R. E. Society's
R. P. Gogate College of Arts and Science
&
R. V. Jogalekar College of Commerce
(Autonomous)
Ratnagiri
(Affiliated to University of Mumbai)

Syllabus for

M. Sc. I

Chemistry

Sem I and II

Under Choice Based Credit System

(CBCS)

As per framework of NEP 2020

with effect from Academic Year 2023 - 24

Name of Programme	**Master of Science**
Level	PG
No of Semesters	04
Year of Implementation	**2023-24**
Programme Specific Outcomes (PSO)	At the end of the Programme, learners will be able to 1. Gain knowledge of the advanced concepts in the branch of chemistry, scrutinize and accomplish a solution to problems encountered in the field of research and analysis. 2. Apply the basic knowledge of chemistry to perform various tasks assigned to them at the workplace in industry and academia to meet global standards. 3. Deduce qualitative and quantitative information of chemical compounds using advanced spectroscopic methods which can further be analyzed using practical skills inculcated in them during the course. 4. Imbibe the attitude as well as aptitude of a scientific approach along with analytical reasoning with respect to the novel techniques actually implemented in the Industry. 5. Use the subject knowledge, communication and ICT skills to become an effective team leader/team member in the interdisciplinary fields. 6. Understand, Manage and contribute to solve basic societal issues and environmental concerns ethically based on principles of scientific knowledge gained. 7. Exhibit professional work ethics and norms of scientific development 8. Conduct research projects, utilize appropriate Methodologies and effectively execute projects in the field of science.
Relevance of PSOs to the local, regional, national, and global developmental needs	Postgraduates with strong chemical knowledge and laboratory skills can support industries, research institutions, and local communities in solving local environmental issues, water purification, waste management, and sustainable resource utilization. Chemistry Postgraduates can foster economic growth by driving innovation and entrepreneurship. They can contribute to regional research and development initiatives, enhance product quality, and support industries in adopting green practices. Additionally, their expertise in chemical safety and ethics can promote responsible industrial practices and environmental protection, benefiting the region. Chemistry graduates can contribute to addressing pressing global challenges, such as climate change mitigation, renewable energy development, and pollution control. Their research and problem-solving abilities can lead to the discovery of new materials, technologies, and treatments with global applications.

Revised Examination Scheme
Faculty of Science
(Post-graduate Programme)
Choice Based Credit System (CBCS)
Scheme of Examination
Master of Science (M.Sc.) Programme

The performance of the learners shall be evaluated into two parts. The learner's performance shall be assessed by **Internal Assessment with 40% marks** and by conducting the **Semester End Examinations with 60% marks**. The allocation of marks for the Internal Assessment and Semester End Examinations are as shown below –

A) Internal Assessment: 40 % (40 Marks)

Sr. No.	Particulars	Marks
01	One Periodical Class Test / Written objectives / Assignments / Short answer Questions / Seminar to be conducted in the given semester	30
02	Active participation in routine class instructional deliveries and overall conduct as a responsible learner, mannerism and articulation and exhibit of leadership qualities in organizing related academic activities	10

B) Semester End Examination: 60% (60 Marks)

60 Marks per paper Semester End Theory Examination:
1. Duration - These examinations shall be of two hours duration.
2. Theory question paper pattern:
   a) There shall be 04 questions each of 12 marks on each unit and one question of 12 marks on all units.
   b) All questions shall be compulsory with internal choice within the questions.

Standard of Passing

The learner to pass a course shall have to obtain a minimum of 40% marks in aggregate for each course where the course consists of Internal Assessment and Semester End Examination. The learner shall obtain **minimum of 40% marks (i.e. 16 out of 40) in the Internal Assessment** and **40% marks in Semester End Examination (i.e. 24 out of 60)** separately, to pass the course and minimum of Letter Grade "P" in the project component, wherever applicable to pass a particular semester. A learner will be said to have passed the course if the learner passes the Internal Assessment and Semester End Examination together.

Performance Grading

Letter Grades and Grade Points

Semester GPA/ Program CGPA Semester/Program	**% of Marks**	**Alpha-Sign / Letter Grade Result**
9.00-10.00	90.0 -100	O (Outstanding)
8.00 ≤ 9.00	80.0 ≤ 90.0	A+ (Excellent)
7.00 ≤ 8.00	70.0 ≤ 80.0	A (Very Good)
6.00 ≤ 7.00	60.0 ≤ 70.0	B+ (Good)
5.50 ≤ 6.00	55.0 ≤ 60.0	B (Above Average)
5.00 ≤ 5.50	50.0 ≤ 55.0	C (Average)
4.00 ≤ 5.00	40.0 ≤ 50.0	P (Pass)
Below 4.00	Below 40	F (Fail)
Ab (Absent)	-	Absent

Master of Science (M.Sc.) Programme
Under Choice Based Credit System
Course Structure
M. Sc. I
(with effect from Academic Year 2023-24)

Semester I				**Semester II**			
Course Code	Nomenclature	Credits		Course Code	Nomenclature	Credits	
Mandatory Courses				Mandatory Courses			
23_PSCH101	Inorganic Chemistry – I	04		23_PSCH201	Inorganic Chemistry – II	04	
23_PSCH102	Organic Chemistry – I	04		23_PSCH202	Organic Chemistry – II	04	
23_PSCH103	Analytical Chemistry – I	04		23_PSCH203	Analytical Chemistry – II	04	
23_PSCH104	Chemistry Practical – I (Organic Chemistry and Analytical Chemistry)	02		23_PSCH204	Chemistry Practical – II (Organic Chemistry and Analytical Chemistry)	02	
Elective Course (Any one)				Elective Course (Any one)			
23_PSCH105	Physical Chemistry – I	02	04	23_PSCH205	Physical Chemistry III	02	04
23_PSCH106	Chemistry Practical E – I (Physical and Inorganic Chemistry)	02		23_PSCH206	Chemistry Practical E – III (Physical and Inorganic Chemistry)	02	
OR				**OR**			
23_PSCH107	Physical Chemistry – II	02	04	23_PSCH207	Physical Chemistry – IV	02	04
23_PSCH108	Chemistry Practical E – II (Physical and Inorganic Chemistry)	02		23_PSCH208	Chemistry Practical E – IV (Physical and Inorganic Chemistry)	02	
25_PSCH109	Research Methodology	04		23_PSCH209	On Job Training / Internship	04	
TOTAL		**22**		**TOTAL**		**22**	

Revised Syllabus of Courses of Master of Science (M.Sc.)

Programme at Semester I with Effect from the Academic Year 2023-2024

SMART Criteria for Course Outcomes

- **Specific:** Each course outcome is specific, outlining the knowledge and skills students are expected to acquire in relation to the specific topics covered.
- **Measurable:** Each outcome can be measured through assessments, tests, or projects to determine the level of understanding and proficiency achieved by the students.
- **Achievable:** The outcomes are achievable within the duration of the course, considering the number of lectures allocated to each topic.
- **Relevant:** The outcomes are relevant to the subject of financial services and capital market, addressing important concepts, types, and mechanisms involved.
- **Time-bound:** The outcomes are expected to be achieved by the end of the course, providing a clear timeline for assessment and evaluation.

Course Code	Nomenclature	Credits	
Mandatory Courses			
23_PSCH101	Inorganic Chemistry – I	04	
23_PSCH102	Organic Chemistry – I	04	
23_PSCH103	Analytical Chemistry – I	04	
23_PSCH104	Chemistry Practical – I (Organic Chemistry and Analytical Chemistry)	02	
Elective Courses (any one)			
Elective I			
23_PSCH105	Physical Chemistry – I	02	04
23_PSCH106	Chemistry Practical E – I (Physical and Inorganic Chemistry)	02	
Elective II			
23_PSCH107	Physical Chemistry – II	02	04
23_PSCH108	Chemistry Practical E – II (Physical and Inorganic Chemistry)	02	
25_PSCH109	Research Methodology	04	
TOTAL		22	

Name of the Course	Inorganic Chemistry – I
Course Code	23_PSCH101
Class	M.Sc.
Semester	I
No of Credits	4
Nature	Theory
Type	Major: Mandatory
Employability/ Entrepreneurship/ Skill Development	Inorganic chemistry plays a significant role in employability, entrepreneurship and skill development due to its wide-ranging applications and relevance in various industries, such as material science, electronics, ceramics, pharmaceuticals, and environmental science. Entrepreneurs in fields like material science and nanotechnology rely on inorganic chemistry principles to innovate. Thus, a course provides Postgraduates with analytical skills, problem solving skills, and research capabilities which empower them to pursue a diverse path career.

Modules at a Glance

Sr. No.	Modules	No. of Hours
1	Chemical Bonding	15
2	Molecular Symmetry and Group Theory	15
3	Materials Chemistry and Nanomaterials	15
4	Characterization of Coordination compounds	15
Total		**60**

Course Outcomes

On the successful completion of this course learners will be able to:

CO1 :	Derive wave functions and analyze the role of d-orbitals in hybrid orbitals, explain nature of bonding in electron rich; electron deficient molecules and diatomic molecules of d-block elements, analyze and explain physical forces of attraction.
CO2 :	Explain fundamental concepts of group theory, derive character tables and explain their applications, analyze and explain properties and nature of bonding in polyatomic molecules.
CO3 :	Apply band theory for justification of conductivity, analyze other theories of conductivity, analyze crystal structures of various molecules and lasers, classify nanomaterials and explain preparation methods and applications of nanomaterials.
CO4 :	Explain various techniques used for characterization of co-ordination compounds, develop skill in interpretation of electronic spectra, analyze and explain Orgel diagrams and Tanabe – Sugano diagrams and their applications.

Curriculum

Unit	Modules
I	Chemical Bonding (15 Hours)
	1.1 Recapitulation of hybridization Derivation of wave functions for sp, sp^2, sp^3 orbital hybridization types considering only sigma bonding. 1.2 Discussion of involvement of d orbitals in various types of hybridizations. Concept of resonance, resonance energy derivation expected. Formal charge with examples. 1.3 Molecular Orbital Theory for diatomic species of First transition Series. 1.4 Molecular Orbital Theory for Polyatomic species considering σ bonding for SF_6, CO_2, B_2H_6, I_3^- molecular species. 1.5 Weak forces of attraction: Hydrogen bonding – concept, types, properties, methods of detection and importance. Van der Waal's forces, ion-dipole, dipole-dipole, London forces.
II	Molecular Symmetry and Group Theory (15 Hours)
	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 a) 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 C_{2h}, structure of character tables. b) Determination of symmetry species for translations and rotations. c) Mulliken's notations for irreducible representations. d) Reduction of reducible representations using reduction formula. 2.4 Applications of Group Theory Symmetry adapted linear combinations (SALC), symmetry aspects of MO theory, sigma bonding in AB_n (NH_3, CH_4) molecule.
III	Materials Chemistry and Nanomaterials (15 Hours)
	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)] 3.1.3 Solid state lasers: Introduction, Types, Working and Applications 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 microorganism). 3.2.2 Applications in the field of semiconductors, solar cells.
IV	Characterization of Coordination compounds (15 Hours)
	4.1 Methods of Characterization: thermal studies, Conductivity measurements, electronic spectral and magnetic measurements, IR, NMR and ESR spectroscopic methods. 4.2 Introduction to Orgel and Tanabe Sugano Diagram, Terms, Splitting of terms in Octahedral weak field, Calculation of electron parameters Δ, β, C and Nephelauxetic ratio with suitable examples. 4.3 Determination of formation constants of metal complexes (Overall and Stepwise), Comparative studies of Potentiometric and spectrophotometric methods.

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2. C. E. House croft and A. G. Sharpe, Inorganic Chemistry, Pearson Education Limited, 2nd Edition 2005.
3. R. L. Dekock and H.B. Gray, Chemical Structure and Bonding, the Benjamin Cummings Publishing Company, 1989.
4. F. A. Cotton, Chemical Applications of Group Theory, 2nd Edition, Wiley Eastern Ltd., 1989.
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13. Nanotechnology: Principles and applications, Sulabha K. Kulkarni, Springer.

Evaluation Pattern

(Max 100 marks)

A) Internal Assessment: 40% (40 marks)

Sr. No.	Particulars	Marks
01	One Periodical Class Test / Written objectives / Assignments / Short answer Questions / Seminar to be conducted in the given semester	30
02	Active participation in routine class instructional deliveries and overall conduct as a responsible learner, mannerism and articulation and exhibit of leadership qualities in organizing related academic activities	10

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

60 Marks per paper Semester End Theory Examination:

1. Duration - These examinations shall be of two hours duration.
2. Theory question paper pattern:
   a) There shall be 04 questions each of 12 marks on each unit and one question of 12 marks on all units.
   b) All questions shall be compulsory with internal choice within the questions.

Name of the Course	Organic Chemistry – I

Course Code	23_PSCH102
Class	M.Sc.
Semester	I
No of Credits	4
Nature	Theory
Type	Major: Mandatory
Employability/ Entrepreneurship/ Skill Development	Organic chemistry plays a significant role in employability, entrepreneurship and skill development due to its wide-ranging applications and relevance in various industries, such as polymer, pharmaceuticals, petrochemicals, agrochemicals, cosmetics, and environmental science. Understanding Organic reactions and synthesis is essential for designing and creating new compounds with specific properties. Learners can apply organic chemistry knowledge to develop innovative products such as specialty chemicals, natural based products to meet specific market demand.

Modules at a Glance

Sr. No.	Modules	No. of Hours
1	Physical Organic Chemistry	15
2	Stereochemistry	15
3	Nucleophilic substitution reactions and Aromaticity	15
4	Oxidation and Reduction	15
Total		**60**

Course Outcomes

On the successful completion of this course learners will be able to:

CO1 :	Analyze and apply thermodynamics; stereochemistry and acid-base theory to predict reaction rate; feasibility and reaction mechanism, analyze reaction coordinate diagrams, explain transition states; intermediates; activation energy.
CO2 :	Know and represent chiral molecules, interconvert projection formulae, apply configurational descriptors, explain and apply stereochemistry of molecules containing chiral axis; plane, analyze and apply prochirality.
CO3 :	Learn the mechanisms of nucleophilic substitution reactions (SN1, SN2), including the factors affecting reaction rates such as substrate structure, nucleophile, leaving group, and solvent. Explain nucleophilic substitution in aromatic systems and ester hydrolysis (acid- and base-catalyzed). Define aromaticity and apply Huckel's rule to classify compounds as aromatic, anti-aromatic, or non-aromatic.
CO4 :	Grasp the definitions of oxidation and reduction in organic molecules, identify common oxidizing and reducing agents, and learn mechanisms for reactions like alcohol oxidation and carbonyl reduction. Explain the stereochemical outcomes of these reactions and apply them in organic synthesis to construct complex molecules.

Curriculum

Unit	Modules

I	Physical Organic Chemistry	(15 Hours)
	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 based on pKa values, Leveling effect and non-aqueous solvents. Acid and base catalysis – general and specific catalysis with examples.	
II	Stereochemistry	(15 Hours)
	2.1 **Concept of Chirality:** Recognition of symmetry elements. 2.2 **Molecules with tri- and tetra-coordinate centers**: Compounds with carbon, silicon, nitrogen, phosphorous and sulphur chiral centers, relative configurational stabilities. 2.3 **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 pseudo asymmetric centres. R-S nomenclature for chiral centers in acyclic and cyclic compounds. 2.4 **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. 2.5 **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-pseudo-asymmetric centre. Symbols for enantiotopic and diastereotopic faces.	
III	Nucleophilic substitution reactions and Aromaticity	(15 Hours)
	3.1. Nucleophilic substitution reactions: (9L) **3.1.1 Aliphatic nucleophilic substitution:** SN^1, SN^2, SN^i reactions, mixed SN^1 and SN^2 and SET mechanisms. SN reactions involving NGP - participation by aryl rings, σ and pi-bonds. Factors affecting these reactions: substrate, nucleophilicity, solvent, steric effect, hard-soft interaction, leaving group. Ambident nucleophiles. SNcA, SN^1 and SN^2 reactions. SN at sp^2 (vinylic) carbon. **3.1.2 Aromatic nucleophilic substitution:** S_NAr, S_N1, benzyne mechanisms. Ipso, cine, tele and vicarious substitution. **3.1.3 Ester hydrolysis:** Classification, nomenclature and study of all eight mechanisms of acid and base catalyzed hydrolysis with suitable examples. **3.2. Aromaticity: (6L)** **3.2.1** Huckel's (4n+2) and 4n rules, structural, thermochemical, and magnetic criteria	

	for aromaticity, including NMR characteristics of aromatic systems. Delocalization and aromaticity. **3.2.2** 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).
IV	Oxidation and reduction (15 Hours)
	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 metal (Pt, Pd, Ni) and organic reagents (chloranil, 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 ozone, $KMnO_4$, 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 arylmethanes 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** N_2H_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 NH3 mediated reduction of aromatic compounds (Birch reduction) and Alkynes.

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19. R.O.C. Norman and J.M. Coxon, Nelson Thornes, Principles of Organic Synthesis.

Evaluation Pattern

(Max 100 marks)

A) Internal Assessment: 40% (40 marks)

Sr. No.	Particulars	Marks
01	One Periodical Class Test / Written objectives / Assignments / Short answer Questions / Seminar to be conducted in the given semester	30
02	Active participation in routine class instructional deliveries and overall conduct as a responsible learner, mannerism and articulation and exhibit of leadership qualities in organizing related academic activities	10

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

60 Marks per paper Semester End Theory Examination:

1. Duration - These examinations shall be of two hours duration.
2. Theory question paper pattern:
   a) There shall be 04 questions each of 12 marks on each unit and one question of 12 marks on all units.
   b) All questions shall be compulsory with internal choice within the questions.

Name of the Course	Analytical Chemistry – I
Course Code	23_PSCH103
Class	M.Sc.
Semester	I
No of Credits	4
Nature	Theory
Type	Major: Mandatory
Employability/ Entrepreneurship/ Skill Development	Analytical chemistry plays a significant role in employability, entrepreneurship and skill development due to its wide-ranging applications and relevance in various industries, such as polymer, pharmaceuticals, cement, ceramics, petrochemicals, agrochemicals, cosmetics, and environmental science. Learners can apply Analytical chemistry knowledge to develop and validate analytical methods for pharmaceutical product. Learner can work as Quality control chemist in Laboratories of various chemical industry. Entrepreneurs can establish analytical testing laboratories that offer services to various industries including QC and environmental analysis.

Modules at a Glance

Sr. No.	Modules	No. of Hours
1	Language of Analytical Chemistry and Quality in Analytical Chemistry	15
2	Calculations based on Chemical Principles	15
3	Optical Methods	15
4	Instrumental Methods-I	15
Total		**60**

Course Outcomes

On the successful completion of this course learners will be able to:

CO1 :	Design an experimental procedure, interpret the results, and draw logical conclusions. Implement quality assurance and quality control measures for analytical procedures to ensure the reliability and validity of the analytical data.
CO2 :	Demonstrate the ability to perform accurate quantitative calculations in analytical chemistry, including normality, molarity, and parts per million (ppm), parts per billion (ppb), solubility product (Ksp), limiting reagent, pH, percentage yield, and formality, to analyze and interpret chemical data effectively.
CO3 :	Explain the fundamental principles of UV-Visible spectroscopy, Infrared spectroscopy, and Fourier Transform Infrared (FTIR) spectroscopy, including their working principles and the interaction of electromagnetic radiation with matter.
CO4 :	Describe thermal analysis techniques and automation strategies in chemical analysis, enabling students to select appropriate methods, operate relevant instruments, analyze data, and apply automation principles to enhance accuracy, efficiency, and reproducibility in chemical measurements.

Curriculum

Unit	Modules
I	Language of Analytical Chemistry and Quality in Analytical Chemistry (15 Hours)
	1.1 Language of Analytical Chemistry [8L] 1.1.1 **Analytical perspective** [3L] Analytical approach. Common analytical problems. Terms involved in analytical chemistry - Analysis, Analyte, Matrix, Determination, Measurement, Techniques, Methods, Procedures and protocol. 1.1.2 **An overview of analytical methods** [3L] Analytical methods - Types, classification and selection. Quantitative method of Analysis- Calibration method, Method of Standard addition, Internal standard method. Performance Characteristics of analytical method- Accuracy, Precision, Selectivity, Sensitivity, Detection limit (LOD, LOQ, LOL), Dynamic range and Robustness and Ruggedness. 1.1.3 **Errors** [2L] Types of errors. Absolute error, Relative error, Constant error and Proportionate errors. Minimization of errors. **1.2 Quality in Analytical Chemistry** [7L] 1.2.1 **Total Quality Management- TQM** [3L] Definition, Principles, Importance and benefits. Philosophy of implementation of TQM - Process steps, Advantages and Limitations i) Kaizen -Six steps ii) Six Sigma approach iii) 5S and 5S audit check for laboratories. 1.2.2 **Safety in laboratories** [2L] Basic concept of safety in laboratory- The Industrial Hygiene Principles. Personal protection equipment (PPE).Occupational Safety and Health Administration (OSHA). 1.2.3 **Accreditations** [2L] Accreditation of laboratories, NABL, Indian Government standards (ISI, HALLMARK, AGMARK). Meaning and significance.
II	Calculations based on Chemical Principles (15 Hours)
	2.1 Calculations based on Chemical Principles 2.1.1 Concentration of a solution based on volume and mass units. 2.1.2 Calculations of ppm, ppb and dilution of the solutions, concept of mmol. 2.1.3 Stoichiometry of chemical reactions, concept of kg/mol, limiting reactant, theoretical and practical yield. 2.1.4 Solubility and solubility equilibria, effect of presence of common ion in solution. 2.1.5 Calculations of pH of acids, bases, acidic and basic buffers. 2.1.6 Concept of formation constants, stability and instability constants, stepwise formation constants. 2.1.7 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 an oxidizing / reducing agent and its relationship with molarity).
III	Optical Methods (15 Hours)

	3.1 Infrared Absorption Spectroscopy [6L] 3.1.1 Instrumentation: Sources, Sample handling, Transducers, Dispersive, non-dispersive instrument. 3.1.2 Applications of IR [Mid IR, Near IR, Far IR]: Qualitative with emphasis on "Finger print" and Quantitative analysis. 3.1.3 Advantages and Limitations of IR. **3.2 FT Technique** [3L] 3.2.1 Introduction of Fourier Transform. 3.2.2 Laser as a source of radiation, sample containers. 3.2.3 Detectors, Fiber optics. 3.2.4 FTIR and its advantages. **3.3 Molecular Ultraviolet and Visible Spectroscopy** [6L] 3.3.1 Factors affecting molecular absorption: pH, temperature, solvent and effect of substituents, types of transitions [emphasis on charge transfer absorption]. 3.3.2 Applications of Ultraviolet and Visible spectroscopy: i) On charge transfer absorption ii) Simultaneous spectroscopy iii) Derivative Spectroscopy 3.3.3 Dual spectrometry- Introduction, principle, instrumentation and applications.
IV	Instrumental Methods-I (15 Hours)
	4.1 Thermal Methods: [9L] 4.1.1 Introduction: Types of thermal methods, comparison between TGA and DTA. 4.1.2 Differential Scanning Calorimetry-Principle, comparison of DTA and DSC. **4.1.3** Instrumentation, Block diagram, Nature of DSC Curve, Factors affecting DSC Curves. **4.1.3** Applications - Heat of reaction, Safety screening, Polymers, liquid crystals, Drug analysis. **4.2 Automation in chemical analysis: [6L]** 4.2.1 Need for automation, Objectives of automation. 4.2.2 An overview of automated instruments. 4.2.3 Process control analysis, flow injection analysis, discrete automated systems, automatic analysis based on multi-layered films, gas monitoring equipment's. 4.2.4 Automatic titrators.

References

1. David Harvey, McGraw-Hill, Higher Education, Modern Analytical Chemistry; (2000).
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7. M N Vyas, Atlantic Publisher, Safety and Hazards Management in Chemical Industries; Ch: 4, Ch: 5 and Ch: 19.
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15. Vogel's Quantitative Chemical Analysis,; 6th Edition, Chapter 12.
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Evaluation Pattern

(Max 100 marks)

A) Internal Assessment: 40% (40 marks)

Sr. No.	Particulars	Marks
01	One Periodical Class Test / Written objectives / Assignments / Short answer Questions / Seminar to be conducted in the given semester	30
02	Active participation in routine class instructional deliveries and overall conduct as a responsible learner, mannerism and articulation and exhibit of leadership qualities in organizing related academic activities	10

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

60 Marks per paper Semester End Theory Examination:

1. Duration - These examinations shall be of two hours duration.
2. Theory question paper pattern:
   a) There shall be 04 questions each of 12 marks on each unit and one question of 12 marks on all units.
   b) All questions shall be compulsory with internal choice within the questions.

Name of the Course	Chemistry Practical-I (Organic Chemistry and Analytical Chemistry)
Course Code	23_PSCH104
Class	M.Sc.
Semester	I
No of Credits	2
Nature	Practical
Type	Major: Mandatory - I
Employability/ Entrepreneurship/ Skill Development	Practical Skills of organic and analytical chemistry experiments involve wide range of laboratory techniques Synthesis/preparation, distillation, extraction and purification, chromatography, Instrumental analysis. Learners who have hands-on experience with these techniques are highly sought in industries like pharmaceuticals, polymers, petrochemicals. Product development and analytical method development knowledge can be valuable for entrepreneurs looking to develop new products and their analytical method development.

Course Outcomes

On the successful completion of this course, learners will be able to:

CO1 :	learn to design and plan organic synthesis, synthesize organic compounds
CO2 :	Use SOPs and handle instruments, analyze and apply complexometric titrations, develop scientific temperament and research-based skills accomplish to encounter in the field of research

Curriculum

Course	Credits
Organic Chemistry	01
One step preparations (1.0 g scale) 1. Bromobenzene to *p*-nitrobromobenzene 2. Anthracene to anthraquinone 3. Benzoin to benzyl 4. Anthracene to Anthracene maleic anhydride adduct 5. 2-Naphthol to BINOL 6. p-Benzoquinone to 1,2,4-triacetoxybenzene 7. Ethyl acetoacetate to 3-methyl-phenylpyrazol-5-one 8. o-Phenylenediamine to 2-methylbenzimidazole 9. o-Phenylenediamine to 2,3-diphenylqunooxaline 10. Urea and benzil to 5,5-diphenylhydantoin **(Minimum 08 experiments are expected)**	
Analytical Chemistry	01
• **Non-Instrumental** 1. To carry out assay of the sodium chloride injection by Volhard's 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 number of nitro groups in the given compound using $TiCl_3$.	

- **Instrumental**

1. To determine percentage purity of sodium carbonate in washing soda pH metrically.
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.

References

1. A. I. Vogel's, Quantitative Inorganic Analysis including Elementary Instrumental Analysis, 3rd Ed. ELBS (1964).
2. Mendham, Denny, Barnes, Thomas, Pearson education, Vogel's textbook of quantitative chemical analysis, Sixth Ed.
3. F. J. Welcher, Standard methods of chemical analysis; 1975.
4. F. J. Welcher, Standard methods of chemical analysis: Instrumental methods of Analysis; vol. 3, 1966.
5. W. W. Scott, "Standard methods of Chemical Analysis"; Vol. I, Van Nostrand Company, Inc., 1939.
6. E. B. Sandell and H. Onishi, "Spectrophotometric Determination of Traces of Metals" Part II, 4th Ed., A Wiley Inter science Publication, New York, 1978.

Evaluation Pattern

(Max 50 marks)

A) Internal Assessment: 40 % (20 Marks)

Sr. No.	Particulars	Marks
01	Assessment during practicals (Interaction/Performance) Skill, Accuracy, precision of measurement, Record of observation, calculations, graph, result and conclusion. Timely submission of journal	15
02	Overall performance (attendance, punctuality, interaction during Practical session throughout semester)	05
Total		**20**

B) Semester End Examination: 60% (30 Marks)

Sr. No.	Name of course	Method	Duration	Marks
1.	Analytical Chemistry	Experiment performance as per the practical slip	Three and half hours	25
2.	Organic Chemistry	Experiment performance as per the practical slip	Three and half hours	25
3.	Journal + Viva			5+5
Total				**60**

N. B.:- The practical examination will be of 60 marks at the end of semester which will be converted to 30 Marks.

Name of the Course	Physical Chemistry-I
Course Code	23_PSCH105

Class	M.Sc.
Semester	I
No of Credits	2
Nature	Theory
Type	Major: Elective – 1
Employability/ Entrepreneurship/ Skill Development	Chemical kinetics plays a crucial role in optimizing industrial process by understanding reaction rates and being able to design efficient reactors. Learners can apply the concept of kinetics in drug stability studies and understanding pathways of drug synthesis. Electrochemistry offers entrepreneurs the chance to create environmentally friendly and sustainable solutions such as water purification systems and renewable energy technologies.

Modules at a Glance

Sr. No.	Modules	No. of Hours
1	Chemical Kinetics and Molecular Dynamics-I	15
2	Electrochemistry	15
Total		**30**

Course Outcomes

On the successful completion of this course, learners will be able to:

CO1 :	Study composite reactions, analyze consecutive reactions and chain reactions, study inorganic mechanisms; organic decompositions and gas-phase combustions, analyze kinetics of polymerization reactions, calculate polymerization degree and chain length
CO2 :	Explain and apply Debye – Huckel theory, analyze interactions in electrolytes and Debye – Onsager equation considering real system deviations, study fuel cells, apply principles of electrochemistry to biochemical reactions, study Goldmann equation

Curriculum

Unit	Modules
I	Chemical Kinetics and Molecular Dynamics-I (15 Hours)
	1.1 Composite Reactions: Recapitulation: Rate laws, Differential rate equations Consecutive reactions, Steady state Approximation, rate determining steps, Microscopic Reversibility and Detailed Balanced Chain reactions-chain initiation processes. 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. 1.2 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.
II	Electrochemistry (15 Hours)
	2.1 Debye-Hückel theory of activity coefficient, Debye-Hückel limiting law and its 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: Alkaline fuel cells, Phosphoric acid fuel cells, High temperature fuel cells [Solid –Oxide Fuel Cells (SOFC) and Molten Carbonate Fuel Cells] 2.4 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-catalyzed oxidation of styrene. Goldmann equation. (derivations are expected) **[Note: Numerical and theoretical problems from each unit are expected]**

References

1. Peter Atkins and Julio de Paula, Atkin's Physical Chemistry, 7th Edn, Oxford University Press, 2002.
2. K.J. Laidler and J.H. Meiser, Physical Chemistry, 2nd Ed., CBS Publishers and Distributors, New Delhi, 1999.
3. Ira R. Levine, Physical Chemistry, 5th Edn, Tata McGraw-Hill New Delhi, 2002.
4. G.W. Castellan, Physical Chemistry, 3rd Edn Narosa Publishing House, New Delhi, 1983.
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7. Bockris, John O'M., Reddy, Amulya K.N., Gamboa-Aldeco, Maria E., Modern Electrochemistry, 2A, Plenum Publishers, 1998.
8. Gurtu and Gurtu, Physical Chemistry.
9. Dr. Harichandra A Parbat and Dr. Damodar V Prabhu, Essence of Chemical Kinetics, Sara Publication, First Edition, Sept. 2022.

Evaluation Pattern

(Max 50 marks)

A) Internal Assessment: 40% (20 marks)

Sr. No.	Particulars	Marks
01	One Periodical Class Test / Written objectives / Assignments / Short answer Questions / Seminar to be conducted in the given semester	30
02	Active participation in routine class instructional deliveries and overall conduct as a responsible learner, mannerism and articulation and exhibit of leadership qualities in organizing related academic activities	10

B) Semester End Examination: 60% (30 marks)

30 Marks per paper Semester End Theory Examination:
1. Duration - These examinations shall be of two hours duration.
2. Theory question paper pattern:
   a) There shall be 02 questions each of 10 marks on each unit and one question of 10 marks on all units.
   b) All questions shall be compulsory with internal choice within the questions.

Name of the Course	Chemistry Practical E-I (Physical Chemistry and Inorganic Chemistry)
Course Code	23_PSCH106
Class	M.Sc.

Semester	I
No of Credits	2
Nature	Practical
Type	Major: Elective I
Employability/ Entrepreneurship/ Skill Development	Practical Skills of physical and inorganic chemistry experiments involve a wide range of laboratory techniques like synthesis/preparation, extraction and purification, Instrumental analysis. Learners who have hands-on experience with these techniques are highly sought in industries like pharmaceuticals, fine chemicals, and ceramics. Product development and analytical method development knowledge can be valuable for entrepreneurs looking to develop new products and its analytical method development.

Course Outcomes

On the successful completion of this course learners will be able to:

CO1 :	gain knowledge of the advanced concepts in pH metry, potentiometry and conductometry experiments and handle instruments
CO2 :	Apply concepts of thermodynamics and chemical kinetics in chemical reactions.
CO3 :	To usage of subject fundamentals principles with practical knowledge to design experiments, analyze and interpret data so as to reach proper conclusions.
CO4 :	Develop scientific temper and research-based skills accomplish to encounter in the field of research.
CO5 :	To apply basic concepts of separation and estimation of metals ions from constituent ores/alloys effectively using chemical analysis.
CO6 :	It explains various methods, concepts, and highlights the effect of environment on human beings.

Curriculum

Course	Credits
Physical Chemistry	01
• **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) Graph Plotting of mathematical functions –linear, exponential and trigonometry and identify whether functions are acceptable or non-acceptable? • **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	
Inorganic Chemistry	01
• **Non-Instrumental**	

1) Analysis of Devarda‟s alloy
2) Analysis of Cu – Ni alloy
3) Analysis of Limestone.
4) Analysis of Tin Solder alloy

- **Instrumental**

1) Estimation of Fe (III)solution using Ce (IV) ions Potentiometrically
2) Estimation of Copper using Iodometric method Potentiometrically
3) Estimation of Na_2CO_3 in washing soda by pH metry
4) Estimation of Cl^- ion in NaCl / KCl by Conductometry

References

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

Evaluation Pattern

(Max 50 marks)

A) Internal Assessment: 40 % (20 Marks)

Sr. No.	Particulars	Marks
01	Assessment during practicals (Interaction / Performance) Skill, Accuracy, precision of measurement, Record of observation, calculations, graph, result and conclusion. Timely submission of journal	15
02	Overall performance (attendance, punctuality, interaction during Practical session throughout semester)	05
Total		**20**

B) Semester End Examination: 60% (30 Marks)

Sr. No.	Name of course	Method	Duration	Marks
1.	Physical Chemistry	Experiment performance as per the practical slip	Three and half hours	25
2.	Inorganic Chemistry	Experiment performance as per the practical slip	Three and half hours	25
3.	Journal + Viva			5+5
Total				**60**

N. B. The practical examination will be of 60 marks at the end of semester which will be converted to 30 Marks.

Name of the Course	Physical Chemistry – II
Course Code	23_PSCH107
Class	M.Sc.
Semester	I

No of Credits	2
Nature	Theory
Type	Major: Elective – II
Employability/ Entrepreneurship/ Skill Development	Quantum chemistry plays a crucial role in computational chemistry which is used to predict mode of chemical reaction and molecular properties. Learner with knowledge of Chemical thermodynamics and Quantum chemistry are in demand in academia, industries and research institutes.

Modules at a Glance

Sr. No.	Modules	No. of Hours
1	Thermodynamics-I	15
2	Quantum Chemistry	15
Total		**30**

Course Outcomes

On the successful completion of this course learners will be able to:

CO1 :	Apply the advanced thermodynamics, Maxwell equation and its applications to ideal gases. And implement the applications of chemical thermodynamics to real gases, solutions, surfaces and their energetics.
CO2 :	Elaborate the applications of operators and Schrodinger equation in the field of quantum Chemistry. And accomplish a solution to problems encountered in the field of research.

Curriculum

Unit	Modules
I	Thermodynamics - I (15 Hours)
	1.1 State function and exact differentials. Maxwell equations, Maxwell thermodynamic Relations; its significance and applications to ideal gases, Joule Thomson experiment, Joule Thomson coefficient, inversion temperature, Joule Thomson coefficient in terms of van der Waals constants. [8L] 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. [7L]
II	Quantum Chemistry (15 Hours)
	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 value equation, Schrodinger 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 time – independent wave equation from Schrodinger time dependant wave equation

	2.4. 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 recursion formula.

References

1. Peter Atkins and Julio de Paula, Atkin's Physical Chemistry, 7th Edn, Oxford University Press, 2002.
2. K.J. Laidler and J.H. Meiser, Physical Chemistry, 2nd Ed., CBS Publishers and Distributors, New Delhi, 1999.
3. S. Glasstone, Text Book of Physical Chemistry, 2nd Edn., McMillan and Co. Ltd., London, 1962
4. B.K. Sen, Quantum Chemistry including Spectroscopy, Kalyani Publishers, 2003.
5. A.K. Chandra, Introductory Quantum Chemistry, Tata McGraw – Hill, 1994.
6. R.K. Prasad, Quantum Chemistry, 2nd Edn, New Age International Publishers, 2000.
7. W.G. Davis, Introduction to Chemical Thermodynamics – A Non – Calculus Approach, Saunders, Philadelphia, 1972.
8. Peter A. Rock, Chemical Thermodynamics, University Science Books, Oxford University Press, 1983.
9. Ira N. Levine, Quantum Chemistry, 5th Edn, Pearson Education (Singapore) Pte. Ltd., Indian Branch, New Delhi, 2000.

Evaluation Pattern

(Max 50 marks)

A) Internal Assessment: 40% (20 marks)

Sr. No.	Particulars	Marks
01	One Periodical Class Test / Written objectives / Assignments / Short answer Questions / Seminar to be conducted in the given semester	30
02	Active participation in routine class instructional deliveries and overall conduct as a responsible learner, mannerism and articulation and exhibit of leadership qualities in organizing related academic activities	10

B) Semester End Examination: 60% (30 marks)

30 Marks per paper Semester End Theory Examination:
1. Duration - These examinations shall be of two hours duration.
2. Theory question paper pattern:
   a) There shall be 02 questions each of 10 marks on each unit and one question of 10 marks on all units.
   b) All questions shall be compulsory with internal choice within the questions.

Name of the Course	Chemistry Practical E-II (Physical Chemistry and Inorganic Chemistry)
Course Code	23_PSCH108
Class	M.Sc.
Semester	I
No of Credits	2
Nature	Practical

Type	Major: Elective II
Employability/ Entrepreneurship/ Skill Development	Practical Skills of physical and inorganic chemistry experiments involve a wide range of laboratory techniques like synthesis/preparation, extraction and purification, Instrumental analysis. Learners who have hands-on experience with these techniques are highly sought in industries like pharmaceuticals, fine chemicals, and ceramics. Product development and analytical method development knowledge can be valuable for entrepreneurs looking to develop new products and its analytical method development.

Course Outcomes

On the successful completion of this course learners will be able to:

CO1 :	gain knowledge of the advanced concepts in pH metry, potentiometry and conductometry experiments and handle instruments
CO2 :	Apply concepts of thermodynamics and chemical kinetics in chemical reactions.
CO3 :	To usage of subject fundamentals principles with practical knowledge to design experiments, analyze and interpret data so as to reach proper conclusions.
CO4 :	Develop scientific temper and research-based skills accomplish to encounter in the field of research.
CO5 :	To apply basic concepts of separation and estimation of metals ions from constituent ores/alloys effectively using chemical analysis.
CO6 :	It explains various methods, concepts, and highlights the effect of environment on human beings.

Curriculum

Course	Credits
Physical Chemistry	01
• **Non-Instrumental** 5) To determine the heat of solution (ΔH) of a sparingly soluble acid (benzoic/salicylic acid) from solubility measurement at three different temperature. 6) To study the variation of calcium sulphate with ionic strength and hence determine the thermodynamic solubility product of $CaSO_4$ at room temperature. 7) To investigate the reaction between acetone and iodine. 8) Graph Plotting of mathematical functions –linear, exponential and trigonometry and identify whether functions are acceptable or non-acceptable? • **Instrumental** 5) To determine the mean ionic activity coefficient of an electrolyte by e.m.f. measurement. 6) To study the effect of substituent on the dissociation constant of acetic acid conductometrically. 7) To determine pKa values of phosphoric acid by potentiometric titration with sodium hydroxide using glass electrode. 8) To verify Ostwald's dilution law and to determine the dissociation constant of a weak mono-basic acid conductometrically	
Inorganic Chemistry	01
• **Non-Instrumental** 5) Analysis of Devarda‟s alloy 6) Analysis of Cu – Ni alloy 7) Analysis of Limestone. 8) Analysis of Tin Solder alloy	

- **Instrumental**

5) Estimation of Fe (III)solution using Ce (IV) ions Potentiometrically
6) Estimation of Copper using Iodometric method Potentiometrically
7) Estimation of Na_2CO_3 in washing soda by pH metry
8) Estimation of Cl^- ion in NaCl / KCl by Conductometry

References

7. B. Viswanathan and P.S. Raghavan, Viva Books Private Limited, Practical Physical Chemistry, 2005.
8. A.M. James and F.E. Prichard, Practical Physical Chemistry, 3rd Edn, Longman Group Ltd., 1974.
9. V.D. Athawale and P. Mathur, Experimental Physical Chemistry, New Age International Publishers, 2001
10. G. N. Mukherjee., Advanced experiments in Inorganic Chemistry., 1st Edn, 2010, U.N. Dhuri and Sons Pvt. Ltd.
11. William L. Jolly, The Synthesis and Characterization of Inorganic Compounds.
12. Dr. Deepak Pant, Inorganic Chemistry Practical under UGC Syllabus for M.Sc. in all India Universities.

Evaluation Pattern

(Max 50 marks)

A) Internal Assessment: 40 % (20 Marks)

Sr. No.	Particulars	Marks
01	Assessment during practicals (Interaction / Performance) Skill, Accuracy, precision of measurement, Record of observation, calculations, graph, result and conclusion. Timely submission of journal	15
02	Overall performance (attendance, punctuality, interaction during Practical session throughout semester)	05
Total		**20**

B) Semester End Examination: 60% (30 Marks)

Sr. No.	Name of course	Method	Duration	Marks
1.	Physical Chemistry	Experiment performance as per the practical slip	Three and half hours	25
2.	Inorganic Chemistry	Experiment performance as per the practical slip	Three and half hours	25
3.	Journal + Viva			5+5
Total				**60**

N. B. The practical examination will be of 60 marks at the end of semester which will be converted to 30 Marks.

Name of the Course	Research Methodology
Course Code	25_PSCH109
Class	M.Sc.
Semester	I
No of Credits	4
Nature	Theory
Type	Major: Mandatory

Employability/ Entrepreneurship/ Skill Development	Learners will gain knowledge of Research Methodology in Chemistry. Further, the learner will benefit in the form of an increase in research aptitude, analytical and decision-making skills. Acquisition of the knowledge in the field of research will increase the chances of employability and will offer better prospects in industry.

Modules at a Glance

Sr. No.	Modules	No. of Hours
1	Literature Survey	15
2	Data analysis	15
3	Methods of scientific research and writing scientific papers	15
4	Chemical safety and ethical handling of chemicals	15
Total		**60**

Course Outcomes

On the successful completion of this course learners will be able to:

CO1 :	Explain the fundamentals of research methods
CO2 :	Design and measurement concepts of research
CO3 :	Describe data collection and analysis tools
CO4 :	Test the hypothesis and communicate the research findings effectively, write Research report; research proposal; research paper etc. and get acquainted with ethical considerations in research tools.

Curriculum

Unit	Modules
I	Literature Survey (15 lectures)
	1.1 Print Primary, Secondary and Tertiary sources. 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. 1.2 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.
	1.3 Information Technology and Library Resources The Internet and World wide web, Internet resources for Chemistry, finding and citing published information
II	Data analysis (15 lectures)
	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 (15 lectures)
	Reporting practical and project work, writing literature surveys and reviews, organizing a poster display, giving an oral presentation. 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 and ethical handling of chemicals (15 lectures)
	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.

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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
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8. R. Kothari, (2008). Research Methodology, New Age International, New Delhi, India.

Evaluation Pattern

(Max 100 marks)

A) Internal Assessment: 40% (40 marks)

Sr. No.	Particulars	Marks
01	One Periodical Class Test / Written objectives / Assignments / Short answer Questions / Seminar to be conducted in the given semester	30
02	Active participation in routine class instructional deliveries and overall conduct as a responsible learner, mannerism and articulation and exhibit of leadership qualities in organizing related academic activities	10

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

60 Marks per paper Semester End Theory Examination:

1. Duration - These examinations shall be of two hours duration.
2. Theory question paper pattern:
   a) There shall be 04 questions each of 12 marks on each unit and one question of 12 marks (objective / short answer) on all units.
   b) All questions shall be compulsory with internal choice within the questions.

Revised Syllabus of Courses of Master of Science (M.Sc.)

Programme at Semester II with Effect from the Academic Year 2023-2024

SMART Criteria for Course Outcomes

- **Specific:** Each course outcome is specific, outlining the knowledge and skills students are expected to acquire in relation to the specific topics covered.
- **Measurable:** Each outcome can be measured through assessments, tests, or projects to determine the level of understanding and proficiency achieved by the students.
- **Achievable:** The outcomes are achievable within the duration of the course, considering the number of lectures allocated to each topic.
- **Relevant:** The outcomes are relevant to the subject of financial services and capital market, addressing important concepts, types, and mechanisms involved.
- **Time-bound:** The outcomes are expected to be achieved by the end of the course, providing a clear timeline for assessment and evaluation.

Course Code	Nomenclature	Credits	
Mandatory Courses			
23_PSCH201	Inorganic Chemistry – II	04	
23_PSCH202	Organic Chemistry – II	04	
23_PSCH203	Analytical Chemistry – II	04	
23_PSCH204	Chemistry Practical – II (Organic Chemistry and Analytical Chemistry)	02	
Elective Courses (any one)			
Elective I			
23_PSCH205	Physical Chemistry – III	02	04
23_PSCH206	Chemistry Practical E – III (Physical and Inorganic Chemistry)	02	
Elective II			
23_PSCH207	Physical Chemistry – IV	02	04
23_PSCH208	Chemistry Practical E – IV (Physical and Inorganic Chemistry)	02	
23_PSCH209	On Job Training / Field Project	04	
TOTAL		22	

Name of the Course	Inorganic Chemistry-I
Course Code	23_PSCH201
Class	M.Sc.
Semester	I
No of Credits	4
Nature	Theory
Type	Major: Mandatory II
Employability/ Entrepreneurship/ Skill Development	Inorganic chemistry plays a significant role in employability, entrepreneurship and skill development due to its wide-ranging applications and relevance in various industries, such as material science, electronics, ceramics, pharmaceuticals, and environmental science. Entrepreneurs in fields like material science and nanotechnology rely on inorganic chemistry principles to innovate. Thus a course provides Postgraduates with analytical skills, problem solving skills, and research capabilities which empower them to pursue a diverse path career.

Modules at a Glance

Sr. No.	Modules	No. of Hours
1	Inorganic Reaction Mechanism	15
2	Organometallic Chemistry of Transition metals	15
3	Environmental Chemistry	15
4	Bioinorganic Chemistry	15
Total		**60**

Course Outcomes

On the successful completion of this course learners will be able to:

CO1 :	Define rate of reactions, explain factors affecting rate of reactions and various methods to determine rate of reactions, analyze and explain substitution reactions; trans effect; use of trans effect in designing of synthesis, explain redox reactions and analyze their mechanisms, and explain racemization and isomerization reactions.
CO2 :	Define 18- and 16-electron rule, analyze and predict importance of 18- and 16-electron rule, explain preparation and chemical properties of metal complexes, analyze nature of bonding in various organometallic compounds and explain their structural features
CO3 :	Explain the occurrence and effect of toxic metals like Pb, As, Cu, Cd, and Hg on the environment, analyze and explain the different diseases caused by poisoning of metals and the impact these metals have on the living organism.
CO4 :	Explain role of Inorganic chemistry in biological systems, analyze the structure of various biological oxygen carriers and molecules involved in electron storage and transport, and explain structure and mechanism of enzyme catalyzed reactions.

Curriculum

Unit	Modules
I	Inorganic Reaction Mechanism (15 Hours)
	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** a) Octahedral complexes without breaking of metal-ligand bond (Use of isotopic labelling method). b) Square planar complexes, trans-effect, its theories and applications. Mechanism and factors affecting these substitution reactions. 1.3 **Redox reactions:** inner and outer sphere mechanisms, complimentary and non-complimentary reactions. 1.4 Isomerization and racemization reactions.
II	Organometallic Chemistry of Transition metals (15 Hours)
	2.1 Eighteen electron rule and electron counting with examples, sixteen electron rule, Square Planar complexes. 2.2 Preparation 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 Fe, Cr and Half Sandwich compounds of Cr, Mo. 2.3 Structure and bonding on the basis of VBT and MOT in the following organometallic compounds: Zeise's salt, ferrocene and bis(arene)chromium(0), bis(triphenylphosphine)diphenylacetylene platinum (0) $[Pt(PPh_3)_2(HC{\equiv}CPh)_2]$, diallylnickel (diallylnickel(II), tricarbonyl (η^2-butadiene) iron(0).
III	Environmental Chemistry (15 Hours)
	3.1. **Conception of Heavy Metals:** Critical discussion on heavy metals 3.2. **Toxicity of metallic species:** a) Mercury, lead, cadmium, arsenic, copper and chromium, with respect to their sources, distribution, speciation, biochemical effects and toxicology, control and treatment. b) Itai-itai disease for Cadmium toxicity, c) Arsenic Poisoning in the Indo-Bangladesh region. 3.3. **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 Hours)
	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. **4.3** Copper containing enzymes- superoxide dismutase, **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.

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Evaluation Pattern

(Max 100 marks)

A) Internal Assessment: 40% (40 marks)

Sr. No.	Particulars	Marks
01	One Periodical Class Test / Written objectives / Assignments / Short answer Questions / Seminar to be conducted in the given semester	30
02	Active participation in routine class instructional deliveries and overall conduct as a responsible learner, mannerism and articulation and exhibit of leadership qualities in organizing related academic activities	10

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

60 Marks per paper Semester End Theory Examination:

1. Duration - These examinations shall be of two hours duration.
2. Theory question paper pattern:
   a) There shall be 04 questions each of 12 marks on each unit and one question of 12 marks on all units.
   b) All questions shall be compulsory with internal choice within the questions.

Name of the Course	Organic Chemistry – II
Course Code	23_PSCH202
Class	M.Sc.
Semester	I
No of Credits	4
Nature	Theory
Type	Major: Mandatory
Employability/ Entrepreneurship/ Skill Development	Organic chemistry plays a significant role in employability, entrepreneurship and skill development due to its wide-ranging applications and relevance in various industries, such as polymer, pharmaceuticals, petrochemicals, agrochemicals, cosmetics, and environmental science. Understanding Organic reactions and synthesis is essential for designing and creating new compounds with specific properties. Learners can apply organic chemistry knowledge to develop innovative products such as specialty chemicals, natural based products to meet specific market demand.

Modules at a Glance

Sr. No.	Modules	No. of Hours
1	Alkylation of Nucleophilic Carbon Intermediates and Reaction of carbon nucleophiles with carbonyl groups	15
2	Introduction to Molecular Orbital Theory for Organic Chemistry and Applications of UV and IR spectroscopy	15
3	Reactions and Rearrangements	15
4	^{1}H and ^{13}C NMR spectroscopy and Mass spectrometry	15
Total		**60**

Course Outcomes

On the successful completion of this course learners will be able to:

CO1 :	recognize; classify and study preparation of stabilized carbanions (enolates and azaenolates), predict and analyze product of nucleophilic substitution reaction (alkylation) of enolates, study nucleophilic additions to carbonyl compounds and analyze their stereochemistry, explore use of enolate chemistry in organic synthesis
CO2 :	Analyze molecular orbitals for simple organic molecules, including the bonding and anti-bonding interactions, Explain the concept of frontier molecular orbitals (HOMO and LUMO) and their role in organic reactions, Apply molecular orbital theory to predict chemical reactivity, stability, and electronic transitions in organic compounds, Apply the principles behind UV-Vis spectroscopy and how electronic transitions (π-π^*, n-π^*) occur in organic molecules, Identify functional groups and bonding patterns in organic molecules by interpreting IR spectra.
CO3 :	Analyze mechanisms of organic reactions, analyze the driving forces behind rearrangements and predict products based on different substrates, learn to break down complex organic reactions into elementary steps and what intermediates are involved, learn to predict the structure and stability of the rearranged products.

CO4 :	Ability to interpret chemical shifts, which provide information about the electronic environment around hydrogen atoms in a molecule, Recognize splitting patterns and determine the number of neighboring protons, providing insight into molecular connectivity, Understanding of chemical shifts specific to carbon atoms and how they correlate to different carbon types, Ability to identify the molecular ion peak (M+) in the mass spectrum, which corresponds to the molecular weight of the compound, Interpretation of common fragmentation patterns, providing insight into the structure of the molecule.

Curriculum

Unit	Modules
I	Alkylation of Nucleophilic Carbon Intermediates and Reaction of carbon nucleophiles with carbonyl groups (15 Hours)
	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 catalyzed 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	Introduction to Molecular Orbital Theory for Organic Chemistry and Applications of UV and IR spectroscopy (15 Hours)
	2.1. Introduction to Molecular Orbital Theory for Organic Chemistry: (7L) 2.1.1 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. 2.1.2 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. 2.1.3 Application of FMO concepts in (a) SN^2 reaction, (b) Lewis acid base adducts (BF_3-NH_3 complex), (c) ethylene dimerization to Cyclobutane, (d) Diels-Alder cycloaddition, (e) regioselective reaction of allyl cation with allyl anion (f) addition of hydride to formaldehyde.

	2.2. Applications of UV and IR spectroscopy: (8L) 2.2.1 **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). 2.2.2 **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.
III	Reactions and Rearrangements (15 Hours)
	Mechanisms, stereochemistry (if applicable) and applications of the following: **3.1. Reactions:** Baylis-Hillman reaction, McMurry Coupling, Corey-Fuchs reaction, Nef reaction, Passerini reaction. **3.2. Concerted rearrangements:** Hofmann, Curtius, Lossen, Schmidt, Wolff, Boulton Katritzky. **3.3. Cationic rearrangements:** Tiffeneau-Demjanov, Pummerer, Dienone-phenol, Rupe, Wagner-Meerwein. **3.4. Anionic rearrangements:** Brook, Neber, Von Richter, Wittig, Gabriel–Colman, Baker-Venkataraman.
IV	^{1}H and ^{13}C NMR spectroscopy and Mass spectrometry (15 Hours)
	4.1 Proton magnetic resonance spectroscopy: Principle, Chemical shift, Factors affecting on 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, Karplus equation, long range coupling (allylic and aromatic). **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:** Basic Principle, 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.

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Evaluation Pattern

(Max 100 marks)

A) Internal Assessment: 40% (40 marks)

Sr. No.	Particulars	Marks
01	One Periodical Class Test / Written objectives / Assignments / Short answer Questions / Seminar to be conducted in the given semester	30
02	Active participation in routine class instructional deliveries and overall conduct as a responsible learner, mannerism and articulation and exhibit of leadership qualities in organizing related academic activities	10

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

60 Marks per paper Semester End Theory Examination:

1. Duration - These examinations shall be of two hours duration.
2. Theory question paper pattern:
   a) There shall be 04 questions each of 12 marks on each unit and one question of 12 marks on all units.
   b) All questions shall be compulsory with internal choice within the questions.

Name of the Course	Analytical Chemistry – II
Course Code	23_PSCH203
Class	M.Sc.
Semester	I
No of Credits	4
Nature	Theory
Type	Major: Mandatory
Employability/ Entrepreneurship/ Skill Development	Analytical chemistry plays a significant role in employability, entrepreneurship and skill development due to its wide-ranging applications and relevance in various industries, such as polymer, pharmaceuticals, cement, ceramics, petrochemicals, agrochemicals, cosmetics, and environmental science. Learners can apply Analytical chemistry knowledge to develop and validate analytical method for pharmaceutical product. Learner can work as Quality control chemist in Laboratories of various chemical industry. Entrepreneurs can establish analytical testing laboratories that offer services to various industries including QC, environmental analysis.

Modules at a Glance

Sr. No.	Modules	No. of Hours
1	Chromatography	15
2	Instrumental methods – II	15
3	Instrumental methods – III	15
4	Electro analytical Methods	15
Total		**60**

Course Outcomes

On the successful completion of this course learners will be able to:

CO1 :	Describe basic concepts and theories of chromatography, including the use of the Van Deemter equation to explain the broadening of chromatographic peaks. Discuss the principles, instrumentation, and applications of Gas Chromatography (GC) and High-Performance Liquid Chromatography (HPLC) for the separation, identification, and quantification of chemical compounds in various fields such as pharmaceuticals, environmental science, and food analysis.
CO2 :	Explain the principles, instrumentation & applications of X-ray Spectroscopy, Mass spectroscopy and radio analytical methods for qualitative & quantitative analysis of material across various scientific and industrial field.
CO3 :	Develop proficiency in utilizing surface analytical techniques such as Scanning Electron Microscopy (SEM), Scanning Tunneling Microscopy (STM), and Transmission Electron Microscopy (TEM), atomic spectroscopy based on plasma sources and understanding of its advantages and limitations.
CO4 :	Apply electrochemical techniques for qualitative and quantitative analysis of chemical species. This includes understanding and utilizing methods like ion selective potentiometry, polarography, electrogravimetry and coulometry.

Curriculum

Unit	Modules
I	Chromatography (15 Hours)
	1.1 Basic concepts and theories of chromatography: [5L] 1.1.1 Introduction and Classification of chromatographic methods. 1.1.2 Concept of plate and rate theories in chromatography, efficiency, resolution, selectivity and separation capability. 1.1.3 Van Deemter equation and broadening of chromatographic peaks. Optimization of chromatographic conditions. **1.2 Gas Chromatography:** [5L] 1.2.1 Instrumentation –sample injection systems (split/split less), column types (solid/ liquid stationary phases), column switching techniques, temperature programming. 1.2.2 Requirements of an ideal detector and types of detectors in GLC and GSC. 1.2.3 Applications -Qualitative and quantitative analysis. **1.3 High Performance Liquid Chromatography (HPLC):** [5L] 1.3.1 Normal phase and reversed phase with special reference to types of commercially available columns (Use of C8 and C18 columns). 1.3.2 Diode array type and fluorescence detector. 1.3.3 Applications of HPLC.
II	Instrumental methods – II (15 Hours)
	2.1 X-ray spectroscopy: [6L] Principle, instrumentation, applications, advantages and limitations of 2.1.1 X-ray absorption spectroscopy. (XAS) 2.1.2 X-ray fluorescence spectroscopy (XRF) 2.1.3 X-ray diffraction spectroscopy. (XRD) **2.2 Mass spectrometry:** [6L] 2.2.1 **Instrumentation:** i) Ion sources - electron impact, field ionization, field absorption, chemical ionization and fast atom bombardment sources. ii) Mass analyzers: Quadrupole, time of flight and ion trap. 2.2.2 **Applications** **2.3 Radio analytical Methods:** [3L] 2.3.1 Neutron Activation Analysis (NAA) - Introduction, Principle, Theory and Applications. 2.3.2 Advantages and Limitations of NAA.
III	Instrumental methods – III (15 Hours)
	3.1 Surface Analytical Techniques – [9L] 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) **3.2 Atomic Spectroscopy [6L]** 3.2.1 Atomic Spectroscopy based on plasma sources – Introduction, Principle, Instrumentation and Applications. 3.2.2 Advantages and Limitations of AAS.

IV	Electro analytical Methods (15 Hours)
	4.1 Ion selective potentiometry and Polarography: [10L] (Numericals are Expected) 4.1.1 Ion selective electrodes: Applications of - solid state, precipitate, liquid – liquid, enzyme, gas sensing, bio-catalytic membrane and enzyme-based biosensors electrodes. 4.1.2 **Polarography:** Ilkovic equation, Cottrell equation, effect of complex formation on the polarographic waves. **4.2 Electrogravimetry: [2L]** 4.2.1 Introduction, Principle and Instrumentation. 4.2.2 Factors affecting the nature of the deposit. 4.2.3 Applications **4.3 Coulometry: [3L]** 4.3.1 Introduction, Principle and Instrumentation. 4.3.2 Coulometry at controlled potential and controlled current.

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Evaluation Pattern

(Max 100 marks)

A) Internal Assessment: 40% (40 marks)

Sr. No.	Particulars	Marks
01	One Periodical Class Test / Written objectives / Assignments / Short answer Questions / Seminar to be conducted in the given semester	30
02	Active participation in routine class instructional deliveries and overall conduct as a responsible learner, mannerism and articulation and exhibit of leadership qualities in organizing related academic activities	10

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

60 Marks per paper Semester End Theory Examination:

1. Duration - These examinations shall be of two hours duration.
2. Theory question paper pattern:
   a) There shall be 04 questions each of 12 marks on each unit and one question of 12 marks on all units.
   b) All questions shall be compulsory with internal choice within the questions.

Name of the Course	Chemistry Practical-II (Organic Chemistry and Analytical Chemistry)
Course Code	23_PSCH204
Class	M.Sc.
Semester	I
No of Credits	2
Nature	Practical
Type	Major: Mandatory
Employability/ Entrepreneurship/ Skill Development	Practical Skills of organic and analytical chemistry experiments involve wide range of laboratory techniques Synthesis/preparation, distillation, extraction and purification, chromatography, Instrumental analysis. Learners who have hands-on experience with these techniques are highly sought in industries like pharmaceuticals, polymers, petrochemicals. Product development and analytical method development knowledge can be valuable for entrepreneurs looking to develop new products and their analytical method development.

Course Outcomes

On the successful completion of this course learners will be able to:

CO1 :	Determine of chemical types of different organic binary mixture, separate; purify and characterize organic compounds
CO2 :	Use SOPs and handle instruments, analyze and apply complexometric titrations, develop scientific temperament and research-based skills accomplish to encounter in the field of research

Curriculum

Course	Credits
Organic Chemistry	01

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 by derivative preparation and determination of 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 two mixtures from each type and a total of eight mixtures are expected.)

Analytical Chemistry	01

- **Instrumental Experiments**

1. To determine the amount of Fe (II) and Fe (III) in a mixture using 1, 10 - phenanthroline spectrophotometrically.
2. Simultaneous determination of Cr (VI) and Mn (VII) in a mixture spectrophotometrically.
3. 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 $BaCl_2$.
4. To determine amount of potassium in the given sample of fertilizers using flame

photometer by standard addition method.

- **Non-Instrumental Experiments**

1. To determine the lead and tin content of a solder alloy by titration with EDTA.
2. To determine amount of Cu (II) present in the given solution containing a mixture of Cu (II) and Fe (II).
3. To determine the break through capacity of a cation exchange resin.
4. Estimation of a mixture of Hydrochloric acid and boric acid by acid base titration.

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Evaluation Pattern

(Max 50 marks)

A) Internal Assessment: 40 % (20 Marks)

Sr. No.	Particulars	Marks
01	Assessment during practicals (Interaction / Performance) Skill, Accuracy, precision of measurement, Record of observation, calculations, graph, result and conclusion. Timely submission of journal	15
02	Overall performance (attendance, punctuality, interaction during Practical session throughout semester)	05
Total		**20**

B) Semester End Examination: 60% (30 Marks)

Sr. No.	Name of course	Method	Duration	Marks
1.	Analytical Chemistry	Experiment performance as per the practical slip	Three and half hours	25
2.	Organic Chemistry	Experiment performance as per the practical slip	Three and half hours	25
3.	Journal + Viva			5+5
Total				**60**

N. B.

The practical examination will be of 60 marks at the end of semester which will be converted to 30 Marks.

Name of the Course	Physical Chemistry-III
Course Code	23_PSCH205
Class	M.Sc.
Semester	I
No of Credits	2
Nature	Theory
Type	Major: Elective – III
Employability/ Entrepreneurship/ Skill Development	Understanding photochemistry and chemical kinetics is essential for chemist working in various industries such as pharmaceuticals, material science. These fields often rely on reactions that are influenced by light (photochemical reaction) or reaction rates (Chemical kinetics). Entrepreneurs with a background in photochemistry and chemical kinetics have opportunities to develop and commercialize innovative technologies.

Modules at a Glance

Sr. No.	Modules	No. of Hours
1	Photochemistry	15
2	Chemical Kinetics and Molecular Reaction Dynamics-II	15
Total		**30**

Course Outcomes

On the successful completion of this course learners will be able to:

CO1 :	apply basic concepts of photochemistry to explore various photochemical reactions, study and analyze fluorescence and phosphorescence, explain photochemical reactions taking place in environment
CO2 :	Study and analyze solvent effect on reactions, explain kinetics of enzyme catalyzed reactions; inhibition of enzyme, analyze kinetics of solid-state reactions

Curriculum

Unit	Modules
I	Photochemistry (15 Hours)
	1.1 Absorption of light, laws of photochemistry, electronic structure of molecules, molecular orbital, electronically excited singlet states, designation based on multiplicity rule, construction of Jablonski diagram, electronic transition, Frank Condon principle, selection rules, and intensity of absorption bands, nature of electronic spectra and primary process, photo-dissociation, predissociation. **1.2 Photo physical phenomena:** Physical pathways of excited molecular system (radiative and non-radiative), prompt fluorescence, delayed fluorescence, and phosphorescence, fluorescence quenching: concentration quenching, collisional quenching, quenching by excimer and exciplex emission, and fluorescence resonance energy transfer between photo-excited donor and acceptor systems. 1.3 Stern-Volmer relation, critical energy transfer distances, energy transfer efficiency, examples and applications in chemical analysis. Photochemical reactions, photo-oxidation, photoreduction, photodimerization, photoisomerization and

	photosensitized reactions. Photochemistry of environment: Greenhouse effect.
II	Chemical Kinetics and Molecular Reaction Dynamics-II (15 Hours)
	2.1. 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 Enzyme action **2.2.** Kinetics of reactions catalyzed by enzymes Michaelis-Menten analysis, Lineweaver-Burk and Eadie Analyses. **2.3.** Inhibition of Enzyme action: Competitive, Non-competitive and Uncompetitive Inhibition. Effect of pH, Enzyme activation by metal ions, Regulatory enzymes. **2.4.** 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

References

1. C. H. DePuy, O. L. Chapman, Molecular reactions and photochemistry, Prentice hall of India PVT. LTD. 1988
2. K. K. Rohatgi-Mukherjee. Fundamentals of Photochemistry. Reprint 2002. New Age International Publisher, 1978
3. K.J. Laidler and J.H. Meiser, Physical Chemistry, 2nd Ed., CBS Publishers and Distributors, New Delhi, 1999
4. Principles of Chemical Kinetics, 2nd Ed., James E. House, ELSEVIER, 2007
5. Dr. Hari chandra A Parbat and Dr. Damodar V. Prabhu, Essence of Chemical Kinetics, Sara Publication, First Edition, Sept. 2022

Evaluation Pattern

(Max 50 marks)

A) Internal Assessment: 40% (20 marks)

Sr. No.	Particulars	Marks
01	One Periodical Class Test / Written objectives / Assignments / Short answer Questions / Seminar to be conducted in the given semester	30
02	Active participation in routine class instructional deliveries and overall conduct as a responsible learner, mannerism and articulation and exhibit of leadership qualities in organizing related academic activities	10

B) Semester End Examination: 60% (30 marks)

30 Marks per paper Semester End Theory Examination:

1. Duration - These examinations shall be of two hours duration.
2. Theory question paper pattern:
   a) There shall be 02 questions each of 10 marks on each unit and one question of 10 marks on all units.
   b) All questions shall be compulsory with internal choice within the questions.

Name of the Course	Chemistry Practical E-III (Physical Chemistry and Inorganic Chemistry)
Course Code	23_PSCH206
Class	M.Sc.
Semester	I
No of Credits	2
Nature	Practical
Type	Major: Elective III
Employability/ Entrepreneurship/ Skill Development	Practical Skills of physical and inorganic chemistry experiments involve a wide range of laboratory techniques like synthesis/preparation, extraction and purification, Instrumental analysis. Learners who have hands-on experience with these techniques are highly sought in industries like pharmaceuticals, fine chemicals, and ceramics. Product development and analytical method development knowledge can be valuable for entrepreneurs looking to develop new products and its analytical method development.

Course Outcomes

On the successful completion of this course learners will be able to:

CO1 :	Use the concept of quantum chemistry to interpret the shape and information about orbitals like 1s, 2pz and $3dz^2$.
CO2 :	apply the subject fundamentals-principles with practical knowledge to design experiments, analyze and interpret data so as to reach to proper conclusions
CO3 :	Handle sophisticated instruments like digital potentiometer, conductivity meter, and spectrophotometer.
CO4 :	Calculating the equilibrium constant for Fe^{3-}/SCN^{1-} by slope intercept method
CO5 :	Determine the electrolytic nature of some inorganic compounds by conductance measurements
CO6 :	Synthesize complexes and estimate amount of metal in a complex

Curriculum

Course	Credits
Physical Chemistry	01

- **Non – Instrumental:**

1. Polar plots of atomic orbitals such as 1s, p_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 dilatometric method.

- **Instrumental**

5. To determine the formula of silver ammonia complex by potentiometric method.
6. To determine CMC of sodium Lauryl Sulphate from measurement of conductivities at different concentrations. To determine Hammette constant of m- and p- amino benzoic acid/nitro benzoic acid by pH measurement.
7. To determine the Michaelis – Menten's constant value (Km) of the enzyme Beta Amylase spectrophotometrically

Inorganic Chemistry	01

- **Inorganic Preparations (Synthesis and Characterization)**

1. Bis-(tetramethylammonium) tetrachloroCuprate (II) $(Me_4N)_2[CuCl_4]$
2. Bis-(tetramethylammonium) tetrachloroNickelate (II) $(Me_4N)_2$ $[NiCl_4]$
3. Bis (ethylenediammine) Copper (II) Sulphate $[Cu(en)_2]SO_4$
4. HexaaamineNi(II) Sulfate $[Ni(NH_3)_6]SO_4$
5. Potassiumtrioxalato Chromate(III) $K_3[Cr(C_2O_4)_3]$
6. Tetramminemonocarbanato Cobalt (III) Nitrate $[Co(NH_3)_4CO_3]NO_3$

- **Instrumental**

1. Determination of equilibrium constant by Slope intercepts method for Fe^{+3}/ SCN system.
2. Determination of Electrolytic nature of inorganic compounds by Conductance measurement.

References

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

Evaluation Pattern

(Max 50 marks)

A) Internal Assessment: 40 % (20 Marks)

Sr. No.	Particulars	Marks
01	Assessment during practicals (Interaction / Performance) Skill, Accuracy, precision of measurement, Record of observation, calculations, graph, result and conclusion. Timely submission of journal	15
02	Overall performance (attendance, punctuality, interaction during Practical session throughout semester)	05
Total		**20**

B) Semester End Examination: 60% (30 Marks)

Sr. No.	Name of course	Method	Duration	Marks
1.	Physical Chemistry	Experiment performance as per the practical slip	Three and half hours	25
2.	Inorganic Chemistry	Experiment performance as per the practical slip	Three and half hours	25
3.	Journal + Viva			5+5
Total				**60**

N. B. - The practical examination will be of 60 marks at the end of the semester which will be converted to 30 Marks.

Name of the Course	Physical Chemistry – IV
Course Code	23_PSCH207
Class	M.Sc.
Semester	I
No of Credits	2
Nature	Theory
Type	Major: Elective – IV
Employability/ Entrepreneurship/ Skill Development	Quantum chemistry plays a crucial role in computational chemistry which is used to predict mode of chemical reaction and molecular properties. Learner with knowledge of Chemical thermodynamics and Quantum chemistry are in demand in academia, industries and research institutes.

Modules at a Glance

Sr. No.	Modules	No. of Hours
1	Thermodynamics-II	15
2	Quantum Chemistry-II	15
Total		**30**

Course Outcomes

On the successful completion of this course learners will be able to:

CO1 :	To learn the concept of quantum chemistry and able to solve problems related to 1D box, 2D box, 3D box, explain the role of operators in quantum chemistry, use of Schrodinger wave equation in 1D and 2D- electron systems along with applications of HMO.
CO2 :	To develop the skill to solve the problems based on chemical thermodynamics, molecular dynamics and quantum Chemistry and apply the concept of Jablonski mechanism in photochemical reactions.

Curriculum

Unit	Modules
I	Thermodynamics-II (15 Hours)
	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 Hours)
	1.1 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. 1.2 Hydrogen atom, the two particle problem, separation of the energy as translational and potential, separation of variables, the Radial (R), Zenith (theta) and Azimuthal (Phi) 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. 1.3 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. 1.4 Hückel Molecular Orbitals theory for ethylene, 1, 3-butadiene, cyclobutadiene and benzene.

References

1. Peter Atkins and Julio de Paula, Atkin's Physical Chemistry, 7th Edn, Oxford University Press, 2002.
2. K.J. Laidler and J.H. Meiser, Physical Chemistry, 2nd Ed., CBS Publishers and Distributors, New Delhi, 1999
3. R.K. Prasad, Quantum Chemistry, 2nd Edn, New Age International Publishers, 2000.
4. S. Glasstone, Thermodynamics for Chemists, Affiliated East-West Press, New Delhi, 1964.
5. W.G. Davis, Introduction to Chemical Thermodynamics – A Non – Calculus Approach, Saunders, Philadelphia, 1972.
6. Principles of Chemical Kinetics, 2nd Ed., James E. House, ELSEVIER, 2007.
7. B.K. Sen, Quantum Chemistry including Spectroscopy, Kalyani Publishers, 2003.
8. A.K. Chandra, Introductory Quantum Chemistry, Tata McGraw – Hill, 1994.

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(Max 50 marks)

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30 Marks per paper Semester End Theory Examination:

1. Duration - These examinations shall be of two hours duration.
2. Theory question paper pattern:
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   b) All questions shall be compulsory with internal choice within the questions.

Name of the Course	Chemistry Practical E-IV (Physical Chemistry and Inorganic Chemistry)
Course Code	23_PSCH208
Class	M.Sc.
Semester	I
No of Credits	2
Nature	Practical
Type	Major: Elective IV
Employability/ Entrepreneurship/ Skill Development	Practical Skills of physical and inorganic chemistry experiments involve a wide range of laboratory techniques like synthesis/preparation, extraction and purification, Instrumental analysis. Learners who have hands-on experience with these techniques are highly sought in industries like pharmaceuticals, fine chemicals, and ceramics. Product development and analytical method development knowledge can be valuable for entrepreneurs looking to develop new products and its analytical method development.

Course Outcomes

On the successful completion of this course learners will be able to:

CO1 :	Use the concept of quantum chemistry to interpret the shape and information about orbitals like 1s, 2pz and $3dz^2$.
CO2 :	apply the subject fundamentals-principles with practical knowledge to design experiments, analyze and interpret data so as to reach to proper conclusions
CO3 :	Handle sophisticated instruments like digital potentiometer, conductivity meter, and spectrophotometer.
CO4 :	Calculating the equilibrium constant for Fe^{3-}/SCN^{1-} by slope intercept method
CO5 :	Determine the electrolytic nature of some inorganic compounds by conductance measurements
CO6 :	Synthesize complexes and estimate amount of metal in a complex

Curriculum

Course	Credits
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- **Non – Instrumental:**

1. Polar plots of atomic orbitals such as 1s, Pz and $3dz^2$ 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 dilatometric 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. To determine Hammette constant of m- and p- amino benzoic acid/nitro benzoic acid by pH measurement.
3. To determine the Michaelis – Menten's constant value (Km) of the enzyme Beta Amylase spectrophotometrically

Inorganic Chemistry	01

- **Inorganic Preparations (Synthesis and Characterization)**

1. Bis-(tetramethylammonium) tetrachloroCuprate (II) $(Me_4N)_2[CuCl_4]$
2. Bis-(tetramethylammonium) tetrachloroNickelate (II) $(Me_4N)_2[NiCl_4]$
3. Bis (ethylenediammine) Copper (II) Sulphate $[Cu(en)_2]SO_4$
4. HexaaamineNi(II) Sulfate $[Ni(NH_3)_6]SO_4$
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6. Tetramminemonocarbanato Cobalt (III) Nitrate $[Co(NH_3)_4CO_3]NO_3$

- **Instrumental**

1. Determination of equilibrium constant by Slope intercepts method for Fe^{+3}/ SCN system.
2. Determination of Electrolytic nature of inorganic compounds by Conductance measurement.

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A) Internal Assessment: 40 % (20 Marks)

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02	Overall performance (attendance, punctuality, interaction during Practical session throughout semester)	05
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B) Semester End Examination: 60% (30 Marks)

Sr. No.	Name of course	Method	Duration	Marks
1.	Physical Chemistry	Experiment performance as per the practical slip	Three and half hours	25
2.	Inorganic Chemistry	Experiment performance as per the practical slip	Three and half hours	25
3.	Journal + Viva			5+5
Total				**60**

N. B. - The practical examination will be of 60 marks at the end of the semester which will be converted to 30 Marks.

Name of the Course	On Job Training
Course Code	23_PSCH209
Class	PG
Semester	II
No of Credits	4
Nature	Practical
Type	On Job Training
Relevance with Employability/ Entrepreneurship/ Skill development	On the job training provides learner with the opportunity to acquire hands on experience and practical skills required for specific job roles. It bridges the gap between theoretical knowledge and the practical requirements of the job. Learner can gain valuable insights into the industry practice, company culture, this experience makes them confident and competent candidate when applying for the position increasing the employability prospects. OJT is instrumental in skill development as it focuses on practical job specific competencies like technical skills, soft skills. Overall OJT enhances employability, foster entrepreneurship by providing valuable exposure in various field.

Guidelines and Evaluation pattern for On Job Training
(100 Marks)

Introduction:

Inclusion of On Job Training in the course curriculum of the PG and UG programme is one of the ambitious aspects in the programme structure. The main objective of inclusion of On Job Training is to inculcate ability to interpret aspect of the study in his/ her own words.

Course Objectives:

By the end of the course, students should be able to:

1. Gain exposure to real-world insights and apply theoretical knowledge to practical situations
2. Enhance skills regarding problem-solving, decision-making, and communication skills.
3. Understand organizational dynamics and work culture.
4. Build industry connections and networking opportunities.

Course Outcomes:

1. Apply theoretical knowledge and concepts acquired during the academic program to real-world work scenarios.
2. Develop practical skills and competencies necessary for successful professional engagement.
3. Demonstrate effective problem-solving, decision-making, and critical thinking abilities in a work environment.
4. Adapt to and navigate organizational dynamics and work culture in the chosen industry.
5. Prepare a comprehensive report documenting the training/project experience, findings, and recommendations.

Guidelines for On Job Training:

The course aims to provide students with practical exposure and hands-on experience in a professional work environment related to their field of study. Students will be required to undertake a designated project or tasks in an organization or industry relevant to their field of study. On job training may of following types:

i) Industry-based (corporate, manufacturing, R&D, etc.)

ii) Research internships (national labs, universities other than parent institute)

iii) Online internships with sufficient documentation and mentor verification

iv) Hands on training courses with industry collaboration.

For alternative on job training modes like Research internships, online internships or Hands on training courses with industry collaboration student should follow the standard guidelines as follows

General Guidelines for alternative on job training modes

1. The alternative training must match the minimum hours or weeks defined for traditional OJT
2. The proposed training must align with the student's academic program and career goals.

Guidelines for Research Internships

1. Research Internships must be conducted under a recognized professor or scientist from an accredited institute (other than parent institute) or national research organization.
2. The student shall submit: i) Internship offer letter ii) Final research report iii) Mentor's feedback and evaluation
3. Evaluation of research internship to be done by internal (college) assessor and external (mentor) assessors.

Guidelines for Online Internships

1. Only platforms or programs with proper documentation, project deliverables, and mentor interaction will be accepted.
2. Required submissions:
    - Proof of enrolment and completion certificate
    - Screenshots or copies of live project work
    - Mentor verification form with comments on engagement and deliverables
3. Students must also give a viva/presentation evaluated internally

Guidelines for Hands-on Training Courses with Industry Collaboration

1. The training partner must be MoU partner, or an industry recognized by the institution.
2. Students must be involved in real-time application or simulation-based training.
3. Required documents:
    - Letter from the industry/training provider
    - Training schedule and modules covered
    - Evaluation or skill certificate from the trainer/industry expert
    - A short report with photographs

Course Duration:

Minimum **120 hours** of On Job Training with an Organization /Private firm / Hands-on Training Courses.

- The OJT should relate to the major subject area of the program.
- Students should undertake on-job training, preferably in summer or winter vacation period
- Project Report should be comprehensive.

- Completion Certificate from the host organization is Mandatory.

Report Structure:

The students will be required to submit a comprehensive report at the end of the On-the-Job Training. A project report must be brief in content and must include the following aspects:

a) **Title Page:**
   Mentioning the title of the report, name of the student, program, institution, and the period of training.
b) **Certificate of Completion:**
   A certificate issued by the organization or supervisor confirming the successful completion of the training.
c) **Declaration:**
   A statement by the student declaring that the report is their original work and acknowledging any assistance or references used.
d) **Acknowledgments:**
   Recognizing individuals or organizations that provided support, guidance, or resources during the training.
e) **Table of Contents:**
   Providing a clear outline of the report's sections and page numbers.
f) **Executive Summary:**
   A bird's eye view of your entire presentation has to be precisely offered under this category.
g) **Introduction of the Company:**
   A concise representation of company/ organization defining its scope, products/ services and its SWOT analysis.
h) **Role of student in the Organization during the On Job Training:**
   The key aspects handled, the department under which you were deployed and brief Summary report duly acknowledged by the reporting head.
i) **Challenges:**
   The challenges confronted while churning out theoretical knowledge into practical world.
j) **Conclusion:**
   A brief overview of your experience and suggestions to bridge the gap between theory and practice.

Broad guidelines for project report:

The project report of On Job Training shall be prepared as per the broad guidelines given below**:**

- Font type: Times New Roman
- Font size: 12-For content, 14-for Title
- Line Space: 1.5-for content and 1-for in table work
- Paper Size: A4
- Margin: in Left-1.5, Up-Down-Right-1
- The final report must be submitted as a bound hard copy.
- Number of Copies of report: 02 (Department copy and candidate copy)

Format

1st page (Main Page)

Title of the Report

Submitted

To

R. P. Gogate College of Arts & Science and

R.V. Jogalekar College of Commerce (Autonomous), Ratnagiri

Under

University of Mumbai

For partial completion of the degree

of

Bachelor / Master of Science

Under the

Faculty of Science

for Academic Year [----]

by

Name of Student

Under the Guidance

of

Name of the Guiding Teacher

R. P. Gogate College of Arts & Science and

R.V. Jogalekar College of Commerce (Autonomous), Ratnagiri

Month and Year

On separate page

Index

[Company/Institution Logo]

CERTIFICATE OF COMPLETION

This is to certify that [Student's Full Name] [Student's Roll Number], has successfully completed the Academic On-the-Job Training Programme at [Company/Institution Name]

This training covered a period of 120 hours, during which [he/she] actively participated and demonstrated excellent dedication and commitment to learning.

The following work was performed by [him/her]:

- [Brief description of the work performed during the training period]

This training has provided [him/her] with valuable insights and practical experience in [relevant field/industry]. [He/She] has exhibited commendable skills, enthusiasm, and a keen interest in learning.

Certifying Authority:

_____

[Name and Designation]

[Company/Institution Name]

[Contact Information]

[Date]

[Seal/Signature]

On separate page

Declaration by learner

I the undersigned Miss/Mr. **[Name of the learner]** hereby, declare I have completed internship at **[company name]** from **[date]** to **[date]** under the guidance of **[Name of the guiding teacher]**

I, hereby further declare that all information of this document has been obtained and presented in accordance with academic rules and ethical conduct.

Name and Signature of the learner

Certified by

Name and signature of the Guiding Teacher

Verified by

Name and Signature of the Head of the Department

On separate page

Acknowledgment
(Model structure of the acknowledgement)

To list who all have helped me is difficult because they are so numerous and the depth is so enormous.

I would like to acknowledge the following as being idealistic channels and fresh dimensions in the completion of this project.

I thank the **R. P. Gogate college of Arts & Science and R.V. Jogalekar College of Commerce (Autonomous), Ratnagiri** for giving me opportunity to do this project.

I would like to thank the Principal, Prof. Dr M.R. Sakhalkar Sir, for providing the necessary facilities required for completion of this project.

I take this opportunity to thank Vice Principal ------ and HOD ---------- for moral support and guidance.

I would also like to express my sincere gratitude towards my project guide _____whose guidance and care made the project successful.

Lastly, I would like to thank each and every person who directly or indirectly helped me in the completion of the project especially my Parents and Peers who supported me throughout my project.

Date: 14/10/2024

Place: Ratnagiri

Signature

Dr. M. G. Gore

Chairperson & HOD, Chemistry

Ratnagiri Education Society's
R. P. Gogate College of Arts and Science and R. V. Jogalekar College of Commerce
(Autonomous), Ratnagiri

Meeting of BoS in Chemistry

Date	14th October 2023
Time	12.00PM
Venue	Meeting Room
Mode	Hybrid

Attendance

Sr. No.	Name and type of the Member	Present mode Online / Offline	Signature
1	Name: Dr. Milind Ganesh Gore (Chairman) Head of the Department	offline	
2	Name: Dr. Ghanashyam B. Sathe (VC nominee) HOD Chemistry Dapoli Urban Bank Senior Science College, Dapoli	Online	
3	Name: Prof. Savita Ladage (Subject Expert) Dean. HBCSE, TIFR Mumbai	Absent	Absent
4	Name: Dr. Ganpat K. Naik (Subject Expert) HOD Chemistry, Parvatibai Chougule College Madgaon, Goa.	Online	
5	Name: Mr. Sandeep Suresh Gongale (Industry representative) GM (HR) Finolex Industries Pvt Ltd, Ranpar	Online	
6	Name: Dr. Vikas Kulkarni, GM, Lupin (Alumini representative) Phrmaceuticals, Mumbai	Online	
7	Name: Dr. Mrs. Aparna M. Kulkarni Department faculty member (1)	offline	
8	Name: Mr. Maruti B. Kamble Department faculty member (2)	offline	
9	Name: Dr. Swaminath L Bhattar Department faculty member (3)	Absent	Absent
10	Name: Dr. Umesh B. Sankpal Department faculty member (4)	offline	
11	Name:Dr. Meghana E. Mhadaye Department faculty member (5)	offline	
12	Name: Mrs. Pratiksha Barsakar Department faculty member (6)	offline	
13	Name:Mr. Ankit A Surve Department faculty member (7)	offline	
14	Name: Trupti Gajanan Joshi Department faculty member (8)	offline	
15	Name: Miss Rina B. Shinde Department faculty member (9)	offline	