critical temperature super conductors, magnetic properties of superconductors.	
	IV	**Non-equilibrium thermodynamics**:	**(15L)**
		4.1 Features of non-equilibrium thermodynamics, second law of thermodynamics, uncompensated heat and its relation to thermodynamics function. **4.2** Entropy production and its rate. Entropy production in heat transfer process and during mixing of gases. Entropy production and efficiency of galvanic cell. **4.3** Onsager's theory: Reciprocal relation, principle of microscopic reversibility. **4.4** Coupled and uncoupled reactions and their condition. **4.5**Transport phenomena across membranes. Electro kinetic effect and thermomechanical effects.	

Reference Books:

1. Keer H.V, Principles of the Solid State, first reprint, Wiley Eastern Limited,(1994).
2. R.S. Drago, Physical Methods for Chemists, 2nd edition, Saunders College Publishing (1992)
3. A.R.West,Solid State Chemistry and its Applications,John Wiley and Sons (Asia) Pvt.Ltd.,
4. L.E.Smart and E.A.Moore, Solid State Chemistry–An Introduction,3rdEd., Taylor and Francis, (2005).
5. P.W, Physical Chemistry, Oxford University Press, 6th edition, (1998).
6. E.D.Kaufmann, Advanced Concepts in Physical Chemistry, McGraw-Hill,(1966).
7. C.Kalidas and M.V.Sangaranarayan, Non-Equilibrium Thermodynamics, Principlesand Applications, McMillanIndia Ltd.,(2002).
8. S. Glasstone, Theoretical Chemistry, Affiliated East–West Press Pvt. Ltd., New Delhi, (1973).

Course Code: RPSCHEP403

Course Title : Symmetry, Spectroscopy and Catalysis

Academic year 2020-21

Course Outcomes:

After completing this course, the learner will be able to:	
CO 1	Describe the selection rule for infrared-active transitions.
CO 2	Determine whether the molecular vibrations of a triatomic molecule are Raman active.
CO 3	Analyse the hybridization of given compounds.
CO 4	Explain concepts of equivalent and non-equivalent hydrogens.
CO 5	Assess effect of structure on chemical shift and coupling constants.
CO 6	Elucidate the electronic structure of free radicals and paramagnetic transition metal complexes.
CO 7	Comprehend magnetic properties of the materials and its order of orientations.

DETAILED SYLLABUS

Course Code	Unit	Course Title / Unit Title	Credits/ Lectures
RPSCHEP403	**Symmetry , Spectroscopy & Catalysis**		**4**
	I	**Symmetry in Chemistry**	**(15L)**
		1.1 Recapitulation of Points groups and Character tables. **1.2** Applications of Group theory in Infrared and Raman spectroscopy. Molecular Vibrations, determining the Symmetry Types of the Normal Modes; symmetry-based Selection Rules of IR and Raman, application in Infrared and Raman spectroscopy for molecules belongs to point group C_{2v}, C_{3v}, C_{4v}, D_{2h}, D_{3h}, $D_{\infty h}$ and T_d. **1.3** Group theory and quantum mechanics. Wave function as bases for irreducible representation. **1.4.**Symmetry Adapted Linear Combinations - (SALC) - projection operators and their use to construct SALC. **1.5** Molecular Orbital Theory. Transformation properties of atomic orbitals, MO's for Sigma and pi - molecular orbitals in AB_n molecules, AB_4 (tetrahedral) and AB_6 (octahedral) molecules, Hybrid orbitals.	
	II	**N.M.R. Spectroscopy**	**(15 L)**
		2.1 Nuclear Magnetic Resonance (NMR) Spectroscopy: Nuclear spin and its interaction with applied field, population of energy state, relaxation time, ^{1}H NMR Spectroscopy: Chemical Shift; Multiplet Splitting of NMR peaks arises through Spin–Spin Coupling,	

		Multiplet Splitting when more than two spins interact. **2.3 Pulse technique in NMR:** The magnetization vector, spin-spin relaxation, spin-lattice relaxation. **2.4.^{13}C NMR Spectroscopy:** Fourier Transform NMR; Off-Resonance and Spin-Decoupled, DEPT, Applications, 2-D NMR Spectroscopy (COSY). Nuclear Overhauser Effect Spectroscopy (NOESY). **2.5**Solid-state NMR **2.6** Magnetic Resonance Imaging (MRI); **2.7** NMR Spectroscopy of ^{19}F, ^{15}N and ^{31}P nuclides.	
	III	**ESR and Mossbauer Spectroscopy**	**(15L)**
		3.1 Electron spin Resonance Spectroscopy- **3.1.1** Basic principle, hyperfine splitting (isotropic systems); **3.1.2**.g-value and the factors affecting there of; interactions affecting electron energies in paramagnetic complexes (Zero-field splitting and Kramer's degeneracy); **3.1.3.**An isotropic effect (the g-value and the hyperfine couplings); The EPR of triplet states; Structural applications to transition metal complexes. **3.2 Mossbauer Spectroscopy:** Basic principles of Mössbauer spectroscopy, instrumentation, spectral parameters a) Mössbauer Parameters- Isomer Shifts, quadrupole splitting, Magnetic hyperfine interaction. b) Application of Mössbauer spectroscopy with respect to	

		i) Oxidation states of metal ion in compounds ii) Structural elucidation iii) Covalent and ionic compounds iv) High spin low spin behaviour	
	IV	**Catalysis**	**(15L)**
		4.1 Introduction, history and importance of catalysis, concept of activity, selectivity, poisoning, promotion, turnover number and deactivation, **4.2** Types of catalysis: homogeneous catalysis: examples of homogeneous catalysis in gas phase, and in solution phase, acid-base catalysis. **4.3** heterogeneous catalysis: heterogeneous catalysis with gaseous reactants, liquid reactants, and gaseous reactants, biocatalysis, autocatalysis, negative catalysis, characteristics of catalytic reactions, activation energy and catalysis, theories of catalysis: the intermediate compound formation theory, the adsorption theory **4.4** Mechanism of heterogeneous catalysis, kinetics of heterogeneous catalytic reactions, Langmuir-Hinshelwood model, Catalysis by semiconductors, Boundary Layer theory, Wolkenstein's theory, **4.5** Preparation and Characterisation of Catalysts: General methods of preparation of catalysts: precipitation, sol-gel, hydrothermal, impregnation, hydrolysis, vapour deposition. Activation of catalysts: calcinations, reduction. Catalyst characterization: surface area, pore size distribution, particle size determination, XPS, AES, UV-Vis, FTIR and thermal methods	

Reference Books:

1. Heterogeneous Catalysis, D. K. Chakrabarty and B. Viswanathan, Hardcover - Oct 2008 New Age International Publishers).
2. Catalytic Chemistry, B. C. Gates, John Wiley and Sons Inc. (1992).
3. R.L.Carter, Molecular symmetry and Group theory, Wiley Learner Ed., 1996, John Wiley and Sons, (Asia) Pvt.Ltd.
4. C.N.Banwell and E.M.McCash, Fundamentals of Molecular Spectroscopy, 4thEd., Tata-McGraw-Hill, (1994).
5. M. L. Gupta, Atomic and Molecular Spectroscopy, New Age International Publishers, (2001).
6. G.Aruldas, Molecular Structure and Spectroscopy, Prentice-Hall of India, (2001).
7. J.Michael Hollas, Modern Spectroscopy, 4thEd., John Wiley and Sons, (2004).
8. F.A.Cotton, Chemical applications of Group Theory, Wiley Learner Ed., 2006, John Wiley and Sons,(Asia) Pvt.Ltd.

Course Code: RPSCHEPOC-I 404
Course Title : INTELLECTUAL PROPERTY RIGHTS & CHEMINFORMATICS
Academic year 2020-21

Course Outcomes:

After completing this course, the learner will be able to:	
CO 1	Relate concept of intellectual property and the terms involved with respect to Indian Patent Law.
CO 2	Distinguish between patents and copyrights.
CO 3	Compare the economic impact and legislature involved in Intellectual property rights.
CO 4	Build knowledge about software tools pertaining to Cheminformatics and Molecular Modelling.
CO 5	Determine structure and sub-structure search online, determine SMILES codes for various molecules.
CO 6	Summarize knowledge about the application of the research-based tools.

DETAILED SYLLABUS

Course Code	Unit	Course Title / Unit Title	Credits/ Lectures
RPSCHEPOC-I 404	**INTELLECTUAL PROPERTY RIGHTS & CHEMINFORMATICS**		**4**
	I	**Intellectual Property Rights-I**	**(15 L)**
		1.1 Introduction to Intellectual Property: Historical Perspective, Different types of IP, Importance of protecting IP **1.2 Patents:** Historical Perspective, Basic and associated right, WIPO, PCT system, Traditional Knowledge, Patents and Health care-balancing promoting innovation with public health, Software patents and their importance for India. **1.3 Industrial Designs:** Definition, how to obtain, features, International design registration. **1.4 Copyrights:** Introduction, how to obtain, Differences from Patents. **1.5 Trade Marks:** Introduction, how to obtain, Different types of marks – Collective marks, certification marks, service marks, trade names etc. **1.6 Geographical Indications:** Definition, rules for registration, prevention of illegal exploitation, importance to India.	
	II	**Intellectual Property Rights-II**	**(15 L)**
		2.1 Trade Secrets: Introduction and Historical Perspectives, Scope of Protection, Risks involved and legal aspects of Trade Secret Protection.	

		2.2 IP Infringement issue and enforcement: Role of Judiciary, Role of law enforcement agencies – Police, Customs etc. **2.3 Economic Value of Intellectual Property:** Intangible assets and their valuation, Intellectual Property in the Indian context – Various Laws in India Licensing and Technology transfer. **2.4 Different International agreements:** - **World Trade Organization (WTO):** (i) General Agreement on Tariffs and Trade (GATT), Trade Related Intellectual Property Rights (TRIPS) agreement (ii) General Agreement on Trade Related Services (GATS) Madrid Protocol. (iii)Berne Convention (iv)Budapest Treaty - **Paris Convention** - **WIPO** and **TRIPS, IPR** and Plant Breeders Rights, IPR and Biodiversity.	
	III	**Cheminformatics-I**	**(15L)**
		3.1 Introduction to Cheminformatics: History and evolution of cheminformatics, Use of Cheminformatics, Prospects of cheminformatics, Molecular modelling and structure elucidation. **3.2 Representation of molecules and chemical reactions:** Nomenclature, Different types of notations, SMILES coding, Matrix representations, Structure of Molfiles and Sdfiles, Libraries and toolkits, Different electronic effects, Reaction classification. **3.3 Searching Chemical Structures:**	

		Full structure search, sub-structure search, basic ideas, similarity search, three-dimensional search methods, basics of computation of physical and chemical data and structure descriptors, data visualization.	
	IV	**Cheminformatics-II**	**(15L)**
		4.1 Prediction of Properties of Compound, Linear Free Energy Relations, Quantitative Structure – Property Relations, Descriptor Analysis, Model Building, Modelling Toxicity, Structure – Spectra correlations, Prediction NMR, IR and Mass spectra. **4.2** Computer Assisted Structure elucidations, Computer assisted Synthesis Design, Introduction to drug design, Target Identification and Validation, Lead Finding and Optimization, analysis of HTS data, Virtual Screening, Design of Combinatorial Libraries, Ligand-based and Structure based Drug design. **4.3** Application of Cheminformatics in Drug Design.	

Reference Books:

1. Vivien Irish, Intellectual Property Rights for Engineers, 2nd Edition, British Library, (2008).
2. David I. Bainbridge, Intellectual Property, 8th Edition, Pearson, (2010).
3. Stephen Elias and Richard Stim, Patent Copyright & Trade Mark, 8th Edition, Nolo and Richard, (2013).
4. Johann Gasteiger and Thomas Engel, Chemoinformatics, Wiley-VCH, (2003).
5. Andrew R. Leach, Valerie J. Gillet, An Introduction to Chemoinformatics, Springer, (2007).
6. Barry A. Bunin, Jurgen Bajorath, Brian Siesel and Guillermo Morales, Chemoinformatics-Theory, Practice and Products, Springer, (2007)

Course Code: RPSCHEPOC-II 404
Course Title : RESEARCH METHODOLOGY
Academic year 2020-21

Course Outcomes:

After completing this course, the learner will be able to:	
CO 1	Perceive basics of research methodology
CO 2	Conduct research by developing a problem
CO 3	Develop research paper writing, study formats of existing research papers and review papers
CO 4	Appraise importance of lab-safety and the safety protocols in R&D laboratories.

DETAILED SYLLABUS

Course Code	Unit	Course Title / Unit title	Credits/ Lectures
RPSCHEPOC-II 404	**RESEARCH METHODOLOGY**		**4**
	I	**Review of Literature**	**(15L)**
		1.1 Print: Primary, Secondary and Tertiary sources. **1.2 Journals:** 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. **1.3 Digital:** 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. **1.4 Information Technology and Library Resources:** The Internet and World wide web, Internet resources for Chemistry, finding and citing published information.	
	II	**Data Analysis**	**(15 L)**
		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**	**(15L)**
		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**	**(15L)**
		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 Books:

1. C. R. Kothari, Research Methodology- Methods and techniques, New Age International (P) Limited Publisher, (2004).
2. Yogesh Kumar Singh, Fundamental of Research Methodology and Statistics, New Age International (P) Limited Publisher, (2006).
3. Carol Ellison, Concise Guide to Writing Research Ppaers, McGraw-Hill, (2016).
4. Introductory Statistics, Prem S. Mann, C. Jay Lacke, 7th Edition, John Wiley and Sons, (2010).
5. Statistics From A to Z - Confusing Concepts Clarified, Andrew A. Jawlik, John Wiley and Sons, (2016)

SEMESTER-IV

Practical

Credits: 8

RPSCHEP4P1
1. To determine hydrolysis constant and degree of hydrolysis of ammonium chloride and hence to estimate the dissociation constant of the base. 2. To determine the liquid junction potential with a concentration cell with and without transference. 3. To determine the molar conductance of a weak electrolyte at infinite dilution hence to determine its dissociation constant. 4. Determination of energy of n to Π* transition in acetone and study of effect of solvent on energy of this transition by recording absorbance spectra in n-hexane and water. 5. Determination of isosbestic point of a given dye molecule by spectrophotometric method. 6. To determine the proton ligand stability constant of an organic acid and metal ligand stability constant of its complex by pH measurement.
RPSCHEP4P2
1. To determine the formula of the zinc (II) ammonia complex by partition method. 2. Determination of the chain linkage in poly (vinyl alcohol) from viscosity measurements. 3. To study the kinetics of the decomposition of hydrogen peroxide in presence of ferric chloride solution and hence to study the effect of the catalyst on the decomposition reaction. 4. To determine the rate constant and the order of the reaction between persulphate and iodide ions. 5. To determine the energy of activation and other thermodynamic parameters of activation for the reaction between persulphate and potassium iodide. 6. To determine the equilibrium constant for the reaction. $CaSO_4$ (s) + $2Ag^{+1}$ (aq) = Ag_2SO_4(s) + Ca^{-2} (aq)
RPSCHEP4P3
A. Interpretation of spectra/data: 1. Interpretation of vibrational-rotational spectra of rigid and non-rigid diatomic molecules 2. Interpretation of electronic spectra of diatomic molecules.

3. Interpretation of electronic spectra of simple polyatomic molecules. 4. Interpretation of NMR, ESR spectra. 5. Analysis of XRD pattern of cubic system 6. Interpretation of DTA, TG, and DTG curves **B. Use of plane-wave DFT based code: Quantum Espresso** **Part 1:** Using DFT for structure optimization or relaxation of structures and self-consistent field calculations for simple molecules or crystals. **Part 2:** Interpretation of data from relaxation process, plotting of total and partial atom projected Density of States (DOS), obtaining band gap and deducing magnetic properties.
RPSCHEP4P4
Project Evaluation

Reference books:

1. Practical Physical Chemistry, A. Findary, T.A. Kitchner (Longmans, Green and Co)
2. Experiments in Physical Chemistry, J.M. Wilson, K.J. Newcombe, A.R. Denko, R.M.W. Richett (Pergamon Press)
3. Senior Practical Physical Chemistry, B.D. Khosla and V.S. Garg (R. Chand and Co., Delhi)

MODALITY OF ASSESSMENT

Theory Examination Pattern:

F) 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 %

Semester End Theory Assessment - 60 marks

1. Duration - These examinations shall be of **2.5 hours** duration.
2. Paper Pattern:

There shall be **04** questions each of **15** marks. On each unit, there will be one question.

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

Questions	Options	Marks	Questions 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	

Practical Examination Pattern:

Semester End Practical Examination: 50 marks

Experimental work	**40**
Viva	**05**
Journal	**05**

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	**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**

Total: 600 marks

Resolution Number: AB/II (20-21).2.RPS5

S. P. Mandali's

Ramnarain Ruia Autonomous College

(Affiliated to University of Mumbai)

Syllabus for SEMESTER III and IV

Program: M.Sc. (Inorganic Chemistry)

Program Code: RPSCHEI

(Credit based semester and grading system with effect from the academic year 2020-2021)

SEMESTER III			
Course Code	**Unit**	**Course Title / Unit Title**	**Credits**
RPSCHEI301		**SOLID STATE CHEMISTRY**	**4**
	I	Descriptive Crystal Chemistry	
	II	Imperfection in crystals and Non Stoichiometry	
	III	Methods of Preparations	
	IV	Behavior of Inorganic Solids	
RPSCHEI302		**ADVANCED INSTRUMENTAL TECHNIQUES**	**4**
	I	Spectral Methods	
	II	Hyphenated Techniques	
	III	Radiochemical and Thermal Methods	
	IV	Electroanalytical Methods	
RPSCHEI303		**BIOINORGANIC AND COORDINATION CHEMISTRY**	**4**
	I	Bioinorganic Chemistry	
	II	Reactivity of Chemical Species –I	
	III	Reactivity of Chemical Species –II	
	IV	Synthesis, Structure, Bonding and Stereochemistry	
RPSCHEIEC-I 304		**APPLIED CHEMISTRY-I**	**4**
	I	Manufacture and Applications of Inorganic Compounds	
	II	Metallurgy	
	III	Inorganic Pharmaceuticals	
	IV	Environmental Monitoring and Assessment	
RPSCHEIEC-II 304		**APPLIED CHEMISTRY-II**	**4**
	I	Advances in Nanomaterials	
	II	Inorganic Materials	
	III	Nuclear Chemistry and Some Selected Topics	
	IV	Safety in Chemistry Laboratories	
RPSCHEI3P1		**Practical**	**8**
RPSCHEI3P2			
RPSCHEI3P3			
RPSCHEI3P4			

SEMESTER IV			
Course Code	**Unit**	**Course Title / Unit Title**	**Credits**
RPSCHEI401		**Solid state chemistry & Molecular spectroscopy**	**4**
	I	Inorganic Materials Properties – I (Electrical and Thermal Properties)	
	II	Inorganic Materials Properties – II (Magnetic and Optical Properties)	
	III	Diffraction Methods	
	IV	Molecular Spectroscopy	
RPSCHEI402		**Organometallic &Main group chemistry**	**4**
	I	Clusters and The Isolobal Analogy	
	II	Applications of Organometallic Chemistry to Organic Synthesis	
	III	Inorganic Cluster and Cage compounds	
	IV	Inorganic – Rings – Chains –Polymer	
RPSCHEI403		**Symmetry , Spectroscopy techniques &Catalysis**	**4**
	I	Symmetry in Chemistry	
	II	N.M.R. Spectroscopy	
	III	ESR and Mossbauer Spectroscopy	
	IV	Catalysis	
RPSCHEIOC-I 404		**Intellectual Property Rights &Cheminformatics**	**4**
	I	Intellectual Property – I	
	II	Intellectual Property – II	
	III	Cheminformatics – I	
	IV	Cheminformatics – II	
RPSCHEIOC-II 404		**Research methodology**	**4**
	I	Review of Literature	
	II	Data Analysis	
	III	Methods of Scientific Research And Writing Scientific Papers	
	IV	Chemical Safety & Ethical Handling Of Chemicals	
RPSCHEI4P1		**Practical**	**8**
RPSCHEI4P2			
RPSCHEI4P3			
RPSCHEI4P4			

Course Code: RPSCHEI301
Course Title: SOLID STATE CHEMISTRY
Academic year 2020-21

Course Outcomes:

After studying this course, the learners will be able to-	
CO 1	Predict the structures of some known type of compounds based on their stoichiometry like AB, AB_2 etc.
CO 2	Classify the oxides based on structure whether inverse, normal or random and how the polyhedra forms by sharing its corner, edge or face.
CO 3	Have a clear distinction between Perfect and imperfect crystals and how these defects lead to change the properties of solids.
CO 4	Be well versed with the methods available to synthesize the inorganic solids based on the compositions.
CO 5	Identify the importance of Single Crystal and its method of preparation.
CO 6	Understand the behavior studies of solids using diffusion as property. Applications of Liquid Crystals.

DETAILED SYLLABUS

Course Code	Unit	Course Title / Unit Title	Credits/ Lectures
RPSCHEI301		**SOLID STATE CHEMISTRY**	**4**
	I	**Descriptive Crystal Chemistry**	**(15L)**
		1.1.Simple structures: Structures of **AB** type compounds (PbO and CuO), **AB_2**type (β cristobalite, CaC_2 and Cs_2O), **A_2B_3**type (Cr_2O_3 and Bi_2O_3), AB_3 (ReO_3, Li_3N), **ABO_3**type, relation between ReO_3 and perovskite $BaTiO_3$ and its polymorphmic forms, Oxide bronzes, ilmenite structure, **AB_2O_4**type, normal, inverse, and random spinel Structures. **1.1 Linked Polyhedra:** **1.1.1** Corner sharing: tetrahedral structure (Silicates) and octahedral structure (ReO_3) and rotation of	

		ReO_3 resulting in VF_3, RhF_3 and calcite type structures. **1.1.2** Edge sharing: tetrahedral structures (SiS_2) and octahedral structures (BiI_3 and $AlCl_3$). pyrochlores, octahedral tunnel structures and lamellar structures.	
	II	**Imperfection in crystals and Non- Stoichiometry**	**(15L)**
		2.1 Point defects: Point defects in metals and ionic Crystal – Frenkel defect and Schottky defect. Thermodynamics formation of these defects(Mathematical derivation to find defect concentration); Defects in non- Stoiochiometric compounds, colourcentres. **2.2 Line defects**: Edge and Screw Dislocations. Mechanical Properties and Reactivity of Solids. **2.3 Surface Defects**: Grain Boundary and Stacking Fault. Dislocation and Grain Boundaries, Vacancies and Interstitial Space in Non-Stoichiometric Crystals, Defect Clusters, Interchangeable Atoms and Extended Atom Defects.	
	III	**Methods of Preparations**	**(15L)**
		3.1 Methods of Synthesis: Chemical Method, High Pressure Method, Arc Technique and Skull Method (with examples). **3.2 Different methods for single crystal growth:** **3.2.1** Crystal Growth from Melt: Bridgman and Stockbargar, Czochralski and Vernuilmethods. **3.2.2** Crystal growth from liquid solution: Flux growth and temperature gradient methods **3.2.3** Crystal growth from vapor phase: Epitaxial growth methods.	

		3.3 Thin film preparation: Physical and Chemical methods. **3.4 Solid Solutions:** Formation of Substitutional, Interstitial and Complex Solid Solutions; Mechanistic Approach; Study of Solid solutions by X-ray Powder Diffraction and Density Measurement.	
	IV	**Behavior of Inorganic Solids**	**(15L)**
		4.1 Diffusion in Solids: Fick's Laws of Diffusion; Kirkendal Effect; Wagner mechanism, Diffusion and Ionic Conductivity; Applications of Diffusion in Carburizing and non-Carburizing Processes in Steel Making. **4.2 Solid state reactions**: General principles and factors influencing reactions of solids, Reactivity of solids. **4.3 Liquid Crystals**: Introduction and classification of thermotropic liquid crystals, Polymorphism in liquid crystal, Properties and applications of liquid crystals.	

Reference Books:

1. A.F. Wells, Structural Inorganic Chemistry, 4th Edition, Clarendon Press-Oxford University Press, 1975.
2. Ulrich Muller, Inorganic Structural Chemistry, 2nd Edition, John Wiley & Sons Ltd, 2006.
3. Anthony R. West, Solid State Chemistry and its Applications, Learner Edition, 2nd Edition, John Wiley & Sons Ltd, 2014.
4. Lesley E. Smart, Elaine A. Moore, Solid State Chemistry Introduction, 3rd Edition, Taylor & Francis Group, LLC, 2005.
5. Richard J. D. Tilley, Understanding Solids: the Science of Materials, John Wiley & Sons Ltd, 2004.
6. Richard J. D. Tilley, Crystals and Crystal Structures, John Wiley & Sons Ltd, 2006.
7. William D. Callister, David G. Rethwisch, Materials Science and Engineering - An Introduction, John Wiley & Sons Ltd, 2014.

Course Code: RPSCHEI302
Course Title: ADVANCED INSTRUMENTAL TECHNIQUES
Academic year 2020-21

Course Outcomes:

After studying this course, the learner will be able to:	
CO 1	Make use of the surface analytical techniques (such as SIMS, PIXE) for obtaining information about the surfaces while characterizing the samples.
CO 2	Enlist the advantages of development of hyphenated techniques and will be able to explain the different types of interfaces that are used to achieve this hyphenation.
CO 3	Apply the principle underlying spectro-electrochemistry & the use of optically transparent electrodes to carry out the analysis of samples.
CO 4	Elaborate on the essential principles underlying the applications of thermal methods and radiochemical methods.
CO 5	Develop a working knowledge of various methods used in Voltammetry.
CO 6	Explain anodic, cathodic and adsorptive stripping methods in voltammetry.
CO 7	Select a suitable method of voltammetry for the analysis of a particular sample.

DETAILED SYLLABUS

Course Code	Unit	Course Title / Unit Title	Credits/ Lecture
RPSCHEI302	**ADVANCED INSTRUMENTAL TECHNIQUES**		**4**
	I	**Spectral Methods**	**(15L)**
		1.1 Surface Analytical Techniques: Preparation of the surface, difficulties involved in the surface analysis. **1.2 Principle, instrumentation and applications of the following:** **1.2.1** ATR-FTIR spectroscopy **1.2.2** Secondary Ion mass spectroscopy (SIMS) **1.2.3** X-Ray Photoelectron Spectroscopy (XPS)	

		1.2.4 Low-Energy Ion Scattering Spectroscopy (LEIS) and Rutherford Backscattering **1.2.5** Scanning Probe Microscopy including AFM, CFM **1.3 Nuclear Quadrupole Resonance (NQR), ENDOR, ELDOR.**	
	II	**Hyphenated Techniques**	**(15L)**
		2.1 Concept of hyphenation, need for hyphenation, possible hyphenations. **2.2** Interfacing devices, instrumentation and applications of GC – MS,(Head space GC, Pyrolysis GC), GC - FTIR **2.3** LC-MS: Interface and Ionization techniques for LC-MS, Thermospray, Particle beam, FAB, and Atmospheric Pressure Ionization (API) Techniques. **2.4** Different Mass Analyzers, Magnetic Sector, Quadrupole, Ion Trap, Time of Flight, FTICR **2.5** LC-MS/MS: Tandem MS, Triple Quad MS, Collision Induced Dissociation Cell, Different scan events, MRM transitions. Hybrid MS/MS. Applications of Tandem MS. **2.6** Radiochromatography	
	III	**Radiochemical And Thermal Methods**	**(15L)**
		3.1 Enthalpimetric methods and thermometric titrations. **3.2 Thermal analysis-** Principle, Interfacing, instrumentation and Applications of (a) Simultaneous Thermal Analysis- TG-DTA and TG-DSC **3.3 Evolved gas analysis**- TG-MS and TG-FTIR **3.4 Activation analysis**- NAA, radiometric titrations and radio-release methods, isotope dilution method, introduction, principle, single dilution method, double dilution method and applications. **3.4.1** Auto, X-ray and Gamma Radiography	

	IV	Electroanalytical Methods	(15L)
		4.1 Current Sampled (TAST) Polarography, Normal and Differential Pulse Polarography, Differential double Pulse Polarography **4.2 Potential Sweep methods-** Linear Sweep Voltammetry and Cyclic voltammetry. **4.3 Potential Step method-** Chronoamperomertry **4.4 Controlled potential technique-** Chronopotentiometry **4.5 Stripping Voltammetry-** anodic, cathodic, and adsorption **4.6** Chemically and electrolytically modified electrodes and ultra- microelectrodes in voltammetry, Biosensor **4.7** Corrosion and electrochemistry, Use of Galvano stat and potentio stat **4.8 Spectro-electrochemistry**	

Reference Books:

1. D. A. Skoog, F. J. Holler and J.A. Niemann, Principles of Instrumental Analysis, 5th Edition, 2004.
2. H. H. Willard, L. L. Merritt Jr., J. A. Dean and F. A. Settle Jr., Instrumental Methods of Analysis, 7thEdition, CBS 1986.
3. R. D. Braun, Introduction to Instrumental Analysis, McGraw Hill, 1987.
4. G. D. Christian, Analytical Chemistry, 4thEdition, John Wiley, New York, 1986.
5. D. A. Skoog, D. M. West and F. J. Holler Holt- Saunders, Fundamentals of Analytical Chemistry, 6thEdition, 1992.
6. A. J. Bard and Marcel Dekker, Electroanalytical Chemistry, New York, (A series of volumes).
7. J.J. Lingane, Electroanalytical Chemistry, 2nd Edition, Interscience, New York, 1958.
8. A. M. Bond, Marcel Dekker, Modern Polarographic Methods in Analytical Chemistry, New York, 1980.
9. Kamla Zutski, Introduction to polarography and allied techniques, 2006.
10. John C. Vickerman and Ian S. Gilmore, Surface Analysis –The Principal Techniques, 2nd Edition, John Wiley & Sons, Ltd., 2009.

Course Code: RPSCHEI303
Course Title: BIOINORGANIC AND COORDINATION CHEMISTRY
Academic year 2020-21

Course Outcomes:

After studying this course , the learner will be able to:	
CO 1	Outline the role of Iron, Zinc, Manganese and Nickel in different biological processes.
CO 2	Illustrate the reactivity of Lewis acids and bases and Classification based on Frontier Molecular Orbital concept.
CO 3	Know the different features of groups from 13-17 with respect to the acidity.
CO 4	Predict the strength, hardness and softness of acids and bases.
CO 5	Be well versed with the Latimer, Pourbaix and Frost diagrams.
CO 6	Explain the different routes of synthesizing coordination complexes.
CO 7	Differentiate between sigma and pi bonding of coordination complexes and geometries of tetrahedral and octahedral.
CO 8	Rationalize the chiral and fluxional behavior of coordination complexes.

DETAILED SYLLABUS

Course Code	**Unit**	**Course Title/Unit Title**	**Credits/ Lectures**
RPSCHEI303		**BINORGANIC & COORDINATION CHEMISTRY**	**4**
	I	**Bioinorganic Chemistry**	**(15L)**
		1.1 Coordination geometry of the metal ion and functions. **1.2** Zn in biological systems: Carbonic anhydrase, protolytic enzymes, e.g. carboxy peptidase, Zinc finger **1.3** Role of metal ions in biological electron transfer processes: iron sulphur proteins,	

		1.4 Less common ions in biology e.g. Mn (arginase; structure and reactivity), Ni (urease; structure and reactivity) **1.5** Biomineralization	
	II	**Reactivity of Chemical Species –I**	**(15L)**
		2.1 Recapitulation of the definition of Lewis acids and bases, **2.2** Classification of Lewis acids and bases based on frontier Molecular orbital topology, Reactivity matrix of Lewis acids and bases. **2.3** Group Characteristic of Lewis acids (Group -1, 13-17). **2.4** Pauling rules to determine the strength of oxoacids; classification and Structural anomalies.	
	III	**Reactivity of Chemical Species –II**	**(15L)**
		3.1 Pourbaix Diagrams. **3.1.1** Amphoteric behavior, Periodic trends in amphoteric properties of p-block and d-block elements **3.1.2** Measures of hardness and Softness of Acids and Bases **3.1.3** Applications of acid-base Chemistry: Super acids and Super bases, heterogeneous acid-base reactions. **3.1.4** Pauling and Drago-Wayland Equation **3.2** Latimer Diagrams **3.3** Frost diagrams.	
	IV	**Synthesis, Structure, Bonding and Stereochemistry**	**(15L)**
		4.1 Synthesis of Coordination Compounds Addition Reactions, Substitution Reactions, Redox Reactions, Thermal Dissociation of Solid Complexes,	

		Reactions in Absence of Oxygen, Reactions of Coordination Compounds, Trans Effect. **4.2 Structure and Bonding.** **4.2.1** Molecular Orbital Theory for Complexes with Coordination Number 4 and 5 for the central ion (sigma as well as Pi bonding) **4.2.2** Angular Overlap Model for octahedral and tetrahedral complexes for sigma and pi bond. **4.3 Stereochemistry of Coordination Compounds.** **4.3.1** Chirality and Fluxionality of Coordination Compounds with Higher Coordination Numbers. **4.3.2** Geometries of Coordination compounds from Coordination number 6 to 9.	

Reference Books:

1. Wolfgang Kaim, Brigitte Schwederski and Axel Klein, Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life, 2nd Edition, John Wiley & Sons Ltd, 2013.
2. Robert R. Crichton, Biological Inorganic Chemistry - An Introduction, Elsevier, 2008.
3. Gary Wulfsberg, Inorganic Chemistry, Viva Books PA Ltd., New Delhi, 2002.
4. James E. House, Inorganic Chemistry, 2nd Edition,Elsevier, 2013.
5. W.W.Porterfield,Inorganic Chemistry-An Unified Approach, Academic press, 1993.
6. D.F.Shriver, P.W.Atkins and C.H. Langford, Inorganic Chemistry, 3rdedition Oxford University Press, 1999.
7. Asim K.Das, Fundamental Concepts of Inorganic Chemistry,(Volumes-I, II and III) CBS Publication, 2000.
8. F.Basolo and R.G.Pearson, Mechanisms of Inorganic Reactions, Wiley, New York, 1967.
9. J.D.Lee, Concise Inorganic Chemistry, 5thEdition, Blackwell Science Ltd., 2005.
10. F. A. Cotton, G. Wilkinson, C. Murillo and M. Bochmann, Advanced Inorganic Chemistry, 6th ed., John Wiley, New York, 1999.
11. Catherine E. Housecroft and Alan G. Sharpe, Inorganic Chemistry, 2nd Edition, Pearson Education Limited, 2005

Course Code: RPSCHEIEC - I 304
Course Title: APPLIED CHEMISTRY I
Academic year 2020-21

Course Outcomes:

After studying this course, the learner will be able to:	
CO 1	Have a clear idea of the some important inorganic chemicals and materials and their application in day to day life.
CO 2	Explain the process by which metals are extracted, recovered and recycled.
CO 3	Be well versed with the inorganic chemicals or materials used in pharmaceuticals.
CO 4	Outline the importance of environment monitoring and assessment.
CO 5	Have an idea about the different aspects of environmental legislation pertaining to e-waste, Forest Act and plastic manufacture.

DETAILED SYLLABUS

Course Code	Unit	Course Title / Unit Title	Credits/ Lecture
RPSCHEIEC - I 304	**APPLIED CHEMISTRY-I**		**4**
	I	**Manufacture and Applications of Inorganic Compounds**	**(15L)**
		1.1 Ceramics and refractory materials **1.2** Cement **1.3** Fertilizers and micronutrients **1.4** Inorganic pesticides **1.5** Inorganic Pigments	
	II	**Metallurgy**	**(15L)**
		2.1 Occurrence, extraction and metallurgy of Zirconium, Hafnium, Niobium, Tantalum Platinum and Palladium metals. Physical and chemical properties and applications of these metals, compounds of these metals, alloys and their uses.	

		2.2 Recycling& recovery of metals with reference to Silver, Lead, Nickel and Chromium.	
	III	**Inorganic Pharmaceuticals**	**(15L)**
		3.1 Radiopharmaceuticals containing Tc and Bi, contrast agents for X-ray and NMR imaging. Gastrointestinal agent's viz. (i) antacids (aluminium hydroxide, milk of magnesia, sodium bicarbonate and (ii) Cathartics(magnesium sulphate and sodium phosphate). Topical agent's viz. (i) protective and adsorbents (talc, calamine), (ii) antimicrobial agents (potassium permanganate, tincture iodine, boric acid) and astringents (potash alum). **3.2** Supramolecular chemistry	
	IV	**Environmental Monitoring and Assessment**	**(15L)**
		4.1 Environmental Monitoring: Advantages of Environmental Monitoring, Deterioration of environmental quality with reference to anthropogenic impact; Methods of assessment of environmental quality- Short term studies/surveys, Rapid assessment, Continuous short and long term monitoring. **4.2 Environmental Impact Assessment (EIA)**: Need of EIA; Scope and objectives; Environmental Impact Assessment techniques-Ad-hoc method, checklist method, overlay mapping method, simulation and modeling technique, and system diagram technique; Merits and Demerits of EIA studies.	

		4.3 Objectives and Provisions of Acts and Rules: Indian Forest Act 1927, Forest Conservation Act 1980 , Environment (Protection) Act 1986, National Green Tribunal Act 2010, E-waste Management and Handling Rules 2011, Plastics Manufacture, Sale and Usage Rules, 2011	

Reference Books:

1. Fathi Habashi, Handbook of Extractive Metallurgy, Volume I-IV, WILEY-VCH, 1997.
2. Thomas W. Swaddle, Inorganic Chemistry- An Industrial and Environmental Perspective, Elsevier Science & Technology Books, 1997.
3. Karl Heinz Buchel, Hans-Heinrich Moretto and Peter Woditsch, Industrial Inorganic Chemistry, WILEY-VCH, 2000.
4. Kent and Riegel, Handbook of Industrial Chemistry and Biotechnology, Volume I, Springer, 2007.
5. Peter Morris and Riki Therivel, Methods of Environmental Impact Assessment, Routledge, Taylor & Francis Group,2009.
6. Philippe Sands, Principles of International Environmental Law, Cambridge University Press, 2nd Edition, 2003.
7. Gilbert M. Masters, Wandell P. Ela, Introduction to Environmental Engineering and Science, 3rd Edition, Pearson Education Limited, 2014.
8. Thomas F. P. Sullivan, Environmental Law Handbook, 22nd Edition, Bernan Press, 2014.
9. Indian Forest Act 1927, NGT Act 2010, Sales and Usage Rules 2011.

Course Code: RPSCHEIEC - II 304
Course Title: APPLIED CHEMISTRY II
Academic year 2020-21

Course Outcomes:

After studying this course, the learner will be able to:	
CO 1	Synthesize nanomaterials by choosing an appropriate method out of the various methods learned.
CO 2	Prepare some of the industrially important inorganic chemicals and materials used in day to day life.
CO 3	Explain the PUREX process used for the recovery of Uranium & Plutonium from spent nuclear fuel.
CO 4	Be well versed with the super heavy elements and its importance in Chemistry.
CO 5	Elaborate on the importance of Safety in Chemical Laboratory.
CO 6	Have an idea about the Environment Protection act.

DETAILED SYLLABUS

Course Code	Unit	Course Title / Unit Title	Credits/ Lectures
RPSCHEIEC - II 304		**APPLIED CHEMISTRY II**	**4**
	I	**Advances in Nanomaterials**	**(15L)**
		1.1 Types of nanomaterials, e.g. nanotubes, nanorods, solid spheres, core-shell nanoparticles, mesoporous materials; General preparative methods for various nanomaterials. **1.2 Some important properties of nanomaterials:** optical properties of metal and semiconductor nanoparticles, magnetic properties. **1.3 Some special nanomaterials:** Carbon nanotubes: Types, synthesis using various	

		methods, growth mechanism, electronic structure; Porous silicon: Preparation and mechanism of porous silicon formation, Factors affecting porous structure, properties of porous silicon; Aerogels: Types of aerogels, Properties and applications of aerogels. **1.4 Applications of nanomaterials in** electronics, energy, automobiles, sports and toys, textile, cosmetics, medicine, space and defense. Environmental effects of nanotechnology.	
	II	**Inorganic Materials**	**(15L)**
		2.1 Classification, manufacture and applications; **2.1.1** Inorganic fibers **2.1.2** Inorganic fillers **2.1.3** Study of (i) Condensed phosphates, and (ii) Coordination polymers. **2.2 Preparation, properties and uses of industrially important chemicals** – potassium permanganate, sodium thiosulphate, bleaching powder, hydrogen peroxide, potassium dichromate, Lime, Chlorine and Caustic soda.	
	III	**Nuclear Chemistry and Some Selected Topics**	**(15L)**
		3.1 Nuclear Chemistry: **3.1.1** Introduction to nuclear fuels andseparation of fission products fromspent fuel rods by PUREX process.	

		3.1.2 Super heavy element:, discovery, preparation, position in the periodic table. **3.2 Some Selected Topics** **3.2.1** Isopoly and Hetropoly acids, **3.2.2** Intercalation compounds **3.2.3** Inorganic explosives (mercury fulminate, Lead azide).	
	IV	**Safety in Chemistry Laboratories**	**(15L)**
		4.1 Good Laboratory Practices: Elements of Good Laboratory Practices; Standard Operating Procedures; Quality Assurance **4.2** Handling of Hazardous Materials **4.2.1** Toxic Materials (Various types of toxins and their effects on humans) **4.2.2** Explosives and Inflammable Materials **4.2.3** Types of fire extinguishers **4.2.4** Bioactive materials. **4.3** Legal provisions regarding Chemical Laboratories. **4.4** Environment Protection Act, 1986.	

Reference Books:

1. Sulabha K. Kulkarni, Nanotechnology-Principles and Practices,Capital Publishing Co., 2007.
2. Thomas W. Swaddle, Inorganic Chemistry- An Industrial and Environmental Perspective, Elsevier Science & Technology Books, 1997.
3. Karl Heinz Buchel, Hans-Heinrich Moretto and Peter Woditsch, Industrial Inorganic Chemistry, WILEY-VCH, 2000.
4. Kent and Riegel, Handbook of Industrial Chemistry and Biotechnology, Volume I, Springer, 2007.
5. Philippe Sands, Principles of International Environmental Law, Cambridge University Press, 2nd Edition, 2003.
6. Gilbert M. Masters, Wandell P. Ela, Introduction to Environmental Engineering and Science, 3rd Edition, Pearson Education Limited, 2014

SEMESTER – III
PRACTICAL

RPSCHEI3P1: Analysis of Alloys	
1.	Analysis of Brass alloy: i) Cu content by iodometric method, ii) Zn content by complexometric method.
2.	Analysis of Magnelium alloy: i) Al content by gravimetric method as basic succinate, ii) Mg content by complexometric method.
3.	Analysis of Bronze alloy: i) Cu content by complexometric method, ii) Sn content by gravimetric method.
4.	Analysis of steel nickel alloy: Ni content by homogeneous precipitation method.
RPSCHEI3P2: Solvent Extraction	
1.	Separation of Co and Ni using n-butyl alcohol and estimation of Co
2.	Separation of Mn and Fe using isoamyl alcohol and estimation of Mn
3.	Separation of Cu and Fe using n-butyl acetate and estimation of Cu
4.	Separation of Fe and Mo using isoamyl alcohol and estimation of Mo

RPSCHEI3P3: Inorganic Preparations	
1.	Preparation of $V(oxinate)_3$
2.	Preparation of $Co(\alpha\text{-nitroso-}\beta\text{-naphthol})_3$
3.	Preparation of $Ni(salicylaldoxime)_2$
4.	Hexaamine cobalt (III) chloride
5.	Preparation of Trans-bis (glycinato) Cu(II)
RPSCHEI3P4: Analysis of the following Commercial Samples	
1.	Calcium tablet for its calcium content by complexometric titration.
2.	Bleaching powder for its available chlorine content by iodometric method.
3.	Iron tablet for its iron content colorimetry by 1, 10-phenonthroline method.
4.	Nycil powder for its Zn content complexometrically.

References for Practical:

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. 2000.
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.

MODALITY OF ASSESSMENT

Theory Examination Pattern:

G) 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 %

Semester End Theory Assessment - 60 marks

1. Duration - These examinations shall be of **2.5 hours** duration.
2. Paper Pattern:
   There shall be **04** questions each of **15** marks. On each unit, there will be one question.
   All questions shall be compulsory with internal choice within the questions.

Questions	Options	Marks	Questions 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	

Practical Examination Pattern:

Semester End Practical Examination: 50 marks

Experimental work	**40**
Viva	**05**
Journal	**05**

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	**301**			**302**			**Grand Total**
	Internal	**External**	**Total**	**Internal**	**External**	**Total**	
Theory	**40**	**60**	**100**	**40**	**60**	**100**	**200**
Practical			**50**			**50**	**100**
Course	**303**			**304**			**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: RPSCHEI401
Course Title: SOLID STATE CHEMISTRY AND MOLECULAR SPECTROSCOPY
Academic year 2020-21

Course Outcomes:

After studying this course , the learner will be able to:	
CO 1	Understand the electrical properties of inorganic solids and how these materials can be used as superconductors.
CO 2	Outline the importance of inorganic materials in making batteries and sensors.
CO 3	Make use of hopping model to describe the carrier transport in a disordered semiconductor or in amorphous solid.
CO 4	Know transition metal oxides such as spinels, garnets and the strength of magnets.
CO 5	Elaborate on the thermal properties and optical behaviour of inorganic solids.
CO 6	Know the different models available to understand optical properties of inorganic solids.
CO 7	Elucidate the structure by powder diffraction and single crystal X-ray diffraction patterns.
CO 8	Determine the crystal structure using X-ray diffraction.
CO 9	Comprehend the general principles and theory of spectroscopy.
CO 10	Grasp the specialties and applications of various types of spectroscopic methods.

DETAILED SYLLABUS

Course Code	Unit	Course Title / Unit Title	Credits/ Lectures
RPSCHEI401		**SOLID STATE CHEMISTRY AND SPECTROSCOPY**	**4**
	I	**Inorganic Materials Properties – I(Electrical and Thermal Properties)**	**(15L)**
		1.1 Electrical properties of solids: Conductivity: Solid Electrolytes; Fast Ion Conductors; Mechanism of Conductivity; Hopping Conduction. **1.2 Other Electrical Properties:** Thomson and Seebeck Effects; Thermocouples and their Applications; Hall Effect; Dielectric, Ferroelectric, Piezoelectric and Pyrroelectric Materials and their Inter-relationships and Applications. **1.3 Thermal Properties:** Introduction, Heat Capacity and its Temperature Dependence; Thermal Expansion of Metals; Ceramics and Polymers and Thermal Stresses.	
	II	**Inorganic Materials Properties – II (Magnetic and Optical Properties)**	**(15L)**
		2.1 Magnetic Properties: Behaviour of substances in magnetic field, mechanism of ferromagnetic and antiferromagnetic ordering , superexchange, Hysteresis, Hard and soft magnets, structures and magnetic Properties of Metals and Alloys. **2.2 Transition Metal Oxides:** Spinels, garnets, Ilmenites, Perovskite and Magneto plumbites, Application in transformer cores, information storage, magnetic bubble memory devices and as permanent magnets. **2.3 Optical properties:**	

		Color Centers and Birefringence; Luminescent and Phosphor Materials, Coordinate Model, Phosphor Model, Anti Stokes Phosphor; Ruby Laser and Neodymium Laser.	
	III	**Diffraction Methods**	**(15L)**
		3.1 X-Ray Diffraction: Bragg Condition, Miller Indices, Laue Method, Bragg Method, Debye Scherrer Method of X-Ray Structural Analysis of Crystals **3.2 Electron Diffraction:** Scattering of electrons, Scattering Intensity versus Scattering Angle, Weirl Measurement Technique and Elucidation of Structures of Simple gas Phase Molecules. **3.3 Neutron Diffraction:** Scattering of Neutrons: Scattering of neutrons by Solids and Liquids, Magnetic Scattering, Measurement Technique.	
	IV	**Molecular Spectroscopy**	**(15L)**
		4.1 Rotational spectroscopy: Einstein coefficients, classification of poly atomic Molecules spherical top, symmetric top and asymmetric top molecules, rotational Spectra of polyatomic molecules Stark modulated microwave Spectrometer. **4.2 Infrared spectroscopy:** Fundamental modes of vibrations, selection rules, IR absorption bands of metal - donor atom, effect of complexation on the IR spectrum of ligands formations on the IR of ligands like NH_3, CN-, CO, olefins (C=C) and $C_2O_4^{2-}$ **4.3 Raman Spectroscopy-**	

		Classical theory of molecular polarizability, pure rotational, vibrational and vibration-rotation spectra of diatomic and polyatomic molecules polarization and depolarization of Raman lines correlation between IR and Raman spectroscopy Instrumentation.	

Reference Books:

1. Anthony R. West, Solid State Chemistry and its Applications, Learner Edition, 2nd Edition, John Wiley & Sons Ltd, 2014.
2. Lesley E. Smart, Elaine A. Moore, Solid State Chemistry Introduction, 3rd Edition, Taylor & Francis Group, LLC, 2005.
3. Richard J. D. Tilley, Understanding Solids: the Science of Materials, John Wiley & Sons Ltd, 2004.
4. Richard J. D. Tilley, Crystals and Crystal Structures, John Wiley & Sons Ltd, 2006.
5. William D. Callister, Jr. and David G. Rethwisch, Materials Science and Engineering - An Introduction, John Wiley & Sons Ltd, 2014.
6. Colin N. Banwell and Elaine M. McCash, Fundamentals of molecular spectroscopy, 4th Edition.
7. G. Aruldas, Molecular structure and spectroscopy, 2nd Edition.
8. H.S. Randhawa, Modern Molecular Spectroscopy, McMillan India Ltd., 2003
9. R.S. Drago, Physical Methods for Chemists, 2nd Edition, Saunders College Publishing 1992.
10. P.W, Physical Chemistry, Oxford University Press, 6th Edition, 1998.

Course Code: RPSCHEI402
Course Title: ORGANOMETALLIC AND MAIN GROUP CHEMISTRY
Academic year 2020-21

Course Outcomes:

After Studying this course , the learner will be able to:	
CO 1	Discuss classification of clusters and different structural patterns of metal clusters.
CO 2	Explain how low nuclearity clusters differ from high nuclearity clusters and capping rules in metal clusters.
CO 3	Be well versed with the Synthesis of various palladium Coupling complexes and its properties along with applications.
CO 4	Enlist the Homogenous and heterogeneous catalytic applications of organometallic compounds in various industrial fields.
CO 5	Explain the preparation methods and properties of silicates, inorganic polymers.

DETAILED SYLLABUS

Course Code	Unit	Course Title / Unit Title	Credits/ Lectures
RPSCHEI402		**ORGANOMETALLIC AND MAIN GROUP CHEMISTRY**	**4**
	I	**Clusters and The Isolobal Analogy**	**(15L)**
		1.1 Metal Cluster **1.1.1** Carbonyl Cluster **1.1.1.1** Low Nuclearity Carbonyl Cluster (LNCC) **1.1.1.2** High Nuclearity Carbonyl Cluster (HNCC) **1.1.1.3** Electron Counting for LNCC and HNCC **1.1.1.4** Capping Rules: Limitation and Exceptions **1.1.1.5** Synthesis and reactions of Metal Carbonyl clusters **1.1.1.6** Wade's Rule **1.2** Halide type Clusters **1.3** Total Valence Electron Counts in d-block organometallic clusters	

		1.4 Chevrel Phases **1.5** Zintl Ions **1.6** Concept of Isolobality and Isolobal Analogies.	
	II	**Applications of Organometallic Chemistry to Organic Synthesis**	**(15L)**
		2.1 Alkene Metathesis **2.1.1** Synthesis of Grub's and Schrock Catalysts **2.1.2** Mechanism of Metathesis: Ring Opening Metathesis, Ring Closing Metathesis, Cross Metathesis **2.2** Palladium Catalyzed C-C and C-N Cross Coupling Reactions **2.2.1** Discovery and Industrial application of Cross Coupling Reactions **2.2.2** The Heck Reaction **2.2.3** Suzuki-Miyaura Coupling **2.2.4** Sonogashira Coupling **2.2.5** Stille Coupling **2.2.6** Negishi Coupling **2.2.7** Buchwald-Hartwig C-N Cross Coupling **2.3** Methanol Carbonylation and Alkenes Oxidation: The Monsanto Process and The Wacker Process **2.4** Fischer- Tropsch Synthesis, Hydrosilylation of Alkenes, Hydroformylation using Cobalt Catalyst, Water gas Shifts Reaction, Carbonylation of Alcohol	
	III	**Inorganic Cluster and Cage compounds**	**(15L)**
		3.1 Boranes **3.1.1** Introduction **3.1.2** Method for Classifying Structures **3.1.3** Wade's rules and its Origin **3.1.4** Structural correlations and Bonding **3.1.5** Synthesis of higher boranes	

		3.1.6 Characteristic reactions of boranes **3.2** Carboranes **3.2.1** Introduction **3.2.2** Method for Classifying Structures **3.2.3** Wade's rules **3.2.4** Synthesis of Carboranes **3.3** Heteroboranes **3.3.1** Introduction **3.3.2** Method for Classifying Structures **3.4** Metallaboranes and Metallacarboranes **3.4.1** Introduction **3.4.2** Method for Classifying Structures **3.5** Polyhedral Skeletal Electron Pair approach or Mingo's Rules **3.6** Electron precise compounds and their relation to clusters.	
	IV	**Inorganic – Rings – Chains –Polymer**	**(15L)**
		4.1 Silicates: Types of Silicates **4.2** Zeolites **4.3** Silicones **4.4** Phospho Nitrilic Compounds: Phosphazenes and PhosphazinesPolymers **4.5** Sulphur Nitrogen Compounds: S_4N_4 and S_3N_3 **4.6** Flurocarbons	

Reference Books:

1. B D Gupta and A J Elias, Basic Organometallic Chemistry- Concept, Synthesis and Applications, 2nd Edition, University Press, 2013**.**
2. Gary O. Spessard and Gary L. Miessler, Organometallic Chemistry, Oxford University Press, 2nd Edition, 2010.
3. Catherine E. Housecroft and Alan G. Sharpe, Inorganic Chemistry, 2nd Edition, Pearson Education Limited, 2005.
4. F. A. Cotton, G. Wilkinson, C. Murillo and M. Bochmann, Advanced Inorganic Chemistry, 6th ed., John Wiley, New York, 1999.
5. D. F. Shriver, P. W. Atkins and C.H. Langford, Inorganic Chemistry, 3rd edition Oxford University Press, 1999.
6. J. D. Lee, Concise Inorganic Chemistry, 5thEdition, Blackwell Science Ltd., 2005.
7. James E. House, Inorganic Chemistry, 2nd Edition, Elsevier, 2013.
8. Robert H. Crabtree, The Organometallic Chemistry Of The Transition Metals, 4thEdition, John Wiley & Sons Ltd, 2005.

Course Code: RPSCHEI403
Course Title: SYMMETRY, SPECTROSCOPY TECHNIQUES AND CATALYSIS
Academic year 2020-21

Course Outcomes:

After studying this course, the learner will be able to:	
CO 1	Describe the selection rule for infrared-active transitions.
CO 2	Determine whether the molecular vibrations of a triatomic molecule are Raman active.
CO 3	Analyse the hybridization of given compounds.
CO 4	Understand the concepts of equivalent and non-equivalent hydrogens.
CO 5	Identify the effect of structure on chemical shift and coupling constants.
CO 6	Elucidate the electronic structure of free radicals and paramagnetic transition metal complexes.
CO 7	Illustrate the magnetic properties of the materials and its order of orientation.

DETAILED SYLLABUS

Course Code	Unit	Course Title /Unit Title	Credits/ Lectures
RPSCHEI403		**SYMMETRY, SPECTROSCOPY TECHNIQUES AND CATALYSIS**	**4**
	I	**Symmetry in Chemistry**	**(15L)**
		1.1. Recapitulation of Points groups and Character tables. **1.2.** Applications of Group theory in Infrared and Raman spectroscopy. Molecular Vibrations, determining the Symmetry Types of the Normal Modes; symmetry-based Selection Rules of IR and Raman, application in Infrared and Raman spectroscopy for molecules belongs to point group C_{2v}, C_{3v}, C_{4v}, D_{2h} , D_{3h} , $D_{\infty h}$ and T_d. **1.3.** Group theory and quantum mechanics. Wave function as bases for irreducible representation. **1.4** Symmetry Adapted Linear Combinations - (SALC) - projection operators and their use to construct SALC.	

		1.5 Molecular Orbital Theory. Transformation properties of atomic orbitals, MO's for Sigma and pi - molecular orbitals in AB_n molecules, AB_4 (tetrahedral) and AB_6 (octahedral) molecules, Hybrid orbitals.	
	II	**N.M.R. Spectroscopy**	**(15L)**
		2.1. Nuclear Magnetic Resonance (NMR) Spectroscopy: Nuclear spin and its interaction with applied field, population of energy state, relaxation time, ^{1}H NMR Spectroscopy: Chemical Shift; Multiplet Splitting of NMR peaks arises through Spin–Spin Coupling, Multiplet Splitting when more than two spins interact. **2.2.** Pulse technique in NMR: The magnetization vector, spin-spin relaxation, spin-lattice relaxation. **2.3.** ^{13}C NMR Spectroscopy: Fourier Transform NMR; Off-Resonance and Spin-Decoupled, DEPT, Applications, 2-D NMR Spectroscopy (COSY). Nuclear Overhauser Effect Spectroscopy (NOESY). **2.4**.Solid-state NMR **2.5**.Magnetic Resonance Imaging (MRI); **2.6**.NMR Spectroscopy of ^{19}F, ^{15}N and ^{31}P nuclides.	
	III	**ESR and Mossbauer Spectroscopy**	**(15L)**
		3.1 Electron spin Resonance Spectroscopy- **3.1.1** Basic principle, hyperfine splitting (isotropic systems) **3.1.2** g-value and the factors affecting thereof; interactions affecting electron energies in paramagnetic complexes (Zero-field splitting and Kramer's degeneracy); **3.1.3** An isotropic effect (the g-value and the hyperfine couplings); The EPR of triplet states; Structural applications to transition metal complexes. **3.2 Mossbauer Spectroscopy:**	

		3.2.1 Basic principles of Mössbauer spectroscopy, instrumentation, spectral parameters Mössbauer Parameters- Isomer Shifts, quadrupole splitting, Magnetic hyperfine interaction. **3.2.2** Application of Mössbauer spectroscopy with respect to Oxidation states of metal ion in compounds, Structural elucidation, Covalent and ionic compounds and High spin low spin behavior	
	IV	**Catalysis**	**(15L)**
		4.1 Introduction, history and importance of catalysis, concept of activity, selectivity, poisoning, promotion, turnover number and deactivation, **4.2** Types of catalysis: homogeneous catalysis: examples of homogeneous catalysis in gas phase, and in solution phase, acid-base catalysis. **4.3** Heterogeneous catalysis: heterogeneous catalysis with gaseous reactants, liquid reactants, and gaseous reactants, biocatalysis, autocatalysis, negative catalysis, characteristics of catalytic reactions, activation energy and catalysis, theories of catalysis: the intermediate compound formation theory, the adsorption theory. **4.4** Mechanism of heterogeneous catalysis, kinetics of heterogeneous catalytic reactions, Langmuir-Hinshelwood model, Catalysis by semiconductors, Boundary Layer theory, Wolkenstein's theory. **4.5** Preparation and Characterization of Catalysts: General methods of preparation of catalysts: precipitation, sol-gel, hydrothermal, impregnation, hydrolysis, vapour deposition. Activation of catalysts: calcinations, reduction. Catalyst characterization: surface area, pore size distribution, particle size determination, XPS, AES, UV-Vis, FTIR and thermal methods.	

Reference Books:

1. K. Veera Reddy, Symmetry and Spectroscopy of molecules, 2nd Edition, New Age International publishers.
2. F. A. Cotton, Chemical applications of Group Theory, John Wiley and Sons, Pvt. Ltd., 2006.
3. R. L. Carter, Molecular symmetry and Group theory, John Wiley and Sons, Pvt. Ltd., 1996.
4. C. N. Banwell and E. M. McCash, Fundamentals of Molecular Spectroscopy, 4th Edition, Tata-McGraw-Hill, 1994.
5. M. L. Gupta, Atomic and Molecular Spectroscopy, New Age International Publishers, 2001.
6. H. S. Randhawa, Modern Molecular Spectroscopy, McMillan India Ltd., 2003.
7. Aruldas, Molecular Structure and Spectroscopy, Prentice-Hall of India, 2001.
8. J. Michael Hollas, Modern Spectroscopy, 4th Edition, John Wiley and Sons, 2004.
9. Heterogeneous Catalysis, D. K. Chakrabarty and B. Viswanathan, Hardcover - Oct 2008 New Age International Publishers.
10. Catalytic Chemistry, B. C. Gates, John Wiley and Sons Inc. 1992.

Course Code: RPSCHEIOC - I 404

Course Title: INTELLECTUAL PROPERTY RIGHTS & CHEMINFORMATICS

Credits 4

Academic year 2020-21

Course outcomes:

After completing this course, the learner will be able to:	
CO 1	Be well versed with the concept of intellectual property and the terms involved with respect to Indian Patent Law.
CO 2	Distinguish between patents and copyrights.
CO 3	Elaborate on the economic impact and legislature involved in Intellectual property rights.
CO 4	Make use of the software tools pertaining to Cheminformatics and Molecular Modelling.
CO 5	Conduct structure and sub-structure search online, determine SMILES codes for various molecules.
CO 6	Gain knowledge about the application of the research-based tools.

DETAILED SYLLABUS

Course Code	Unit	Course Title / Unit Title	Credits/ Lectures
RPSCHEIOC - I 404	**INTELLECTUAL PROPERTY RIGHTS & CHEMINFORMATICS**		**4**
	I	**Intellectual Property – I**	**(15L)**
		1.1 Introduction: Historical Perspective, Different types of IP, Importance of protecting IP. **1.2 Patents:** Historical Perspective, Basic and associated right, WIPO, PCT system, Traditional Knowledge, Patents and Health care-balancing promoting innovation with public health, Software patents and their importance for India. **1.3 Industrial Designs:**	

		Definition, How to obtain, features, International design registration. **1.4 Copyrights:** Introduction, How to obtain, Differences from Patents. **1.5 Trade Marks:** Introduction, How to obtain, Different types of marks – Collective marks, certification marks, service marks, trade names etc. **1.6 Geographical Indications:** Definition, rules for registration, prevention of illegal exploitation, importance to India.	
	II	**Intellectual Property – II**	**(15L)**
		2.1 Trade Secrets: Introduction and Historical Perspectives, Scope of Protection, Risks involved and legal aspects of Trade Secret Protection. **2.2 IP Infringement issue and enforcement:** Role of Judiciary, Role of law enforcement agencies – Police, Customs etc. **2.3 Economic Value of Intellectual Property:** Intangible assets and their valuation, Intellectual Property in the Indian context – Various Laws in India Licensing and Technology transfer. **2.4 Different International agreements:** **2.4.1 World Trade Organization (WTO):** General Agreement on Tariffs and Trade (GATT), Trade Related Intellectual Property Rights (TRIPS) agreement, General Agreement on Trade Related Services (GATS) Madrid Protocol, Berne Convention, Budapest Treaty **2.4.2 Paris Convention:**	

		WIPO and **TRIPS, IPR** and Plant Breeders Rights, IPR and Biodiversity.	
	III	**Cheminformatics – I**	**(15L)**
		3.1 History and evolution of cheminformatics, Use of Cheminformatics, Prospects of cheminformatics, Molecular modeling and structure elucidation. **3.2 Representation of molecules and chemical reactions:** Nomenclature, Different types of notations, SMILES coding, Matrix representations, Structure of Molfiles and Sdfiles, Libraries and toolkits, Different electronic effects, Reaction classification. **3.3 Searching Chemical Structures:** Full structure search, sub-structure search, basic ideas, similarity search, three dimensional search methods, basics of computation of physical and chemical data and structure descriptors, data visualization.	
	IV	**Cheminformatics – II**	**(15L)**
		4.1 Prediction of Properties of Compound, Linear Free Energy Relations, Quantitative Structure – Property Relations, Descriptor Analysis, Model Building, Modeling Toxicity, Structure – Spectra correlations, Prediction NMR, IR and Mass spectra, **4.2** Computer Assisted Structure elucidations, Computer assisted Synthesis Design, Introduction to drug design, Target Identification and Validation, Lead Finding and Optimization, analysis of HTS data, Virtual Screening, Design of Combinatorial	

		Libraries, Ligand-based and Structure based Drug design. **4.3** Application of Cheminformatics in Drug Design.	

Reference Books:

1. Vivien Irish, Intellectual Property Rights for Engineers, 2nd Edition, British Library, 2008.
2. David I. Bainbridge, Intellectual Property, 8th Edition, Pearson, 2010.
3. Stephen Elias and Richard Stim, Patent Copyright & Trade Mark, 8th Edition, Nolo and Richard, 2013.
4. Johann Gasteiger and Thomas Engel, Cheminformatics, Wiley-VCH, 2003.
5. Andrew R. Leach, Valerie J. Gillet, An Introduction to Cheminformatics, Springer, 2007.
6. Barry A. Bunin, Jurgen Bajorath, Brian Siesel and Guillermo Morales, Cheminformatics-Theory, Practice and Products, Springer, 2007.

Course Code: RPSCHEIOC - II 404
Course Title: RESEARCH METHODOLOGY
Credits 4
Academic year 2020-21

Course Outcomes:

After studying this course, the learner will be able to:	
CO 1	Know basics of research methodology.
CO 2	Get the technical know-how of research from developing a problem.
CO 3	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/ Lectures
RPSCHEIOC - II 404		**Research Methodology**	**4**
	I	**Review of Literature**	**(15L)**
		1.1 Print: Primary, Secondary and Tertiary sources. **1.2 Journals:** Journal abbreviations, abstracts, current titles, reviews, monographs, dictionaries, textbooks,current contents, Introduction to Chemical Abstracts and Beilstein, Subject Index, Substance Index, Author Index, Formula Index, and other Indices with examples. **1.3 Digital:** Web sources, E-journals, Journal access, TOC alerts, Hot articles, Citation Index,Impact factor, H-index, E-consortium, UGC infonet, E-books, Internet discussiongroups and communities, Blogs, preprint servers, Search engines, Scirus, Google	

		Scholar, ChemIndustry, Wiki-databases, ChemSpider, Science Direct, SciFinder, Scopus. **1.4 Information Technology and Library Resources:** The Internet and World Wide Web, Internet resources for Chemistry, finding and citing published information.	
	II	**Data Analysis**	**(15L)**
		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**	**(15L)**
		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**	**(15L)**
		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 Books:

1. C. R. Kothari, Research Methodology- Methods and techniques, New Age International (P) Limited Publisher, 2004.
2. Yogesh Kumar Singh, Fundamental of Research Methodology and Statistics, New Age International (P) Limited Publisher, 2006.
3. Carol Ellison, Concise Guide to Writing Research Papers, McGraw-Hill, 2016.
4. Introductory Statistics, Prem S. Mann, C. Jay Lacke, 7th Edition, John Wiley and Sons, 2010.
5. Statistics From A to Z - Confusing Concepts Clarified Andrew A. Jawlik, John Wiley and Sons, 2016.

SEMESTER – IV PRACTICAL

RPSCHEI4P1: Analysis of ores/alloys	
1.	Analysis of galena ore: i) Pb content as PbCrO4 by gravimetric method using 5% potassium chromate ii) Fe content by colorimetrically using 1, 10- phenonthroline
2.	Analysis of Zinc blend ore: i) Zn content by complexometric method ii) Fe content by colorimetric method (Azide method)
3.	Analysis of Pyrolusite ore: i) Mn content by complexometric method ii) Acid insoluble residue by gravimetric method
RPSCHEI4P2: Coordination Chemistry	
1.	Determination of Stability constant of $[Zn(NH_3)_4]^{2+}$ by potentiometry.
2.	Determination of Stability constant of $[Ag(en)]^{+}$ by potentiometry
3.	Determination of Stability constant of $[Fe(SCN)]^{2+}$ by slope ratio method
4.	Determination of CFSE values of hexa-aqua complexes of Ti^{3+} and Cr^{3+}.
5.	Determination of Racah parameters for complex $[Ni(H_2O)_6]^{2+}$ and $[Ni(en)_3]^{2+}$
RPSCHEI4P3: Commercial sample Analysis	
1.	Electral powder for Na/K content flame photometrically.
2.	Fasting salt for chloride content conductometrically.
3.	Sea water for percentage salinity by Volhard's method.
4.	Soil for mixed oxide content by gravimetric method.
5.	Fertilizer for potassium content by flame photometry.
RPSCHEI4P4: Project Evaluation	

References for Practical:

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. 200.
3. H N Patel, S P Turakhia, S SKelkar, S R Puniyani, Post Graduate Practical Chemistry Part I, Himalaya Publishing House, 5th Edition, 2008.

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 %

Semester End Theory Assessment - 60 marks

1. Duration - These examinations shall be of **2.5 hours** duration.
2. Paper Pattern:
   There shall be **04** questions each of **15** marks. On each unit, there will be one question.
   All questions shall be compulsory with internal choice within the questions.

Questions	Options	Marks	Questions 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	

Practical Examination Pattern:

Semester End Practical Examination: 50 marks

Experimental work	**40**
Viva	**05**
Journal	**05**

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	**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**

Total: 600 marks

Resolution Number: AB/II (20-21).2.RPS5

S. P. Mandali's

Ramnarain Ruia Autonomous College

(Affiliated to University of Mumbai)

Syllabus for Semester III and Semester IV

Program: MSc Organic Chemistry

Program Code: RPSCHEO

(Credit Based Semester and Grading System for academic year 2020–2021)

SEMESTER III			
Course Code	**Unit**	**Course Title / Unit Title**	**Credits/ Lectures**
RPSCHEO301		**Theoretical Organic Chemistry-I**	**4**
	I	Organic reaction mechanisms	
	II	Pericyclic Reactions	
	III	Stereochemistry – I	
	IV	Photochemistry	
RPSCHEO302		**Synthetic Organic Chemistry-I**	**4**
	I	Name reactions with mechanism and application	
	II	Radicals in Organic Synthesis	
	III	Enamines, Ylides and α-C-H functionalization	
	IV	Metals / Non-metals in organic synthesis	
RPSCHEO303		**Natural Products & Spectroscopy**	**4**
	I	Natural Products- I	
	II	Natural Products –II	
	III	Advanced Spectroscopic Techniques- I	
	IV	Advanced Spectroscopic Techniques- II	
RPSCHEOEC-I 304		**Medicinal , Enzymes & Green Chemistry**	**4**
	I	Drug discovery, design and development	
	II	Drug design, development and synthesis	
	III	Enzymes in Organic Synthesis	
	IV	Green Chemistry	
RPSCHEOEC-II 304		**Bioorganic Chemistry**	**4**
	I	Biomolecules – I	
	II	Biomolecules- II	
	III	Biomolecules – III	
	IV	Biogenesis and Biosynthesis of Natural Products	
RPSCHEO3P1		**Practical**	**8**
RPSCHEO3P2			
RPSCHEO3P3			
RPSCHEOP4			

SEMESTER IV			
Course Code	**Unit**	**Course Title / Unit Title**	**Credits**
RPSCHEO401		**Theoretical Organic Chemistry -II**	**4**
	I	Physical Organic Chemistry	
	II	Supramolecular Chemistry	
	III	Stereochemistry – II	
	IV	Asymmetric Synthesis	
RPSCHEO402		**Synthetic Organic Chemistry-II**	**4**
	I	Designing Organic Synthesis – I	
	II	Designing Organic Synthesis – II	
	III	Electro-Organic Chemistry and Selected Methods of Organic Synthesis	
	IV	Transition and Rare Earth Metals in Organic Synthesis	
RPSCHEO403		**Natural Products & heterocyclic Chemistry**	**4**
	I	Natural Products – I	
	II	Natural Products – II	
	III	Heterocyclic Compounds – I	
	IV	Heterocyclic Compounds – II	
RPSCHEOEC-I 404		**Intellectual Property Rights & Cheminformatics**	**4**
	I	Intellectual Property – I	
	II	Intellectual Property – II	
	III	Cheminformatics – I Introduction	
	IV	Cheminformatics – II Applications	
RPSCHEOEC-II 404		**Research Methodology**	**4**
	I	Review of Literature	
	II	Data Analysis	
	III	Methods of Scientific Research And Writing Scientific Papers	
	IV	Chemical Safety & Ethical Handling of Chemicals	
RPSCHEO4P1		**Practical**	**8**
RPSCHEO4P2			
RPSCHEO4P3			
RPSCHEO4P4		**Project Evaluation**	

SEMESTER III

Course Code: RPSCHEO301

Course Title: THEORETICAL ORGANIC CHEMISTRY-I

Academic year 2020-21

Course Outcomes:

After studying this course, the learner will be able to:	
CO 1	Predict pathways of reaction mechanism and stability of intermediates.
CO 2	Study of stereochemistry of pericyclic reactions.
CO 3	Determine point groups based on symmetry elements and carry out conformational analysis of ring compounds.
CO 4	Understand photochemical reactions with special reference to cleavage of carbonyl compounds and photochemistry of olefins.

DETAILED SYLLABUS

Course Code	Unit	Course Title / Unit Title	Credits/ Lectures
RPSCHEO301	**THEORETICAL ORGANIC CHEMISTRY-I**		**4**
	I	**Organic reaction mechanisms**	**(15L)**
	1.1	Organic reactive intermediates, methods of generation, structure, stability and important reactions involving carbocations, nitrenes, carbenes, arynes and ketenes.	**(05L)**
	1.2	Neighbouring group participation: Mechanism and effects of anchimeric assistance, NGP by unshared/ lone pair electrons, π-electrons, aromatic rings, σ-bonds with special reference to norbornyl and bicyclo(2.2.2)octyl cation systems (formation of non-classical carbocation)	**(03L)**
	1.3	Role of FMOs in organic reactivity**:** Reactions involving hard and soft electrophiles and nucleophiles, ambident nucleophiles, ambident electrophiles, the α effect	**(02L)**

	1.4	Pericyclic reactions: Classification of pericyclic reactions; thermal and photochemical reactions. Three approaches: Evidence for the concertedness of bond making and breaking Symmetry-Allowed and Symmetry-Forbidden Reactions • The Woodward-Hoffmann Rules-Class by Class • The generalised Woodward-Hoffmann Rule Explanations for Woodward-Hoffmann Rules • The Aromatic Transition structures (Huckel and Mobius) • Frontier Orbitals • Correlation Diagrams, FMO and PMO approach Molecular orbital symmetry, Frontier orbital of ethylene, 1,3 butadiene, 1,3,5 hexatriene and allyl system	**(05L)**
	II	**Pericyclic reactions**	**(15L)**
	2.1	Cycloaddition reactions: Supra and antra facial additions, 4n and 4n+2 systems, 2+2 additions of ketenes. Diels-Alder reactions, 1, 3-Dipolar cycloaddition and cheletropic reactions, ene reaction, retro-Diels-Alder reaction, regioselectivity, periselectivity, torquoselectivity, site selectivity and effect of substituents in Diels-Alder reactions Other Cycloaddition Reactions- (4+6) Cycloadditions, Ketene Cycloaddition, Allene Cycloadditions, Carbene Cycloaddition, Epoxidation and Related Cycloadditions.	**(07L)**

		Other Pericyclic reactions: Sigmatropic Rearrangements, Electrocyclic Reactions, Alder 'Ene' Reactions	
	2.2	Electrocyclic reactions: Conrotatory and disrotatary motions, 4nπ and (4n+2)π electron and allyl systems	**(03L)**
	2.3	Sigmatropic rearrangements: H-shifts and C-shifts, supra and antarafacial migrations, retention and inversion of configurations. Cope (including oxy-Cope and aza-Cope) and Claisen rearrangements. Formation of Vitamin D from 7-dehydrocholesterol, synthesis of citral using pericyclic reaction, conversion of Endiandric acid E to Endiandric acid A	**(05L)**
	III	**Stereochemistry-I**	**(15L)**
	3.1	Classification of point groups based on symmetry elements with examples (nonmathematical treatment)	**(02L)**
	3.2	Conformational analysis of medium rings: Eight to ten membered rings and their unusual properties**,** I-strain, transannular reactions.	**(03L)**
	3.3	Stereochemistry of fused ring and bridged ring compounds: decalins, hydrindanes, perhydroanthracenes, steroids, and Bredt's rule.	**(05L)**
	3.4	Anancomeric systems, Effect of conformation on reactivity of cyclohexane derivatives in the following reactions (including mechanism): electrophilic addition, elimination, molecular rearrangements, reduction of cyclohexanones(with $LiAlH_4$, selectride and MPV reduction) and oxidation of cyclohexanols.	**(05L)**
	IV	**Photochemistry**	**(15L)**
	4.1	Principles of photochemistry: quantum yield, electronic states and transitions, selection rules, modes of dissipation of energy (Jablonski diagram), electronic energy transfer: photosensitization and quenching process, calculation of quantum yield.	**(03L)**

	4.2	Photochemistry of carbonyl compounds:π→ˊπ*, n→ˊπ* transitions, Norrish- I and Norrish-II cleavages, Paterno-Buchi reaction. Photoreduction, photochemistry of enones, photochemical rearrangements of α, β-unsaturated ketones and cyclohexadienones. Photo Fries rearrangement, Barton reaction.	**(08L)**
	4.3	Photochemistry of olefins: cis-trans isomerizations, dimerizations, hydrogen abstraction, addition and Di-π- methane rearrangement including aza-di- π -methane. Photochemical Cross-Coupling of Alkenes, Photodimerisation of alkenes.	**(02L)**
	4.4	Photochemistry of arenes**:** 1, 2- , 1, 3- and 1, 4-additions. Photocycloadditions of aromatic Rings.	**(01L)**
	4.5	Singlet oxygen and photo-oxygenation reactions. Photochemically induced Radical Reactions. Chemiluminescence.	**(01L)**

REFERENCES:

1. Organic Chemistry, J. Clayden, S. Warren, N. Greeves, P. Wothers, 1st Edition, Oxford University Press, 2001
2. Organic Chemistry, Part A and B, Fifth edition, Francis A. Carey and Richard J. Sundberg, Springer, 2007
3. March's Advanced Organic Chemistry, Jerry March, sixth edition, John Wiley and sons, 2007
4. A guide to mechanism in Organic Chemistry, 6th edition, Peter Sykes, Pearson education, New Delhi, 2009
5. Modern physical chemistry, Eric V Anslyn, Dennis A. Dougherty, University science books, 2006
6. Advanced organic chemistry, Jagdamba Singh L. D. S. Yadav, Pragati Prakashan, 2011.
7. Pericyclic reactions, Ian Fleming, Oxford university press, 1999
8. Pericyclic reactions-A mechanistic approach, S. M. Mukherji, Macmillan Co. of India, 1979
9. Stereochemistry of Carbon Compounds: Principles and Applications, D, Nasipuri, 3rd edition, New Age International Ltd
10. Stereochemistry of Organic Compounds, Ernest L. Eliel and Samuel H. Wilen, Wiley-India edition
11. Stereochemistry, P. S. Kalsi, 4th edition, New Age International Ltd
12. Photochemistry and Pericyclic Reactions, Jagdamba Singh, Jaya Singh, New Age International Ltd., 3rd edition, 2011
13. Photochemistry, R. P. Kundall and A. Gilbert, Thomson Nelson
14. Molecular Photochemistry, N. J. Turro, W. A. Benjamin
15. Introductory Photochemistry, A. Cox and T. Camp, McGraw-Hill

Course Code: RPSCHEO302

Course Title : SYNTHETIC ORGANIC CHEMISTRY-I

Academic year 2020-21

Course outcomes:

After studying this course, the learner will be able to:	
CO 1	Write mechanism for various named reactions, including Multicomponent reactions and Click reactions.
CO 2	Predict the product formed in the above reactions.
CO 3	Give the method for preparing synthetically important compounds involving radicals.
CO 4	Give the method for preparing synthetically important compounds via enamines and ylides.
CO 5	Understand and explore the application of various metals and non metals in organic synthesis.

DETAILED SYLLABUS

Course Code	Unit	Course Title / Unit Title	Credits / Lectures
RPSCHEO302	**SYNTHETIC ORGANIC CHEMISTRY-I**		**4**
	I	**Name reactions with mechanism and application**	**(15L)**
	1.1	Mukaiyama esterification, Mitsonobu reaction, Darzen's Glycidic Ester syntheis, Ritter reaction, Yamaguchi esterification, Peterson olefination	**(05L)**
	1.2	Domino reactions: Characteristics; Nazerov cyclization	**(03L)**
	1.3	Multicomponent reactions: Strecker Synthesis, Ugi 4CC, Biginelli synthesis, Hantzsch synthesis, Pictet-Spengler synthesis	**(05L)**
	1.4	Click Reactions: Characteristics; Huisgen 1,3-Dipolar Cycloaddition	**(02L)**
	II	**Radicals in organic synthesis**	**(15L)**

	2.1	Introduction: Generation, stability, reactivity and structural and stereochemical properties of free radicals, Persistent and charged radicals, Electrophilic and nucleophilic radicals	**(03L)**
	2.2	Radical Initiators: azobisisobutyronitrile (AIBN) and dibenzoyl peroxide	**(01L)**
	2.3	Characteristic reactions - Free radical substitution, addition to multiple bonds. Radical chain reactions, Radical halogenation of hydrocarbons (Regioselectivity),radical cyclizations, autoxidations: synthesis of cumene hydroperoxide from cumene	**(04L)**
	2.4	Radicals in synthesis: Inter and intra molecular C-C bond formation via mercuric hydride, tin hydride, thiol donors. Cleavage of C-X, C-Sn, C-Co, C-S, O-O bonds. Oxidative coupling, C-C bond formation in aromatics: $S_{RN}Ar$ reactions	**(04L)**
	2.5	Hunsdiecker reaction, Pinacol coupling, McMurry coupling, Sandmeyer reaction, Acyloin condensation	**(03L)**
	III	**Enamines, Ylides and α-C-H functionalization**	**(15L)**
	3.1	Enamines: Generation & application in organic synthesis with mechanistic pathways, Stork enamine reaction. Reactivity, comparison between enamines and enolates. Synthetic reactions of enamines including asymmetric reactions of chiral enamines derived from chiral secondary amines	**(04L)**
	3.2	Phosphorus, Sulfur and Nitrogen Ylides: Preparation and their synthetic applications along with their stereochemical aspects. Wittig	**(06L)**

		reaction, Horner-Wadsworth-Emmons Reaction, Barton-Kellogg olefination	
	3.3	α-C-H functionalization: By nitro, sulfoxide, sulfone and phosphonate groups: generation of carbanions by strong bases (LDA/n-butyl lithium) and applications in C-C bond formation. Bamford-Stevens reaction, Julia olefination and its modification, Seyferth–Gilbert homologation, Steven's rearrangement	**(05L)**
	IV	**Metals / Non-metals in organic synthesis**	**(15L)**
	4.1	Mercury in organic synthesis: Mechanism and regiochemistry of oxymercuration and demercuration of alkenes, mercuration of aromatics, transformation of aryl mercurials to aryl halides. Organomercurials as carbene transfer reagents	**(03L)**
	4.2	Organoboron compounds: Mechanism and regiochemistry of hydroboration of alkenes and alkynes, asymmetric hydroboration using chiral boron reagents, 9-BBN hydroboration, oxazaborolidine (CBS catalyst) and functional group reduction by diborane	**(03L)**
	4.3	Organosilicons: Salient features of silicon governing the reactivity of organosilicons, preparation and important bond-forming reactions of alkylsilanes, alkenylsilanes, aryl silanes and allylsilanes. β-silylcations as intermediates. Iodotrimethylsilane in organic synthesis	**(03L)**
	4.4	Silylenol ethers: Application: As nucleophiles (Michael reaction, Mukaiyamaaldol reaction), in ring contraction reactions	**(02L)**

	4.5	Organotin compounds: Preparation of alkenyl and allyl tin compounds; application in C-C bond formation, in replacement of halogen by H at the same C atom	**(02L)**
	4.6	Selenium in organic synthesis: Preparation of selenols/selenoxide, selenoxide elimination to create unsaturation, selenoxide and selenoacetals as α-C-H activating groups	**(02L)**

References

1. Advanced Organic Chemistry, Part A and Part B: Reaction and Synthesis, Francis A. Carey, Richard J. Sundberg, 5th Edition, Springer Verlag
2. Modern Methods of Organic Synthesis, 4th Edition, W. Carruthers and Iain Coldham, Cambridge University Press, 2004
3. Organic Chemistry, Clayden Greeves, Warren and Wothers, Oxford Press, 2001
4. Advanced Organic Chemistry: Reaction Mechanism, R. Bruckner, Academic Press, 2002
5. Principles of Organic Synthesis, R.O.C. Norman & J. M. Coxon, 3rdEdition, Nelson Thornes
6. Organic Chemistry, 7th Edition, R. T .Morrison, R. N. Boyd, & S. K. Bhattacharjee, Pearson
7. Strategic Applications of Name Reactions in Organic Synthesis, L. Kurti& B. Czako, Elsevier Academic Press, 2005
8. Organic reactions and their mechanisms, 3rdrevisededition, P.S. Kalsi, New Age International Publishers
9. Organic Synthesis: The Disconnection Approach, Stuart Warren, John Wiley & Sons, 2004
10. Name Reactions and Reagents in Organic Synthesis, 2ndEdn., Bradford P. Mundy, Michael G. Ellard, and Frank Favoloro, Jr., Wiley-Interscience
11. Name Reactions, Jie Jack Lie, 3rdEdn., Springer.
12. Organic Electrochemistry, H. Lund, and M. Baizer, 3rded., Marcel Dekker.

Course Code: RPSCHEO303

Course Title : NATURAL PRODUCTS AND SPECTROSCOPY

Academic year 2020-21

Course outcomes:

After studying this course, the learner will be able to:	
CO 1	Know basic structural elucidation of carbohydrates, organic pigments and alkaloids.
CO 2	Understand the synthetic strategies towards the synthesis of important biologically active molecules.
CO 3	Develop a problem solving approach towards the structural elucidation from spectral data.

DETAILED SYLLABUS

Course Code	Unit	Course Title / Unit Title	Credits/ Lectures
RPSCHEO303	**NATURAL PRODUCTS & SPECTROSCOPY**		**4**
	I	**Natural products-I**	**(15L)**
	1.1	Carbohydrates: Introduction to naturally occurring sugars: Deoxysugars, aminosugars, branched sugars. Structure elucidation of lactose and D-glucosamine (synthesis not expected).Structural features and applications of inositol, starch, cellulose, chitin and heparin.	**(05L)**
	1.2	Natural pigments: General structural features, occurrence, biological importance and applications of: carotenoids, anthocyanins, quinones, flavones, pterins and porphyrins (chlorophyll). Structure elucidation of β-carotene(with synthesis) and Cyanin (with synthesis).Synthesis of ubiquinone from 3, 4, 5-trimethoxyacetophenone.	**(05L)**
	1.3	Insect pheromones: General structural features and importance. Types of pheromones	**(03L)**

		(aggregation, alarm, releaser, primer, territorial, trail, sex pheromones etc.), advantage of pheromones over conventional pesticides. Synthesis of bombykol from acetylene, disparlure from 6-methylhept-1-ene, grandisol from 2-methyl-1, 3-butadiene.	
	1.4	Alkaloids: Occurrence and physiological importance of morphine and atropine. Structure elucidation, spectral data and synthesis of coniine.	**(02L)**
	II	**Natural products-II**	**(15L)**
	2.1	Multi-step synthesis of natural products: Synthesis of the following natural products with special reference to reagents used, stereochemistry and functional group transformations:	**(08L)**
		a) Woodward synthesis of Reserpine from benzoquinone	
		b) Corey synthesis of Longifoline from resorcinol	
		c) Gilbert-Stork synthesis of Griseofulvin from phloroglucinol	
		d) Corey's Synthesis of Caryophyllene from 2-Cyclohexenone and Isobutylene	
		e) Synthesis of Juvabione from Limonene f) Synthesis of Taxol.	
	2.2	Prostaglandins: Classification, general structure and biological importance. Structure elucidation of PGE_1.	**(02L)**
	2.3	Lipids: Classification, role of lipids, Fatty acids and glycerol derived from oils and fats.	**(02L)**
	2.4	Insect growth regulators: General idea, structures of JH_2 and JH_3 .	**(01L)**

	2.5	Plant growth regulators: Structural features and applications of arylacetic acids, gibberellic acids and triacontanol. Synthesis of triacontanol (synthesis of stearyl magnesium bromide and 12-bromo-1-tetrahydropyranyloxydodecane expected).	**(02L)**
	III	**Advanced spectroscopic techniques-I**	**(15L)**
	3.1	Proton NMR spectroscopy: Recapitulation, chemical and magnetic equivalence of protons, First order, second order, Spin system notations (A_2, AB, AX, AB_2, AX_2, AMX and A_2B_2-A_2X_2 spin systems with suitable examples). Long range coupling (Allylic coupling, 'W' coupling and Coupling in aromatic and heteroaromatic systems), Temperature effects, Simplification of complex spectra, nuclear magnetic double resonance, chemical shift reagents.	**(07L)**
	3.2	^{13}C –NMR spectroscopy: Recapitulation, equivalent and non-equivalent carbons (examples of aliphatic and aromatic compounds), ^{13}C- chemical shifts, calculation of ^{13}C- chemical shifts of aromatic carbons, heteronuclear coupling of carbon to ^{19}F and ^{31}P.	**(04L)**
	3.3	Spectral problems based on UV, IR, ^{1}HNMR and ^{13}CNMR and Mass spectroscopy .	**(04L)**
	IV	**Advanced spectroscopic techniques-II**	**(15L)**
	4.1	Advanced NMR techniques: DEPT experiment, determining number of attached hydrogens (Methyl/methylene/methine and quaternary carbons), two dimensional spectroscopic techniques, COSY and HETCOR spectra, NOE and NOESY techniques and spectra	**(10L)**

	4.2	Spectral problems based on UV, IR, ^{1}HNMR, ^{13}CNMR (Including 2D technique) and Mass spectroscopy.	**(05L)**

REFERENCES:

1. Natural products chemistry and applications, Sujata V. Bhat, B.A. Nagasampagi and S. Meenakshi, Narosa Publishing House, 2011
2. Organic Chemistry Natural Products Volume-II, O. P. Agarwal, Krishna Prakashan, 2011
3. Chemistry of natural products, V.K. Ahluwalia, Vishal Publishing Co.
4. Organic Chemistry, Vol 2, I.L. Finar, ELBS, 6th edition, Pearson, 2008
5. Total Synthesis of Longifolene, J. Am. Chem. Soc., E. J. Corey, M. Ohno, R. B. Mitra, and P. A. Vatakencherry. 1964,86, 478.
6. The Total Synthesis of Reserpine, Woodward, R. B.; Bader, F. E.; Bickel, H., Frey, A. J.; Kierstead, R. W. Tetrahedron 1958, 2, 1-57.
7. Total synthesis of Griseofulvin, Stork, G.; Tomasz, M. J. Am. Chem. Soc. 1962, 84, 310.
8. Spectroscopy of Organic compounds, P.S. Kalsi, New Age International Pub. Ltd. And Wiley Eastern Ltd., Second edition, 1995.
9. Spectrometric Identification of Organic compounds, R.M. Silverstein and others, John Wiley and Sons Inc., 5th ed., 1991
10. Organic structures from spectra, L. D. Field, S. Sternhell, John R. Kalman, Wiley, 4th ed., .2011
11. Introduction to spectroscopy, Donald L. Pavia, Gary M. Lampman, George S. Kriz, James R. Vyvyan, 4th ed., 2009..
12. Organic Spectroscopy: Principles And Applications, Jag Mohan, Alpha Science International Ltd., 30-Mar-2004

Course Code: RPSCHEOEC- I 304

Course Title : MEDICINAL, ENZYMES AND GREEN CHEMISTRY

Academic year 2020-21

Course outcomes:

After studying this course, the learners will be able to:	
CO 1	Know basic terms involved in medicinal chemistry, procedures involved in drug design and factors affecting the activity and potency of a particular drug,
CO 2	Understand the effect of Structure-Activity Relationship on drug function and the concept of prodrugs.
CO 3	Summarize the twelve principles of Green Chemistry and study their applications in synthetic organic chemistry.

DETAILED SYLLABUS

Course Code	Unit	Course Title / Unit Title	Credits/ Lectures
RPSCHEOEC-I304	**MEDICINAL , ENZYMES & GREEN CHEMISTRY**		**4**
	I	**Drug discovery, design and development**	**(15L)**
	1.1	Introduction, important terms used in medicinal chemistry: receptor, therapeutic index, bioavailability, drug assay and drug potency. General idea of factors affecting bioactivity: Resonance, inductive effect, bioisosterism, spatial considerations. Basic pharmacokinetics: drug absorption, distribution, metabolism (biotransformation) and elimination. Physical and chemical parameters like solubility, lipophilicity, ionization, pH, redox potential, H-bonding, partition	**(07L)**

		coefficient and isomerism in drug distribution and drug-receptor binding.	
	1.2	**Procedures in drug design**: Drug discovery without a lead: Penicillin, Librium. Lead discovery: random screening, non-random (or targeted) screening. Lead modification: Identification of the pharmacophore, Functional group modification. Structure-activity relationship, Structure modification to increase potency and therapeutic index: Homologation, chain branching, ring-chain transformation, bioisosterism, combinatiorial synthesis (basic idea).	**(08L)**
	II	**Drug design, development and synthesis**	**(15L)**
	2.1	Introduction to quantitative structure activity relationship studies. QSAR parameters: - steric effects: The Taft and other equations; Methods used to correlate regression parameters with biological activity: Hansch analysis- A linear multiple regression analysis.	**(05L)**
	2.2	Introduction to modern methods of drug design and synthesis- computer-aided molecular graphics based drug design, drug design via enzyme inhibition (reversible and irreversible), bioinformatics and drug design.	**(03L)**
	2.3	Concept of prodrugs and soft drugs. (a) Prodrugs: Prodrug design, types of prodrugs, functional groups in prodrugs, advantages of prodrug use. (b) Soft drugs: concept and properties	**(03L)**

	2.4	Synthesis and application of the following drugs: Fluoxetine, cetrizine, esomeprazole, fluconazole, zidovudine, methotrexate, diclofenac, labetalol, fenofibrate.	**(04L)**
	III	**Enzymes in Organic Chemistry**	**(15L)**
	3.1	Role of main enzymes involved in the synthesis and breakdown of glycogen.	**(02L)**
	3.2	Enzyme catalyzed organic reactions: Hydrolysis, hydroxylation, oxidation and reduction	**(06L)**
	3.3	Enzymes in organic synthesis. Fermentation: Production of drugs/drug intermediates by fermentation. Production of chiral hydroxy acids, vitamins, amino acids, β-lactam antibiotics. Synthesis of chemicals via microbial transformation, synthesis of L-ephedrine. Chemical processes with isolated enzymes in free form (hydrocyanation of m-phenoxybenzaldehyde) and immobilized form (production of 6-aminopenicillanic acid).	**(07L)**
	IV	**Green chemistry**	**(15L)**
	4.1	Introduction, basic principles of green chemistry. Designing a green synthesis: Green starting materials, green reagents, green solvents and reaction conditions, green catalysts.	**(01L)**
	4.2	Use of the following in green synthesis with suitable examples:	**(09L)**

		a) Green reagents: dimethylcarbonate, polymer supported reagents.	
		b) Green catalysts: Acid catalysts, oxidation catalysts, basic catalysts, phase transfer catalysts (Aliquat 336, benzyltrimethyl ammonium chloride (TMBA), Tetra-n-butyl ammonium chloride, crown ethers), biocatalysts.	
		c) Green solvents: water, ionic liquids, deep eutectic solvents, supercritical carbon dioxide.	
		d) Solid state reactions: solid phase synthesis, solid supported synthesis.	
		e) Microwave assisted synthesis: reactions in water, reactions in organic solvents, solvent free reactions.	
		f) Ultrasound assisted reactions.	
	4.3	Comparison of traditional processes versus green processes in the syntheses of ibuprofen, adipic acid, 4-aminodiphenylamine, p-bromotoluene and benzimidazole	**(03L)**
	4.4	Green Catayst s :Nanocatalyst, Types of nanoctalysts, Advantages and Disadvantages of Nanocatalysts, Idea of Magnetically separable nanocatalysts	**(02L)**

REFERENCES:

1. Lehninger principles of Biochemistry 5th Edition, Nelson, D. L, and Cox, M. M, (2008) W. H. Freeman and Company, NY., USA
2. Biochemistry, 3rd Edition, Voet, D. and J. G. Voet (2004) John Wiley & sons, Inc. USA
3. Nanomaterials in catalysis, First Edition. Edited by P. Serp and K. Philippot; 2013 Wiley –VCH Verlag GmbH & Co. K GaA
4. Nanomaterials and Catalysis, D. Astruc, Wiley-VCH Verlag GmbH & Co. KGaA, 2008
5. The chemistry of Nanomaterials, C. N. R. Rao, A. Muller and A. K. Cheetham, Wiley-VCH Verlag GmbH & Co. KGaA, 2005
6. The organic chemistry of drug design and drug action, Richard B. Silverman, 2nd edition, Academic Press
7. Medicinal chemistry, D.Sriram and P. Yogeeswari, 2nd edition, Pearson
8. Burger's medicinal chemistry and drug discovery. by Manfred E. Wolf
9. Principles of medicinal chemistry (Vol. I and II)-S. S. Kadam, K. R. Mahadik and K.G. Bothara, Nirali prakashan
10. Enzyme catalysis in organic synthesis, 3rd edition. Edited by Karlheinz Drauz, Harold Groger, and Oliver May, Wiley-VCH Verlag GmbH & Co KgaA, 2012
11. The Organic Chemistry of Enzyme-Catalysed Reactions, Academic Press, By Richard B. Silverman
12. Enzymes: Practical Introduction to structure, mechanism and data analysis, By Robert A. Copeland, Wiley-VCH, Inc.
13. Bioorganic chemistry - A chemical approach to enzyme action by Herman Dugas and Christopher Penney.
14. Green Chemistry: An Introductory Text, 2nd Edition, Published by Royal Society of Chemistry, Authored by Mike Lancater.
15. Green chemistry, Theory and Practical, Paul T. Anastas and John C. Warner.
16. New trends in green chemistry By V. K. Ahulwalia and M. Kidwai, 2nd edition, Anamaya Publishers, New Delhi.
17. An introduction to green chemistry, V. Kumar, Vishal Publishing Co.
18. Organic synthesis: Special techniques. V.K.Ahulwalia and Renu Aggarwal

Course Code: RPSCHEOEC-II 304
Course Title : BIOORGANIC CHEMISTRY
Academic year 2020-21

Course Outcomes:

After studying this course, the learner will be able to:	
CO 1	Develop a deeper understanding in the Chemistry of Proteins and Nucleic Acids.
CO 2	Infer the effect of physical parameters on the structure and function of nucleic acids.
CO 3	Apply the basic concepts of organic reaction mechanism to enzyme action and the action of coenzymes.
CO 4	Understand the biomimetic approach towards enzyme activity.
CO 5	Understand the various pathways towards the biosynthesis of important molecules and predict their pathways of synthesis.

DETAILED SYLLABUS

Course Code	Unit	Course Title / Unit Title	Credits/ Lectures
RPSCHEOEC-II 304	**BIOORGANIC CHEMISTRY**		**4**
	I	**Biomolecules-I**	**(15L)**
	1.1	Amino acids, peptides and proteins: Chemical and enzymatic hydrolysis of proteins to peptides, amino acid sequencing. Secondary structure of proteins, forces responsible for holding of secondary structures, α-helix, β-sheets, super secondary structure. Tertiary structure of protein: folding and domain structure. Quaternary structure.	**(02L)**
	1.2	Nucleic acids: Structure and function of physiologically important nucleotides (c-AMP, ADP, ATP) and nucleic acids (DNA and RNA),	**(03L)**

		replication, genetic code, protein biosynthesis, mutation.	
	1.3	Structure: Purine & pyrimidine bases, ribose, deoxyribose, nucleosides and nucleotides(ATP, CTP, GTP, TTP, UTP) formation of polynucleotides strand with its shorthand representation.	(03L)
	1.4	RNAs (various types in prokaryotes and eukaryotes) *m*- RNA and *r*- RNA – general account ,*t*- RNA-clover leaf model, Ribozymes.	(02L)
	1.5	DNA: Physical properties – Effect of heat on physical properties of DNA (Viscosity, buoyant density and UV absorption), Hypochromism, Hyperchromism and Denaturation of DNA. Reactions of nucleic acids (with DPA and Orcinol).	(02L)
	1.6	Chemical synthesis of oligonucleotides: Phosphodiester, Phosphotriester, Phosphoramidite and H- phosphonate methods including solid phase approach.	(03L)
	II	**Biomolecules-II**	**(15L)**
	2.1	Chemistry of enzymes: Introduction, nomenclature, classes and general types of reactions catalyzed by enzymes. Properties of enzymes: a) enzyme efficiency/ catalytic power b) enzyme specificity; Fischer's 'lock and key' and Koshland	(04L)

		'induced fit' hypothesis. Concept and identification of active site.	
	2.2	Factors affecting enzyme kinetics: Substrate concentration, enzyme concentration, temperature, pH, product concentration etc. Reversible and irreversible inhibition.	(06L)
	2.3	Mechanism of enzyme action: transition-state theory, orientation and steric effect, acid-base catalysis, covalent catalysis, strain or distortion. Mechanism of chymotrypsin catalyzed hydrolysis of a peptide bond.	(05L)
	III	**Biomolecules – III**	**(15L)**
	3.1	Chemistry of coenzymes. Structure, mechanism of action and bio-modeling studies of the following coenzymes: nicotinamide adenine dinucleotide, flavin adenine dinucleotide, thiamine pyrophosphate, pyridoxal phosphate, Vitamin B12, biotin, lipoic acid, Coenzyme A.	(12L)
	3.2	Oxidative phosphorylation, chemiosmosis, rotary model for ATP synthesis and role of cytochrome in oxygen activation.	(03L)
	IV	**Biogenesis and biosynthesis of natural products**	**(15L)**
	4.1	Primary and secondary metabolites and the building blocks, general pathway of amino acid biosynthesis.	(03L)

	4.2	Acetate pathway: Biosynthesis of malonyl CoA, saturated fatty acids, prostaglandins from arachidonic acid, aromatic polyketides.	(04L)
	4.3	Shikimic Acid pathway: Biosynthesis of shikimic acid, aromatic amino acids, cinnamic acid and its derivatives, lignin and lignans, benzoic acid and its derivatives, flavonoids and isofalvonoids.	(04L)
	4.4	Mevalonate pathway: Biosynthesis of mevalonic acid, monoterpenes – geranyl cation and its derivatives, sesquiterpenes – farnesyl cation and its derivatives and diterpenes.	(04L)

REFERENCES:

1. Lehninger principles of Biochemistry , Nelson, D. L, and Cox, M. M, 5th Edition, W. H. Freeman and Company, NY., USA, 2008
2. Biochemistry, Voet, D. and J. G. Voet,3rd Edition, John Wiley & sons, Inc. USA. 2004
3. Biochemistry, Dr U Satyanarayan and Dr U Chakrapani, Books and Allied (P) Ltd.
4. Bioorganic, Bioinorganic and Supramolecular chemistry, P.S. Kalsi and J.P. Kalsi. New Age International Publishers
5. The Organic Chemistry of Biological Pathways By John McMurry, Tadhg Begley by Robert and company publishers
6. Biochemistry: The chemical reactions in living cells, by E. Metzler. Academic Press
7. Bioorganic chemistry - A chemical approach to enzyme action by Herman Dugas and Christopher Penney
8. Medicinal Natural Products: A Biosynthetic Approach by Paul M. Dewick. 3rd Edition, Wiley
9. Natural products Chemistry and applications, Sujata V Bhat, B.A. Nagasampagi and S. Meenakshi, Narosa Publishing House
10. Natural Products Volume 2, By O. P. Agarwal
11. Chemistry of Natural Products, F. F. Bentley and F. R. Dollish, 1974
12. Biogenesis of Natural Products, Baldev Kumar, Narosa Publishing House.

Semester III: Practicals

(Credits-08)

Course code: RPSCHEO3P1 and RPSCHEO3P2

Separation of a ternary mixture of organic compounds and identification including derivative preparations using micro-scale technique

1. Separation of a ternary mixture (S-S-S, S-S-L, S-L-L and L-L-L) (for solid mixture: water insoluble/ soluble including carbohydrates) based upon differences in the physical and the chemical properties of the components
2. Identification of the two components (indicated by the examiner) using micro-scale technique
3. Preparation of derivatives (any one of separated compound indicated by the examiner)

(**Minimum 8 experiments**)

Course code: RPSCHEO3P3 and RPSCHEO3P4

Single step organic preparation involving purification by Steam distillation / Vacuum distillation or Column chromatography.

1. Preparation of acetanilide from aniline and acetic acid using Zn dust. (Purification by column chromatography)
2. Preparation of 1-nitronaphthalene from naphthalene. (Purification by steam distillation)
3. .Preparation of acetyl ferrocene from ferrocene. (Purification by column chromatography)
4. .Preparation of 3-nitroaniline from 1,3-dinitrobenzene. (Purification by column chromatography)
5. Preparation of benzyl alcohol from benzaldehyde. (Purification by vacuum distillation).
6. Preparation of methyl salicylate from salicylic acid. (Purification by vacuum distillation).
7. .Preparation of 4-methylacetophenone from toluene. (Purification by vacuum distillation).
8. .Preparation of phenyl acetate from phenol. (Purification by vacuum distillation)
9. Preparation of 2-chlorotoluene from o-toluidine. (Purification by steam distillation)

10. Preparation of 4-nitrophenol from phenol. (Purification by steam distillation/ column chromatography)

11. Preparation of fluorenone from fluorene. (Purification by column chromatography)

12. Preparation of dimethylphthalate from phthalic anhydride. (Purification by vacuum distillation)

(Minimum 8 experiments)

Note:

1. Learners are expected to know (i) the planning of synthesis, effect of reaction parameters including stoichiometry, and **safety aspects including MSDS** (ii) the possible mechanism, expected spectral data (IR and NMR) of the starting material and final product.

2. Learners are expected to purify the product by Steam distillation / Vacuum distillation or Column chromatography, measure its mass or volume, check the purity by TLC, determine physical constant and calculate percentage yield.

References for Practicals

1.Advanced Practical Organic Chemistry – N. K. Vishnoi, Third Addition, Vikas Publishing House PVT Ltd

2.Systematic Identification of Organic compounds, 6th edition, R. L. Shriner, R. C. Fusonand D.Y. Curtin Wiley, New York

3. Systematic Qualitative Organic Analysis, H. Middleton, Adward Arnold.

4. Handbook of Organic Analysis- Qualitative and Quantitative, H. Clark, Adward Arnold

7. Vogel's Textbook of Practical Organic Chemistry, Fifth edition,2008, B.S.Furniss, A. J.Hannaford, P. W. G. Smith, A. R. Tatchell, Pearson Education.

8. Laboratory Manual of Organic Chemistry, Fifth edition, R K Bansal, New Age Publishers

Note:

1. The candidate is expected to submit a journal certified by the Head of the Department /institution at the time of the practical examination.

2. A candidate will not be allowed to appear for the practical examination unless he/she produces a certified journal or a certificate from the Head of the institution/department stating that the journal is lost and the candidate has performed the required number of experiments satisfactorily. The list of the experiments performed by the candidate should be attached with such certificate.

3. Use of non-programmable calculator is allowed both at the theory and the practical examination.

MODALITY OF ASSESSMENT

Theory Examination Pattern

B) 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 %

Semester End Theory Assessment - 60 marks

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

ii. Paper Pattern:

There shall be **4** questions each of **15** marks. On each unit there will be one question.
All questions shall be compulsory with internal choice within the questions.

Questions	Options	Marks	Questions based on
Q.1) (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	

Practical Examination Pattern:

External (Semester end practical examination):

Particulars	Marks
Laboratory work	40
Journal	05
Viva	05
Total	**50**

Overall Examination and Marks Distribution Pattern

Course	301			302			Grand Total
	Internal	External	Total	Internal	External	Total	
Theory	40	60	100	40	60	100	200
Practical			50			50	100
Course	303			304			Grand Total
	Internal	External	Total	Internal	External	Total	
Theory	40	60	100	40	60	100	200
Practical			50			50	100

Total 600 marks

Semester – IV
Course Code: RPSCHEO401
Course Title : THEORETICAL ORGANIC CHEMISTRY-II
Academic year 2020-21

Course Outcomes:

After studying this course, the learner will be able to:	
CO 1	Correlate the effects of substituent's on a substrate with its reactivity.
CO 2	Understand the concept of molecular assembly and intermolecular bond in macromolecules and their effects on their catalytic activity.
CO 3	Determine enantiomeric and diastereomeric compositions using various available methods.
CO 4	Understand the properties of molecules by studying physical phenomenon like Circular Dichroism (CD) and Optical Rotatory Dispersion (ORD).
CO 5	Discuss the types of Assymetric Synthesis controlled by Chiral Auxiliary, chiral catalyst, chiral substrate and chiral reagent with examples .
CO 6	Appreciate the importance and challenges in asymmetric synthesis, exemplified by Felkin-Anh and chelation models and asymmetric aldol reactions.

DETAILED SYLLABUS

Course Code	Unit	Course Title / Unit Title	Credits/ Lectures
RPSCHEO401		**THEORETICAL ORGANIC CHEMISTRY-II**	**4**
	I	**Physical organic chemistry**	**(15L)**
	1.1	Structural effects and reactivity: Linear free energy relationship (LFER) in determination of organic reaction mechanism, The Hammett equation, substituent constants, theories of substituent effects, interpretation of σ-values, reaction constants ρ, Yukawa-Tsuno equation.	**(07L)**
	1.2	Uses of Hammett equation, deviations from Hammett equation. Dual parameter correlations, Inductive substituent constants. The Taft model, σ_I and σ_R scales, steric	**(08L)**

		parameters Es and β. Solvent effects, Okamoto-Brown equation, Swain-Scott equation, Edward and Ritchie correlations, Grunwald-Winstein equation, Dimroth's E_T parameter, Solvatochromism Z-scale, Spectroscopic Correlations, Thermodynamic Implications.	
	II	**Supramolecular chemistry**	**(15L)**
	2.1	Principles of molecular associations and organizations as exemplified in biological macromolecules like nucleic acids, proteins and enzymes.	**(03L)**
	2.2	Synthetic molecular receptors: receptors with molecular cleft, molecular tweezers, receptors with multiple hydrogen sites.	**(03L)**
	2.3	Structures and properties of crown ethers, cryptands, cyclophanes, calixarenes, rotaxanes and cyclodextrins. Synthesis of crown ethers, cryptands and calixarenes.	**(05L)**
	2.4	Molecular recognition and catalysis, molecular self-assembly. Supramolecular Polymers, Gelsand Fibres.	**(04L)**
	III	**Stereochemistry- II**	**(15L)**
	3.1	Racemisation and resolution of racemates including conglomerates: Mechanism of racemisation, methods of resolution: mechanical, chemical, kinetic and equilibrium asymmetric transformation and through inclusion compounds.	**(03L)**
	3.2	Determination of enantiomer and diastereomer composition: enzymatic method, chromatographic methods. Methods based on NMR spectroscopy: use of chiral derivatising	**(03L)**

		agents (CDA), chiral solvating agents (CSA) and Lanthanide shift reagents (LSR).	
	3.3	Correlative method for configurational assignment: chemical, optical rotation, and NMR spectroscopy.	**(04L)**
	3.4	Molecular dissymmetry and chiroptical properties: Linearly and circularly polarized light. Circular birefringence and circular dichroism. ORD and CD curves. Cotton effect and its applications. The octant rule and the axial α–haloketone rule with applications.	**(05L)**
	IV	**Asymmetric synthesis**	**(15L)**
	4.1	Principles of asymmetric synthesis: Introduction, the chiral pool in Nature, methods of asymmetric induction – substrate, reagent and catalyst controlled reactions.	**(03L)**
	4.2	Synthesis of L-DOPA (Knowles's Mosanto process). Asymmetric reactions with mechanism: Aldol and related reactions, Cram's rule, Felkin-Anh model, Sharpless enantioselective epoxidation, hydroxylation, aminohydroxylation, Diels-Alder reaction, reduction of prochiral carbonyl compounds and olefins.	**(09L)**
	4.3	Use of chiral auxiliaries in diastereoselective reductions, asymmetric amplification. Use of chiral BINOLs, BINAPs and chiral oxazolines, asymmetric transformations.	**(03L)**

References:

1. Modern physical chemistry, Eric V Anslyn, Dennis A. Dougherty, University science books, 2006

2. A guide to mechanism in Organic Chemistry, 6th edition, 2009, Peter Sykes, Pearson education, New Delhi
3. Supramolecular Chemistry; Concepts and Perspectives, J. M. Lehn, VCH
4. Crown ethers and analogous compounds, M. Hiraoka, Elsevier, 1992
5. Large ring compounds, J.A.Semlyen, Wiley-VCH, 1997
6. Stereochemistry of Carbon Compounds: Principles and Applications, D, Nasipuri, 3rd edition, New Age International Ltd
7. Stereochemistry, P. S. Kalsi, 4th edition, New Age International Ltd
8. Stereochemistry of Organic Compounds, Ernest L. Eliel and Samuel H.
9. Wilen, Wiley-India edition
10. Organic Stereochemistry, M. J. T. Robinson, Oxford University Press,New Delhi, India edition, 2005
11. Stereochemistry of Carbon Compounds: Principles and Applications, D,Nasipuri, 3rd edition, New Age International Ltd

Course Code: RPSCHEO402

Course Title : SYNTHETIC ORGANIC CHEMISTRY-II

Academic year 2020-21

Course outcomes:

After studying this course, the learner will be able to:	
CO 1	Propose a reterosynthetic strategy for an organic compound.
CO 2	Give the forward synthesis, recognizable starting material and steps involved in the synthesis of the compound.
CO 3	Know the current trends in synthesizing organic compound.
CO 4	Explore the applications of modern and greener methods of organic synthesis.
CO 5	Understand the application of transition metal reagents and catalysts in organic synthesis.
CO 6	Know the use of electrochemical methods for organic synthesis.

DETAILED SYLLABUS

Course Code	Unit	Course Title / Unit Title	Credits/ Lectures
RPSCHEO402	**SYNTHETIC ORGANIC CHEMISTRY-II**		**4**
	I	**Designing Organic Synthesis-I**	**(15L)**
	1.1	Protecting groups in Organic Synthesis: Protection and deprotection of the hydroxyl, carbonyl, amino and carboxyl functional groups and its applications.	**(03L)**
	1.2	Concept of umpolung (Reversal of polarity): Generation of acyl anion equivalent using 1,3-dithianes, methyl thiomethylsulfoxides, cyanide ions, cyanohydrin ethers, nitro compounds and vinylated ethers.	**(03L)**
	1.3	Introduction to Retrosynthetic analysis and synthetic planning: Linear and convergent synthesis; Disconnection approach: An introduction to synthons, synthetic equivalents, disconnection approach, functional group interconversions (FGI), functional group addition (FGA), functional group removal (FGR) importance of order of events in	**(09L)**

		organic synthesis, one and two group C-X disconnections (1,1; 1,2; 1,3 difunctionalized compounds), selective organic transformations: chemoselectivity, regioselectivity, stereoselectivity, enantioselectivity.	
	II	**Designing Organic Synthesis-II**	**(15L)**
	2.1	General strategy: choosing a disconnection-simplification, symmetry, high yielding steps, and recognisable starting material.	**(03L)**
	2.2	One group C-C Disconnections: Alcohols (including stereoslectivity), carbonyls (including regioselectivity), Alkene synthesis, use of acetylenes and aliphatic nitro compounds in organic synthesis.	**(06L)**
	2.3	Two group C-C Disconnections: 1,2- 1,3- 1,4- 1,5- and 1,6-difunctionalized compounds, Diels-Alder reactions, α, β-unsaturated compounds, control in carbonyl condensations, Michael addition and Robinson annelation.	**(06L)**
	III	**Electro-organic chemistry and Selected methods of Organic synthesis**	**(15L)**
	3.1	**Electro-organic chemistry:**	**(07L)**
	3.1.1	Introduction: Electrode potential, cell parameters, electrolyte, working electrode, choice of solvents, supporting electrolytes.	
	3.1.2	Cathodic reduction: Reduction of alkyl halides, aldehydes, ketones, nitro compounds, olefins, arenes, electro-dimerization.	
	3.1.3	Anodic oxidation: Oxidation of alkylbezene, Kolbe reaction, Non-Kolbe oxidation, Shono oxidation.	
	3.2	**Selected Methods of Organic synthesis**	**(08L)**

		Applications of the following in organic synthesis:	
	3.2.1	Crown ethers, cryptands, micelles, cyclodextrins, catenanes.	
	3.2.2	Organocatalysts: Proline, Imidazolidinone.	
	3.2.3	Pdcatalysedcycloadditionreactions:Stille reaction, Saeguse-Ito oxidation to enones, Negishi couple	
	3.2.4	Use of Sc(OTf), and Yb(OTf) as water tolerant Lewis acid catalyst in aldol condensation, Michael reaction, Diels-Alder reaction, Friedel – Crafts reaction.	
	IV	**Transition and rare earth metals in organic synthesis**	**(15L)**
	4.1	Introduction to basic concepts: 18 electron rule, bonding in transition metal complexes, C-H activation, oxidative addition, reductive elimination, migratory insertion.	**(03L)**
	4.2	Palladium in organic synthesis: π-bonding of Pd with olefins, applications in C-C bond formation, carbonylation, alkene isomerisation, cross-coupling of organometallics and halides. Representative examples: Heck reaction, Suzuki-Miayura coupling, Sonogashira reaction and Wacker oxidation. Heteroatom coupling for bond formation between aryl/vinyl groups and N, S, or P atoms.	**(05L)**
	4.3	Olefin metathesis using Grubb's catalyst	**(01L)**
	4.4	Application of Ni, Co, Fe, Rh, and Cr carbonyls in organic synthesis	**(04L)**
	4.5	Application of samarium iodide including reduction of organic halides, aldehydes and ketones, α-functionalised carbonyl and nitro compounds.	**(01L)**

	4.6	Application of Ce(IV) in synthesis of heterocyclic quinoxaline derivatives and its role as a de-protecting agent.	**(01L)**

REFERENCES:

1. Advanced Organic Chemistry, Part A and Part B: Reaction and Synthesis, Francis A. Carey, Richard J. Sundberg, 5th Edition, Springer Verlag
2. Modern Methods of Organic Synthesis,4th Edition, W. Carruthers and Iain Coldham, Cambridge University Press, 2004
3. Chem.Rev. 2002, 102, 2227-2302, Rare Earth Metal Triflates in Organic Synthesis, S. Kobayashi, M. Sugiura, H. Kitagawa, and W.W.L. Lam
4. Organic Chemistry, Clayden Greeves Warren and Wothers, Oxford Press, 2001
5. Modern Organic Synthesis: An Introduction, G.S. Zweifel and M.H. Nantz, W.H. Freeman and Company, 2007
6. Advanced Organic Chemistry: Reaction Mechanism, R. Bruckner, Academic Press, 2002
7. Principles of Organic Synthesis, R.O.C. Norman & J. M. Coxon,3rdEdn., Nelson Thornes
8. Organic Chemistry, 7thEdn, R. T .Morrison, R. N. Boyd, & S. K. Bhattacharjee, Pearson
9. Strategic Applications of Name Reactions in Organic Synthesis, L. Kurti& B. Czako, Elsevier Academic Press, 2005
10. Advanced Organic Chemistry: Reactions & Mechanisms, 2ndEdn.,B. Miller & R. Prasad, Pearson
11. Organic reactions and their mechanisms, 3rdrevisededition, P.S. Kalsi, New Age International Publishers
12. Organic Synthesis: The Disconnection Approach, Stuart Warren, John Wiley & Sons, 2004
13. Name Reactions and Reagents in Organic Synthesis, 2ndEdn., Bradford P. Mundy, Michael G. Ellard, and Frank Favoloro, Jr., Wiley-Interscience
14. Name Reactions, Jie Jack Lie, 3rdEdn., Springer.
15. Organic Electrochemistry, H. Lund, and M. Baizer, 3rdEdn., Marcel Dekker

Course Code: RPSCHEO403

Course Title : NATURAL PRODUCTS AND HETEROCYCLIC CHEMISTRY

Academic year 2020-21

Course Outcomes:

After studying this course, the learner will be able to-:	
CO 1	Understand the occurrence and biological roles of steroids, vitamins, terpenoids and antibiotics.
CO 2	Have an enhanced approach towards structural elucidation.
CO 3	Apply the rules of IUPAC nomenclature and other methodologies towards nomenclature of heterocycles.
CO 4	Understand the reactivity of various heterocyclic molecules and their importance towards synthesis of certain biologically active molecules.

Course Code	Unit	Course Title/Unit Title	Credits/ Lectures
RPSCHEO403	**NATURAL PRODUCTS & HETEROCYCLIC CHEMISTRY**		**4**
	I	**Natural products-III**	**(15L)**
	1.1	Steroids: General structure, classification. Occurrence, biological role, important structural and stereochemical features of the following: corticosteroids, steroidal hormones, steroidal alkaloids, sterols and bile acids.	**(05L)**
	1.2	Synthesis of 16-DPA from cholesterol and plant sapogenin.	**(02L)**
	1.3	Synthesis of the following from 16-DPA: androsterone, testosterone, oestrone, oestriol,oestradiol and progesterone.	**(05L)**
	1.4	Synthesis of cinerolone, jasmolone, allethrolone, exaltone and muscone.	**(03L)**
	II	**Natural products-IV**	**(15L)**
	2.1	Vitamins: Classification, sources and biological importance of vitamin B_1, B_2, B_6, folic acid,	**(05L)**

		B_{12}, C, D_1, E (α-tocopherol), K_1, K_2, H (β-biotin).	
		Synthesis of the following:	
		Vitamin A from β-ionone and bromoester moiety.	
		Vitamin B_1 including synthesis of pyrimidine and thiazole moieties	
		Vitamin B_2 from 3, 4-dimethylaniline and D(-)ribose	
		Vitamin B_6 from: 1) ethoxyacetylacetone and cyanoacetamide, 2) ethyl ester of N-formyl-DL-alanine (Harris synthesis)	
		Vitamin E (α-tocopherol) from trimethylquinol and phytyl bromide	
		Vitamin K_1 from 2-methyl-1, 4-naphthaquinone and phytol.	
	2.2	Antibiotics: Classification on the basis of activity. Structure elucidation, spectral data of penicillin-G, cephalosporin-C and chloramphenicol. Synthesis of chloramphenicol (from benzaldehyde and β-nitroethanol) penicillin-G and phenoxymethylpenicillin from D-penicillamine and t-butyl phthalimidemalonaldehyde (synthesis of D-penicillamine and t-butyl phthalimidemalonaldehyde expected).	**(06L)**
	2.3	Naturally occurring insecticides: Sources, structure and biological properties of pyrethrums (pyrethrin I), rotenoids (rotenone). Synthesis of pyrethrin I.	**(02L)**

	2.4	Terpenoids: Occurrence, classification, structure elucidation, stereochemistry, spectral data and synthesis of zingiberene	**(02L)**
	III	**Heterocyclic compounds-I**	**(15L)**
	3.1	Heterocyclic compounds: Introduction, classification, Nomenclature of heterocyclic compounds of monocyclic (3-6 membered) (Common, systematic (Hantzsch-Widman) and replacement nomenclature)	**(07L)**
	3.2	Structure, reactivity, synthesis and reactions of pyrazole, imidazole, oxazole, isoxazole, thiazole, isothiazole, pyridazines, pyrimidine,pyrazines and oxazines.	**(08L)**
	IV	**Heterocyclic compounds-II**	**(15L)**
	4.1	Nomenclature of heterocyclic compounds of bicyclic/tricyclic (5-6 Membered) fused heterocycles (up to three hetero atoms). (Common, systematic (Hantzsch-Widman) and replacement nomenclature)	**(4L)**
	4.2	Nucleophilic ring opening reactions of oxiranes, aziridines, oxetanes and azetidines.	**(5L)**
	4.3	Structure, reactivity, synthesis and reactions of coumarins, quinoxalines,cinnolines,indole, benzimidazoles, benzoxazoles, benzothiazoles, Purines andacridines.	**(6L)**

REFERENCES:

1. Natural products chemistry and applications, Sujata V. Bhat, B.A. Nagasampagi and S. Meenakshi, Narosa Publishing House, 2011
2. Organic Chemistry Natural Products Volume-II, O. P. Agarwal, Krishna Prakashan, 2011
3. Chemistry of natural products, V.K. Ahluwalia, Vishal Publishing Co. 2008
4. Heterocyclic chemistry, 3rd edition, Thomas L. Gilchrist, Pearson Education, 2007

5. Medicinal Natural Products, a Biosynthetic Approach, Derick Paul, John Wiley and Sons, 2002
6. Heterocyclic Chemistry, Synthesis, Reactions and Mechanisms, R. K. Bansal, Wiley Eastern Ltd, 1990
7. Heterocyclic Chemistry, J. A. Joule and G. F. Smith, ELBS, 2nd edition, 1982
8. Natural Products: Chemistry and Biological Significance Interscience, J. Mann, R.S. Davidson, J.B.Hobbs, D.V. Banthrope and J. B. Harborne, Longman,Essex, 1994.
9. Organic Chemistry, Vol 2, I.L. Finar, ELBS, 6th edition, Pearson.
10. Stereoselective Synthesis: A Practical Approach, M. Nogradi, Wiley-VCH, 1995.
11. New Trends in Natural Product Chemistry, Atta-ur-Rahman and M.I. Choudhary, Harwood AcademicPublishers, 1998.
12. Insecticides of Natural Origin, SukhDev, Harwood Academic Publishers.

Course Code: RPSCHEOOC-I 404

Course Title : INTELLECTUAL PROPERTY RIGHTS & CHEMINFORMATICS

Academic year 2020-21

Course Outcomes:

After studying this course, the learner will be able to:	
CO 1	Be well versed with the concept of intellectual property and the terms involved with respect to Indian Patent Law.
CO 2	Distinguish between patents and copyrights.
CO 3	Elaborate on the economic impact and legislature involved in Intellectual property rights.
CO 4	Make use of the software tools pertaining to Cheminformatics and Molecular Modelling.
CO 5	Conduct structure and sub-structure search online, determine SMILES codes for various molecules.
CO 6	Gain knowledge about the application of the research based tools.

DETAILED SYLLABUS

Course Code	**Unit**	**Course Title / Unit Title**	**Credits/ Lectures**
RPSCHEOOC-I 404	**INTELLECTUAL PROPERTY RIGHTS & CHEMINFORMATICS**		**4**
	I	**Intellectual Property- I**	**(15L)**
	1.1	Introduction to Intellectual Property:	**(02L)**
		Historical Perspective, Different types of IP, Importance of protecting IP.	
	1.2	Patents:	**(05L)**
		Historical Perspective, Basic and associated right, WIPO, PCT system, Traditional Knowledge, Patents and Health care-balancing promoting innovation with public health, Software patents and their importance for India.	
	1.3	Industrial Designs:	**(02L)**
		Definition, How to obtain, features, International design registration.	

	1.4	Copyrights:	**(02L)**
		Introduction, How to obtain, Differences from Patents.	
	1.5	Trade Marks:	**(02L)**
		Introduction, How to obtain, Different types of marks – Collective marks, certification marks, service marks, trade names etc.	
	1.6	Geographical Indications:	**(02L)**
		Definition, rules for registration, prevention of illegal exploitation, importance to India.	
	II	**Intellectual Property - II**	**(15L)**
	2.1	Trade Secrets:	**(02L)**
		Introduction and Historical Perspectives, Scope of Protection, Risks involved and legal aspects of Trade Secret Protection.	
	2.2	IP Infringement issue and enforcement:	**(02L)**
		Role of Judiciary, Role of law enforcement agencies – Police, Customs etc.	
	2.3	Economic Value of Intellectual Property:	**(02L)**
		Intangible assests and their valuation, Intellectual Property in the Indian context – Various Laws in India Licensing and Technology transfer.	
		Different International agreements:	
	2.4	(a) World Trade Organization (WTO):	**(05L)**
		(i) General Agreement on Tariffs and Trade (GATT), Trade Related Intellectual Property Rights (TRIPS) agreement	

		(ii) General Agreement on Trade Related Services (GATS) Madrid Protocol.	
		(iii) Berne Convention	
		(iv) Budapest Treaty	
	2.5	(b) Paris Convention	**(04L)**
		WIPO and TRIPS, IPR and Plant Breeders Rights, IPR and Biodiversity.	
	III	**Cheminformatics - I**	**(15L)**
	3.1	Introduction to Cheminformatics:	**(05L)**
		History and evolution of cheminformatics, Use of Cheminformatics, Prospects of cheminformatics, Molecular modeling and structure elucidation.	
	3.2	Representation of molecules and chemical reactions:	**(05L)**
		Nomenclature, Different types of notations, SMILES coding, Matrix representations, Structure of Molfiles and Sdfiles, Libraries and toolkits, Different electronic effects, Reaction classification.	
	3.3	Searching Chemical Structures:	**(05L)**
		Full structure search, sub-structure search, basic ideas, similarity search, three dimensional search methods, basics of computation of physical and chemical data and structure descriptors, data visualization.	
	4	**Cheminformatics - II**	**(15L)**
		Prediction of Properties of Compound, Linear Free Energy Relations, Quantitative Structure – Property Relations, Descriptor Analysis, Model Building, Modeling Toxicity, Structure – Spectra correlations,	

		Prediction NMR, IR and Mass spectra, Computer Assisted Structure elucidations, Computer assisted Synthesis Design, Introduction to drug design, Target Identification and Validation, Lead Finding and Optimization, analysis of HTS data, Virtual Screening, Design of Combinatorial Libraries, Ligand-based and Structure based Drug design, Application of Cheminformatics in Drug Design.	

REFERENCES:

1. Andrew R. Leach & Valerie J. Gillet (2007) An Introduction to Cheminformatics. Springer: The Netherlands.
2. Gasteiger, J. & Engel, T. Cheminformatics: A textbook. Wiley–VCH , 2003
3. Gupta, S. P. QSAR and Molecular Modelling. Springer-Anamaya Pub.: New Delhi.
4. Barry A. Bunin Cheminformatics: Theory, Practice and Products–Springer

Course Code: RPSCHEOOC-II 404

Course Title : RESEARCH METHODOLOGY

Academic year 2020-21

Course Outcomes:

After studying this course, the learner will be able to:	
CO 1	Know basics of research methodology.
CO 2	Get the technical know-how of research from developing a problem.
CO 3	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.

Course Code	Unit	Course Title / Unit Title	Credits/ Lectures
RPSCHEOOC-II404	**RESEARCH METHODOLOGY**		**4**
	I	**Review of Literature**	**(15L)**
	1.1	Print:	**(05L)**
		Primary, Secondary and Tertiary sources.	
		Journals:	
		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.	
	1.2	Digital:	**(05L)**
		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.	
	1.3	**Information Technology and Library Resources:**	**(05L)**
		The Internet and World wide web, Internet resources for Chemistry, finding and citing published information.	
	II	**Data Analysis**	**(15L)**
		The Investigative Approach:	
		Making and recording Measurements, SI units and their use, Scientific methods and design of experiments.	
		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**	**(15L)**
	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:	
	3.3	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**	**(15L)**
		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, 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.	

REFERENCES:

1. Dean, J. R., Jones, A. M., Holmes, D., Reed, R., Weyers, J., & Jones, A., (2011), Practical skills in Chemistry, 2nd Ed., Prentice Hall, Harlow.
2. Hibbert, D. B. & Gooding, J. J. (2006) Data Analysis for Chemistry Oxford University Press.
3. Topping, J., (1984) Errors of Observation and their Treatment 4th Ed., Chapman Hill, London.
4. Harris, D. C. (2007) Quantative Chemical Analysis 6th Ed., Freeman Chapters 3-5
5. Levie, R. De. (2001) How to use Excel in Analytical Chemistryand in general scientific data analysis Cambridge Universty Press.
6. Chemical Safety matters – IUPAC-IPCS, (1992) Cambridge University Press.
7. OSU Safety manual 1.01

Semester IV: Practicals

Credits 08

Course code: RPSCHEO4P1and RPSCHEO4P2

Two steps preparations

1. Acetophenone →Acetophenone phenyl hydrazine → 2-phenyl indole.
2. 2-naphthol → 1-phenyl azo-2-naphthol → 1-amino-2-naphthol.
3. Cyclohexanone → cyclohexanoneoxime → Caprolactum.
4. Hydroquinone → hydroquinone diacetate → 2,5-dihydroxyacetophenone.
5. 4-nitrotoluene → 4-nitrobenzoic acid → 4-aminobenzoic acid.
6. *o*-nitroaniline → *o*-phenylenediamine → Benzimidazole.
7. Benzophenone → benzophenoneoxime → benzanilide.
8. *o*-chlorobenzoic acid → N-phenyl anthranilic acid → acridone.
9. Benzoin → benzil → benzilic acid.
10. Phthalic acid →phthalimide→anthranilic acid.
11. Resorcinol → 4-methyl-7-hydroxy coumarin→ 4-methyl-7-acetoxy coumarin.
12. Anthracene→anthraquinone→anthrone.

(Minimum 8 experiments)

Note:

1. Learners are expected to know (i) the planning of synthesis, effect of reaction parameters including stoichiometry, and safety aspects including MSDS (ii) the possible mechanism, expected spectral data (IR and NMR) of the starting material and final product.
2. Learners are expected to purify the product by recrystallization, measure its mass or volume, check the purity by TLC, determine physical constant and calculate percentage yield.

Course code: RPSCHEO4P3 and RPSCHEO4P4

Session-I: (RPSCHEO4P3) Combined spectral identification: Interpretation of spectral data of organic compounds(UV, IR, PMR, CMR and Mass spectra).

A learner will be given UV, IR, PMR, CMR, and Mass spectra of a compound from which preliminary information should be reported within first half an hour of the examination without referring to any book/reference material. The complete structure of the compound may then be elucidated by referring to any standard values table etc
(Minimum 8 spectral analysis).
Session-II:(RPSCHEO4P4) Project evaluation

References for Practicals

1. 1. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis- V.K. Ahluwalia and Renu Aggarwal, Universities Press India Ltd., 2000
2. Advanced Practical Organic Chemistry – N. K. Vishnoi, Third Addition, Vikas Publishing House PVT Ltd
3. Practical Organic Chemistry- F. G. Mann, B.C. Saunders 4th ed. ELBS
4. 5.Vogel's Textbook of Practical Organic Chemistry, Fifth edition,2008, B.S. Furniss, A. J. Hannaford, P. W. G. Smith, A. R. Tatchell, Pearson Education.
5. Laboratory Manual of Organic Chemistry, Fifth edition, R K Bansal, New Age Publishers.
6. Organic structures from spectra, L. D. Field, S. Sternhell, John R. Kalman, Wiley, 4th ed., 2011.

Note:

1. The candidate is expected to submit a journal and project certified by the Head of the Department /institution at the time of the practical examination.
2. A candidate will not be allowed to appear for the practical examination unless he/she produces a certified journal or a certificate from the Head of the institution/department stating that the journal is lost and the candidate has performed the required number of experiments satisfactorily. The list of the experiments performed by the candidate should be attached with such certificate.
3. Use of non-programmable calculator is allowed both at the theory and the practical examination.

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 %

Semester End Theory Assessment - 60 marks

I) Duration - These examinations shall be of 2.5 hours duration.

II) Paper Pattern:

There shall be 4 questions each of 15 marks. On each unit there will be one question. All questions shall be compulsory with internal choice within the questions.

Questions	Options	Marks	Questions based on
Q.1) (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	

Practical Examination Pattern:

External (Semester end practical examination):

Particulars	Marks
Laboratory work	40
Journal	05
Viva	05
Total	50

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

Total 600 marks

Resolution Number: AB/II (20-21).2.RPS5

S.P. Mandali
Ramnarain Ruia Autonomous College

(Affiliated to University of Mumbai)

RUIA COLLEGE
Explore • Experience • Excel

Syllabus for Semester III and IV

Program: M.Sc. (Analytical Chemistry)

Program Code: (RPSCHEA)

(Credit Based Semester and Grading System with effect from the academic year 2020–2021)

SEMESTER-III			
Course Code	**Unit**	**Course Title / Unit Title**	**Credits**
RPSCHEA301	**Quality in Analytical Chemistry**		**4**
	I	Quality in Analytical Chemistry – I	
	II	Quality in Analytical Chemistry – II	
	III	Chromatographic Techniques -I	
	IV	Chromatographic Techniques -II	
RPSCHEA302	**Advanced Instrumental Techniques**		**4**
	I	Spectral Methods I	
	II	Hyphenated Techniques	
	III	Radiochemical & Thermal methods	
	IV	Electroanalytical Methods	
RPSCHEA303	**Bioanalytical Chemistry & Food Analysis**		**4**
	I	Bioanalytical chemistry	
	II	Immunological Methods	
	III	Food Analysis – I	
	IV	Food Analysis – II	
RPSCHEAEC-I 304	**Environmental & Certain Industrially Important Materials**		**4**
	I	Air Pollution	
	II	Water Quality Standards	
	III	Other Types Of Pollution	
	IV	Green Chemistry	
RPSCHEAEC-II 304	**Pharmaceutical & Organic Analysis**		**4**
	I	Pharmaceutical Analysis	
	II	Drugs	
	III	Forensic Science	
	IV	Cosmetic Analysis	
RPSCHEA3P1	**Practical**		**8**
RPSCHEA3P2			
RPSCHEA3P3			
RPSCHEA3P4			

SEMESTER-IV			
Course Code	**Unit**	**Course Title/Unit Title**	**Credits**
RPSCHEA401	**Separation Techniques & Industrial Materials**		**4**
	I	Separation Science	
	II	Electrophoresis	
	III	Separation, Analysis and Standardization of Herbal based products.	
	IV	Industrial Materials	
RPSCHEA402	**Advanced Instrumental Techniques**		**4**
	I	Spectral Methods II	
	II	Spectral Methods III	
	III	Spectral Methods IV	
	IV	Micellaneous Techniques	
RPSCHEA403	**Environmental & Certain Industrially Important Materials**		**4**
	I	Effluent Treatment	
	II	Solid Waste Management	
	III	Plastics and Polymers	
	IV	Metallurgy	
RPSCHEAOC-I 404	**Intellectual Property Rights & Cheminformatics**		**4**
	I	Introduction to Intellectual Property – I	
	II	Introduction to Intellectual Property - II	
	III	Cheminformatics-I	
	IV	Cheminformatics-II	
RPSCHEAOC-II 404	**Research Methodology**		**4**
	I	Review of Literature	
	II	Data Analysis	
	III	Methods of Scientific Research and Writing Scientific Papers	
	IV	Chemical Safety & Ethical Handling of Chemicals	
RPSCHEA4P1	**Practical**		**8**
RPSCHEA4P2			
RPSCHEA4P3			
RPSCHEA4P4	**Project Evaluation**		

SEMESTER-III
Course Code : RPSCHEA301

Course Title : QUALITY IN ANALYTICAL CHEMISTRY

Academic year 2020-21.

Course Outcomes:

After completion of this course, the learner will be able to,	
CO 1	Elaborate on the concept of Sampling and various methods involved in sample preparation and storage.
CO 2	Select the best method out of all the methods available for the analysis of samples.
CO 3	Calculate the uncertainty involved in a measurement.
CO 4	Describe the sources & different methods used for the enhancement of signal to noise ratio.
CO 5	Apply the parameters involved in method validation for developing a new method for the analysis of a sample.
CO 6	Make use of the principles involved in various chromatographic techniques such as Ionexchange, Size exclusion, SCF, Affinity, Inverse & UPLC to carry out separation & analysis of sample.

DETAILED SYLLABUS

Course Code	**Unit**	**Course Title/Unit Title**	**Credits/ Lectures**
RPSCHEA301	**QUALITY IN ANALYTICAL CHEMISTRY**		**4**
	I	**Quality in Analytical Chemistry-I**	**`15 L**
		1.1. **Sampling:** Definition, types of sample, sampling plan, quality of sample, sub-sampling, Sampling of raw materials, intermediates and finished products. Sample preparations – dissolution technology and decomposition, storage of samples. Pre-treatment of samples: soil, food and cosmetics. (8L) **1.2**. **Selection of the Method:** Sources of methods, factors to consider when selecting a	

		method, performance criteria for methods used, reasons for incorrect analytical results, method validation, and quality by design (PAT). (7L)	
	II	**Quality in Analytical Chemistry – II**	**15 L**
		2.1. Measurement of uncertainty: Definition and evaluation of uncertainty, putting uncertainty to use, interpretation of results and improving the quality of results. (4L) **2.2. Signal to noise:** Signal to noise ratio, sources of noise in instrumental analysis. Signal to noise enhancement, hardware devices for noise reduction and software methods for noise reduction. (6L) **2.3. Principle, process and application of solid phase extraction and Solid phase micro extraction** (5L)	
	III	**Chromatographic Techniques -I**	**15 L**
		3.1. Ion exchange chromatography: Ion exchange equilibria, breakthrough capacity, inorganic ion exchangers, synthetic ion exchangers, chelating resins and their applications for separation of inorganic and organic compounds. (5L) **3.2. Ion chromatography:** Principle, instrumentation with special reference to separation and suppressor columns, applications. (2L) **3.3. Exclusion chromatography:** Theory, instrumentation including new detector technology like Laser light scattering detectors and applications of gel permeation chromatography, retention behavior, inorganic molecular sieves, determination of molecular	

		weight of polymers and application to biomolecule (5L) **3.4 Advances in HPLC:** UPLC, 2D LC, Multi-dimensional LC, Automation in LC, New column technologies. Sub 3 micron columns, Core columns, capillary columns, micro LC, Nano LC etc. (4L)	
	IV	**Chromatographic Techniques -II**	**15 L**
		4.1.Supercritical Fluid Chromatography (SFC) and Supercritical Fluid Extraction (SFE): Theory, concept of critical state of matter and supercritical state, types of supercritical fluids, theory behind the separation, instrumentation, applications to environmental, food, pharmaceuticals and polymeric analysis. (7L) **4.2.Affinity Chromatography:** Principle, instrumentation and applications (3L) **4.3.Chiral Chromatography:** Principle, Instrumentation, chiral columns, applications (3L) **4.4. Inverse gas Chromatography** (2L)	

References:

1. E Prichard, Quality in the analytical chemistry laboratory, John Wiley and sons N.Y(1997).
2. W Funk, V Dammann, G. Donnevert, Quality assurance in analytical Chemistry, VCH Weinheim (1995).
3. Richard Anderson, Sample Pretreatment & Separation, (Open learning).
4. Lalit Singh and Vijay Sharma, Quality by Design (QbD) Approach in Pharmaceuticals: Status, Challenges and Next Steps, Drug Delivery Letters, 2015, 5, 2-8.
5. D. A. Skoog, F. J. Holler and J.A. Niemann, Principles of Instrumental Analysis, 5th Edition (1998).
6. H. H. Willard, L. L. Merritt Jr, J. A. Dean and F. A. Settle Jr, Instrumental Methods of Analysis, 7th Ed CBS (1986).
7. R. D. Braun, Introduction to Instrumental Analysis, Mc Graw Hill (1987).
8. G. D. Christian, Analytical Chemistry, 4th Ed. John Wiley, New York (1986).
9. D .A. Skoog and D. M. West and F. J. Holler Holt- Saunders, Fundamentals of Analytical Chemistry 6th Edition (1992).
10. J A Dean, Van Nostrand Reinhold, Chemical methods of separation,(1969).
11. J Marcus and A. S. Kertes, Solvent extraction and ion exchange, Wiley INC (1969).
12. Larry Taylor, Supercritical Fluid Extraction, Wiley publishers N.Y.(1996).
13. O Samuelson, Ion exchange separation in analytical chemistry, John Wiley 2nd ed.(1963).

Course Code : RPSCHEA302

Course Title: ADVANCED INSTRUMENTAL TECHNIQUES

Academic year 2020-21

Course Outcomes:

After completion of this course, the learner will be able to,	
CO 1	Make use of the surface analytical techniques(such as SIMS,PIXE) for obtaining information about the surfaces while characterizing the samples.
CO 2	Enlist the advantages of development of hyphenated techniques and will be able to explain the different types of interfaces that are used to achieve this hyphenation.
CO 3	Apply the principle underlying spectroelectrochemistry& the use of optically transparent electrodes to carry out the analysis of samples.
CO 4	Elaborate on the essential principles underlying the applications of thermal methods and radiochemical methods.
CO 5	Develop a working knowledge of various methods used in polarography.
CO 6	Explain anodic , cathodic and adsorptive stripping methods in voltammetry.
CO 7	Select a suitable method of voltammetry for the analysis of a particular sample.

DETAILED SYLLABUS

Course Code	**Unit**	**Course Title / Unit Title**	**Credits/ Lectures**
RPSCHEA302		**ADVANCED INSTRUMENTAL TECHNIQUES**	**4**
	I	**Spectral Methods I**	**15 L**
		1.1 Surface Analytical Techniques: Preparation of the surface, difficulties involved in the surface analysis. (1L) **1.2 Principle, instrumentation and applications of the following:** **a.** ATR-FTIR spectroscopy (2L) **b.** Secondary Ion mass spectroscopy (SIMS) (2L)	

		c. X-Ray Photoelectron Spectroscopy (XPS) (2L) **d.** Low-Energy Ion Scattering Spectroscopy (LEIS) and Rutherford Backscattering (2L) **e.** Scanning Probe Microscopy including AFM, CFM (3L) **1.4 Nuclear Quadrupole Resonance (NQR), ENDOR, ELDOR.** (3L)	
	II	**Hyphenated Techniques**	**15 L**
		2.1 Concept of hyphenation, need for hyphenation, possible hyphenations. (1L) **2.2.** Interfacing devices, instrumentation and applications of GC – MS,(Head space GC, Pyrolysis GC), GC -FTIR (3L) **2.3** LC-MS: Interface and Ionization techniques for LC-MS, Thermospray, Particle beam, FAB, and Atmospheric Pressure Ionization (API) Techniques. (3L) **2.4** Different Mass Analyzers, Magnetic Sector, Quadrupole, Ion Trap, Time of Flight, FTICR (3L) **2.5** LC-MS/MS: Tandem MS, Triple Quad MS, Collision Induced Dissociation Cell, Different scan events, MRM transitions. Hybrid MS/MS. Applications of Tandem MS. (3L) **2.6** Radiochromatography (2L)	
	III	**Radiochemical And Thermal Methods**	**15 L**
		3.1 Enthalpimetric methods and thermometric titrations. **3.2 Thermal analysis-** Principle, Interfacing, instrumentation and Applications of (a) Simultaneous Thermal Analysis- TG-DTA and TG-DSC	

		3.3 Evolved gas analysis- TG-MS and TG-FTIR (8L) **3.4**.**Activation analysis**- NAA, radiometric titrations and radio-release methods,isotope dilution method, introduction, principle, single dilution method, double dilution method and applications. **3.5** Auto, X-ray and Gamma Radiography (7L).	
	IV	**Electroanalytical Methods**	**15 L**
		4.1 Current Sampled (TAST) Polarography, Normal and Differential Pulse Polarography, Differential double Pulse Polarography (2L) **4.2 Potential Sweep methods-** Linear Sweep Voltammetry and Cyclic voltammetry. **Potential Step method-** Chronoamperomertry (2L) **4.3 Controlled potential technique-** Chronopotentiometry (2L) **4.4 Stripping Voltammetry-** anodic, cathodic, and adsorption (2L) **4.5**.Chemically and electrolytically modified electrodes and ultra- microelectrodes in voltammetry, Biosensor (2L) **4.6** Corrosion and electrochemistry, Use of Galvano stat and potentio stat (3L) **4.7 Spectro-electrochemistry** (2L)	

References:

1. D. A. Skoog, F. J. Holler and J.A. Niemann, Principles of Instrumental Analysis, 5th Edition (1998).
2. H. H. Willard, L. L. Merritt Jr, J. A. Dean and F. A. Settle Jr Instrumental Methods of Analysis, 7th Ed CBS (1986).
3. R. D. Braun, Introduction to Instrumental Analysis, Mc Graw Hill (1987).
4. G. D. Christian, Analytical Chemistry, 4th Ed. John Wiley, New York (1986).
5. D .A. Skoog and D. M. West and F. J. Holler Holt- Saunders, Fundamentals of Analytical Chemistry, 6th Edition (1992).
6. A. J. Bard and Marcel Dekker, Electroanalytical Chemistry, New York, (A series of volumes).
7. J.J. Lingane, Electroanalytical Chemistry, 2nd Ed Interscience, New York (1958).
8. A. M. Bond, Marcel Dekker, Modern Polarographic Methods in Analytical Chemistry, New York, (1980).
9. KamlaZutski, Introduction to polarography and allied techniques,(2006).
10. R. V. Parish. Ellis Horwood,Chichester, NMR, NQR, EPR, and Mössbauer Spectroscopy in Inorganic Chemistry.

Course Code : RPSCHEA303

Course Title: BIOANALYTICAL CHEMISTRY AND FOOD ANALYSIS

Academic year 2020-21

Course Outcomes:

After completion of this course,the learner will be able to	
CO 1	Describe the composition of body fluids (blood & Urine).
CO 2	Enlist the physiological and nutritional significance of vitamins & biological macromolecules.
CO 3	Apply the various analytical (microbiological techniques) learned for the analysis of these vitamins and biological macromolecules which in turn will help them in identification and diagnosis of diseases.
CO 4	Explain the mechanism of operation of immune system.
CO 5	Describe the various food preservation techniques that are widely practiced in food industries as quality control measure.
CO 6	Design an experiment to confirm the presence and amount of various components present in different types of food samples for further label claim studies.

DETAILED SYLLABUS

Course Code	Unit	Course Title / Unit Title	Credits/ Lectures
RPSCHEA303	**BIOANALYTICAL CHEMISTRY AND FOOD ANALYSIS**		**4**
	I	**Bioanalytical Chemistry**	**15 L**
		1.1. Body Fluids- Composition of body fluids and detection of abnormal levels of glucose, creatinine, uric acid in blood, protein, ketone bodies and bilirubin in urine leading to diagnosis of diseases. (5L) **1.2.** Physiological and nutritional significance of vitamins (water soluble and fat soluble) and minerals. (5L) **1.3.** Analytical techniques (including microbiological techniques) for vitamins. (5L)	
	II	**Immunological Methods**	**15 L**

		2.1. General processes of immune response, antigen-antibody reactions, precipitation reactions, radio, enzyme and fluoro-immunoassays.(8L) **2.2. Human Nutrition:** Biological values and estimation of enzymes, carbohydrates, proteins, essential amino acids and lipids.(7L)	
	III	**Food Analysis – I**	**15 L**
		3.1. Fuel value of food and importance of food nutrients (2L) **3.2. Food Additives –** General idea about Food processing and preservation, Chemical preservatives, fortifying agents, emulsifiers, texturizing agents, flavours, colours, artificial sweeteners, enzymes. Analysis of food products for flavoring agents and colour. (5L) **3.3.Food Contaminants–** Trace metals and pesticide residues, contaminants from industrial wastes (polychlorinated polyphenols, dioxins), toxicants formed during food processing (aromatic hydrocarbons, nitrosamines), veterinary drug residues and melamine contaminants. Identification and estimation technique use for contamination (8L)	
	IV	**Food Analysis – II**	**15 L**
		4.1. Food packaging – Introduction, types of packing materials, properties and industrial requirements.(2L) **4.2.** Processing and Quality requirements of Milk and milk products (cheese, butter and ice cream), vegetables and fruits, meat and meat Products. (6L) **4.3 Analysis of Milk –** Fat content, proteins, acidity, bacteriological quality, milk adulterants and antibiotics.(2L) **4.4. Analysis of Oils and Fats –** Acid value, sap value, iodine value. Determination of rancidity and antioxidants, Unsaturated or saturated fats, triglyceride analysis (2L) **4.5. Analysis of spices** (cloves, cinnamon, pepper, mustard) Determination of volatile oils and fixed oils.(3L) (Emphasis on analytical techniques)	

References:

1. H. Stephen Stoker, General, organic and biological chemistry, Cengage Learning.
2. S. R. Mikkelesen and E. Corton, Bioanalytical Chemistry, John Wiley and sons (2004).
3. D, J. Homes and H. Peck, Analytical Biochemistry, Longman (1983).
4. S.K.Sawhney and Randhir Singh, Introductory practical biochemistry , 1st edition, Narosa Publishing house.
5. S. Sadashivam and A. Manickam ,Biochemical methods, 3rd edition, New age international (P) limited,Publishers.
6. A.Y.Sathe, A first Course in Food Analysis, New age international (P) limited,Publishers.
7. David Pearson, Chemical Analysis of food, 7thedition,Chemical publishing company, New York.
8. Morris B Jacobs, The chemical analysis of Food and Food Products.
9. Gribbin et al, Principles of package development.
10. MacgraWreyco, Modern packaging Encyclopedia and planning guide.

Course Code : RPSCHEAEC-I 304

Course Title : ENVIRONMENTAL AND CERTAIN INDUSTRIALLY IMPORTANT MATERIALS

Academic year 2020-21

Course outcomes:

After completion of this course, the learner will be able to	
CO 1	List the major sources of different types of pollutants.
CO 2	Classify the different types of pollutants.
CO 3	Estimate the pollutants present in air.
CO 4	Outline the role of pollution control boards in monitoring and controlling pollution.
CO 5	Apply the methods learned in sampling of these pollutants to procure a sample for analysis.
CO 6	Indicate appropriate measures to reduce/or minimize the effects of these pollutants on environment.
CO 7	Evaluate the quality of potable water based on the guidelines laid down by the regulatory bodies.
CO 8	Acquire awareness of the principles of green chemistry.
CO 9	Plan out the synthesis of a sample by incorporating benign and environmentally safe solvents.

DETAILED SYLLABUS

Course Code	Unit	Course Title/Unit Title	Credits/ Lectures
RPSCHEAEC-I 304	**ENVIRONMENTAL AND CERTAIN INDUSTRIALLY IMPORTANT MATERIALS**		**4**
	I	**Air Pollution**	**15 L**
		1.1. Sources, classification, pollutants and permissible limits.(2L) **1.2** Sampling methods for air, flew gas, Industrial Exhaust, stag samples etc. (2L) **1.3.** Importance of automobile exhaust control and its limits New BS VI regulations(2L) **1.4.** Sampling and analysis of: Particulate matter, aerosols, ammonia and organic vapors. SPM analysis on ESP (3L) **1.5**. Carbon credit and global issues related to air pollution. (3L) **1.6.** Greenhouse gases and their substitutes. (1L) **1.7.** Environmental Legislation: role of pollution control boards, article 48A and 51A, Motor Vehicle Act and method of analysis with respect to PUC. (2L)	
	II	**Water Quality Standards**	**15 L**
		2.1 Water: quality and requirements of potable water, direct and indirect pollutants for potable water reservoirs, quality of potable water from natural sources. (4L) **2.2** TOC, DO, BOD, COD and TN measurement in water (2L) **2.3.** Bore well water quality and analytical parameters. Quality of bottled mineral water (3L) **2.4**. Process of purification of bore well water to bottled mineral water. (2L) **2.5** Regulatory requirements for packaged drinking water (4L)	
	III	**Other Types Of Pollution**	**15 L**

		3.1 Soil pollution and Soil Analysis : sources of soil pollution and their control, sampling of soil, determination of water holding capacity, determination total nitrogen, ammonia and nitrates, fertility of soil and effect of pollution on it, synthetic fertilizers and their long term effect on soil quality. (6L) **3.2 Noise Pollution :** sources, effects, methods of measurements and control measures.(2L) **3.3 Thermal Pollution:** definition, source, impact, control measures, working of cooling towers and cooling ponds, involved economy (3L) **3.4 Radioactive pollutants:** source, exposure hazards, precautions in handling and safety, Long term effects. (2L) **3.5 Environmental Audits:** concept of audit, authorities, evaluation methodology, benefits and certification (2L)	
	IV	**Green Chemistry**	**15 L**
		4.1. Principle and concepts of green chemistry: sustainable development and green chemistry, atom economy, examples of atom economic and atom uneconomic reactions, reducing toxicity (4L) **4.2. Organic solvents:** environmentally benign solutions, solvent free systems, supercritical fluids (only introduction) Ionic liquids as catalysts and solvents (4L) **4.3 Emerging Green Technologies:** photochemical reactions (advantages and challenges), examples. Chemistry using microwaves, sonochemistry and electrochemical synthesis. (4L) **4.4. Designing Greener Processes:** Inherently Safer Designs (ISD), Process intensification (PI) in-process monitoring. (3L)	

References:

1. A. K. De, Environmental Chemistry, 2nd Edition. Wiley (1989).
2. S. M. Khopkar, Environmental Pollution Analysis, John Wiely (1993).
3. SharadGokhale, Air Pollution Sampling And Analysis, IIT Guwahati, May (2009).
4. S. M. Khopkar, Environmental Pollution Analysis, New Age International publication (2011).
5. Seonard'lCiacere, Water And Water Pollution (hand book) Ed.,Vol I to IV, Marcel Dekker inc. New.York(1972).
6. Arvindkumar, Water pollution, APH publishing (2004)
7. Simon Parsons, Bruce Jefferson, Introduction to Potable Water Treatment Processes, Paperback publication.
8. Guidelines for drinking-water quality, Third edition, (incorporating first and second addenda). WHO report.
9. S.G. Misra and Dinesh Mani, Soil pollution, APH Publishing Corporation, (2009).
10. AbrahimMirsal, Soil Pollution: origin, monitoring and remediation, Springer (2010).
11. Donald F Anthrop, Noise Pollution, Lexington Books, (1973)
12. N. Birsen, Kairat K. Kadyrzhanov, Environmental Protection Against Radioactive Pollution Springer publication , (2003).
13. Green chemistry An Introductory text, Mzike Lancaster, Royal Society of Chemistry (2002).
14. K. G. Das, Dekker, Pesticide Analysis, (1981).
15. S. L Chpra, J.S Kanwar, Analytical, Agricultural Chemistry Kalyani publication.

Course Code : RPSCHEAEC-II 304

Course Title : PHARMACEUTICAL AND ORGANIC ANALYSIS

Academic year 2020-21

Course Outcomes:

After completion of this course, the learners will be able to,	
CO 1	Categorize the different types of drugs and dosage forms.
CO 2	Outline the role of FDA in pharmaceutical industry.
CO 3	Make use of the different methods learned to estimate the amount of drug present in a sample.
CO 4	Apply the concept of impurity profiling, stability studies, limit tests, bioavailability and bioequivalence while ensuring the uniformity in standards of quality , efficacy & safety of pharmaceutical products.
CO 5	Elaborate on the role of analytical chemistry in forensic laboratories.
CO 6	Identify and estimate the amount of the toxins found at crime scenes.
CO 7	Evaluate the quality of the cosmetic products by carrying out their analysis using the methods learned.

DETAILED SYLLABUS

Course Code	Unit	Course Title / Unit Title	Credits/ Lectures
RPSCHEAEC-II 304	**PHARMACEUTICAL AND ORGANIC ANALYSIS**		**4**
	I	**Pharmaceutical Analysis**	**15 L**
		1.1 General idea regarding the Pharmaceutical Industry, definition and classification of drugs, introduction to pharmaceutical formulations, classification of dosage forms. Role of FDA in pharmaceutical industries.(5L) **1.2** Sources of impurities in pharmaceutical products and raw materials. (3L) **1.3** Standardization of finished products and their characteristics, official methods of quality control. (3L) **1.4. Pharmaceutical Legislation:** Introduction to drug acts, drug rules (schedules), concept of regulatory affairs	

		in pharmaceuticals, review of GLP and GMP and their regulations for analytical labs, roles and responsibilities of personnel, appropriate design and placement of laboratory equipment, requirements for maintenance and calibration. (4L)	
	II	**Drugs**	**15**
		2.1. Analysis of compounds based on functional groups, instrumental methods for analysis of drugs, assays involving chromatographic separations, proximate assays, assays of enzyme containing substances, biological and microbiological assays and tests. (6L) **2.2** Limit tests, solubility tests, disintegration tests, stability studies (4L) **2.3** Bioequivalence and bioavailability studies. (2L) **2.4** Impurity profile of drugs (2L) **2.5**.Polymers in pharmaceuticals and novel drug delivery systems.(1L)	
	III	**Forensic Science**	**15**
		3.1 Analytical Chemistry in Forensic Science: General idea.(2L) **3.2 Forensic Analysis:** Blood, DNA profiling, Hair analysis, Finger printsAlcohol in body fluids, systematic drug identification.(5L) **3.3 Analytical Toxicology:** Isolation, identification and determination of: **3.3.1 Narcotics:** Heroin, morphine and cocaine. **3.3.2 Stimulants:** Amphetamines and caffeine. **3.3.3 Depressants:** Benzodiazepines, Barbiturates and Mandrax. **3.3.4 Hallucinogens:** LSD and Cannabis. **3.3.5** Metabolites of drugs in blood and urine of addicts. **3.3.6** Viscera, stomach wash, vomit and postmortem blood for poisons like – cyanide, arsenic, mercury,	

		insecticides and pesticides. **3.3.7 Analysis of explosives** (8L)	
	IV	**Cosmetic Analysis**	**15**
		4.1. Cosmetics: Introduction. Evaluation of cosmetic materials, raw materials and additives. Formulation, standards and methods of analysis.(2L) **4.2. Deodorants and antiperspirants:** Al, Zn, Boric acid, chlorides, sulphates, hexachlorophene, methanamine, phenolsulphonates and urea.(3L) **4.3. Face powder:** Fats, fatty acids, boric acid, barium sulphate, Ca, Mg, Ti, Fe, oxides of Ti, Fe and Al (total).(3L) **4.4. Hair tonic:** 2,5-diaminotoluene, potassium borates, sodium perborate, pyrogallol, resorcinol, salicylic acid, dithioglycollic acid (in permanent wavers) (3L) **4.5 Creams and Lotions:** Types of emulsions, chloroform soluble materials, glycerol, pH emulsion, ash analysis, nonvolatile matter (IR spectroscopy) (2L) **4.6 Lipsticks:** General analysis, determination of - nonvolatile matter, lakes and fillers, trichloroethylene-acetone soluble contents.(2L)	

References:

1. Kenneth Antonio Connors, Text book of Pharmaceutical Analysis, Wiley, (2001).
2. Indian Pharmacopeia, Volume I and II.
3. M L Mehra, The Handbook of Drug Laws, University Book Agency, Ahmedabad,(1997).
4. Takeru Higuchi, Chemical Analysis of Drugs, Interscience Publishers, (1995).
5. Foster Dee Snell et al, Encyclopedia of Industrial Chemical Analysis, Interscience Publishers,(1967).
6. Official methods of analysis of AOAC international,18th edition 2005,AOAC international.
7. Suzanne Bell, Forensic Chemistry, Pearson Prentice Hall Publication,(2006).
8. David E Newton, Forensic Chemistry, Infobase Publishing,(2007).
9. Harry's Cosmetology, 7th Ed, Longman Scientific Co.
10. Edward Sagarin, Cosmetic Technology, Interscience Publishers,(1957).

11. Edgar George Thommsen, Francis Chilson, Modern Cosmetics, Drug and Cosmetic Industry,(1947).
12. Government of India Publications of Food, Drug and Cosmetic Act and Rules.
13. Encyclopedia of Analytical Chemistry, Volume 3, Academic Press,(1995).

SEMESTER – III

Practical

RPSCHEA3P1	Group A		Credits
	1.	Determination of the pK value of an indicator.	**02**
	2.	Determination of aniline and ethanolamine in a mixture of two in acetonitrile by potentiometric titration.	
	3.	Determination of mixture of halides potentiometrically.	
	4.	Estimation of strong acid, weak acid and salt in the given mixture conductometrically.	
	5.	Analysis of mixture of carbonate and bicarbonate using pH metry	
	6.	Simultaneous determination of mixture of metal ions (copper and lead) by electrogravimetry.	
	7.	Separation of parabenes using HPLC. Find number of theoretical plates	
	8.	Separation of alcohol / ester by GC.	
RPSCHEA3P2	**Group B**		**Credits**
	1.	Estimation of drugs by non aqueous titration: Pyridoxine hydrochloride, Mebendazole.	**02**
	2.	Determination of percent purity of methyleneblue.	
	3.	Estimation of cholesterol and Uric acid in the given sample of blood serum	
	4.	Estimation of Glucose by Folin-Wu method.	
	5.	Estimation of fluoride in a tooth paste	
	6.	Estimation of Ca in Ca-pentathonate/calcium lactate tablets**.**	
	7.	HPTLC separation of amino acids.	
RPSCHEA 3P3	**Group C**		**Credits**
	1.	Total reducing sugars before and after inversion in honey using: (a) Cole's Ferricyanide (b) Lane - Eynon method.	**02**
	2.	Analysis of lactose in milk	

	3.	Estimation of Vitamin C in lemon Juice/squash by Dichlorophenol-indophenol method	
	4.	Analysis of oil sample for the determination of SAP value, Iodine value.	
	5.	Estimation of aldehyde in lemon oil / Cinnamon oil	
	6.	Analysis of milk for its Ca, P and Fecontent.	
	7.	Caffeine in tea by HPLC and UV.	
RPSCHEA 3P4	**Group D**		**Credits**
	1.	Determination of Silica by molybdenum blue method.	**02**
	2.	Estimation of copper by extractive photometry.	
	3.	Estimation of Glycine by Sorensen formol titration .	
	4.	Separation of Ni(II) and Co(II) using anion exchanger column.	
	5.	Estimation of vitamin C using $KBrO_3$ method.	
	6.	Analysis of detergents: Active detergent matter, alkalinity and Oxygen releasing capacity.	

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. Official methods of analysis of AOAC international,18th edition 2005,AOAC international.

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 %

Semester End Theory Assessment - 60 marks

1. Duration - These examinations shall be of **2.5 hours** duration.
2. Paper Pattern:
   a. There shall be **04** questions each of **15** marks. On each unit, there will be one question.
   b. All questions shall be compulsory with internal choice within the questions.

Questions	Options	Marks	Questions 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	

Practical Examination Pattern:

Semester End Practical Examination: 50 marks

Experimental work	40
Viva	05
Journal	05

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	301			302			Grand Total
	Internal	External	Total	Internal	External	Total	
Theory	40	60	100	40	60	100	200
Practical			50			50	100
Course	303			304			Grand Total
	Internal	External	Total	Internal	External	Total	
Theory	40	60	100	40	60	100	200
Practical			50			50	100

Total: 600 marks

SEMESTER-IV
Course Code : RPSCHEA 401
Course Title : SEPARATION TECHNIQUES AND INDUSTRIAL MATERIALS
Academic year 2020-21

Course Outcomes:

After completion of this course, the learners will be able to,	
CO 1	Identify and design the suitable membrane separation technique for intended problem.
CO 2	Elaborate on the importance of concept of pH ½ in solvent extraction.
CO 3	Select an appropriate method for the processing, extraction using different techniques and standardization of the herbal materials as per WHO cGMP guidelines.
CO 4	Recommend methods for the biodegradation of insecticides and pestiscides.
CO 5	Judge the quality of the detergents by making use of the various methods which are used in industries for carrying out their analysis.
CO 6	Enlist properties of an ideal fuel.
CO 7	Determine the calorific value of fuels using the methodologies learned.
CO 8	Separate & estimate the amount of biomolecules using appropriate electrophoretic technique.

DETAILED SYLLABUS

Course Code	Unit	Course Title/Unit Title	Credits/ Lectures
RPSCHEA 401		**SEPARATION TECHNIQUES AND INDUSTRIAL MATERIALS**	**4**
	I	**Separation Science**	**15**
		1.1.Membrane separation processes: operating principles and applications of microfiltration, ultra-filtration, reverse osmosis, dialysis and electro-dialysis. (6L) **1.2**.Recapitulation of solvent extraction, roles of solvent extraction in analytical chemistry, solvent extraction in sample preparation and pretreatment	

		steps, microwave assisted extraction. (4L) **1.1 Concept of pH 1/2**, expression for pH ½ and its significance (2L) **1.5 Craig countercurrent extraction** : Theoretical treatment and application in biological sample.(3L).	
	II	**Electrophoresis**	**15 L**
		2.1. Electrophoresis: Introduction, factors affecting migration rate, supporting media (gel, paper, cellulose, acetate, starch, polyacrylamide, agarose, sephedax and thin layers) (7L) **2.2 Techniques of Electrophoresis:** low and high voltage, SDS-PAGE, continuous electrophoresis, capillary electrophoresis, zone, gel, isoelectric focusing, isotaechophoresis, 2D gel electrophoresis and miceller electro kinetic capillary chromatography, instrumentation, detection and applications. (8L)	
	III	**Separation, Analysis and Standardization of Herbal based products.**	**15 L**
		3.1. Herbs as a raw material: Definition of herb, herbal medicine, herbal Medicinal products, herbal drug preparation. Sources of herbs. Selection, identification and authentication of herbal materials, drying and processing of herbal raw materials, drying and processing of herbal raw material.(6L) **3.2 Extraction of herbal materials:** Choice of solvent for extraction, methods used for extraction and principles involved in extraction.(3L) **3.3** Standardization of herbal formulation and herbal extracts: Standardization of herbal extract as per	

		WHO cGMP guidelines, physical, chemical, spectral and toxicological standardization, qualitative and quantitative estimations.(6L)	
	IV	**Industrial Materials**	**15 L**
		4.1 Insecticides, Pesticides: Definition, classification of insecticides pesticides. Biodegradation of insecticides and pesticides (5L). **4.2 Soaps and Detergents:** Classification and composition, qualitative analysis, quantitative analysis of detergents- alkalinity, active ingredients and oxygen releasing capacity. Biodegradable detergents (5L) **4.3 Petrochemical products:** Crude oils, fuels, and calorific values, fractional distillation process and fractions, properties of fuel, composition of fuel, flashpoint, fire point, corrosion test, carbon residue and impact on environment. (5L)	

References:

1. Kaushik Nath , Membrane Separation Processes , 2nd edition, Prentice Hall of India Private limited, (2008).
2. G. D. Christian, Analytical Chemistry, 4th Ed. John Wiley, New York (1986).
3. D. A. Skoog and D. M. West and F. J Holler Holt- Saunders, Fundamentals of Analytical Chemistry, 6th Edition (1998).
4. J.B.Harborne,Phytochemical Methods-A Guide to modern techniques in plant analysis, 3rdedition,Chapman & Hall.
5. O.P.Varmani,A.K.Narula, Industrial chemistry, Galgotia.
6. O.P.Varmani,A.K.Narula, Applied Chemistry Theory and practice, 2nd edition, New age international publishers.
7. Upadhyay,Nath, Biophysical chemistry Principles and techniques ,Himalaya Publishing House.
8. Maureen Melvin , Electrophoresis , (Analytical Chemistry by Open learning).

Course Code : RPSCHEA 402

Course Title : ADVANCED INSTRUMENTAL TECHNIQUES

Academic year 2020-21

Course Outcomes:

After completion of this course, the learners will be able to,	
CO 1	Explain the basic theory of 1H NMR spectroscopy & Raman Spectroscopy.
CO 2	Describe the working of the different components of NMR spectrophotometer & Raman spectrometer and will be able to explain how the spectrum is recorded.
CO 3	Apply ^{1}H ,^{13}C, $^{31}P$and ^{19}F NMR spectroscopy techniques in combination with other spectroscopic data to carry out structure determination.
CO 4	Explain the mechanism of formation and fragmentation of ions in gas phase.
CO 5	Interpret the information contained in the mass spectra.
CO 6	Apply the basic working principles involved in the spectroscopic techniques learned for carrying out identification and analysis of samples.
CO 7	Make use of the phenomenon of chemiluminescence for varied applications.
CO 8	Elaborate on the concept of ORD & CD.
CO 9	Discuss the principle , instrumentation involved in Photoacoustic spectroscopy and will be able to use it for the trace analysis of solid , liquid and gaseous samples.

DETAILED SYLLABUS

Course Code	Unit	Course Title/ Unit Title	Credits/ Lectures
RPSCHEA402	**ADVANCED INSTRUMENTAL TECHNIQUES**		**4**
	I	**Spectral Methods II**	**15 L**
		NMR Spectroscopy **1.1.** Theory and Instrumentation- recapitulation, FTNMR, 2D NMR,- FID signal generation mechanism, Techniques in 2D NMR- homo nuclear correlation spectroscopy (COSY), total correlation spectroscopy (TOCSY), heteronuclear correlation (HETCOR).Application of NMR in structural elucidation (9L) **1.2** Radio waves in imaging- principle instrumentation and applications of MRI(1L) **1.3.** Application of NMR to other nuclei ^{13}C, ^{31}P and ^{19}F spectroscopy (3L) **1.4 Electron spin resonance spectroscopy (ESR)**: basics, instrumentation and applications (2L)	
	II	**Spectral Methods III**	**15 L**
		2.1 Mass spectroscopy: recapitulation, correlation of mass spectra with molecularstructure- EI and CI Ionization, Instrumentation, and Fragmentation. interpretation of mass spectra, analytical information derived frommass spectra- molecular identification, meta stable peaks, Fragmentation Reactions (9L) **2.2 Raman spectroscopy:** Theory, Mechanism of Raman and Rayleigh Scattering,Instrumentation, Applications. Resonance and Surface enhanced Raman Spectroscopy.(4L)	

		The problems based on MS, NMR and IR Spectra (2L)	
	III	**Spectral Methods IV**	**15 L**
		Principle, Instrumentation, and Applications of **3.1. Atomic Emission Spectroscopy-** based on plasma and electrical discharge sources, quantitation with Inductively couple plasma spectroscopy. (5L) **3.2.** Background correction in Graphite Furnace AAS and Correction of spectral interference in ICP. (4L) **3.3** Quantitative analysis by AAS and ICP using external standard and standard addition method. (3L) **3.4 ICP-MS:** Instrumentation, Interface and applications for trace level analysis of elements. (3L)	
	IV	**Miscellaneous Techniques**	**15 L**
		Principle, Instrumentation and Applications of: **4.1. Chemiluminesescence Methods:** Principle, Apparatus, Quantitative Chemiluminescence - Gas phase and liquid phase chemiluminescent analysis and titrations(application for detection of S and N) (3L) **4.2.Chirooptical Methods :** ORD, CD (special application for Bioanalysis) (5L) **4.3. Photoacoustic spectroscopy** (3L) **4.4. Laser Induced Fluorescence (LIF) Spectroscopy** (4L)	

References:

1. G. D. Christian, Analytical Chemistry, 4th edition. John Wiley, New York (1986).
2. D. A. Skoog and D. M. West and F. J Holler Holt- Saunders, Fundamentals of Analytical Chemistry, 6th Edition (1998).
3. D. A. Skoog, F. J. Holler and J.A. Niemann, Principles of Instrumental Analysis, 5th edition.
4. H. H. Willard, L. L. Merritt Jr, J. A. Dean and F. A, Instrumental methods of Analysis,.
5. P. J. Haines, Thermal methods of Analysis, Blackie Academic & Professional, London (1995).
6. W. W. Wendlandt, Thermal Analysis, 3rd Edition , John Wiley, N.Y. (1986).
7. E. P. Bertain, Principles and Practices of X-ray spectrometric Analysis, 2nd edition, Plenum Press, NY, (1975)
8. D. Bane, B. Forkman, B. Persson, Nuclear Analytical Chemistry, Chartwell - Bratt Ltd (1984).
9. Roger S. Macomber, A Complete Introduction to Modern NMR Spectroscopy,1st Edition
10. Robert. M.Silverstein, Spectrometric Identification of Organic Compounds Hardcover , Wiley.

Course Code : RPSCHEA 403

Course Title : ENVIRONMENTAL AND CERTAIN INDUSTRIALLY IMPORTANT MATERIALS

Academic year 2020-21

Course Outcomes:

After completion of this course, the learner will be able to,	
CO 1	Elaborate on the various physical , chemical and biological processes which are used in CETP to remove the contaminants from wastewater.
CO 2	Apply the concept of recycling, reuse & reclamation in managing solid waste in real life.
CO 3	Classify the different types of plastics.
CO 4	Outline the importance of additives in plastic.
CO 5	Estimate the amount of metallic impurities in plastics.
CO 6	Describe the composition of paints.
CO 7	Make use of the methodologies learned to carry out the analysis of each and every component present in paints.
CO 8	Develop an understanding of zone refining and vacuum fusion and extraction techniques.
CO 9	Classify the kinds of elements that can be purified by the process of zone refining.
CO 10	Suggest a method for analyzing different elements present in ores & alloys.

DETAILED SYLLABUS

Course Code	Unit	Course Title/Unit Title	Credits/ Lectures
RPSCHEA 403		**ENVIRONMENTAL AND CERTAIN INDUSTRIALLY IMPORTANT MATERIALS**	**4**
	I	**Effluent Treatment**	**15 L**
		1.1.Effluent treatment: primary secondary and tertiary (2L) **1.2** Plant general construction and process flow charts(3L) **1.3** Treatment and disposal of sewage.(3L) **1.4.** Effluent parameters for metallurgical industry Permissible limits for metal (example Cr, As, Pb, Cd etc) traces in the effluent.(2L) **1.5** Recycle and reuse of process and treated (effluent) water. (2L) **1.6** Recovery of metals from effluent, modern methods – electrodialysis, electrodeposition and Ion Exchange etc.(3L)	
	II	**Solid Waste Management**	**15 L**
		2.1. Solid waste types and characteristic (2L) **2.2.** Solid waste management: objectives, concept of recycle, reuse and recovery (3L) **2.3.** Methods of solid waste disposal.(2L) **2.4.** Treatment and disposal of sludge / dry cake (3L) **2.5** Managing non-decomposable solid wastes (2L) **2.6** Bio- medical waste : Introduction , Classification and methods of disposal (3L)	
	III	**Plastics and Polymers**	**15 L**

		3.1.Plastics: Classification of plastic, determination of additives, molecular weight distribution, analysis of plastic and polymers based on styrene, vinyl chloride,ethylene, acrylic and cellulosic plastics. (5L) **3.2** Metallic impurities in plastic and their determination, (2L) **3.3** Impact of plastic on environment as pollutant.(2L) **3.4 Paints and pigments:** Types of paints pigments, determination of volatile and non - volatile components, Flash point (significance and method of determination), separation and analysis of pigments, binders and thinners.(3L) **3.5** Role of Organo silicones in paints and their impact on environment.(3L)	
	IV	**Metallurgy**	**15 L**
		4.1. Ores and minerals: Dressing of ores, pollution due to metallurgical processes (ore dressing, calcination, smelting) (3L) **4.2.** Chemical analysis of ores for principal constituents :Galena,Pyrolusite, Bauxite, Hematite, Monazite (4L) **4.3 Alloys:** definition, analysis of Cupronickel, Magnelium, Steel And Stainless Steel, Bronze, Gun metal.(4L) **4.4 Techniques of purification:** Zone refining, analysis of high puritymaterials like silicon, vacuum fusion and extraction techniques. (4L)	

References:

1. H.R.Singh, Environmental Biology, S.Chand& Company Ltd.
2. P.S.Sindhu, Environmental Chemistry, New age international (P) limited Publishers.
3. Balram Pani, Textbook of Environmental Chemistry, I.K. International Publishing House Pvt.Ltd (2007).
4. Sameer.K.Banerji , Environmental Chemistry, 2nd edition, Prentice Hall of India Private Limited.
5. K Sasikumar and SanoopGopi Krishna, Solid waste management, PHI publication (2009).
6. Surendrakumar, Solid waste management, Northen Book Center (2009).
7. G. S. Sodhi , Fundamental Concepts of Environmental Chemistry,2nd edition, Alpha Science, (2005).
8. Manual of Procedures for Chemical and Instrumental Analysis of Ores, Minerals, and Ore Dressing Products. Government of India Ministry of Steel & Mines, Indian Bureau of Mines,(1979).
9. Alloying: understanding the basics, edited by Joseph R. Davis, ASM International (2001).
10. Zone refining and allied techniques, Norman L. Parr, G. Newnes Technology &Engineering (1960).

Course Code : RPSCHEAOC-I 404

Course Title : INTELLECTUAL PROPERTY RIGHTS & CHEMINFORMATICS

Academic year 2020-21

Course Outcomes:

After completion of this course, the learner will be able to:	
CO 1	Be well versed with the concept of intellectual property and the terms involved with respect to Indian Patent Law.
CO 2	Distinguish between patents and copyrights.
CO 3	Elaborate on the economical impact and legislature involved in Intellectual property rights.
CO 4	Make use of the software tools pertaining to Cheminformatics and Molecular Modelling.
CO 5	Conduct structure and sub-structure search online, determine SMILES codes for various molecules.
CO 6	Gain knowledge about the application of the research based tools.

DETAILED SYLLABUS

Course Code	Unit	Course Title / Unit Title	Credits/ Lectures
RPSCHEAOC-I 404	**INTELLECTUAL PROPERTY RIGHTS AND CHEMINFORMATICS**		**4**
	I	**Introduction to Intellectual Property - I**	**15 L**
		1.1 Introduction to Intellectual Property:[2L] Historical Perspective, Different types of IP, Importance of protecting IP. **1.2 Patents:[5L]** Historical Perspective, Basic and associated right, WIPO, PCT system, Traditional Knowledge, Patents and Health care-balancing promoting innovation	

		with public health, Software patents and their importance for India. **1.3 Industrial Designs:[2L]** Definition, How to obtain, features, International design registration. **1.4.Copyrights:[2L]** Introduction, How to obtain, Differences from Patents. **1.5 Trade Marks:[2L]** Introduction, How to obtain, Different types of marks – Collective marks, certification marks, service marks, trade names etc. **1.6 Geographical Indications:[2L]** Definition, rules for registration, prevention of illegal exploitation, importance to India.	
	II	**Introduction to Intellectual Property-II**	**15 L**
		2.1 Trade Secrets:[2L] Introduction and Historical Perspectives, Scope of Protection, Risks involved and legal aspects of Trade Secret Protection. **2.2IP Infringement issue and enforcement:[2L]** Role of Judiciary, Role of law enforcement agencies – Police, Customs etc. **2.3 Economic Value of Intellectual Property:[5L]** Intangible assests and their valuation, Intellectual Property in the Indian context – Various Laws in India Licensing and Technology transfer. **2.4 Different International agreements:[6L]** **2.4.1 World Trade Organization (WTO):**General Agreement on Tariffs and Trade (GATT), Trade Related Intellectual	

		Property Rights (TRIPS) agreement.General Agreement on Trade Related Services (GATS) Madrid Protocol.BerneConvention**.**Budapest Treaty **2.4.2 Paris Convention: WIPO** and **TRIPS, IPR** and Plant Breeders Rights, IPR and Biodiversity.	
	III	**Cheminformatics-I**	**15 L**
		3.1 Introduction to Cheminformatics[5L] History and evolution of cheminformatics, Use of Cheminformatics, Prospects of cheminformatics, Molecular modeling and structure elucidation. **3.2 Representation of molecules and chemical reactions:[5L]** Nomenclature, Different types of notations, SMILES coding, Matrix representations, Structure of Molfiles and Sdfiles, Libraries and toolkits, Different electronic effects, Reaction classification. **3.3 Searching Chemical Structures:[5L]** Full structure search, sub-structure search, basic ideas, similarity search, three dimensional search methods, basics of computation of physical and chemical data and structure descriptors, data visualization.	
	IV	**Cheminformatics-II**	**15 L**
		4.1 Prediction of Properties of Compound, Linear Free Energy Relations, Quantitative Structure – Property Relations, Descriptor Analysis, Model Building, Modeling Toxicity, Structure – Spectra correlations, Prediction NMR, IR and Mass spectra.	

		4.2 Computer Assisted Structure elucidations, Computer assisted Synthesis Design, Introduction to drug design, Target Identification and Validation, Lead Finding and Optimization, analysis of HTS data, Virtual Screening, Design of Combinatorial Libraries, Ligand-based and Structure based Drug design, **4.3** Application of Cheminformatics in Drug Design.	

References:

1. Vivien Irish, Intellectual Property Rights for Engineers, 2nd Edition, British Library, (2008).
2. David I. Bainbridge, Intellectual Property, 8th Edition, Pearson, (2010).
3. Stephen Elias and Richard Stim, Patent Copyright & Trade Mark, 8th Edition, Nolo and Richard, (2013).
4. Johann Gasteiger and Thomas Engel, Chemoinformatics, Wiley-VCH, (2003).
5. Andrew R. Leach, Valerie J. Gillet, An Introduction to Chemoinformatics, Springer,(2007).
6. Barry A. Bunin, Jurgen Bajorath, Brian Siesel and Guillermo Morales, Chemoinformatics-Theory, Practice and Products, Springer, (2007).

Course Code : RPSCHEAOC-II 404

Course Title : RESEARCH METHODOLOGY

Academic year 2020-21

Course Outcomes:

After the completion of this course, the learner will be able to:	
CO 1	Know basics of research methodology
CO 2	Get the technical know-how of research from developing a problem.
CO 3	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/ Lectures
RPSCHEAOC-II 404		**Research Methodology**	**4**
	I	**Review of Literature**	**15 L**
		1.1 Print:[5L] Primary, Secondary and Tertiary sources. **1.2 Journals:** 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. **1.3 Digital:[5L]** 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. **1.4 Information Technology and Library Resources:[5L]** The Internet and World wide web, Internet resources for Chemistry, finding and citing published information.	
	II	**Data Analysis**	**15 L**
		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**	**15 L**

		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**	**15 L**
		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.	

References:

6. C. R. Kothari, Research Methodology- Methods and techniques, New Age International (P) Limited Publisher, (2004).
7. Yogesh Kumar Singh, Fundamental of Research Methodology and Statistics, New Age International (P) Limited Publisher, (2006).
8. Carol Ellison, Concise Guide to Writing Research Ppaers, McGraw-Hill,(2016).
9. Prem S. Mann, C. Jay Lacke, Introductory Statistics, 7th Edition, John Wiley and Sons,(2010).
10. Andrew A. Jawlik, Statistics From A to Z – Confusing Concepts Clarified,John Wiley and Sons,(2016).

SEMESTER – IV

Practical

RPSCHEA4P1	Group A		Credits
	1.	Analysis of tamrabhasma by AAS and UV	**02**
	2.	Estimation of Na+ in dairy whitener by flame photometry	
	3.	Spectrophotometric determination of pH of buffer solution.	
	4.	Simultaneous determination of Ti^{3+} and V^{5+} spectrophotometrically by H_2O_2 method	
	5.	Estimation of Aspirin by conductometrically.	
	6.	Recording and interpretation of IR spectra of given compound.	
	7.	Identification of components of essential oils by GCMS.	
	8.	Determination of water in organic solvent by Karl Fischer method.	
RPSCHEA4P2	**Group B**		**Credits**
	1.	To analyze Pyrolusite for: Fe by redox titration and / or Mn by colorimetry.	**02**
	2.	To analyze galena for: Pb by Complexometric	
	3.	Analysis of Cupronickel alloy by electrogravimetry.	
	4.	To analyze Magnelium for Mg titrimetrically.	

	5.	To analyze Bronze for Zn by volumetric method	
	6.	To analyze Steel for: Ni and Cr	
	7.	To analyze Pyrolusite for: Fe by redox titration and / or Mn by colorimetry.	
RPSCHEA4P3	**Group C**		**Credits**
	Interpretation of spectral data (UV, IR, PMR, CMR, Mass spectra, XRD, Thermal) A learner will be given UV, IR, PMR, CMR, Mass spectra, of a compound from which preliminary information should be reported within first half an hour of the examination without referring to any book/reference material. The complete structure of the compound may then be elucidated by referring to any standard text-book/reference material etc (**Minimum 8 spectral analysis)**		**02**
RPSCHEA4P4	**Group D**		**Credits**
	Project Evaluation		**02**

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. Official methods of analysis of AOAC international,18th edition 2005,AOAC international.

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

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

ii. Paper Pattern:

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

Questions	Options	Marks	Questions 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/ Co-ordinator / In-charge of the department; failing which the student will not be allowed to appear for the practical examination.

Overall Examination and Marks Distribution Pattern

Course	**401**			**402**			**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**

Total: 600 marks