SOPHIA COLLEGE FOR WOMEN (AUTONOMOUS)

Affiliated to the University of Mumbai

Programme: **SCIENCE**

Programee code: SCHE

Syllabus for the Academic Year 2024-2025

based on the National Education Policy 2020

(Choice Based Credit System with effect from 2023-2024)

SOPHIA COLLEGE (AUTONOMOUS)

DEPARTMENT OF CHEMISTRY

COURSE DETAILS :

	SEMESTER 1	SEMESTER 2
TYPE OF COURSE	**Major**	**Major**
TITLE	PHYSICAL AND INORGANIC CHEMISTRY (DSC-I)	PHYSICAL AND INORGANIC CHEMISTRY (DSC-I)
CREDITS	6	6
	ORGANIC AND ANALYTICAL CHEMISTRY (DSC-II)	ORGANIC AND ANALYTICAL CHEMISTRY (DSC-II)
CREDITS	6	6
	ADVANCED INSTRUMENTAL TECHNIQUE (DSE)	ADVANCED INSTRUMENTAL TECHNIQUE (DSE)
CREDITS	4	4
	RESEARCH METHODOLOGY	ON JOB TRAINING (OJT)
CREDITS	4	4

Preamble

The M.Sc. Programme in Analytical chemistry was started under the affiliation of Mumbai University and is now brought under Autonomy. Although the same syllabus has been retained with minor modifications structural changes are incorporated to suit the credit system under autonomy.

The objective of the M.Sc. Analytical Chemistry programme is to provide a comprehensive and in-depth understanding of the fascinating world of Analytical Chemistry. The M.Sc. Programme in Analytical

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Chemistry combines core and elective theory courses as well as practical courses and independent research guided by an experienced researcher from the department/industry or a national institute. Through a rigorous academic curriculum, industry training and hands-on research experience, we aim to nurture the intellectual curiosity and scientific acumen of our students, preparing them for successful careers in various sectors of the chemical sciences. On completing the programme, the students will be able to analyze and provide practical solutions to the problems within the broad/specialized field of analytical chemistry.

Our esteemed faculty members with expertise in their respective fields and with a passion for both teaching and research are committed to providing a learning environment, encouraging open discussions, and fostering collaborative research endeavors. Through their mentorship, students will have the opportunity to engage in cutting-edge research projects, pushing the boundaries of scientific knowledge and contributing to the advancement of the chemical sciences. We envision our M.Sc. (Analytical Chemistry) postgraduates act as catalysts for positive change, equipped to drive innovation, shape industries, and address societal challenges through their expertise in chemistry.

PROGRAMME OBJECTIVES

PO 1	To provide students with theoretical and applied knowledge in the interdisciplinary branches of chemistry with emphasis on qualitative and quantitative analysis.
PO 2	To expose the students to the advanced instrumental analysis through hands-on training, internships and research to make them job ready.
PO 3	To train students to address the environmental and societal issues and face the real life challenges more effectively.

PROGRAMME SPECIFIC OUTCOMES

PSO 1	**Critical thinking:** A student with a Master's degree in Analytical chemistry will have an in-depth theoretical and practical knowledge of the subject which will foster their critical thinking.
PSO 2	**Skills in research and industrial field:** Students will build a scientific temper through research, develop entrepreneurial skill and will get an exposure to work in an industrial set up.
PSO 3	**Personality Development:** The students will be able to handle personal, social, environmental issues and will be responsible citizens.

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Programme: Sciences **Chemistry**	**Semester – 1**
Course Title: PHYSICAL AND INORGANIC CHEMISTRY	**Course Code: SCHE511MJ**

COURSE OBJECTIVES:

1. To understand and elucidate the third law of thermodynamics and properties like absolute entropies, heat capacity, entropies of vaporization of liquids etc.
2. To learn kinetics of enzyme catalyzed reactions, different types of inhibitions of enzymes and kinetics of reactions in solid state.
3. To understand different types and thermodynamics of formation of defects
4. To summarize phase equilibria for two component and three component systems.
5. To understand wave functions for different hybridizations and bonding in diatomic and polyatomic species.
6. To understand construction of character tables for different point groups and applications of group theory.
7. To understand the methods of preparation and properties of co-ordination compounds.
8. To understand spectral calculations and magnetic properties of co-ordination compounds.

COURSE OUTCOMES:

The learner will be able to :

1. discuss and elucidate the Third law of thermodynamics, Trouton's rule
2. solve problems using the properties and relationships of thermodynamic fluids
3. elaborate the general mechanisms of acid-base catalysis, enzyme catalysis and effect of pH & temperature on them.
4. extrapolate mathematical equations to find concentration of defects and solve numerical problems based on it.
5. understand and explain two component systems and three component systems.
6. derive wavefunction from different hybridization and plot MOT diagram for diatomic and polyatomic species.
7. Construct character table for different point group and apply of group theory to inorganic molecules.
8. Write the method of preparation and explain the properties of co-ordination compound.
9. Interpret the spectral and the magnetic properties of co-ordination compound.

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Lectures per week (1 Lecture is 60 minutes)		**4**	
Total number of Hours in a Semester		**60**	
Credits		**4**	
Evaluation System	**Summative Assessment**	**2 Hours**	**50 marks**
	Continuous Assessment	**–**	**50 marks**

UNIT I	**THERMODYNAMICS**	**15L**
1.1	State function and exact differentials, 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.	
1.3	Entropies of vaporization of liquids – Trouton's rule , Validity, deviation and application, Hildebrand's rule . [Ref 2 and 1,10,11,12 17]	
UNIT II	**CHEMICAL KINETICS, MOLECULAR REACTION DYNAMICS , SOLID STATE CHEMISTRY AND PHASE EQUILIBRIUM**	**15L**
2.1	**Chemical Kinetics, Molecular Reaction Dynamics**	
	2.1.1 General Catalytic Mechanisms – Equilibrium treatment, steady state treatment, Activation energies for catalyzed reactions Acid base Catalysis – general, theory and mechanism 2.1.2 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. (Ref: 7 and 2)	
2.2	**Solid State Chemistry and Phase equilibria**	

	2.2.1 Types of Defects and Stoichiometry, Zero dimensional (point) Defects, One dimensional (line) Defects, Two dimensional (Planar) Defects Thermodynamics of formation of defects (Mathematical derivation to find concentration of defects and numerical problems based on it) (Ref: 17, 18 and19) 2.2.2 A] Two component system: I. Solid –Gas System : Hydrate formation, Amino compound formation II. Solid – Liquid System: Formation of a compound with congruent melting point, Formation of a compound with incongruent melting point (with suitable examples) B] Three component system: I. Formation of two pair of partially miscible II. Formation of three pair of partially miscible liquid. III. Solid liquid Equilibria - Ternary solutions with common ions – (NaCl – KCl-H_2O and NaCl- Na_4SO_4- H_2O) (Ref: 4, 6, 11, 12 ,13,16, 24)	
UNIT III	**CHEMICAL BONDING, MOLECULAR SYMMETRY & GROUP THEORY**	**15L**
3.1	**Chemical Bonding Valence Bond Theory** Recapitulation of hybridization, Derivation of wave functions for *sp*, sp^2, *sp3* orbital hybridization types considering only sigma bonding, and Critical analysis of VBT. Bent's rule:Structure and reactivity of compounds/ complexes **Molecular Orbital Theory:** Molecular Orbital Theory (considering σ bonding) for - diatomic species of the first transition series -polyatomic species: electron deficient (B_2H_6) and electron rich (I_3) molecular species.	
3.2	Symmetry criterion of optical activity, symmetry restrictions on dipole moment, elements of symmetry, A systematic procedure for symmetry classification of molecules.	
3.3	Concepts of Groups, Sub-groups, Classes of Symmetry operations, Group Multiplication Tables. Abelian and non-Abelian point groups. 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.	

3.4	Applications of Group Theory (a) Symmetry adapted linear combinations (SALC), symmetry aspects of MOT, sigma bonding in AB_n (Ammonia, CH_4) molecule. (b) Determination of symmetry species for translations and rotations. (c) Mulliken's notations for irreducible representations. (d) Reduction of reducible representations using reduction formula. (e)Group subgroup relationships. Applications of Group Theory (a) Symmetry adapted linear combinations (SALC), symmetry aspects of MOT, sigma bonding in AB_n (Ammonia, CH_4) molecule. (b) Determination of symmetry species for translations and rotations. (c) Mulliken's notations for irreducible representations. (d) Reduction of reducible representations using reduction formula. (e)Group subgroup relationships between different groups.	
UNIT IV	**COORDINATION COMPOUNDS: SPECTRAL AND MAGNETIC PROPERTIES**	**15L**
4.1	Methods of preparation, thermal studies, Conductivity measurements, electronic, spectral and magnetic measurements, IR, NMR and ESR spectroscopic methods of characterisation.	
4.2	Spectral calculations using Orgel and Tanabe-Sugano diagrams, calculation of electronic parameters such as Δ, B, C, Nephelauxetic ratio.	
4.3	Magnetic Properties of Coordination Complexes: Origin of magnetism, types of magnetism, Curie law, Curie-Weiss Law, 1st and 2nd Ordered Zeeman effect, quenching of orbital angular momentum by ligand fields, magnetic properties of A, E and T ground terms in complexes, spin free and spin paired equilibria, temperature dependence of magnetism.	

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Robert J. Silby and Robert A. Alberty, Physical Chemistry, 3rd Edition, John Wiley and Sons (Asia) Pte. Ltd., 2002.

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S. Glasstone, Textbook of Physical Chemistry, 2ndEdition., McMillan and Co. Ltd., London, 1962
S. Glasstone, Thermodynamics for Chemists, Affiliated East-West Press, New Delhi, 1964.
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B. R. Puri, L. R. Sharma and K. C. Kalia, Principles of Inorganic Chemistry, Milestone Publishers, 2013-2014.
B. W. Pfennig, Principles of Inorganic Chemistry, Wiley, 2015.
C. E. Housecroft and A. G. Sharpe, Inorganic Chemistry, Pearson Education Limited, 2nd Edition 2005.
J. Huheey, F. A. Keiter and R. I. Keiter, Inorganic Chemistry–Principles of Structure and Reactivity, 4th Ed., Harper Collins, 1993.
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F. A. Cotton, Chemical Applications of Group Theory, 2nd Edition, Wiley Eastern Ltd., 1989.
H. H. Jaffe and M. Orchin, Symmetry in Chemistry, John Wiley & Sons, New York, 1996.
R. L. Carter, Molecular Symmetry and Group Theory, John Wiley & Sons, New York, 1998.
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P. K. Bhattacharya, Group Theory and its Chemical Applications, Himalaya Publishing House. 2014.

COORDINATION COMPOUNDS: SPECTRAL AND MAGNETIC PROPERTIES
J. E. Huheey, E. A. Keiter and R. L. Keiter; Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Education, 2006.
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P.W. Atkins, T. Overton, J. Rourke, M. Weller and F. Armstrong; Shriver & Atkins: Inorganic Chemistry, 4th ed. Oxford University Press, 2006.
F. A. Cotton, G. Wilkinson, C. A. Murillo and M. Bochmann; Advanced Inorganic Chemistry, 6th ed. Wiley, 1999,
B. Douglas, D. McDaniel and J. Alexander. Concepts and Models of Inorganic Chemistry (3rd Edition.), John Wiley & Sons (1994).

PRACTICAL **Course Title:** PHYSICAL AND INORGANIC CHEMISTRY		**Course Code:** SCHE511MJP	
COURSE OUTCOMES: The learner will be able to : 1. carefully handle and use various instruments used in the lab for performing experiments 2. follow instructions thoroughly 3. perform experiments with accuracy and perfection 4. Identify and use simple classical methods and calculate percentage composition of metals in alloys/ores 5. Estimate metal ions and inorganic compounds using instrumental methods			
Lectures per week (1 Lecture is 120 minutes)		**4**	
Total number of Hours in a Semester		**60**	
Credits		**2**	
Evaluation System	**Summative Assessment**	**2 Hours**	**50 marks**

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Non – Instrumental:

1. Determine the heat of solution (ΔH) of a sparingly soluble acid (benzoic /salicylic acid) from solubility measurement at three different temperatures.
2. Study the variation of calcium sulphate with ionic strength and hence determine the thermodynamic solubility product of $CaSO_4$ at room temperature.

Instrumental:

1. Verify Ostwald's dilution law and to determine the dissociation constant of a weak mono-basic acid conductometrically.
2. Determine the stability constant of the complex formed between Fe^{3+} ion and 5-sulphosalicylic acid at pH 2 and pH 3 by spectrophotometric method.

I] Analysis of Ores and Alloys/ preparation of compounds

1) Analysis of Devarda's alloy
2) Analysis of Cu – Ni alloy
3) Analysis of Solder alloy
4) Analysis of Limestone.
5) Analysis of hematite ore.

II] Instrumentation:

1) Estimation of Copper using Iodometric method Potentiometrically.
2) Estimation of boric acid conductometrically

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2. The Synthesis and Characterization of Inorganic Compounds by William L. Jolly
3. Inorganic Chemistry Practical Under UGC Syllabus for M.Sc. in all India Universities By:Dr Deepak Pant
4. Practical Physical Chemistry, B. Viswanathan and P.S. Raghavan, Viva Books Private Limited, 2005
5. Practical Physical Chemistry, A.M. James and F.E. Prichard, 3rd Edition, Longman Group Ltd., 1974.
6. Experimental Physical Chemistry, V.D. Athawale and P. Mathur, New Age International Publishers, 2001

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Programme: Sciences Chemistry	**Semester – 1**
Course Title: ORGANIC AND ANALYTICAL CHEMISTRY	**Course Code:** SCHE512MJ

COURSE OBJECTIVES:

1. Understand the criteria of aromaticity, thermochemical and magnetic criteria for aromatic compounds of benzenoid and non-benzenoid structures.
2. Learn to draw the Frost Musulin Diagrams for various compounds.
3. Understand the stereochemical concepts in molecules with constitutionally symmetric and asymmetric stereoisomers.
4. Understand the principles of axial and planar chirality.
5. Understand the configurational descriptors to allenes, alkylidene cycloalkanes, spirans, biaryls (including BINOLs and BINAPs), ansa compounds, cyclophanes,
6. Understand the concepts of topicity, criteria for enantiotopic and disastereotopic ligands and faces and identify them in a stereoisomer.
7. Understand how to assign configurational descriptors for enantiotopic and diastereotopic faces
8. Understand the concept of prochirality and predicting them in a molecule
9. To introduce important terms involved in analytical chemistry
10. To create awareness about quality, accreditation and GLP
11. To learn and use appropriate concentration units and predict yield of a reaction.

COURSE OUTCOMES:

The learner will be able to :

1. Classify the compounds based on criteria of aromaticity, analyse the thermochemical and magnetic data for aromatic compounds of benzenoid and non-benzenoid structures
2. Predicting the aromaticity in cyclic compounds based on Frost Musulin diagram
3. Predicting the stereochemical concepts in molecules with constitutionally symmetric and asymmetric stereoisomers.
4. Applying the principles of axial and planar chirality.
5. Assigning configurational descriptors to allenes, alkylidene cycloalkanes, spirans, biaryls (including BINOLs and BINAPs), ansa compounds, cyclophanes,
6. Predicting topicity, evaluating the criteria for enantiotopic and disastereotopic ligands and faces and identifying them in a stereoisomer and assigning configurational descriptors
7. Identifying a prochiral center in a given molecule and assigning the configurational descriptors.

8. Predicting Selectivity and specificity of the various oxidizing and reducing reagents and the mechanisms
9. Define and explain the importance of various terms used in analytical chemistry.
10. Elaborate various quality standards and safety rules followed in the laboratories.
11. To interconvert various concentration units and assess conditions to improve reaction yield.

Lectures per week (1 Lecture is 60 minutes)		**4**	
Total number of Hours in a Semester		**60**	
Credits		**4**	
Evaluation System	**Summative Assessment**	**2 Hours**	**50 marks**
	Continuous Assessment	**--**	**50 marks**

UNIT 1	**PHYSICAL ORGANIC CHEMISTRY, AROMATICITY AND OXIDATION REDUCTION REAGENTS**	**15L**
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	Ester hydrolysis: Classification, nomenclature and study of all eight mechanisms of acid and base catalyzed hydrolysis with suitable examples.	
1.3	Aromaticity: Structural, thermochemical, and magnetic criteria for aromaticity, including NMR characteristics of aromatic systems. Delocalization and aromaticity. Application of HMO theory to monocyclic conjugated systems. Frost-Musulin diagrams. Huckel's (4n+2) and 4n rules. Aromatic and antiaromatic compounds up-to 18 carbon atoms. Homoaromatic compounds. Aromaticity of all benzenoid systems, heterocycles, metallocenes, azulenes, annulenes, aromatic ions and Fullerene (C60). [Reference Books 1,2 ,13,16]	

1.4	Oxidation: General mechanism and selectivity of hydrocarbons, alcohols, carbonyl compounds Oxidation of hydrocarbons: Dehydrogenation:(chloranil, DDQ). Oxidation involving C-C bonds cleavage: aromatic rings using RuO4 and NaIO4. Oxidation involving replacement of hydrogen by oxygen: oxidation of CH2 to CO by SeO2, oxidation of aryl methanes by CrO2Cl2 (Etard oxidation). Oxidation of alcohols: CrO3-pyridine (Collin's reagent), hypervalent iodine reagents (IBX, Dess-Martin periodinane). DMSO based reagents (Swern oxidation), Oxidation of aldehydes and ketones: with H2O2 (Dakin reaction), with peroxy acid (Baeyer-Villiger oxidation)	
1.5	Reduction: General mechanism, selectivity, and important applications of the following reducing reagents: Catalytic reduction: Adams Catalyst, Reduction by hydride: diborane, 9-BBN, DIBAL-H, Red Al, Dissolving metal reductions: mediated reduction (Birch reduction) of aromatic compounds and acetylenes. Other Methods of reduction:NH_2NH_2 (diimide reduction) and other non-metal based agents including organic reducing agents (Hantzsch Dihydropyridine).	
UNIT II	**STEREOCHEMISTRY**	**15L**
2.1	Constitutionally symmetrical molecules with odd and even number of chiral centers: enantiomeric and meso forms, concept of stereogenic, chirotopic, and pseudo asymmetric centres.	
2.2	**Axial and planar chirality:** Principles of axial and planar chirality. Recapitulation of : allenes, alkylidene cycloalkanes, spirans, biaryls. 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.	
2.3	**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 stereo heterotopic ligands and faces Symbols for stereo heterotopic 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-pseudo asymmetric centre. Symbols for enantiotopic and diastereotopic faces.	
UNIT III	**LANGUAGE AND QUALITY OF/IN ANALYTICAL CHEMISTRY**	**15L**
3.1	**Language of Analytical Chemistry** **3.1.1** Analytical perspective, Common analytical problems, terms involved in analytical chemistry (analysis, determination, measurement, techniques, methods, procedures and protocol) **3.1.2.** 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. **3.1.3.** Errors, determinate and indeterminate errors. Types of determinate errors, tackling of errors **3.1.4.** Quantitative methods of analysis: calibration curve, standard addition and internal standard method.	
3.2	**Quality in Analytical Chemistry:** **3.2.1 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. **3.2.2 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). **3.2.3. Accreditations:** Accreditation of Laboratories, Introduction to ISO series, Indian Government Standards (ISI, Hallmark, Agmark) **3.2.4. Good Laboratory Practices (GLP):** Principle, Objective, OECD guidelines, The US FDA 21CFR58, Klimisch score	
UNIT IV	**CALCULATIONS BASED ON CHEMICAL PRINCIPLES** **(The topics are to be covered in the form of numerical problems only.)**	**15L**
4.1	Concentration of a solution based on volume and mass units.	

4.2	Calculations of ppm, ppb and dilution of the solutions, concept of mmol.	
4.3	Stoichiometry of chemical reactions, concept of kg mol, limiting reactant, theoretical and practical yield.	
4.4	Solubility and solubility equilibria, effect of presence of common ions	
4.5	Calculations of pH of acids, bases, acidic and basic buffers.	
4.6	Concept of formation constants, stability and instability constants, stepwise formation constants.	
4.7	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).	

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3. Writing Reaction Mechanism in organic chemistry, A. Miller, P.H. Solomons, Academic Press.
4. Mechanism in Organic Chemistry, Peter sykes, 6th edition onwards.
5. Modern Methods of Organic Synthesis, W. Carruthers and Iain Coldham, Cambridge University Press.
6. Organic Synthesis, Jagdamba Singh, L.D.S. Yadav, PragatiPrakashan.
7. Stereochemistry: Conformation and mechanism, P.S. Kalsi, New Age International, New Delhi.
8.Stereochemistry of carbon compounds, E.L Eliel, S.H Wilen and L.N Manden, Wiley.
9. Stereochemistry of Organic Compounds- Principles and Applications, D. Nasipuri. New International Publishers Ltd

UNIT 3
1. Modern Analytical Chemistry by David Harvey, McGraw-Hill Higher Education
2. Principles of Instrumental Analysis - Skoog, Holler and Nieman, 5th Edition
3. Fundamentals of Analytical Chemistry, By Douglas A. Skoog, Donald M. West, F. James Holler, Stanley R. Crouch, 9th Edition, 2004, Ch: 5.
4. Undergraduate Instrumental Analysis, 6th Edition, J W Robinson, Marcel Dekker, Ch:1.
5. ISO 9000 Quality Systems Handbook, Fourth Edition, David Hoyle. (Chapter: 3 & 4) (Free download).
6. Quality Control and Total Quality Management - P.L. Jain-Tata McGraw-Hill (2006) Total Quality Management - Bester field - Pearson Education, Ch:5.

7. OECD Principles of Good Laboratory Practice (as revised in 1997)". OECD Environmental Health and Safety Publications. OECD. 1. 1998.

UNIT 4
1. 3000 solved problems in chemistry, Schaum's Solved problem series, David E. Goldbers McGraw Hill international Editions, Chapter 11,15,16,21,22

PRACTICAL **Course Title:** ORGANIC AND ANALYTICAL CHEMISTRY	**Course Code:** SCHE512MJP

COURSE OUTCOMES:
The learner will be able to :
1. Prepare organic compounds at micro scale
2. To assess the purity of the prepared compound
3. use concepts learnt in theory for solving practical problems.
4. understand and apply the knowledge acquired in theory to different types of samples for its
5. characterisation and estimation.
6. be able to work comfortably at different concentrations with the highest degree of accuracy and reproducibility.

Lectures per week (1 Lecture is 120 minutes)		**4**	
Total number of Hours in a Semester		**60**	
Credits		**2**	
Evaluation System	**Summative Assessment**	**2 Hours**	**50 marks**

PRACTICALS

A. Synthesis of:
1. Anthracene to anthraquinone
2. Benzoin to benzil
3. Anthracene to Anthracene maleic anhydride adduct
4. 2-Naphthol to BINOL
5. p-Benzoquinone to 1,2,4-triacetoxybenzene

6. Ethyl acetoacetate to 3-methyl-1-phenylpyrazol-5-one
7. *o*-Phenylenediamine to 2-methylbenzimidazole

B. To determine (a) the ion exchange capacity (b) exchange efficiency of the given cation exchange resin.
C. To determine the amount of Cr(III) and Fe(II) individually in a mixture of the two by titration with EDTA.
D. To determine the breakthrough capacity of a cation exchange resin.
E. To determine the amount of Cu(II) present in the given solution containing a mixture of Cu(II) and Fe(II).

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1. Quantitative Inorganic Analysis including Elementary Instrumental Analysis by A. I. Vogel's, 3rd Ed.ELBS (1964)
2. Vogel's textbook of quantitative chemical analysis, Sixth Ed. Mendham, Denny, Barnes, Thomas,Pearson education
3. Standard methods of chemical analysis, F. J. Welcher
4. E.B.Sandell and H.Onishi,"Spectrophotometric Determination of Traces of Metals", Part II, 4th Ed., A Wiley Interscience Publication, New York,1978.

Programme: Sciences Chemistry	**Semester – 1**
Course Title: ADVANCED INSTRUMENTAL TECHNIQUE	**Course Code:** SCHE511E

COURSE OBJECTIVES:

1. To learn about FTIR and UV-Vis spectroscopy as an analytical tool.
2. To understand application of different X-ray spectroscopic methods as a tool for surface studies
3. To learn the principle and working of MSwith different analysers as a tool for structural elucidation of organic compounds.

COURSE OUTCOMES:

The learner will be able to :

1. To be able to explain the working and applications of IR, FTIR and UV-Vis spectroscopy in various fields

2. To be able to solve numerical problems on simultaneous spectroscopy.
3. Explain various chromatographic X-ray spectroscopic methods with emphasis on applications of IR, FTIR and UV-Vis spectroscopy in various fields
4. To be able to solve numerical problems on simultaneous spectroscopy.

Lectures per week (1 Lecture is 60 minutes)		**4**	
Total number of Hours in a Semester		**60**	
Credits		**2**	
Evaluation System	**Continuous Assessment**	**–**	**50 marks**

UNIT I	**OPTICAL METHOD**	**15L**
1.1	**1.1**Recapitulation of basic concepts, Electromagnetic spectrum, Sources, Detectors, sample containers. **1.1.2** Laser as a source of radiation, Fibre optics **1.1.3** Introduction of Fourier transformer	
1.2	**1.2** Beer- Lambert's Law, factors affecting molecular absorption, types of transitions [emphasis on charge transfer absorption], pH, temperature, solvent and effect of substituents. Applications of Ultraviolet and Visible spectroscopy: **1.2.2** On charge transfer absorption Simultaneous spectroscopy Derivative Spectroscopy Dual spectrometry – Introduction, Principle, Instrumentation and Applications	
1.3	**1.3.1** Instrumentation: Sources, Sample handling, Transducers, Dispersive, non-dispersive instrument **1.3.2** FTIR and its advantages **1.3.3** Applications of IR [Mid IR, Near IR, Far IR]: Qualitative with emphasis on "Finger print" region, Quantitative analysis, Advantages and Limitations of IR **1.3.4** Introduction and basic principles of diffuse reflectance spectroscopy.	
UNIT II	**SPECTROSCOPY AND RADIOANALYTICAL METHODS**	**15L**
2.1	Principle, instrumentation and applications of X-ray fluorescence, absorption and	

	diffraction spectroscopy.	
2.2	Recapitulation, instrumentation, ion sources for molecular studies, electron impact, field ionization, field desorption, chemical ionization and fast atom bombardment sources. Mass analyzers: Quadrupole, time of flight and ion trap. Applications.	
2.3	Recapitulation, isotope dilution method, introduction, principle, single dilution method, double dilution method and application.	

REFERENCES

Unit 1

D. A. Skoog, F. J. Holler, T. A. Nieman, Principles of Instrumental Analysis, 5th Edition, Harcourt Asia Publisher. Chapter 6, 7.

H. H. Willard, L. L. Merritt, J. A. Dean, F. A. Settle, Instrumental Methods of Analysis,6 th Edition, CBS Publisher. Chapter 2.

R. D. Braun, Introduction to Instrumental Analysis, McGraw Hill Publisher. Chapter 8.

G. W. Ewing, Instrumental Methods of Chemical Analysis, 5 th Edition, McGraw Hill Publisher, Chapter 3.

M. Ito, The effect of temperature on ultraviolet absorption spectra and its relation to hydrogen bonding, J. Mol. Spectrosc. 4 (1960) 106-124

Unit 2

Essentials of Nuclear Chemistry, H J Arnikar, New Age Publishers (2005)

Fundamentals of Radiochemistry D. D. Sood , A. V. R. Reddy and N. Ramamoorthy

Principles of Instrumental Analysis - Skoog, Holler and Nieman, 5th Edition, Ch: 12

PRACTICAL **Course Title:** ADVANCED INSTRUMENTAL TECHNIQUE	**Course Code:** SCHE511EP

COURSE OUTCOMES:

The learner will be able to :

1. Check the quality of any given compound.
2. handle various instruments confidently.
3. perform analysis at various concentrations.

SOPHIA COLLEGE (AUTONOMOUS)

Lectures per week (1 Lecture is 120 minutes)		**4**	
Total number of Hours in a Semester		**60**	
Credits		**2**	
Evaluation System	**Summative Assessment**	**2 Hours**	**50 marks**

1.To determine percentage composition of saline injection. Estimation of sodium chloride by Volhard's method and glucose by polarimetry.
2.To estimate Vitamin B_{12} /fluorescein by fluorimetry.
3.Simultaneous determination of Cr(VI) and Mn(VII) in a mixture spectrophotometrically
4.To determine the percentage purity of a sample (glycine/sodium benzoate/primary amine/ajino motto) by titration with perchloric acid in a non- aqueous medium using a glass calomel system potentiometrically.
5.To determine the amount of Fe(II) and Fe(III) in a mixture using 1,10-phenanthroline spectrophotometrically.
6.To determine the amount of calcium in milk powder by flame photometry.
7.Determination of K^+ in a given sample by standard addition method (flame photometer)
8. Spectral interpretation of IR, mass and XRD spectrum

REFERENCES

1. Quantitative Inorganic Analysis including Elementary Instrumental Analysis by A. I. Vogels, 3rd Ed. ELBS (1964)
2. Standard Instrumental Methods of Chemical Analysis, F. J. Welcher

Programme: Sciences Chemistry	**Semester – 1**
Course Title: RESEARCH METHODOLOGY	**Course Code:** SCHE511RM
COURSE OBJECTIVES:	

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1. Introduce the students to fundamental concepts in research, research process and ethical considerations.
2. Introduce basic statistical methods, data analysis and interpretation in research ,
3. Make students aware of the computational tools available

COURSE OUTCOMES:

The learner will be able to :

1. Design and develop hypotheses suitable for investigation.
2. Apply basic statistical techniques to analyse and interpret research data
3. To use computational tools appropriately to aid their research work.

Lectures per week (1 Lecture is 60 minutes)		**4**
Total number of Hours in a Semester		**60**
Credits		**4**
Evaluation System	**Continuous Assessment**	**50 marks**

UNIT I	**SCIENTIFIC INVESTIGATION**	**15L**
1.1	Measurement and errors: Introduction to measurement; errors and types of errors (gross, systematic and random) with examples and case studies; uncertainty in measurement- accuracy, precision (definition and their estimation), significant figures.	
1.2	Describing Data: Analytical Data, population and sample; measures of central tendencies-mean, median; measures of dispersion or variability- standard deviation, variance, RSD; degrees of freedom and standard deviation of mean; confidence intervals and confidence limits; repeatability and reproducibility of measurement.	
1.3	ICH guidelines for analytical procedures- Introduction to analytical procedure development; Validation of analytical procedures: Specificity, linearity, range, accuracy, precision, detection and quantitation limits, robustness and system suitability testing	
1.4	Scientific Literature and communication: Print, digital, information technology and library resources; scientific reporting of practical and project work, literature review, oral and poster presentations, manuscript- title, abstract and body IMRaD format, acknowledgements and	

	references; scientific misconduct- falsification, fabrication and plagiarism, authorship and ethics in scientific research	
UNIT II	**DATA REPRESENTATION AND INTERPRETATION**	**15L**
2.1	Representation of data: Figures and Tables; Graphs, pictographs, scatter plots; file formats resolution and legends.	
2.2	Testing of hypotheses: Importance of hypotheses testing, levels of confidence and significance, type I & II errors, determining significant systematic errors- Z, t test; normal distribution; testing of means- student's t test; testing Variances- F test, ANOVA.	
2.3	Advanced statistical techniques & calibration: Correlation and regression, curve fitting, linear calibration model, analysis of residuals, interpolation through linear least square fitting, r and r squared.	
2.4	Polynomial fitting and Multivariate analysis: general polynomial fitting, linearizing transformations, exponential function fit, basic aspects of multiple linear regression analysis, discriminant analysis, multivariate analysis of variance, factor and cluster analysis.	
UNIT III	**LABORATORY SAFETY & ETHICAL HANDLING OF CHEMICALS**	**15L**
3.1	Principles, ethics and safety practices: Hazards, risk and safety; RAMP principles of safety; safety ethics and rules	
3.2	Sustainable and green practices in the laboratory: green chemistry principles and practices	
3.3	Safety regulations: employers expectations of safety skills; laws and regulations pertaining to safety- 29 CFR, Indian CMSR (Chemical Management and Safety Rules)	
3.4	Understanding laboratory hazards: Signs, symbols and safety; Hazard information (MSDS, SDS); Globally Harmonized System of Classification and Labelling of Chemicals (GHS); physical hazards in the laboratory and their minimization (case studies)	
UNIT IV	**LOGICAL MATHEMATICAL REASONING & COMPUTATIONAL TOOLS**	**15L**

4.1	Types of reasoning; Number series, Letter series, Codes and Relationships; Mathematical Aptitude (Fraction, Time & Distance, Ratio, Proportion and Percentage, Profit and Loss, Interest and Discounting, Averages etc.)	
4.2	Microsoft excel and origin for Chemists: Determination of central tendencies and dispersion- mean, standard deviation, RSD; confidence limits; plots using excel & origin, correlation and regression, standard errors, error bars	
4.3	Use of excel in analytical chemistry: titration curves and determination of equivalence points, derivative plots; simulation of chemical kinetics	
4.4	Cheminformatics tools: Chemdraw, Chemsketch, Mestrenova, NMRDB, openbabel,Reference manager (Mendeley)	

REFERENCES

Unit 1
1. Hibbert, D. B. & Gooding, J. J. (2006) Data Analysis for Chemistry Oxford University Press
2. Dharmapalan, B. (2012). Scientific Research Methodology. Alpha Science International Ltd.
3. International Council of Harmonisation: https://www.ich.org/page/quality-guidelines

Unit 2
1. Hibbert, D. B. & Gooding, J. J. (2006) Data Analysis for Chemistry Oxford University Press
2. Chandra S. & Sharma M. K. (2013). Research methodology. Alpha Science International.
3. Kothari C. R. (2004). Research methodology : methods & techniques (2nd rev.). New Age International (P).

Unit 3.
1. Hill R. H. & Finster D. C. (2016). Laboratory safety for chemistry students (Second). John Wiley & Sons.
2. Indian Chemical Regulation https://indianchemicalregulation.com/
3. American Chemical Society https://institute.acs.org/courses.html

Unit 4
1. K.V.S. Madaan (2020). Teaching and Research Aptitude, Pearson India Education Services Pvt. Ltd
2. Levie, R. D. (2012, June 5). How to Use Excel® in Analytical Chemistry: And in General Scientific Data Analysis, Cambridge University Press

SOPHIA COLLEGE (AUTONOMOUS)

3. Skoog, D. A., West, D. M., Holler, F. J., & Crouch, S. R. (2021, May 14). Applications of Microsoft Excel in Analytical Chemistry.
4. Levie, R. D. (2012, June 5). How to Use Excel® in Analytical Chemistry: And in General Scientific Data Analysis. Brooks/Cole Cengage Learning
5. Hibbert, D. B. & Gooding, J. J. (2006) Data Analysis for Chemistry Oxford University press

Programme: Sciences Chemistry	**Semester – 2**
Course Title: PHYSICAL AND INORGANIC CHEMISTRY	**Course Code:** SCHE523MJ

COURSE OBJECTIVES:

1. To understand and elucidate the properties of wave function, quantum operators and application of quantum mechanics to different systems.
2. To study Debye Huckel Onsager equation, deviations from it and to understand different types of fuel cells.
3. To understand different types of reactions and their mechanisms for inorganic complexes of varying geometry
4. To explore the structure, bonding and reactivity of organometallic compounds involving transition metals

COURSE OUTCOMES:
The learner will be able to :

1. Explain and use Quantum operators in solving numericals
2. Elucidate Debye Huckel Onsager equation, Debye Falkenhagen effect, Wein effect
3. Identify different types of reactions and their mechanisms for inorganic complexes of varying geometry
4. Comprehend the unique bonding and structural features of organometallic compounds of transition metals and predict the reactivity

Lectures per week (1 Lecture is 60 minutes)	**4**
Total number of Hours in a Semester	**60**

SOPHIA COLLEGE (AUTONOMOUS)

Credits		**4**	
Evaluation System	**Summative Assessment**	**2 Hours**	**50 marks**
	Continuous Assessment	**–**	**50 marks**

UNIT I	**QUANTUM CHEMISTRY**	**15L**
1.1	Classical Mechanics, failure of classical mechanics, Need for Quantum mechanics.	
1.2	Particle waves and Schrödinger wave equation, wave functions, properties of wave functions, Normalization of wave functions,orthogonality of wave functions.	
1.3	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, Schrodinger's Time independent wave equation from Schrodinger's time dependent wave equation.	
1.4	Application of quantum mechanics to the following systems: a) Free particle, wave function and energy of a free particle. b) 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. c) Harmonic oscillator, approximate solution of the equation, Hermite polynomials, expression for wave function, expression for energy,use of the recursion formula.	
UNIT II	**ELECTROCHEMISTRY**	**15L**
2.1	Debye-Hückel theory of activity coefficient, Debye-Hückel limiting law and it's extension to higher concentration (derivations are expected)	
2.2	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.	

2.3	Batteries: Types of fuel cells- Alkaline fuel cells, Phosphoric acid fuel cells, High temperature fuel cells [Solid –Oxide Fuel Cells (SOFC) and Molten Carbonate Fuel Cells]- Principle, construction and working, application in transportation.	
UNIT III	**INORGANIC REACTION MECHANISM**	**15L**
3.1	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).	
3.2	Ligand substitution reactions of: (Mechanism and factors affecting these substitution reactions.) a) Octahedral complexes without breaking of metal-ligand bond (Use of isotopic labelling method) b) Square planar complexes, trans-effect, its theories and applications. c) Tetrahedral complexes.	
3.3	Redox reactions: electron and atom transfer, inner and outer sphere mechanisms, complementary and non-complimentary reactions.	
3.4	Stereochemistry of substitution reactions of octahedral complexes. (Isomerization and racemization reactions and applications.)	
UNIT IV	**ORGANOMETALLIC CHEMISTRY OF TRANSITION METALS**	**15L**
4.1	Eighteen and sixteen electron rule - comparison and electron counting with examples.	
4.2	Preparation, reactions and properties of the following compounds (a) Alkyl and aryl derivatives of Pd and Pt complexes (b) Carbenes and carbynes of Cr, Mo and W (c) Alkene derivatives of Pd and Pt (d) Alkyne derivatives of Pd and Pt (e) Allyl derivatives of nickel (f) Sandwich compounds of Cr and Half Sandwich compounds of Cr, Mo.	
4.3	Structure and bonding on the basis of VBT and MOT in the following organometallic compounds: Zeise's salt, bis(triphenylphosphine)diphenylacetylene platinum(0) $[Pt(PPh_3)_2(HC{\equiv}CPh)_2]$, diallyl nickel(II), ferrocene and bis(arene)chromium(0), tricarbonyl (η_2-butadiene) iron(0).	
REFERENCE		

Ira R. Levine, Physical Chemistry, 5th Edition, Tata McGraw-Hill New Delhi, 2002.
G.W. Castellan, Physical Chemistry, 3rd Edition, Narosa Publishing House, New Delhi, 1983.
S. Glasstone, Textbook of Physical Chemistry, 2ndEdition., McMillan and Co. Ltd., London, 1962
Thomas Engel and Philip Reid, Physical Chemistry, 3rd Edition, Pearson Education Limited 2013.
D.N. Bajpai, Advanced Physical Chemistry, S. Chand 1st Edition, 1992.
Bockris, John O'M., Reddy, Amulya K.N., Gamboa-Aldeco, Maria E., Modern Electrochemistry, 2A, Plenum Publishers, 1998.
Physical Chemistry by Gurtu and Gurtu
A Textbook of Physical Chemistry by K L kapoorVol 5, 2ndEdition
P. Atkins, T. Overton, J. Rourke, M. Weller and F. Armstrong, Inorganic Chemistry, 5 th Ed., Oxford University Press, 2010.
10. W. H. Malik, G. D. Tuli and R. D. Madan, Selected Topics in Inorganic Chemistry, 8th Ed., S. Chand & Company ltd.
11. M. L. Tobe and J. Burgess, Inorganic Reaction Mechanism, Longman, 1999.
12. S. Asperger, Chemical kinetics and Inorganic Reaction Mechanism, 2nd Ed., Kluwer Academic/Plenum Publishers, 2002
13. F. Basalo and R. G. Pearson, Mechanism of Inorganic Reactions, 2nd Ed., Wiley, 1967.
14. R. Gopalan and V. Ramlingam, Concise Coordination chemistry, Vikas Publishing house Pvt Ltd., 2001.
15. Robert B. Jordan, Reaction Mechanisms of Inorganic and Organometallic Systems, 3rd Ed.,Oxford University Press 2008
16. D. Banerjea, Coordination chemistry. Tata McGrew Hill, New Delhi,1993.
17. R.C Mehrotra and A.Singh, Organometallic Chemistry- A unified Approach, 2nded, New Age International Pvt Ltd, 2000.
18. R.H Crabtree, The Organometallic Chemistry of the Transition Metals, 5th edition, Wiley International Pvt, Ltd 2000.
19. B.Doughlas, D.H McDaniel and J.J Alexander. Concepts and Models of Inorganic Chemistry, 2nd edition, John Wiley and Sons. 1983.
20. Organometallic Chemistry by G.S Sodhi. Ane Books Pvt Ltd.

PRACTICAL **Course Title:** PHYSICAL AND INORGANIC	**Course Code:** SCHE523MJP

SOPHIA COLLEGE (AUTONOMOUS)

CHEMISTRY	

COURSE OUTCOMES:
The learner will be able to :

1. carefully handle and use various instruments used in the laboratory for performing experiments
2. follow instructions thoroughly
3. perform experiments with accuracy and perfection
4. identify different types of reactions and their mechanisms for inorganic complexes of varying geometry.
5. write the methods of preparation and explain the properties of coordination compounds.

Lectures per week (1 Lecture is 120 minutes)		**4**	
Total number of Hours in a Semester		**60**	
Credits		**2**	
Evaluation System	**Summative Assessment**	**2 Hours**	**50 marks**

Non-Instrumental

1.Study the variation in the solubility of $Ca(OH)_2$ in presence of NaOH and to determine the solubility product of $Ca(OH)_2$ at room temperature.

2. To investigate the reaction between acetone and iodine.

3. Polar plots of atomic orbitals such as s, p and dz^2orbitals by using angular plots of hydrogen atom wave functions.

Instrumental

1. Study the effect of substituent on the dissociation constant of acetic acid conductometrically.

2. Determine the formula of silver ammonia complex by potentiometric method.

I] Inorganic Preparations (Synthesis and Characterization)

1) Bis-(tetraethylammonium) tetrachlorocuprate (II)- $(Et_4\ N)_2[CuCl_4]$

2) Bis-(tetraethylammonium)tetrachloronickelate(II)- $(Et_4\ N)_2\ [NiCl_4]$

3) Tetramminemonocarbanato cobalt (III) nitrate- $[Co(NH_3)_4CO_3]NO_3$

4) Hydronium dichlorobis(dimethylglyoximato) cobaltate(III)- $H[Co(dmgH)_2Cl_2\ ]$

5) Bis (ethylenediammine) copper (II) sulphate- $[Cu(en)_2]SO_4$

SOPHIA COLLEGE (AUTONOMOUS)

II] Instrumentation
1) Determination of equilibrium constant by Slope intercept method for Fe^{+3} / SCNsystem.

REFERENCES

1.Advanced experiments in Inorganic Chemistry., G. N. Mukherjee., 1stEdition., 2010., U.N.Dhur & Sons Pvt Ltd
2.The Synthesis and Characterization of Inorganic Compounds by William L. Jolly
3.Inorganic Chemistry Practical Under UGC Syllabus for M.Sc. in all India Universities By:Dr Deepak Pant
4.Practical Physical Chemistry, B. Viswanathan and P.S. Raghavan, Viva Books Private Limited, 2005.
5.Practical Physical Chemistry, A.M. James and F.E. Prichard, 3rd Edition, Longman Group Ltd., 1974.
6.Experimental Physical Chemistry, V.D. Athawale and P. Mathur, New Age International Publishers, 2001

Programme: Sciences Chemistry	**Semester – 2**
Course Title: ORGANIC AND ANALYTICAL CHEMISTRY	**Course Code:** SCHE524MJ

COURSE OBJECTIVES:

1. Understanding chemical reactions with the help of FMO.
2. Understanding HOMO - LUMO gap in UV absorption spectra and interpreting there activity of the given compounds.
3. Learn the mechanisms and selectivity of the various rearrangement reactions
4. Know the basic concepts of Molecular spectroscopy.
5. To learn about DSC, DTA and thermometric titration methods for the characterisation of various substances
6. To learn about advanced electroanalytical methods to analyse mixtures.

COURSE OUTCOMES:
The learner will be able to :

1. draw the FMO's of alkenes, Formaldehyde, allyl anion and cation.
2. apply the concept of FMO's to substitution and addition reactions.
3. predict whether the reaction is chemically/ photochemically feasible
4. analyse the effect of certain factors on the spectrum of the compound
5. interpretation of spectral data and elucidation of structure.

6. explain various types of electroanalytical methods and compare advantages and limitations of one over the other. 7. interpret thermograms of various compounds for identification and quantification.			
Lectures per week (1 Lecture is 60 minutes)		**4**	
Total number of Hours in a Semester		**60**	
Credits		**4**	
Evaluation System	**Summative Assessment**	**2 Hours**	**50 marks**
	Continuous Assessment	**--**	**50 marks**

UNIT I	**REACTIONS AND REARRANGEMENTS**	**5L**
	Mechanisms, stereochemistry (if applicable) and applications of the following: 1.1.1 Reactions: Baylis-Hilman reaction,Corey-Fuchs reaction, Nef reaction, Passerini reaction. 1.1.2 Concerted rearrangements: Wolff, Boulton Katritzky. 1.1.3 Cationic rearrangements:Tiffeneau-Demjanov, Pummerer, Dienone-phenol, Rupe. 1.1.4 Anionic rearrangements: Von Richter, Gabriel–Colman	
1.2	**MOLECULAR ORBITAL THEORY**	**10L**
	1.2.1 Molecular orbitals: Formation of σ- and π-MOs by using LCAO method. Formation of π MOs of ethylene, butadiene, 1, 3, 5-hexatriene,. Concept of nodal planes and energies of π-MOs 1.2.2 The Salem-Klopman equation. (no derivation expected) Explanation of the three terms in the equation. Hard and Soft Electrophiles and Nucleophiles. Examples of hard and soft nucleophiles/ electrophiles. Identification of hard and soft reactive sites on the basis of MOs. 1.2.3 Introduction to FMOs: HOMO and LUMO and significance of HOMO-LUMO gap in absorption spectra. HOMO and LUMO in MO of allyl cation, anion and radical and regioselectivity in the chemical reactions of allyl cation with allyl anion.	

	1.2.4 MOs of formaldehyde: The effect of electronegativity perturbation and orbital polarization in formaldehyde. HOMO and LUMO (π and π* orbitals) of formaldehyde. Perturbation Theory of Reactivity. Addition of hydride to formaldehyde. Orbital Symmetry, considerations for photochemical reactions of Alkenes and Dienes, photochemical electrocyclic reactions	
UNIT II	**SPECTROSCOPY**	**15L**
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).	
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.	
2.3	Proton magnetic resonance spectroscopy: Principle, Chemical shift, Factors affecting chemical shift (Electronegativity, H-bonding, Anisotropy effects). Chemical and magnetic equivalence, Chemical shift values and correlation for protons bonded to carbon and other nuclei as in alcohols, phenols, enols, carboxylic acids, amines, amides. Spin-spin coupling, Coupling constant (J), Factors affecting J, geminal, vicinal and long range coupling (allylic and aromatic). First order spectra, Karplus equation. ^{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.	
2.4	Mass spectrometry: Molecular ion peak, base peak, isotopic abundance, Nitrogen rule, Rule of 13.	

	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. Structure determination involving individual or combined use of the above spectral techniques.	
UNIT III	**THERMAL METHODS**	**15L**
3.1	3.1.1.Introduction: Recapitulation of types of thermal methods, comparison between TGA and DTA. 3.1.2 Differential Scanning Calorimetry: Principle, comparison of DTA and DSC, Instrumentation, Block diagram, Nature of DSC Curve, Factors affecting curves (sample size, sample shape, pressure). 3.1.3 Applications: Heat of reaction, Specific heat, Safety screening, Polymers, liquid crystals, Percentage crystallinity, oxidative stability, Drug analysis, Analysis of Polyethylene for its crystallinity.	
3.2	Thermometric titrations: Introduction, instrumentation, applications in the titration of (i) HCl Vs NaOH (ii) Boric acid Vs NaOH (iii) A mixture of Ca^{2+} and Mg^{2+}Vs EDTA (iv) Zn^{2+} with disodium tartarate.	
UNIT IV	**ELECTROANALYTICAL METHODS**	**15L**
4.1	Ion selective potentiometry and Polarography: 4.1.1.Ion selective potentiometry: 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. 4.1.2 Polarography: Ilkovic equation, derivation starting with Cottrell equation, effect of complex formation on the polarographic waves.	

4.2	Electrogravimetry: Introduction, principle, instrumentation, factors affecting the nature of the deposit and applications.	
4.3	Coulometry: Introduction, principle, instrumentation, coulometry at controlled potential and controlled current.	

REFERENCES

1. Organic Chemistry, J. Claydens, N. Greeves, S. Warren and P. Wothers, Oxford University Press.
2. Advanced Organic Chemistry, F.A. Carey and R.J. Sundberg, Part A, page no. 713-769, and B, Plenum Press.
3. March's Advanced Organic Chemistry: Reactions, Mechanisms and Structure, Michael B. Smith, Jerry March, Wiley.
4. Organic Chemistry, R.T. Morrison, R.N. Boyd and S.K. Bhattacharjee, Pearson Publication (7th Edition)
5. Advanced Organic Chemistry: Reactions and mechanism, B. Miller and R. Prasad, Pearson Education.
6. Advanced Organic Chemistry: Reaction mechanisms, R. Bruckner, Academic Press.
7. Understanding Organic Reaction Mechanisms, Adams Jacobs, Cambridge University Press.
8. Writing Reaction Mechanism in organic chemistry, A. Miller, P.H. Solomons, Academic Press.
9. Principles of Organic Synthesis, R.O.C. Norman and J.M Coxon, Nelson Thornes.
10. Advanced Organic Chemistry: Reactions and mechanism, L.G. Wade, Jr., Maya Shankar Singh,Pearson Education.
11. Mechanism in Organic Chemistry, Peter Sykes, 6th Edition.
12. Molecular Orbital and Organic chemical reactions, Ian Fleming Reference Edition, Wiley
13. Introduction to Spectroscopy, Donald L. Pavia, Gary M. Lampman, George S. Kriz, Thomson Brooks.
14. Spectrometric Identification of Organic Compounds, R. Silverstein, G.C Bassler and T.C. Morrill, JJohn Wiley and Sons.
15. Introduction to instrumental methods of analysis by Robert D. Braun, Mc. Graw Hill (1987): Chapter 27
16. Thermal Analysis-theory and applications by R. T. Sane, Ghadge, Quest Publications
17. Instrumental methods of analysis, 7 th Edition, Willard, Merrit, Dean: Chapter 25
18. Instrumental Analysis, 5 th Edition, Skoog, Holler and Nieman: Chapter 31
19. Quantitative Chemical Analysis, 6 th Edition, Vogel: Chapter 12
20. Analytical Chemistry by Open Learning: Thermal Methods by James W. Dodd & Kenneth H. Tonge
21. Principles of Instrumental Analysis – Skoog, Holler, Nieman, 5th Edition, Harcourt College Publishers, 1998. Chapters - 23, 24, 25.
22. Modern Analytical Chemistry David Harvey; McGraw Hill Higher education publishers, (2000).
23. Vogel's Textbook of quantitative chemical analysis, 6th edition, Pearson Education Limited, (2007).

24. Electrochemical Methods Fundamentals and Applications, Allen J Bard and Larry R Faulkner, John Wiley and Sons, (1980).
25. Instrumental Methods of Analysis Willard, Merrit, Dean and Settle, 7th edition, CBS publishers

PRACTICAL **Course Title:** ORGANIC AND ANALYTICAL CHEMISTRY	**Course Code:** SCHE524MJP

COURSE OUTCOMES:
The learner will be able to :

1. To identify the nature of a binary mixture and separate the mixture quantitatively.
2. To perform organic qualitative analysis
3. To purify compounds by distilling/recrystallization techniques
4. use concepts learnt in theory for solving practical problems.
5. understand and apply the knowledge acquired in theory to different types of samples for its characterisation and estimation.
6. be able to analyse samples of different concentrations with the highest degree of accuracy and reproducibility.

Lectures per week (1 Lecture is 120 minutes)		**4**	
Total number of Hours in a Semester		**60**	
Credits		**2**	
Evaluation System	**Summative Assessment**	**2 Hours**	**50 marks**

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:
a) Water soluble/water insoluble solid and water insoluble solid,
b) Non-volatile liquid-Non-volatile liquid (chemical separation)
c) Water-insoluble solid-Non-volatile liquid.

SOPHIA COLLEGE (AUTONOMOUS)

1.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 $BaCl_2$.
2.To determine the amount of nitrite in the given water sample.
3.To determine the amount of Fe(III) in the given solution by photometric titration using EDTA.
4.Determination of Ni spectrophotometry using dimethylglyoxime.

REFERENCES

1. Quantitative Inorganic Analysis including Elementary Instrumental Analysis by A. I. Vogels, 3 rd Ed. ELBS (1964)
2. Standard Instrumental Methods of Chemical Analysis, F. J. Welcher.
3.Systematic Qualitative organic analysis, H. Middleton (Orient Longman)
4. A Handbook of Organic Analysis, H.T. Clark (Orient Longman)
5. Systematic Identification of organic compounds, R.L. Shriner (John Wiley, New York)
6. Practical Organic Chemistry by Mann and Saunders.
7. Advance Practical Organic Chemistry, N.K. Vishnoi, Vikas Publication

Programme: Sciences Chemistry	**Semester – 2**
Course Title: ADVANCED INSTRUMENTAL TECHNIQUE	**Course Code:** SCHE522E

COURSE OBJECTIVES:

1. To understand application of different X-ray spectroscopic methods as a tool for surface studies.
2. To learn the principle and working of various chromatographic methods for separation and identification of mixture of unknown compounds by using suitable detectors.

COURSE OUTCOMES:
The learner will be able to :

1. explain various chromatographic, ICP-AES and X-ray spectroscopic methods with emphasis on principle and working of the instrument.
2. draw a simple block/schematic diagram of the instruments learnt and explain the importance of each component.

SOPHIA COLLEGE (AUTONOMOUS)

Lectures per week (1 Lecture is 60 minutes)		**4**	
Total number of Hours in a Semester		**60**	
Credits		**2**	
Evaluation System	**Continuous Assessment**	**–**	**50 marks**

UNIT I	**SURFACE ANALYTICAL TECHNIQUE**	
1.1	Surface Analytical Techniques: Introduction, Principle, Instrumentation and Applications of: 1.1.1 Scanning Electron Microscopy (SEM) 1.1.2 Scanning Tunnelling Microscopy (STM) 1.1.3 Transmission Electron Microscopy (TEM) 1.1.4 Electron Spectroscopy (ESCA and Auger)	**15L**
1.2	Atomic Spectroscopy:Introduction, Principle, Instrumentation and Applications. 1.2.1 Advantages and Limitations of AAS 1.2.2 Atomic Spectroscopy based on plasma sources	
Chromatography		**15L**
2.1	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.	
2.2	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.	
2.3	HPTLC: Introduction to HPTLC, techniques in HPTLC. Determination by detectors: single beam densitometer, double beam densitometer, fluorimetric detector. Comparison between TLC and HPTLC. Advantages, limitations and applications of HPTLC	

2.4	Size exclusion chromatography: Basic principle and applications in the field of polymers	

REFERENCE

1. Physical Principles of Electron Microscopy, An Introduction to TEM, SEM, and AEM
2. Authors: Ray F. Egerton, ISBN: 978-0- 387-25800- 3 (Print) 978-0- 387-26016- 7 (Online)
3. Modern techniques of surface science by D.P. Woodruff, T.A. Delchar, Cambridge Univ. Press, 1994.
4. Introduction to Scanning Tunneling Microscopy by C. J. Chen, Oxford University Press, NewYork, 1993.
5. Transmission Electron Microscopy: A text book for Material Science, David B Williams and C., Barry Carter, Springer
6. Modern Spectroscopy, by J.M. Hollas, 3rd Edition (1996), John Wiley, New York
7. Principles of Instrumental Analysis – Skoog, Holler, Nieman, 5th ed., Harcourt College Publishers, 1998.
8.Instrumental Analysis, Skoog, Holler & Crouch
9. HPTLC Analysis: Dilip Charegaonkar

PRACTICAL **Course Title:** ADVANCED INSTRUMENTAL TECHNIQUE		**Course Code:** SCHE522EP	
COURSE OUTCOMES: The learner will be able to : 1. Check the quality of any given compound. 2. handle various instruments confidently. 3. perform analysis at various concentrations.			
Lectures per week (1 Lecture is 120 minutes)		**4**	
Total number of Hours in a Semester		**60**	
Credits		**2**	
Evaluation System	**Summative Assessment**	**2 Hours**	**50 marks**

1.To determine the amount of nitro group by the titanium method.

2. Estimation of Vitamin C by titration with potassium borate.
3. Determination of pKa value of phosphoric acid by photometric titration with sodium hydroxide using glass electrode.
4. Separation and estimation of Zn (II) and Ni (II) in a mixture, using an anion exchanger.
5.Estimation of a mixture of hydrochloric acid and boric acid by acid base titration.

REFERENCE

Quantitative Inorganic Analysis including Elementary Instrumental Analysis by A. I. Vogels, 3rd Ed. ELBS (1964)
Standard Instrumental Methods of Chemical Analysis, F. J. Welcher

Programme: Sciences Chemistry	**Semester – 2**
Course Title: ON JOB TRAINING (OJT)	**Course Code:** SCHE521FP

COURSE OBJECTIVES:

1. Apply problem-solving skills to address analytical challenges in pharmaceutical, environmental, industrial, and research sectors through hands-on training.
2. Operate and troubleshoot advanced analytical instruments, such as HPLC, GC, FT-IR, and UV-Vis Spectroscopy, with proficiency.
3. Demonstrate practical expertise by engaging in industry-specific workflows and addressing challenges through on-job training in quality control, R&D, or regulatory labs.
4. Calibrate analytical instruments, identify operational faults, and implement corrective measures to ensure precise and reliable performance.

COURSE OUTCOMES:

The learner will be able to :

1. Operate, calibrate, and maintain analytical instruments independently, demonstrating technical proficiency.
2. Identify, quantify, and characterize chemical substances in various matrices using advanced analytical techniques.
3. Validate analytical methods, perform quality control analyses, and ensure compliance with industry standards such as ISO, FDA, and GLP.
4. Contribute effectively to R&D, quality assurance, or production units by adapting to industrial

environments during on-job training.			
Lectures per week (1 Lecture is 60 minutes)		**4**	
Total number of Hours in a Semester		**60**	
Credits		**2**	
Evaluation System	**Continuous Assessment**	**–**	**50 marks**

Assessment pattern

For Major papers
I.CONTINUOUS ASSESSMENT IA: 50 MARKS
1-ACTIVITY 25 MARKS
1-TEST 25 MARKS

II. SUMMATIVE ASSESSMENT (SEE): 50 MARKS (SUBJECTIVE)
All units of the syllabus will be covered in SEE and will be given equal weightage.

Q.1. Unit 1 (A): Attempt any two of the following. (2 out of 4) [10marks]
Q.2. Unit 2 (A): Attempt any two of the following. (2 out of 4) [10marks]
Q.3. Unit 3 (A): Attempt any two of the following. (2 out of 4) [10marks]
Q.4. Unit 4 (A): Attempt any two of the following. (2 out of 4) [10marks]
Q.5. Attempt any two of the following (2 out of 4) [10 marks]
(1 question from each unit)

III.CONTINUOUS ASSESSMENT(For Elective paper)
DSE
1.CONTINUOUS ASSESSMENT IA: 50 MARKS
2 Subjective test of 25 marks each
RM
1. CONTINUOUS ASSESSMENT IA : 50 MARKS
2. 1 Subjective test of 25 marks
3. Assignment activity of 25 marks

IV. PRACTICAL EXAMINATION

A 50 marks practical examination will be conducted at the end of the semester for 50 marks.

CA, SA and Practical are separate heads of passing. The learner will have to get 20 out of 50 to pass the examination.

Practical 40M
Journal 5M
Viva-voce 5M
Total 50M