

गोंय विद्यापीठ

ताळगांव पठार,

गोंय - ४०३ २०६

फोन : +९१-८६६९६०९०४८



(Accredited by NAAC)

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GU/Acad –PG/BoS -NEP/2025-26/221

Date: 04.07.2025

CIRCULAR

The Academic Council & Executive Council of the University has approved Ordinance OA-35A relating to PG Programmes offered at the University campus and its affiliated Colleges based on UGC 'Curriculum and Credit Framework for Postgraduate Programmes'. Accordingly, the University has proposed introduction of Ordinance OA-35A from the Academic year 2025-2026 onwards.

The Programme structure and syllabus of Semester I of the **Master of Science in Physical Chemistry** Programme approved by the Academic Council in its meeting held on 13th & 14th June 2025 is attached.

The Dean & Vice-Dean (Academic) of the School of Chemical Sciences and the Principals of affiliated Colleges offering the **Master of Science in Physical Chemistry** Programme are requested to take note of the above and bring the contents of the Circular to the notice of all concerned.

(Ashwin V. Lawande)
Deputy Registrar – Academic

To,

1. The Dean, School of Chemical Sciences, Goa University.
2. The Vice-Dean (Academic), School of Chemical Sciences, Goa University.
3. The Principals of affiliated Colleges offering the Master of Science in Physical Chemistry Programme.

Copy to:

1. Chairperson, BoS in Chemistry, Goa University.
2. Programme Director, M.Sc. Physical Chemistry, Goa University.
3. Controller of Examinations, Goa University.
4. Assistant Registrar Examinations (PG), Goa University.
5. Director, Directorate of Internal Quality Assurance, Goa University for uploading the Syllabus on the University website.

GOA UNIVERSITY

MASTER OF SCIENCE IN PHYSICAL CHEMISTRY

(Effective from the Academic Year 2025-26)

ABOUT THE PROGRAMME

This program is designed by integrating academics with research and industrial needs. Students with this degree will be ready for careers in the pharmaceutical, chemical, healthcare, environmental, material science and related industries. Students are equipped with hands-on research experience and skills through projects and dissertations to pursue advanced degrees like Ph.D. programs and contribute to research in the field. Students with this knowledge would excel in competitive exams like NET, GATE, and others.

OBJECTIVES OF THE PROGRAMME

1. To impart a thorough understanding of fundamental principles like thermodynamics, electrochemistry, and chemical kinetics, including concepts like chemical potential, phase equilibria, electrolytic conductance, electrode equilibrium, reaction rates, and reaction mechanisms.
2. To assimilate understanding of underlying theories and principles of physical chemistry, such as the kinetic theory of gases, the liquid state, and crystalline structures, as well as their applications.
3. To expose students to emerging areas of science and technology where physical chemistry principles are crucial, such as materials science, nanotechnology, catalysis and energy.
4. To familiarise students with use of mathematical models and computational tools to analyse data, predict reaction rates, and understand chemical processes.

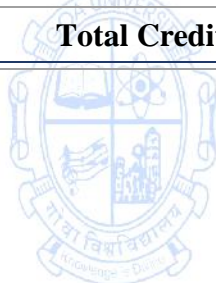
| PROGRAMME SPECIFIC OUTCOMES (PSO) | |
|--|---|
| PSO1 | Understand the fundamental principles and core concepts of Quantum chemistry, Electrochemistry, Spectroscopy, Thermodynamics & Reaction Kinetics, and the scientific theories cum models that govern them. |
| PSO 2 | Demonstrate a proficient understanding of the principles of Group Theory and their applications in chemistry, i.e. molecular symmetry, hybridization, and electronic structure, facilitating the interpretation of spectroscopic data and chemical phenomena. |
| PSO 3 | Understand and interpret spectroscopic data of industrially important compounds using microwave, IR, Raman, NMR, and ESR spectroscopy and elucidate their chemical structure and properties. |
| PSO 4 | Demonstrate hands-on expertise in handling instruments like conductometer, potentiometer, pH meter, colorimeter, linear sweep and cyclic voltammeter, and bomb calorimeter, and use them to monitor the kinetic rates and thermodynamic properties of chemical reactions. |
| PSO 5 | Design, synthesize, and characterize nano-catalysts and use them to address societal problems of wastewater pollution, using adsorption and photocatalytic technology. |
| PSO 6 | Acquire the ability to fabricate efficient electrodes and test their efficiency in electrocatalytic and spectro-electrochemical reactions such as HER and CO ₂ reduction, electrochemical energy generation and storage systems such as batteries, fuel cells, photovoltaics, and supercapacitors. |
| PSO 7 | Determine the fundamental physical properties such as density, viscosity, specific gravity, etc., and use them to construct phase diagrams. |
| PSO 8 | Acquire the ability to write computer programs. Ab-initio programs like Gaussian are used to calculate the molecular and spectroscopic properties of chemical compounds. |

PROGRAMME STRUCTURE
Master of Science in Physical Chemistry
Effective from the Academic Year 2025-2026

| Bridge Course | | | |
|---------------|-------------|--|---------|
| Sr. No. | Course Code | Title of the Course | Credits |
| 1 | CHC-1000 | Bridge Course in mathematical concepts for chemistry | 1 |
| 2 | CHC-1001 | Bridge Course in organic chemistry | 1 |

| SEMESTER I | | | | |
|---|-------------|---|---------|-------|
| Discipline Specific Core (DSC) Courses (16 credits) | | | | |
| Sr. No. | Course Code | Title of the Course | Credits | Level |
| 1 | CHO-5000 | Fundamental Concepts in Organic Chemistry | 4 | 400 |
| 2 | CHI-5000 | Concise Inorganic Chemistry | 4 | 400 |
| 3 | CHP-5000 | Fundamentals of Physical Chemistry | 4 | 400 |
| 4 | CHA-5000 | Analytical Chemistry Techniques | 4 | 400 |
| Total Credits for DSC Courses in Semester I | | | 16 | |
| Discipline Specific Elective (DSE) Course (4 credits) | | | | |
| Sr. No. | Course Code | Title of the Course | Credits | Level |
| 1 | CHO-5201 | Organic Chemistry Practical - I | 2 | 400 |
| 2 | CHO-5202 | Organic Chemistry Practical - II | 2 | 400 |
| 3 | CHI-5201 | Inorganic Chemistry Practical - I | 2 | 400 |
| 4 | CHI-5202 | Inorganic Chemistry Practical - II | 2 | 400 |
| 5 | CHP-5201 | Physical Chemistry Practical - I | 2 | 400 |
| 6 | CHP-5202 | Physical Chemistry Practical - II | 2 | 400 |
| 7 | CHA-5201 | Analytical Chemistry Practical - I | 2 | 400 |
| 8 | CHA-5202 | Analytical Chemistry Practical - II | 2 | 400 |
| Total Credits for DSE Courses in Semester I | | | 4 | |
| Total Credits in Semester I | | | 20 | |

| SEMESTER II | | | | |
|--|-------------|--|---------|-------|
| Discipline Specific Core (DSC) Courses | | | | |
| Sr. No. | Course Code | Title of the Course | Credits | Level |
| 1 | CHP-5001 | Concepts in Quantum Chemistry and Statistical Thermodynamics | 4 | 500 |
| 2 | CHP-5002 | Group Theory and Spectroscopy | 4 | 500 |
| 3 | CHP-5003 | Thermodynamics and Reaction Kinetics | 4 | 500 |
| 4 | CHP-5004 | Principles of Electrochemistry and its Applications | 4 | 500 |
| Total Credits for DSC Courses in Semester II | | | 16 | |
| Discipline Specific Elective (DSE) Courses (4 credits) | | | | |
| Sr. No. | Course Code | Title of the Course | Credits | Level |
| 1 | CHO-5201 | Organic Chemistry Practical - I | 2 | 400 |
| 2 | CHO-5202 | Organic Chemistry Practical - II | 2 | 400 |
| 3 | CHI-5201 | Inorganic Chemistry Practical - I | 2 | 400 |
| 4 | CHI-5202 | Inorganic Chemistry Practical - II | 2 | 400 |
| 5 | CHP-5201 | Physical Chemistry Practical - I | 2 | 400 |
| 6 | CHP-5202 | Physical Chemistry Practical - II | 2 | 400 |
| 7 | CHA-5201 | Analytical Chemistry Practical - I | 2 | 400 |
| 8 | CHA-5202 | Analytical Chemistry Practical - II | 2 | 400 |
| Total Credits for DSE Courses in Semester II | | | 4 | |
| Total Credits in Semester II | | | 20 | |



BRIDGE COURSES

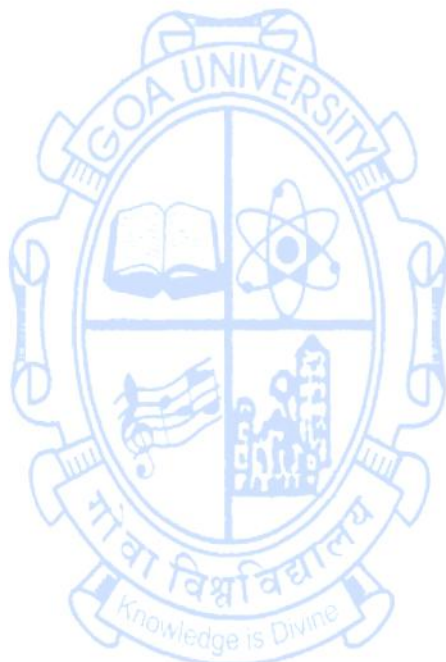
| | | | |
|--|---|----------------------|-------------------------|
| Title of the Course | Bridge Course in Mathematical Concepts for Chemistry | | |
| Course Code | CHC-1000 | | |
| Number of Credits | 1 | | |
| Theory/Practical | Theory | | |
| Level | 400 | | |
| Effective from AY | 2025-26 | | |
| New Course | No | | |
| Bridge Course/ Value added Course | Yes | | |
| Course for advanced learners | No | | |
| Pre-requisites for the Course: | NIL | | |
| Course Objectives: | To introduce mathematical concepts to the students of MSc Part-I (Chemistry). | | |
| Course Outcomes: | Students will be able to solve problems based on: | Mapped to PSO | |
| | CO 1. Matrices in M.Sc. Chemistry | PSO1 | |
| | CO 2. Determinants in M.Sc. Chemistry | PSO1 | |
| | CO 3. Differential calculus in M.Sc. Chemistry | PSO1 | |
| | CO 4. Integral calculus in M.Sc. Chemistry | PSO1 | |
| Content: | | No of | Mapped Cognitive |

| | | hours | to CO | Level |
|----------------------------------|---|-------|-------------|-------|
| Module 1: | 1. Calculus for thermodynamics and kinetics a. Introduction to Differentiation: Notation, Differentiating various f functions, Differentiating a Sum, Product Rule, Quotient Rule, Chain Rule, Partial Differentiation: exact and inexact differentials. b. Introduction to Integration: Notation, Rules for Integrals, Integrating various functions, Definite and indefinite Integrals. | 8 | CO3, CO4 | K5 |
| Module 2: | 2. Matrices, Determinants and vector algebra: a. Types of Matrices: Identity, reflection, rotation, inversion, distance matrix, Matrix Algebra, Matrix similarity transformation. b. The Determinant, Minors and Cofactors, Inverse of a Matrix, Character of a matrix, Linear algebra. c. Vectors and molecular structure. | 7 | CO1, CO2 | K5 |
| Pedagogy: | Mainly lectures and tutorials. Seminars/assignments/presentations/self-study or a combination of some of these can be used. ICT mode should be preferred. Sessions can preferably be interactive to enable peer group learning. | | | |
| Texts: | Robert G. Mortimer, Mathematics for Physical Chemistry, Elsevier, New York. 4th ed., 2013 | | | |
| References/ Readings: | James R. Barrante, Applied Mathematics for Physical Chemistry, 3rd ed., Prentice-Hall, New Jersey, 1998 | | | |

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|--|--|--------------|---------------|----------------------|
| Title of the Course | Bridge Course in Organic Chemistry | | | |
| Course Code | CHC-1001 | | | |
| Number of Credits | 1 | | | |
| Theory/Practical | Theory | | | |
| Level | 400 | | | |
| Effective from AY | 2025-26 | | | |
| New Course | No | | | |
| Bridge Course/ Value added Course | Yes | | | |
| Course for advanced learners | No | | | |
| Pre-requisites for the Course: | NIL | | | |
| Course Objectives: | <ul style="list-style-type: none"> • To understand various principles of organic chemistry. • To apply the importance of chirality in organic syntheses. • To analyse stereoselective reactions. • To interpret oxidation and reduction reactions. | | | |
| Course Outcomes: | Students will be able to: | | | Mapped to PSO |
| | CO 1. understand knowledge of basic reaction mechanisms in organic transformation. | | | PSO2 |
| | CO 2. apply chirality in organic synthesis. | | | PSO2 |
| | CO 3. compare configurations/ conformations of organic molecules. | | | PSO2 |
| | CO 4. assess oxidizing and reducing reagents in organic synthesis. | | | PSO2 |
| Content: | | No of | Mapped | Cognitive |

| | | hours | to CO | Level |
|------------------|--|-------|----------|------------|
| Module 1: | 1. Fundamentals of organic chemistry: Electron movement with arrows, half and double headed arrows (Cleavage of bonds: homolysis and heterolysis) in organic reaction mechanisms; inductive effect, electromeric effect, resonance and hyperconjugation, steric hindrance, hydrogen bonding; reactivity of organic molecules: nucleophiles and electrophiles; reactive intermediates: carbocations, carbanions and free radicals; strength of organic acids and bases, aromaticity, benzenoids and Huckel's rule. | 8 | CO1 | K1, K2 |
| Module 2: | 2. Stereochemistry: Conformations with respect to butane and cyclohexane; interconversion of wedge formula, Newmann, Sawhorse and Fischer representations; CIP Rules: R/S configurations. | 3 | CO2, CO3 | K2, K3, K4 |
| Module 3: | 3. Substitution, elimination and addition reactions: Substitution and elimination reactions (SN1, SN2, E1 and E2), addition of different groups on olefins. | 2 | CO1 | K2, K3 |
| Module 4: | 4. Oxidation and reduction reactions: Basic concepts, oxidizing and reducing reagents and some examples. | 2 | CO4 | K3, K4 |
| Pedagogy: | Mainly lectures and tutorials. Seminars/assignments/presentations/self-study or a combination of some of these can be used. ICT mode should be preferred. Sessions can preferably be interactive to enable peer group learning. | | | |
| Texts: | 1. D. Nassipuri, Stereochemistry of Organic compounds - Principles and Application, 4th ed., Wiley Eastern Limited, New Academic Science Limited, Lucknow, India, 2013 2. E. L. Eliel, Stereochemistry of carbon compounds, Tata MacGraw Hill Publishing Company Ltd., New Delhi, 1990. 3. J. March, Advanced Organic Chemistry: Reaction, Mechanism and Structure, 4th ed., Wiley, USA, 2010. 4. J. Clayden, N. Greeves, S. Warren & Wothers, Organic Chemistry, 2nd ed., Oxford University Press, Oxford, 2012 5. I. L. Finar Stereochemistry and Chemistry of Natural products, Vol. 2, 3rd ed., , Longmans, ELBS London, 1963 6. F. A. Carey and R.J. Sundberg, Advanced Organic Chemistry, Vol. I & II. Plenum Press, New York, 1977 7. E. S. Gould et al., Mechanism and structure in Organic Chemistry, Holt, Rinehart And Winston, New York, 1965 8. F. A. Carey, Organic Chemistry, 4th ed., McGraw-Hill Higher Education, USA, 2000 | | | |

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| | 9. S. H. Pine, Organic Chemistry, 5th ed., McGraw-Hill International Education, New York, 2010 |
| References/ Readings: | 1. V. M. Potapov, Stereochemistry, MIR Publishers, Moscow, 1979 2. J. M. Harris & C.C. Wamser, Fundamentals of Organic Reaction Mechanisms, John Wiley & Sons. Inc. New Jersey, 1976. 3. F. M. Menger, D.J. Goldsmith & L. Mendell, Organic Chemistry, A concise approach, 2nd ed., Addison Wesley Longman, Boston 1975. |



SEMESTER I

Discipline Specific Core Courses

| | | |
|--|---|----------------------|
| Title of the Course | Fundamental Concepts in Organic Chemistry | |
| Course Code | CHO-5000 | |
| Number of Credits | 4 | |
| Theory/Practical | Theory | |
| Level | 400 | |
| Effective from AY | 2025-26 | |
| New Course | Yes | |
| Bridge Course/ Value added Course | No | |
| Course for advanced learners | No | |
| Pre-requisites for the Course: | NIL | |
| Course Objectives: | <ul style="list-style-type: none">• To study the various concepts based on molecular orbital theory, Aromaticity, Acids and bases.• To understand the concepts of stereochemistry and their significance in determining the structure, reactivity, and properties of organic molecules• To understand the mechanistic aspects of various type of reactions in organic synthesis and the use of selective reagents in organic transformations. | |
| Course Outcomes: | Students will be able to: | Mapped to PSO |

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|------------------|---|------------------------|---------------------|------------------------|
| | CO 1. Understand the effect of delocalization of electrons & presence or absence of aromaticity in organic compounds. | PSO1, PSO 2 | | |
| | CO 2. Apply various concepts in stereochemistry to understand stereochemical outcome in a reaction. | PSO1, PSO 2 | | |
| | CO 3. Evaluate plausible mechanisms of organic reactions. | PSO1, PSO2, PSO3 | | |
| | CO 4. Apply various reagents for desired organic transformations. | PSO1, PSO2, PSO3, PSO4 | | |
| Content: | | No of hours | Mapped to CO | Cognitive Level |
| Module 1: | 1.1 Molecular orbitals and delocalized chemical bonding a. Qualitative description of molecular orbitals of simple acyclic and monocyclic systems, frontier molecular orbitals. b. Conjugation, cross conjugation, hyperconjugation and tautomerism (types and examples). c. Aromaticity: Origin of Huckel's rule, examples of aromatic, non-aromatic and antiaromatic compounds; concept of Mobius aromaticity. 1.2 Structure & Reactivity a. Acidity, basicity and pKa of organic compounds; Acid and base strengths; HSAB concept & Factors affecting it, effect of structure & medium on acid and base strength. b. Concept of superacids and superbases. c. Electrophilicity & nucleophilicity, examples of ambident nucleophiles & electrophiles. (Including revision of aromatic electrophilic and nucleophilic substitution) | 15 | CO1 | K1, K2, K3, K4, K5 |
| Module 2: | 2. Stereochemistry a. Brief revision of configurational nomenclature: R & S; D & L; E & Z; cis & trans and <i>syn</i> & <i>anti</i> nomenclature. Chirality in molecules with two and more chiral centers. b. Conformational analysis of open chain compounds (Butane, 2, 3-butane | 15 | CO2, CO3 | K1, K2, K3, K4, K5 |

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| | <p>diol, 2,3-dibromobutane etc.). <i>Erythro</i> and <i>threo</i> nomenclature.</p> <p>c. Topicity and Prostereoisomerism: Topicity of ligands and faces-homotopic, enantiotopic and diastereotopic, ligands and faces.</p> <p>d. Chemoselective, regioselective and stereoselective reactions with examples.</p> <p>e. Conformation and reactivity of cyclohexane and substituted cyclohexanes, cyclohexene / cyclohexanone. Conformational isomerism and analysis in acyclic and simple cyclic systems substituted ethane, cyclopentane, cyclohexane.</p> <p>f. Optical isomerism - optical activity - molecular dissymmetry and chirality - elements of symmetry. optical isomerism in biphenyls, allenes and spirans - optical isomerism of nitrogenous compounds racemisation and resolution.</p> | | | |
| Module 3: | <p>3.1 Reaction Mechanism</p> <p>a. Structure, stability and reactivity of reactive intermediates (carbocations, carbanions, free radicals, carbenes, arynes and nitrenes)</p> <p>b. Types of mechanisms, types of reactions, thermodynamic and kinetic control.</p> <p>c. Methods of determining reaction mechanisms:</p> <ol style="list-style-type: none"> Identification of products. Determination of the presence of intermediates (isolation, detection, trapping and addition of suspected intermediate. Isotopic labelling. Stereochemical evidence. Kinetic evidence and Isotope effect. <p>(at least two examples to be covered for above methods)</p> <p>3.2 Selective reagents for Organic transformation</p> <p>a. Oxidation of organic compounds: PCC, PDC and MnO₂, ozonolysis,</p> | 15 | CO ₂ , CO ₃ | K1, K2, K3, K4, K5 |

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| | peracids. b. Reduction of organic compounds: NaBH ₄ , LAH, DIBAL reduction and reduction with borane and dialkylboranes. Clemmensen reduction, Birch reduction and Wolff-Kishner reduction | | | |
| Module 4: | <p>4.1 Aliphatic Nucleophilic substitution</p> <p>a. Nucleophilic substitutions with respect to mechanism and various factors affecting such reactions.</p> <p>b. The Neighbouring Group Participation (NGP)/ Anchimeric assistance: General approach to various NGP processes; NGP by unshared/lone pair of electrons; NGP by π-electrons; NGP by aromatic rings (formation of phenonium ion intermediate); NGP by sigma bonds with special reference to bornyl and nor- bornyl system (formation of nonclassical carbocation)</p> <p>4.2 Elimination reactions</p> <p>a. The E2, E1 and E1cB mechanisms. Orientation of the double bond, Saytzeff and Hofmann rule.</p> <p>b. Effects of substrate, base, leaving group and medium on:</p> <p>i. Overall reactivity</p> <p>ii. E1 vs. E2 vs. E1cB</p> <p>iii. Elimination vs substitution, mechanism and orientation in pyrolytic <i>syn</i> elimination (various examples involving cyclic and acyclic substrates to be studied).</p> | 15 | CO3. CO4 | K1, K2, K3, K4, K5 |
| Pedagogy: | Mainly lectures and tutorials. Seminars / term papers /assignments / presentations / self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning. | | | |
| Texts: | <ol style="list-style-type: none"> 1. R. T. Morrison, R. N. Boyd, S. K. Bhattacharjee, Organic Chemistry, 7th ed. Pearson Education, New Delhi, 2010 2. D. Nassipuri, Stereochemistry of Organic Compounds: Principles and Applications, 4th ed. New Age International, New Delhi, 2020 3. J. Clayden, N. Greeves, S. Warren, P. Wothers, Organic Chemistry, 2nd ed. Oxford University Press, Oxford, 2012 | | | |

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| | <ol style="list-style-type: none"> 4. J. March, Advanced Organic Chemistry: Reactions, Mechanisms and Structure, 4th ed. Wiley Student Edition, New York, 2003. 5. P. S. Kalsi, Stereochemistry: Conformation and Mechanism, 11th ed. New Age International, New Delhi, 2022 6. E. L. Eliel, S. H. Wilen, Stereochemistry of Organic Compounds, 1st ed. John Wiley and Sons, New York, 1994 7. H. O. House, Modern Synthetic Reactions, 2nd ed. W. A. Benjamin, New York, 1965 8. F. A. Carey, R. J. Sundberg, Advanced Organic Chemistry, 5th ed. Springer India Private Limited, New Delhi, 2007 |
| References/ Readings: | <ol style="list-style-type: none"> 1. R. Bruckner, Advanced Organic Chemistry: Reaction Mechanisms, 1st ed. Harcourt/Academic Press, San Diego, 2002. 2. P. Y. Bruice, Organic Chemistry, 8th ed, Pearson, New Delhi, 2020 |

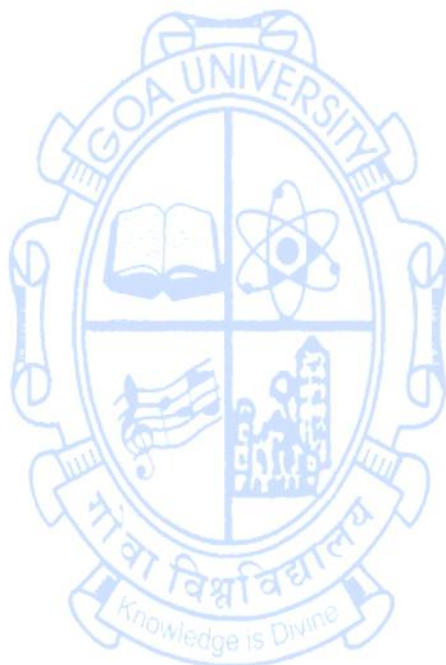
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|--|---|----------------------|
| Title of the Course | Concise Inorganic Chemistry | |
| Course Code | CHI-5000 | |
| Number of Credits | 4 | |
| Theory/Practical | Theory | |
| Level | 400 | |
| Effective from AY | 2025-26 | |
| New Course | Yes | |
| Bridge Course/ Value added Course | No | |
| Course for advanced learners | No | |
| Pre-requisites for the Course: | NIL | |
| Course Objectives: | <ul style="list-style-type: none"> • To explain fundamentals of solid state, coordination, organometallic, bioinorganic, and environmental chemistry. • To describe atomic structure, molecular structure, bonding, and symmetry in molecules. • To know fundamental aspects of elements & their compounds. • To comprehend the effects of pollution, and its treatments. | |
| Course Outcomes: | Students will be able to: | Mapped to PSO |
| | CO 1. Explain basic concepts in solid state, coordination, organometallic, bioinorganic, and environmental chemistry. | PSO1, PSO2 |
| | CO 2. Illustrate characteristic of inorganic compounds related to biology and environment. | PSO2, PSO6 |
| | CO 3. Analyze molecular structure and their properties. | PSO3, PSO5 |

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|------------------|--|--------------------|---------------------|------------------------|
| | CO 4. Design compounds for various applications. | | PSO3, PSO4 | |
| Content: | | No of hours | Mapped to CO | Cognitive Level |
| Module 1: | 1. Atomic structure, molecular structure and bonding a. Atomic Structure: Structures of hydrogenic atoms: some principles of quantum mechanics, atomic orbitals. Many electron atoms: penetration & shielding, building up principle, classification of elements. Spectroscopic terms. Atomic properties: atomic radii, ionic radii, ionization energy, electron affinity, electronegativity, polarizability. b. Molecular Structure & bonding: Lewis structures: octet rule, resonance. VSEPR model: basic shapes, modification of the basic shapes. Valence bond theory: hydrogen molecule, homonuclear diatomic molecules, polyatomic molecules, promotion, hypervalence, hybridization. Molecular orbital theory: approximation, bonding & antibonding orbitals. Homonuclear diatomic molecules & heteronuclear diatomic molecules. | 10 | CO1, CO3 | K1, K4 |
| Module 2: | 2. Solid state chemistry a. Structures of solids: crystal structures, lattices and unit cells, fractional atomic coordinates and projections, close packing of spheres, holes in closed-packed structures. b. Structures of metals & alloys: polytypism, nonclosed-packed structures, polymorphism of metals, atomic radii of metals, alloys, substitutional and interstitial solid solutions, intermetallic compounds. c. Ionic solids: characteristic structures of ionic solids, binary phases, ternary phases, rationalization of structures, ionic radii, radius ratio, structure maps, energetics of ionic bonding, lattice energy and Born Haber cycle, calculation of lattice enthalpies (numerical expected). | 10 | CO1, CO3, CO4 | K1, K4, K5 |
| Module 3: | 3. Molecular Symmetry and chemistry of <i>d</i>- and <i>f</i>- block elements a. Symmetry elements and symmetry operations, equivalent symmetry elements and equivalent atoms, symmetry point groups and molecular symmetry. | 15 | CO1, CO2, CO3, | K1, K2, K4, K5 |

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|------------------|--|----|--------------------|----------------|
| | <p>Systematic procedure for symmetry classification of molecules. Dipole moment, optical activity and point groups.</p> <p>b. <i>d</i>-block elements:</p> <p>Zinc, cadmium and mercury: occurrence and properties. Transition elements: IUPAC definition, occurrence and physical properties, chemical properties, metal halides, metal oxides & oxido compounds, metal sulfides and sulfide compounds, metal-metal bonded compound and clusters, magnetic properties.</p> <p><i>f</i>-block elements:</p> <p>Lanthanides: occurrence and physical properties, lanthanide contraction, oxidation states, compounds of lanthanides, electronic, optical and magnetic properties.</p> <p>Actinoid: occurrence and properties, oxidation states, general trends, electronic spectra, thorium and uranium.</p> | | CO4 | |
| Module 4: | <p>4. Coordination, Organometallic and Bioinorganic Chemistry</p> <p>a. Coordination chemistry: Introduction, representative ligands, IUPAC nomenclature. Constitution and geometry, isomerism & chirality in square planar and octahedral complexes, ligand chirality.</p> <p>Electronic properties of metal complexes: CFT applied to octahedral and tetrahedral complexes, magnetic moments, CFSE.</p> <p>Electronic spectroscopy: basic concepts, Orgel diagram for octahedral and tetrahedral complexes of d^1 to d^9 ions.</p> <p>b. Organometallic Chemistry: Introduction to organometallic chemistry, nomenclature, stability and inert gas rules (neutral atom, and donor pair electron count methods). Homoleptic metal carbonyls - synthesis, properties, and spectroscopic studies.</p> <p>c. Bioinorganic Chemistry: Macronutrients/micronutrients. Role of elements in biology. Metallobiomolecules, metalloporphyrins, structure of porphyrin and heme group, iron porphyrins (Haemoglobin and myoglobin), examples of metalloenzymes of Cu and Zn.</p> | 15 | CO1, CO2, CO3, CO4 | K1, K2, K4, K5 |

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| Module 5: | <p>5. Environmental Chemistry</p> <p>Directive of the Supreme Court in 1993 to introduce environmental education at all levels.</p> <p>a. Air Pollution: Classification of air pollutants and photochemical reactions in the atmosphere. Common air pollutants (e.g. CO, NO_x, SO₂, hydrocarbons and particulates)</p> <p>i. Sources</p> <p>ii. physiological and environmental effect</p> <p>iii. monitoring,</p> <p>iv. various remedial & technological measures to curb pollution. Air quality standards.</p> <p>b. Water pollution: Importance of buffer & buffer index in waste water treatments. Chemical, physical & biological characteristics of water pollution, specific & non-specific characterization of water. DO, BOD, COD, and chlorine demand, typical water treatment & waste water treatment (Municipal). Impact of plastic pollution and its effect.</p> | 10 | CO1, CO2, CO3, CO4 | K2, K3, K4, K5 |
| Pedagogy: | Mainly lectures and tutorials. Seminars / term papers / assignments / presentations / self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning. | | | |
| Texts: | <ol style="list-style-type: none"> 1. P. W. Atkins, T. Overton, J. Rourke, M. Weller, F. Armstrong, Shriver & Atkins Inorganic Chemistry, 5th ed., Oxford University Press, Oxford, 2009. 2. F. A. Cotton, G. Wilkinson, P. L. Gauss, Basic Inorganic Chemistry, 3rd ed., Wiley India, New delhi, 2008 (reprint). 3. F. A. Cotton, Chemical applications of group theory, 3rd ed., Wiley India, New Delhi, 2012 (reprint). 4. A. K. De, Environmental Chemistry, 3rd ed., New Age Intl. Publishers, New Delhi, 2005. 5. J. E. Huheey, E. A. Keiter, R. L. Keiter, O. K. Medhi, Inorganic Chemistry: Principles of Structure & Reactivity, 4th ed., Pearson, New Delhi, 2011. 6. J. D. Lee, Concise Inorganic Chemistry, 5th ed., Wiley India, New Delhi, 2008. 7. H. V. Keer, Principles of Solid State Chemistry, 1st ed., New Age Intl. Ltd, New Delhi, 1993, (reprint 2008). 8. A. R. West, Solid State Chemistry and Its Applications, 1st ed., Wiley India, New Delhi, 1984 (reprint 2007). 9. D. K. Chakrabarty, Solid State Chemistry, 2^{ed} ed., New Age Intl. Publishers, New Delhi, 2010. | | | |

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| | 10. R. S. Drago, Physical Methods in Inorganic Chemistry, Affiliated East West Press Pvt. Ltd., New Delhi, 2017. 11. A. V. Salker, Environmental Chemistry: Pollution and Remedial Perspective, 1 st ed., Narosa Publication, New Delhi, 2017. |
| References/ Readings: | 1. F. A. Cotton, G. Wilkinson, Advanced Inorganic Chemistry, 6 rd ed., Wiley India, New Delhi, 2003 (reprint 2012). 2. G. C. Miessler, D. A. Tarr, Inorganic Chemistry, 3 rd ed., Pearson, New Delhi, 2004. |



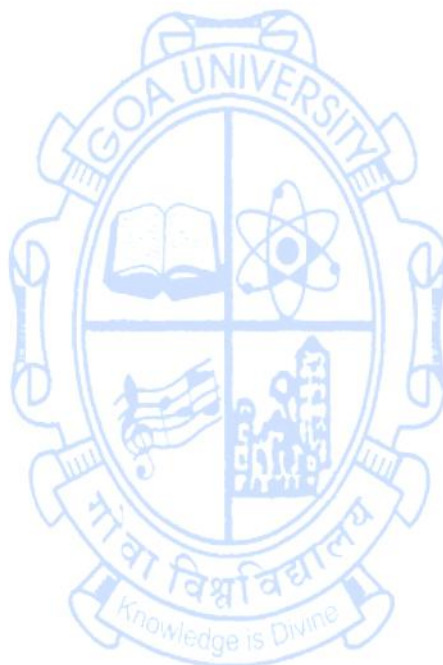
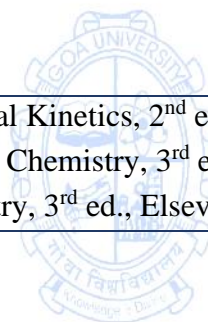
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| Title of the Course | Fundamentals of Physical Chemistry | |
| Course Code | CHP-5000 | |
| Number of Credits | 04 | |
| Theory/Practical | Theory | |
| Level | 400 | |
| Effective from AY | 2025-26 | |
| New Course | Yes | |
| Bridge Course/ Value added Course | No | |
| Course for advanced learners | No | |
| Pre-requisites for the Course: | NIL | |
| Course Objectives: | <ul style="list-style-type: none"> To introduce various mathematical and computational concepts of chemistry To gain knowledge of core concepts of physical chemistry i.e. thermodynamics, kinetics, quantum chemistry and electrochemistry To inculcate critical thinking and apply the knowledge of physical chemistry concepts in problem solving To understand and apply physical chemistry principles to other areas of chemistry | |
| Course Outcomes: | Students will be able to: | Mapped to PSO |
| | CO 1.Explain various concepts in physical chemistry. | PSO1, PSO2 |
| | CO 2.Utilise concepts of electrochemistry and their applications in renewable energy generation and storage. | PSO1, PSO6 |

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| | CO 3. Demonstrate the concepts during the lab course in physical chemistry. | | PSO3, PSO4, PSO5 | |
| | CO 4. Apply fundamentals of chemical kinetics and thermodynamics for understanding reaction processes and mechanisms | | PSO3, PSO7 | |
| Content: | | No of hours | Mapped to CO | Cognitive Level |
| Module 1: | 1. Mathematical Preparations a. Introduction to various functions and function plotting (exponential, logarithmic, trigonometric etc.), functions of many variables. complex numbers and complex functions. b. Linear equations, vectors, matrices and determinants. c. Basic rules of differentiation and integration, Partial differentiation, location and characterization of critical points of a function, Regression methods, curve fitting. d. Introduction to series, convergence and divergence, power series, Fourier series e. Probability (permutations and combinations). | 10 | CO1, CO3 | K1, K2, K3 |
| Module 2: | 2. Quantum Chemistry a. Operators, Functions, Eigen value equations, Postulates. b. Schrödinger equation, application to simple system viz. free particle, particle in one dimensional, two dimensional and three-dimensional box (quantization, separation of variables, degenerate wave functions). c. Hydrogen like atoms, Schrödinger equation and its solutions, atomic orbital wave functions and interpretation. d. Hückel MO theory, Secular equations, Secular determinant, delocalization energy, charge density, π -bond order, free valence, applications to C_2H_4 , C_3H_5 (radical), C_4H_6 , C_4H_4 , C_6H_6 , C_6H_8 . | 20 | CO1, CO3 | K1, K2, K5 |
| Module 3: | 3. Thermodynamics a. Thermodynamic properties: Gas laws, real gases, Boyle temperature, critical temperature, state and path properties. Intensive and extensive properties. Exact and inexact differentials. Internal energy, enthalpy, entropy, free energy and | 12 | CO1, CO3, CO4 | K1, K2, K3, K5 |

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| | <p>their relations and significances. Maxwell relations. Thermodynamic equations of state.</p> <p>b. Joule-Thomson effect. Joule-Thomson coefficient for van der Waals' gas. Joule-Thomson effect and production of low temperature, adiabatic demagnetization, Joule-Thomson coefficient, inversion temperature.</p> <p>c. The third law of thermodynamics. Need for the third law. Apparent exceptions to third law. Application of third law. Use of thermodynamic functions in predicting direction of chemical change. Entropy and third law of thermodynamics.</p> <p>d. Phase equilibria: Phase rule, Discussion of two component systems forming solid solutions with and without maximum or minimum in freezing point curve. Systems with partially miscible solid phases.</p> <p>e. Three component systems: Graphical representation. Three component liquid systems with one pair of partially miscible liquids. Influence of temperature. Systems with two pairs and three pairs of partially miscible liquids. The role of added salts.</p> | | | |
| Module 4: | <p>4. Electrochemistry</p> <p>a. EMF series, cell potential: Nernst equation, Cells at equilibrium. Determination of thermodynamic functions.</p> <p>b. Decomposition potential and overvoltage, electronegativity, basic principles, completeness of deposition, separation with controlled potentials, constant current electrolysis, composition of electrolyte, potential buffers, physical characteristics of metal deposits.</p> <p>c. Electroplating and electroless plating, electrosynthesis.</p> <p>d. Concepts of acid-base aqueous and non-aqueous solvents, hard and soft acid-base concept and applications.</p> | 9 | CO1, CO2, CO3 | K1, K2, K3, K5, K6 |
| Module 5: | <p>5. Chemical Kinetics</p> <p>a. General introduction to various types of order of reaction including fractional order, molecularity of the reaction.</p> | 9 | CO1, CO3, CO4 | K1, K2, K3, K4, K5 |

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| | <ul style="list-style-type: none"> b. Introduction to reversible and irreversible reactions and reactions leading to equilibrium. van't Hoffs equation and analysis of Gibbs free energy of equilibrium reactions. c. Collision theory and Maxwell Boltzmann distribution of energies of colliding molecules. The concept of collisional cross section and reactive cross section and its significance. d. Comparative study of transition state and collision state theory. e. Reaction Mechanisms: elementary reactions, consecutive elementary reactions, steady state approximation, the rate determining step and pre-equilibria. f. Free radical reactions, complex reactions such as acetaldehyde decomposition and reaction between H_2 and Br_2. Homogeneous reactions and acid-base catalysis. g. Elementary enzyme reactions. Lineweaver-Burk plot and its analysis. | | | |
| Pedagogy: | Mainly lectures and tutorials. Seminars / term papers / assignments / presentations / self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning. | | | |
| Texts: | <ul style="list-style-type: none"> 1. P. W. Atkins and J. D. Paula, Physical Chemistry, 8th ed., Oxford University Press, New Delhi. 2007 2. G. M. Barrow, Physical Chemistry, 5th ed., Tata McGraw Hill, New Delhi. 2016 3. J. E. House, Principles of Chemical Kinetics, 2nd ed., Academic Press, Elsevier Burlington, USA, 2007 4. I. N. Levine, Quantum Chemistry, 7th ed., Prentice-Hall, New Delhi. 1999. 5. S. Glasstone, Text Book of Physical Chemistry, D. Van Nostrand Company, New York, Reprint 1942. | | | |
| References/ Readings: | <ul style="list-style-type: none"> 1. B. R. Puri, L. R. Sharma and M. S. Pathania, Principles of Physical Chemistry, 49th ed., Vishal Publishing Co., New Delhi, 2020 2. A. Saggion, R. Faraldo, M. Pierno, Thermodynamics - Fundamental Principles and Applications, Springer, Switzerland, 2019 3. J. Bockris, A. K.N. Reddy, M. E. Gamboa-Aldeco, Modern Electrochemistry: Fundamentals of Electrodics, Vol. 2A, 2nd ed., Kluwer Academic Publishers, New York, 2002 4. J. Bockris, A. Reddy, Modern Electrochemistry: Ionics, Vol. 1, 2nd ed., , 2nd Ed., Kluwer Academic Publishers, New York, 2002 | | | |

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| | <ol style="list-style-type: none">5. J. E. House, Principles of Chemical Kinetics, 2nd ed., Academic Press, Burlington MA, 20076. J. P. Lowe, K. Peterson, Quantum Chemistry, 3rd ed., Elsevier, Burlington MA, 20067. R. G. Mortimer, Physical Chemistry, 3rd ed., Elsevier, Burlington MA, 2008 |
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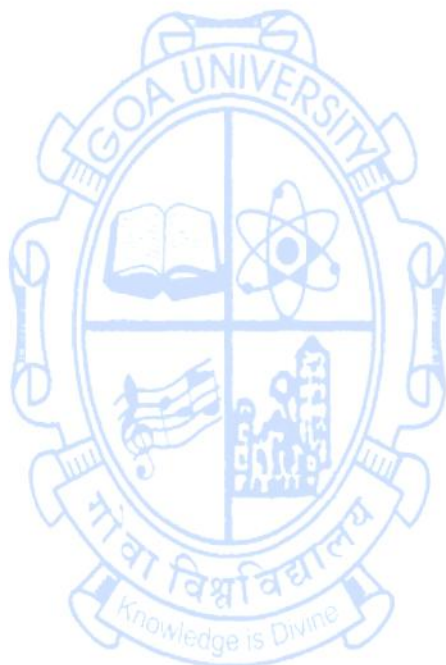
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| Title of the Course | Analytical Chemistry Techniques | |
| Course Code | CHA-5000 | |
| Number of Credits | 4 | |
| Theory/Practical | Theory | |
| Level | 400 | |
| Effective from AY | 2025-26 | |
| New Course | Yes | |
| Bridge Course/ Value added Course | No | |
| Course for advanced learners | No | |
| Pre-requisites for the Course: | NIL | |
| Course Objectives: | <ul style="list-style-type: none"> • To learn various methods of data handling in analysis. • To explain the significance of sampling and calibration techniques. • To understand principles and applications of various types of techniques • To train the students to deduce structures based on IR, NMR, MS combined data. | |
| Course Outcomes: | Students will be able to: | Mapped to PSO |
| | CO 1. Analyze the role of statistical tools for determination of error and organize data management for systematic interpretation. | PSO1 |
| | CO 2. Apply the sampling and calibration methods for obtaining reliable results. | PSO1 |
| | CO 3. Explain basic principles and scope of different methods of separation and Techniques of analysis | PSO2 |

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| | CO 4. Solve problems based on IR, NMR, MS combined spectral data. | | PSO3, PSO5 | |
| Content: | | No of hours | Mapped to CO | Cognitive Level |
| Module 1: | 1.1. Analytical Objectives and Data Handling: Importance of analytical chemistry in research and industry; statistics and data handling in analytical chemistry, standard operating procedures, good laboratory practices: quality assurance, method validation and quality control. | 5 | CO1 | K4 |
| | 1.2. Sampling and Calibration Techniques: Sampling and sample preparation, general steps in chemical analysis, calibration of glassware. Finding the best straight line - least square regression, correlation coefficient; Calibration curves, standard addition, external standards and internal standards. Chemical concentrations. Classical methods of Analysis: Gravimetry and Titrimetric methods: Principle, methodology, advantages & disadvantages over instrumental methods. | 5 | CO2 | K3 |
| | 1.3. Introduction to Thermoanalytical techniques: Principle, instrumentation and applications of Thermogravimetric Analysis (TGA), Differential Thermal Analysis (DTA), and Differential Scanning Calorimetry (DSC). Numericals based on TGA. | 5 | CO3 | K2 |
| Module 2: | 2.1. Introduction to Chromatographic Techniques: Principles of chromatography, classification of chromatographic techniques based on mechanism of retention, configuration, mobile and stationary phase. Efficiency of separation- plate theory (theoretical plate concept) and rate theory (van Deemter equation). | 4 | CO3 | K2 |
| | 2.2. Principles and applications of Paper chromatography, thin layer chromatography, HPTLC, Size exclusion and Ion exchange chromatography. Counter-current chromatography for isolation of natural products. | 4 | CO3 | K2 |
| | 2.3. Gas and Liquid Chromatography: Introduction; Instrumental Modules; Separation System; Choice of Conditions of Analysis; Sample Inlet Systems; | 7 | CO3 | K2 |

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| | Detectors; Practical Considerations in Qualitative and Quantitative Analysis; Coupled Systems-introduction to GCMS, GCIR, LCMS: Applicability, interpretation and numericals. | | | |
| Module 3: | <p>3.1. Introduction to Spectroscopic Techniques: Interaction of Electromagnetic Radiation with Matter, Electromagnetic spectra, regions of spectrum, numericals.</p> <p>Ultraviolet and visible Spectroscopy: Electronic spectra and Molecular structure: types of electronic transition, Chromophore and auxochrome, absorption by isolated chromophore, conjugated chromophores, aromatic compounds, inorganic chelates. Choices and effect of solvents on UV-Vis. Quantitative Calculations: Beer-Lambert Law; Mixtures of absorbing species-laws of additivity of absorbance; calibration curve for calculation of unknown; Spectrometric errors in measurement; Deviation from Beer-Lambert Law - chemical deviation, instrumental deviation; Numericals for quantitative analysis using UV-Vis spectroscopy.</p> <p>Infrared Spectroscopy: Infrared absorption and molecular structures, molecular vibrations, types of vibrations, IR spectra, overtones and bands-basis of NIR absorption.</p> <p>Spectrometric instrumentation of UV-Vis and IR: Sources, monochromators, sample cells, detectors, instrumental wavelength and absorption calibration.</p> | 10 | CO4 | K5 |
| | <p>4.2. Applications of UV-Vis spectroscopy for qualitative analysis: Calculating λ_{max} for Conjugated Dienes, Trienes, polyenes, α,β-unsaturated carbonyl compounds, Numericals.</p> <p>Applications of IR spectroscopy for qualitative analysis: Spectra interpretation, Frequencies of functional group, Spectral Databases, Identification of unknown compounds.</p> | 5 | CO4 | K5 |
| Module 4: | <p>4.1. Raman Spectroscopy: Theory, Basic instrumentation and Structural analysis using Raman Spectra.</p> <p>Mass Spectrometry: Principle, Instrumentation and various fragmentation patterns.</p> | 5 | CO3, CO4 | K2, K5 |
| | 4.2. Proton and Carbon NMR Spectroscopy: Theory of NMR, Instrumentation, | 5 | CO4 | K5 |

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| | Chemical shift, factors influencing chemical shift, solvents used in NMR, spin-spin splitting, coupling constant calculation, factors influencing coupling constant. | | | |
| | 4.3. Conjoint spectrometry problems: Structural elucidation of organic molecules using IR, UV, NMR and MS. | 5 | CO4 | K5 |
| Pedagogy: | Mainly lectures and tutorials. Seminars / term papers / assignments / presentations / self-study or a combination of some of these can also be used. ICT mode should be preferred. Sessions should be interactive in nature to enable peer group learning. | | | |
| Texts: | <ol style="list-style-type: none"> 1. G. D. Christian, Analytical Chemistry, 6th ed., Wiley, Singapore, 2004. 2. G. W. Ewing, Instrumental Methods of Chemical Analysis, 5th ed., McGraw- Hill Int., New York, 1985. 3. W. Kemp, Organic Spectroscopy, 3rd ed., Palgrave, New York, 1991. 4. D. A. Skoog, D. M. West, F. J. Hollar, S. R. Crouch, Fundamentals of Analytical Chemistry, 9th ed., Cengage learning, USA, 2014. 5. R. M. Silverstein, F. X. Webster, Spectrometric identification of Organic Compounds, 6th ed., Wiley, USA, 1998. 6. J. Mendham, R. C. Denney, J. D. Barnes, M. Thomas, B. Sivasankar, Vogel's Text Book of Quantitative Chemical Analysis, 6th ed., Pearson, New Delhi, 2009 7. F. J. Holler, D. A. Skoog, S. R. Crouch, Principles of Instrumental Analysis, 6th ed., Thomson Books, London, 2007. 8. H. Willard, L. L. Merritt, J. A. Dean, F. A. Settle, Instrumental methods of Analysis, 7th ed., HCBS Publishing, India, 2004. 9. C. N. Banwell, E. M. McCash, Fundamentals of Molecular Spectroscopy, 4th ed., Tata McGraw- Hill, India, 2006. 10. P. S. Kalsi, Spectroscopy of Organic Compounds, 2nd ed., New Age International, New Delhi, 2000. | | | |
| References/ Readings: | <ol style="list-style-type: none"> 1. J. H. Kennedy, Analytical Chemistry: Principles, 2nd ed., Saunders College Publishing, Philadelphia, 1990. 2. H. Gunzler, A. Williams, Handbook of Analytical Techniques, 1st ed., Wiley, Germany, 2001. 3. E. Pretsch, P. Bühlmann, C. Affolter, Structural Determination of Organic Compounds, 2nd ed., Springer, Germany, 2005. 4. L. D. Field, S. Sternhell, J. R. Kalman; Organic Structures from Spectra, 4th ed., Wiley, Singapore, 2007. 5. R. A. Day, A. L. Underwood, Quantitative Analysis, 6th ed., Prentice Hall, USA, 2001. 6. B. K Sharma, Instrumental methods of chemical analysis, Goel Publishing House, Meerut, 2004. 7. K. Nakamoto, Infrared and Raman Spectra of Inorganic and Coordination Compounds, 6th ed., Wiley, USA, 2009. 8. P. J. Larkin, Infrared and Raman Spectroscopy: principles and spectral interpretation, 2nd ed., Elsevier, Netherlands, | | | |

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Discipline Specific Elective Courses

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| Title of the Course | Organic Chemistry Practical - I | |
| Course Code | CHO-5201 | |
| Number of Credits | 2 | |
| Theory/Practical | Practical | |
| Level | 400 | |
| Effective from AY | 2025-26 | |
| New Course | Yes | |
| Bridge Course/ Value added Course | No | |
| Course for advanced learners | No | |
| Pre-requisites for the Course: | NIL | |
| Course Objectives: | <ul style="list-style-type: none"> To understand essential laboratory equipment, safety protocols, and fundamental experimental purification techniques To create practical skills in basic organic synthesis through key reactions, including electrophilic substitution and other important transformations. To understand the methods of isolation and purification of naturally occurring organic compounds. | |
| Course Outcomes: | Students will be able to: | Mapped to PSO |
| | CO 1. Understand stoichiometric requirements during organic syntheses. | PSO1, PSO3, PSO4 |
| | CO 2. Apply safe and good laboratory practices and develop skills in handling laboratory glassware, equipment and chemical reagents. | PSO1, PSO3, PSO4 |

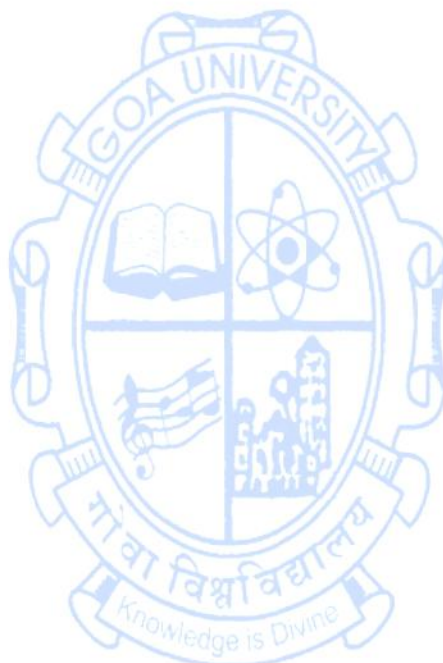
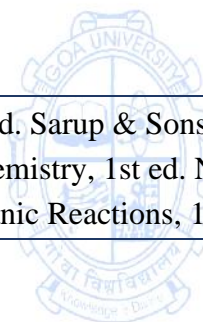
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| | CO 3. Create the practical knowledge to perform experiments involving common laboratory techniques like reflux, distillation, steam distillation, vacuum distillation, aqueous extraction, thin layer chromatography (TLC). | | PSO1, PSO3, PSO4 | |
| | CO 4. Assess their expertise in isolation of some important natural products. | | PSO1, PSO2, PSO3, PSO4 | |
| Content: | | No of hours | Mapped to CO | Cognitive Level |
| Module 1: | <p>1.1 Introduction to laboratory equipment, apparatus and safety</p> <p>a. Use of common laboratory equipment like fume hood, vacuum pump, weighing balance.</p> <p>b. Introduction to various types of quick fit joints and apparatus.</p> <p>c. Safety Techniques:</p> <ol style="list-style-type: none"> Disposal of chemicals Personal Protective Equipment (PPE) First aid Fire extinguishers, types of fire Chemical hazards and risk assessment <p>1.2 Laboratory Techniques-I</p> <p>a. Simple distillation (any one):</p> <ol style="list-style-type: none"> Toluene-dichloromethane mixture using water condenser. Nitrobenzene and aniline using air condenser. <p>b. Steam distillation (any one):</p> <ol style="list-style-type: none"> Separation of o- and p- nitrophenols. Naphthalene from its suspension in water. Clove oil from cloves. <p>c. Crystallisation: Concept of induction of crystallization (any one)</p> <ol style="list-style-type: none"> Crystallisation of phthalic acid from hot water using fluted filter paper and stemless funnel. Acetanilide from boiling water Naphthalene from ethanol. | 16 | CO1, CO2, CO3, CO4 | K1, K2, K3, K4, K5 |

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| | iv. Decolorisation and crystallization of brown sugar (sucrose) with animal charcoal using gravity filtration. | | | |
| Module 2: | 2 Laboratory Techniques-II a. Sublimation: Simple or vacuum sublimation of camphor, naphthalene, anthracene or succinic acid (any one). Vacuum distillation (any one): o-dichlorobenzene, diphenyl ether. Explanation of use of nomograph. b. Thin layer Chromatography (any one): i. Separation of o and p-nitroanilines. ii. Separation of analgesic drugs (ibuprofen/paracetamol) iii. Separation of o and p-nitrophenols | 12 | CO1, CO2, CO3, CO4 | K1, K2, K3, K4, K5 |
| Module 3: | 3. Organic synthesis (Any Four experiments) a. Aliphatic electrophilic substitution: Preparation of iodoform from ethanol & acetone. b. Aromatic electrophilic substitution (any one): i. Preparation of p-bromoacetanilide. ii. Bromination of acetophenone to phenacyl bromide iii. Nitration of naphthalene to 1-nitronaphthalene iv. Nitration of benzaldehyde to 3-nitrobenzaldehyde. c. Oxidation (any one) i. Benzoic acid from toluene. ii. Cyclohexanone from cyclohexanol. iii. Isoborneol to camphor using Jones reagent. d. Reduction (any one) i. Reduction of o-nitroaniline to o-phenylenediamine using Sn/HCl ii. Reduction of p-nitro benzaldehyde to p-nitrobenzyl alcohol using NaBH ₄ . e. Bromination of an alcohol using CBr ₄ / triphenylphosphine. f. Grignard reaction: Triphenylmethanol from benzoic acid ester or benzophenone. g. Aldol condensation: Dibenzalacetone from benzaldehyde h. Acetoacetic ester condensation: Preparation of ethyl n-butylacetoacetate | 16 | CO1, CO2, CO3, CO4 | K1, K2, K3, K4, K5 |

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| | or ethyl acetoacetate. | | | |
| Module 4: | <p>Organic synthesis and synthetic reagents (Any two)</p> <ol style="list-style-type: none"> Cannizzaro reaction using 4-chlorobenzaldehyde as substrate. Friedel Craft's reaction <ol style="list-style-type: none"> using toluene and succinic anhydride Resorcinol to resacetophenone, benzene and maleic anhydride to benzoylacrylic acid. Solvent free preparation of coumarin by the Knoevenagel condensation under MW irradiation. Preparation of oxidizing agent (any one): Pyridinium chlorochromate-silica, pyridinium chlorochromate-alumina, MnO₂. Preparation of cuprous chloride. <p>Isolation from natural sources (Any two)</p> <ol style="list-style-type: none"> Caffeine from tea powder. Piperine from pepper. Cinnamaldehyde from cinnamon Lemongrass oil from lemongrass | 16 | CO1, CO2, CO3, CO4 | K1, K2, K3, K4, K5, K6 |
| Pedagogy: | Students should be given suitable pre- and post-lab assignments and explanation revising the theoretical aspects of laboratory experiments prior to the conduct of each experiment. | | | |
| Texts: | <ol style="list-style-type: none"> A. I. Vogel, A. R. Tatchell, B. S. Furniss, A. J. Hannaford, Vogel's Textbook of Practical Organic Chemistry, 5th ed. Prentice Hall, New Delhi, 2011 K. Tanaka, Solvent-Free Organic Synthesis, 2nd ed, Wiley-VCH, Weinheim, 2009. L. F. Fieser, K. L. Williamson, Organic Experiments, 7th ed. D. C. Heath, Lexington, 1992. K. L. Williamson, K. M. Masters, Macroscale and Microscale Organic Experiments, 6th ed. Cengage Learning, Boston, 2010 R. K. Bansal, Laboratory Manual in Organic Chemistry, 5th ed. New Age International, New Delhi, 2016 O. R. Rodig, C. E. Bell Jr., A. K. Clark, Organic Chemistry Laboratory: Standard and Microscale Experiments, 3rd ed. Saunders College Publishing, Philadelphia, 2009 | | | |

**References/
Readings:**

1. S. Delvin, Green Chemistry, 1st ed. Sarup & Sons, New Delhi, 2005
2. J. Mohan, Organic Analytical Chemistry, 1st ed. Narosa Publishing House, New Delhi, 2014
3. T. Laue, A. Plagens, Named Organic Reactions, 1st ed. John Wiley and Sons, Inc., Hoboken, 2005

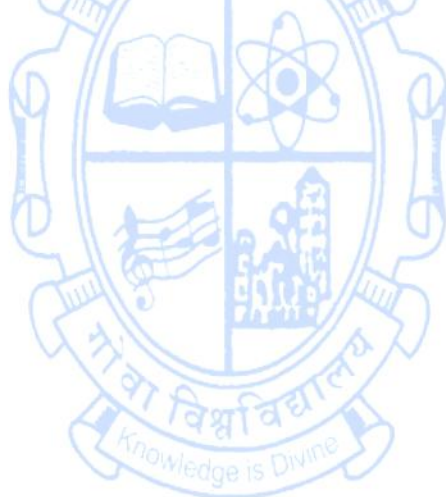


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| Title of the Course | Organic Chemistry Practical - II | |
| Course Code | CHO-5202 | |
| Number of Credits | 2 | |
| Theory/Practical | Practical | |
| Level | 400 | |
| Effective from AY | 2025-26 | |
| New Course | Yes | |
| Bridge Course/ Value added Course | No | |
| Course for advanced learners | No | |
| Pre-requisites for the Course: | NIL | |
| Course Objectives: | <ul style="list-style-type: none"> To familiarize students with essential laboratory equipment, safety protocols, and fundamental experimental purification techniques To develop practical skills in basic organic synthesis through key reactions, including electrophilic substitution and other important transformations. To introduce the methods of isolation and purification of naturally occurring organic compounds. | |
| Course Outcomes: | Students will be able to: | Mapped to PSO |
| | CO 1. Understand stoichiometric requirements during organic syntheses. | PSO1, PSO3, PSO4 |
| | CO 2. Apply safe and good laboratory practices and develop skills in handling laboratory glassware, equipment and chemical reagents. | PSO1, PSO3, PSO4 |
| | CO 3. Create the practical knowledge to perform experiments involving common | PSO1, PSO3, PSO4 |

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| | laboratory techniques like reflux, distillation, steam distillation, vacuum distillation, aqueous extraction, thin layer chromatography (TLC). | | | |
| | CO 4. Assess their expertise in isolation of some important natural products. | | PSO1, PSO2, PSO3, PSO4 | |
| Content: | | No of hours | Mapped to CO | Cognitive Level |
| Module 1: | <p>1.1 Introduction to laboratory equipment, apparatus and safety</p> <p>a. Common Hazards in Chemical Laboratory, Risk assessment</p> <p>b. Accidents and Emergency procedures</p> <p>1.2 Laboratory Techniques (Any Three)</p> <p>a. Simple distillation:</p> <p>i. Simple distillation of thionyl chloride under anhydrous condition</p> <p>ii. Simple distillation under Nitrogen atmosphere of THF</p> <p>b. Fractional distillation:</p> <p>i. Chloroform-dichloromethane mixture using water condenser.</p> <p>ii. Toluene and cyclohexane using fractionating column.</p> <p>c. Vacuum distillation under inert atmosphere:</p> <p>Distillation of DMF, o-dichlorobenzene, POCl₃</p> <p>d. Thin layer Chromatography:</p> <p>i. Purification and isolation of mixture of acids (o-nitrobenzoic acid and p-nitrobenzoic acid) by using Preparative TLC.</p> <p>ii. Purification and isolation of mixture of phenols (o and p-nitrophenols) by using Preparative TLC.</p> <p>iii. Purification and isolation of pharmaceutical drugs (ibuprofen tablet) using Preparative TLC.</p> | 16 | CO1, CO2, CO3, CO4 | K1, K2, K3, K4, K5 |
| Module 2: | <p>Organic Synthesis (Any Four)</p> <p>a. p-Iodonitrobenzene by Sandmeyer reaction</p> <p>b. Pinacol- Pinacolone rearrangement</p> | 16 | CO1, CO2, CO3, CO4 | K1, K2, K3, K4, K5 |

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| | c. Hydrogenation of Maleic acid (Hydrogen balloon) d. Preparation of nitrostyrene from aldehyde e. Preparation of dibromocinnamic acid f. Reduction of nitro compounds g. Synthesis of Urea from ammonium cyanate | | | |
| Module 3: | 3. Two-step Organic Synthesis (Any Two) a. Benzamide-Benzoic acid-Ethyl Benzoate b. Phthalic anhydride-Phthalimide-Anthranilic acid. c. Methyl benzoate- m-nitrobenzoate- m-nitrobenzoic acid d. Chlorobenzene-2, 4 -dinitrochlorobenzene-2,4 dinitrophenol e. Acetanilide-p-Bromoacetanilide-p-Bromoaniline f. Acetophenone-Oxime-Acetanilide | 16 | CO1, CO2, CO3, CO4 | K1, K2, K3, K4, K5 |
| Module 4: | 4.1 Solvent Free Organic synthesis (Any One) a. Reduction using ball milling technique b. Oxidation of 2° alcohol using KMnO ₄ /Alumina by grinding technique. c. Synthesis of 1,1'-Bi-2-naphthol (BINOL) d. Hunsdiecker reaction of cinnamic acid derivatives e. Beckmann rearrangement of oxime derivatives 4.2 Separation, Isolation and Identification of Organic compounds (Any One) Separation, purification and identification of compounds of binary mixture (Solid-Solid, Solid-liquid and Liquid-liquid) using the TLC and column chromatography, chemical tests. IR spectra to be used for functional group identification. | 12 | CO1, CO2, CO3, CO4 | K1, K2, K3, K4, K5, K6 |
| Pedagogy: | Students should be given suitable pre- and post-lab assignments and explanation revising the theoretical aspects of laboratory experiments prior to the conduct of each experiment. | | | |
| Texts: | 1. A. I. Vogel, A. R. Tatchell, B. S. Furniss, A. J. Hannaford, Vogel's Textbook of Practical Organic Chemistry, 5th ed. Prentice Hall, New Delhi, 2011 2. K. Tanaka, Solvent-Free Organic Synthesis, 2nd ed, Wiley-VCH, Weinheim, 2009 | | | |

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| | <ol style="list-style-type: none"> 3. L. F. Fieser, K. L. Williamson, Organic Experiments, 7th ed. D. C. Heath, Lexington, 1992 4. K. L. Williamson, K. M. Masters, Macroscale and Microscale Organic Experiments, 6th ed. Cengage Learning, Boston, 2010 5. R. K. Bansal, Laboratory Manual in Organic Chemistry, 5th ed. New Age International, New Delhi 2016 6. O. R. Rodig, C. E. Bell Jr., A. K. Clark, Organic Chemistry Laboratory: Standard and Microscale Experiments, 3rd ed. Saunders College Publishing, Philadelphia, 2009 |
| References/ Readings: | <ol style="list-style-type: none"> 1. S. Delvin, Green Chemistry, 1st ed. Sarup & Sons, New Delhi, 2005. 2. J. Mohan, Organic Analytical Chemistry, 1st ed. Narosa Publishing House, New Delhi, 2014. 3. T. Laue, A. Plagens, Named Organic Reactions, 1st ed. John Wiley and Sons, Inc., Hoboken, 2005 |



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| Title of the Course | Inorganic Chemistry Practical-I | |
| Course Code | CHI-5201 | |
| Number of Credits | 2 | |
| Theory/Practical | Practical | |
| Level | 400 | |
| Effective from AY | 2025-26 | |
| New Course | Yes | |
| Bridge Course/ Value added Course | No | |
| Course for advanced learners | No | |
| Pre-requisites for the Course: | NIL | |
| Course Objectives: | <ul style="list-style-type: none"> • To acquire skills in synthetic inorganic chemistry. • To gain knowledge about quantitative analysis of coordination compounds. • To determine metal contents in ores and alloys. • To analyse compounds using instrumental techniques. | |
| Course Outcomes: | Students will be able to: | Mapped to PSO |
| | CO 1. Explain the synthesis of coordination compounds. | PSO1 |
| | CO 2. Estimate metals in the coordination compounds by classical methods of analysis. | PSO2, PSO3, PSO5 |
| | CO 3. Characterise commercially available ores and alloys. | PSO3, PSO4, PSO5 |

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| | CO 4. Choose the appropriate instrumental methods of analysis for characterisation of compounds | | PSO4, PSO5 | |
| Content: | | No of hours | Mapped to CO | Cognitive Level |
| Module 1: | 1. Preparations of Inorganic Compounds (ANY 07) a. Preparation of hexaamminenickel(II) chloride or hexaamminenickel(II) sulfate. b. Preparation of tris(ethylenediamine)cobalt(III) chloride. c. Preparation of potash alum from scrap aluminum. d. Preparation of potassium trioxalatoaluminate(III) trihydrate. e. Preparation of potassium hexathiocyanato- κN -chromate(III) tetrahydrate. f. Preparation of potassium trioxalatochromate(III) trihydrate. g. Preparation of γ - and α -Fe ₂ O ₃ . h. Preparation of Zinc acetate or [Zn ₄ O(CH ₃ CO ₂) ₆]. (Powder X-Ray Diffraction (PXRD), Infrared (IR), UV-vis spectroscopy and magnetic studies is expected) | 28 | CO1, CO2 | K2, K3 |
| Module 2: | 2. Estimations / Determinations (ANY 08) a. Estimation of nickel by complexometry or Gravimetry. b. Estimation of cobalt in [Co(en) ₃]Cl ₃ by complexometry. c. Estimation of oxalate in K ₃ [Al(C ₂ O ₄) ₃]·xH ₂ O or K ₃ [Cr(C ₂ O ₄) ₃]·xH ₂ O d. Estimation of nitrite by redox titration. e. Estimation of calcium from calcite ore. f. Iodometric determination of copper in commercial copper compounds / alloys. g. Estimation of sulfate by gravimetry. h. Estimation of zinc by complexometric titration. i. Determination of chromium in chrome alum and K ₃ [Cr(C ₂ O ₄) ₃]·xH ₂ O and to | 32 | CO3, CO4 | K4, K5 |

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| | determine degree of hydration. j. Estimation of potassium from synthesized compounds. k. Colorimetric/Spectrophotometric determination of nickel or chromium or manganese. | | | |
| Pedagogy: | Students will be given pre-lab and post-lab assignments on theoretical aspects of laboratory experiments prior to the conduct of each experiment. Exams will be in the form of ISA, SEA which will involve performing given experiments and conduct of viva, systematic reporting of experiments, results and observations in laboratory report. Sessions should be interactive in nature to enable peer group learning | | | |
| Texts: | 1. J. Mendham, R.C. Denney, J.D. Barnes, M.J. K. Thomas, Vogel's Text Book of Quantitative Chemical Analysis, 6 th ed., Pearson, New Delhi, 2002. 2. G. Svehla, Vogel's Text Book of Qualitative Inorganic Analysis, 7 th ed., Pearson, New Delhi, 2011. 3. G. Brauer, Handbook of Preparative Inorganic Chemistry, Vol. 1 & 2, Academic Press, New York, 1963. 4. G. Pass & H. Sutcliffe, Practical Inorganic Chemistry, Preparations, Reactions and Instrumental Methods, 2 nd ed., Chapman & Hall, New York, 1974. 5. W. L. Jolly, The Synthesis & Characterization of Inorganic Compounds, Prentice-Hall, INC, New Jersey, 1970. 6. G. Marr, B. W. Rockett, Practical Inorganic Chemistry, Van Nostrand Reinhold, London, 1972. | | | |
| References/ Readings: | 1. S. De Meo, J. Chem. Ed., 80(2003)796-798. 2. A. J. Elias, General Chemistry Experiments, Revised ed., University Press, Hyderabad, 2008. | | | |

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| Title of the Course | Inorganic Chemistry Practical-II | |
| Course Code | CHI-5202 | |
| Number of Credits | 2 | |
| Theory/Practical | Practical | |
| Level | 400 | |
| Effective from AY | 2025-26 | |
| New Course | Yes | |
| Bridge Course/ Value added Course | No | |
| Course for advanced learners | No | |
| Pre-requisites for the Course: | NIL | |
| Course Objectives: | <ul style="list-style-type: none"> • To acquire skills in synthetic inorganic chemistry. • To gain knowledge about various laboratory chemicals. • To determine metal and ligand content in a material. • To evaluate compounds molecular formula to find lattice water molecules. | |
| Course Outcomes: | Students will be able to: | Mapped to PSO |
| | CO 1. understand methodologies related to compound synthesis. | PSO1 |
| | CO 2. experiment with various reagents and metal salts to synthesize useful compounds. | PSO2, PSO3, PSO5 |
| | CO 3. analyze synthesized and commercially available compounds. | PSO3, PSO4, PSO5 |
| | CO 4. interpret the chemical composition of materials using chemical methods and instrumental techniques. | PSO4, PSO5 |

| Content: | | No of hours | Mapped to CO | Cognitive Level |
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| Module 1: | 1. Preparations / Estimation of Inorganic Compounds: (Any Nine) a. Preparation of hexaamminecobalt(III) nitrate. b. Estimation of cobalt in hexaamminecobalt(III) nitrate by volumetric titration. c. Preparation of Potassium Trioxalatoferrate(III) Trihydrate d. Estimation of iron and oxalate by redox titration e. Synthesis of metal nanoparticles (Cu, Ag, Au, Ni) and determining the absorption maxima by UV-visible spectrophotometer. f. Estimation of amount of calcium in given sample by gravimetric method. g. Estimation of amount of nickel in given sample by gravimetric method. h. Estimation amount of zinc present in given sample by gravimetric method. i. Estimation of iron by colorimetric / spectrophotometry method. j. Estimation of barium by complexometric titration method. k. Estimation of manganese in presence of iron by complexometric titration method. (Powder X-Ray Diffraction (PXRD), Infrared (IR), UV-vis spectroscopy and magnetic studies is expected) | 40 | CO1, CO2, CO3 | K2, K3, K4 |
| Module 2: | 2. Semi-micro qualitative analysis of cation and anion in a given inorganic mixture: (Any four mixture) Mixture containing total six cations and/or anions. Cations : Pb^{2+} , Cu^{2+} , Cd^{2+} , Sn^{2+} , Fe^{2+} , Fe^{3+} , Al^{3+} , Cr^{3+} , Zn^{2+} , Mn^{2+} , Ni^{2+} , Co^{2+} , Ba^{2+} , Sr^{2+} , Ca^{2+} , Mg^{2+} , $(\text{NH}_4)^+$, K^+ Anions: Cl^- , Br^- , I^- , NO_2^- , NO_3^- , SO_3^{2-} , CO_3^{2-} , SO_4^{2-} , PO_4^{3-} , S^{2-} | 20 | CO3, CO4 | K4, K5 |
| Pedagogy: | Students will be given pre-lab and post-lab assignments on theoretical aspects of laboratory experiments prior to the conduct of each experiment. Exams will be in the form of ISA, SEA which will involve performing given experiments and conduct of viva, systematic reporting of experiments, results and observations in laboratory report. Sessions should be interactive in nature to enable peer group learning. | | | |

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| Texts: | <ol style="list-style-type: none"> 1. J. Mendham, R.C. Denney, J.D. Barnes, M.J. K. Thomas, Vogel's Text Book of Quantitative Chemical Analysis, 6th ed., Pearson, New Delhi, 2002. 2. G. Svehla, Vogel's Text Book of Qualitative Inorganic Analysis, 7th ed., Pearson, New Delhi, 2011. 3. G. Brauer, Handbook of Preparative Inorganic Chemistry, Vol. 1 & 2, Academic Press, New York, 1963. 4. G. Pass & H. Sutcliffe, Practical Inorganic Chemistry, Preparations, Reactions and Instrumental Methods, 2nd ed., Chapman & Hall, New York, 1974. 5. G. Marr, B. W. Rockett, Practical Inorganic Chemistry, Van Nostrand Reinhold, London, 1972. 6. A. J. Elias, General Chemistry Experiments, Revised ed., University Press, Hyderabad, 2008. 7. W. L. Jolly, The Synthesis & Characterization of Inorganic Compounds, Prentice-Hall, INC, New Jersey, 1970. |
| References/ Readings: | S. De Meo, J. Chem. Ed., 80(2003) 796-798. |

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| Title of the Course | Physical Chemistry Practical-I | |
| Course Code | CHP-5201 | |
| Number of Credits | 02 | |
| Theory/Practical | Practical | |
| Level | 400 | |
| Effective from AY | 2025-26 | |
| New Course | Yes | |
| Bridge Course/ Value added Course | No | |
| Course for advanced learners | No | |
| Pre-requisites for the Course: | NIL | |
| Course Objectives: | <ul style="list-style-type: none"> • To develop experimental skills on basic lab techniques in physical chemistry • To understand fundamental laboratory concepts and acquire skills for data acquisition, analysis and interpretation • To understand and follow safety protocols for handling chemicals, equipment and instruments. • To apply the practical laboratory concepts for synthesis, problem solving and critical thinking • To develop research skills through the principles of laboratory chemical research. | |
| Course Outcomes: | Students will be able to: | Mapped to PSO |
| | CO 1. Explain and perform various fundamental lab techniques and experiments. | PSO1 |
| | CO 2. Handle and operate basic laboratory equipment and use it for research work. | PSO1, PSO4 |
| | CO 3. Apply the laboratory knowledge and skills for their dissertation and research work. | PSO4, PSO5, PSO6, PSO7 |

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| | CO 4. Design synthesis and/or experimental methods. | | PSO5, PSO6, PSO7 | |
| Content: | | No of hours | Mapped to CO | Cognitive Level |
| Module 1: | 1. Non- instrumental Experiments (Any 08) 1. To study the kinetics of hydrolysis of ethyl acetate and to determine a) Energy of activation b) Entropy of activation and c) Free energy change. 2. To determine the order of reaction between potassium persulphate and potassium iodide by graphical, fractional change and differential methods. 3. To study the three-component system such as acetic acid, chloroform and water and obtain tie line. 4. To determine the molecular weight of polyvinyl alcohol by viscosity measurement. 5. To study the electro-kinetics of rapid reaction between SO_4^{2-} and I^- in an aqueous solution. 6. To determine the buffer capacity of acidic buffer solution. 7. To determine the partial molal volume of ethanol-water mixture at a given temperature. 8. To measure energy content of various types of plastics using bomb calorimetry 9. To determine number average molecular weight of a polymer sample with an indirect titration method. 10. To investigate basic hydrolysis of ethyl acetate at four different temperatures and find out energy of activation 11. To construct a phase diagram for a two-component system by plotting cooling curves for mixtures of different compositions. 12. To find the surface tension of methyl alcohol, ethyl alcohol and n-hexane at room temperature and then calculate the atomic parachors of carbon, hydrogen and oxygen. | 32 | CO1, CO3, CO4 | K2, K3, K4, K5 |
| Module 2: | 2. Instrumental Experiments (Any 07) 1. To determine the degree of hydrolysis of salt of weak base and strong acid using conductometer. | 28 | CO2, CO3, CO4 | K3, K4, K5 |

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| | <ol style="list-style-type: none"> To determine the dissociation constants of a tribasic acid (Phosphoric acid obtain derivative plot to get equivalence point. To determine formal redox potential of $\text{Fe}^{2+}/\text{Fe}^{3+}$ and $\text{Ce}^{3+}/\text{Ce}^{4+}$ system obtain derivative plot to get equivalence point. To study spectrophotometric titration of ferrous ammonium sulphate with potassium permanganate (or dichromate vs permanganate) To determine Avogadro's number by improved electroplating. To determine the zeta potential of colloidal system and investigate the effect of different surfactants on stability of the colloids. To verify the Kohlrausch's law for weak electrolyte by conductometry. To determine the transport numbers of Cu^{2+} and SO_4^{2-} ions in CuSO_4 solution by Hittorf's method. | | | |
| Pedagogy: | Students will be given pre-lab and post-lab assignments on theoretical aspects of laboratory experiments prior to the conduct of each experiment. Exams will be in the form of ISA, SEA which will involve performing given experiments and conduct of viva, systematic reporting of experiments, results and observations in laboratory report. Sessions can preferably be interactive in nature to enable peer group learning. | | | |
| Texts: | <ol style="list-style-type: none"> V. D. Athawale, P. Mathur, Experimental Physical Chemistry, New Age International Publishers, 1st ed., New Delhi, 2001. J.N. Gurtu, A. Gurtu, Advanced Physical Chemistry Experiments, Pragati Publications, 1st ed., Meerut, 2008. A. Findlay & J. A. Kitchener, Practical Physical Chemistry, Longmans, Green and Co., 1st ed., London 1954. F. Daniels & J. H. Mathews, Experimental Physical Chemistry, McGraw-Hill, 1st ed., New York, 1941. | | | |
| References/ Readings: | <ol style="list-style-type: none"> A. M. James, Practical Physical Chemistry, Prentice Hall Press, 3rd ed., 1974. D.P. Shoemaker & C. W. Garland, Experiments in Physical Chemistry, McGraw-Hill, 1st ed., New York, 1962. T. Kadow & F. Mafune, Progress in experimental and theoretical studies of clusters, World Scientific publishers, 1st ed., New Jersey, 2002. C. Arora & S. Bhattacharya, Advanced Physical Chemistry Practical Guide, Bentham Science Publishers, 1st ed., UAE, 2022. A. K. Hagi, L. Pogliani, A. C. F. Ribeiro, Practical applications of Physical Chemistry in food science and technology, 1st ed., Apple Academic Press, USA, 2021. | | | |

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| Title of the Course | Physical Chemistry Practical-II | |
| Course Code | CHP-5202 | |
| Number of Credits | 02 | |
| Theory/Practical | Practical | |
| Level | 400 | |
| Effective from AY | 2025-26 | |
| New Course | Yes | |
| Bridge Course/ Value added Course | No | |
| Course for advanced learners | No | |
| Pre-requisites for the Course: | NIL | |
| Course Objectives: | <ul style="list-style-type: none"> • To develop experimental skills on basic lab techniques in physical chemistry • To understand fundamental laboratory concepts and acquire skills for data acquisition, analysis and interpretation • To understand and follow safety protocols for handling chemicals, equipment and instruments. • To apply the practical laboratory concepts for synthesis, problem solving and critical thinking • To develop research skills through the principles of laboratory chemical research. | |
| Course Outcomes: | Students will be able to: | Mapped to PSO |
| | CO 1. Explain and perform various fundamental lab techniques and experiments. | PSO1 |
| | CO 2. Handle and operate basic laboratory equipment and use it for research work. | PSO1, PSO4 |
| | CO 3. Apply the laboratory knowledge and skills for their dissertation and research work. | PSO4, PSO5, PSO6, PSO7 |

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| | CO 4. Design synthesis and/or experimental methods. | | PSO5, PSO6, PSO7 | |
| Content: | | No of hours | Mapped to CO | Cognitive Level |
| Module 1: | 1. Non- instrumental Experiments (Any 09) <ol style="list-style-type: none"> To determine the radius of a molecule by viscosity measurements. To determine ΔG, ΔH and ΔS of silver benzoate by solubility product method. To investigate the adsorption of oxalic acid by activated charcoal and test the validity of Freundlich and Langmuir's isotherms. To determine the molecular weight of a given polymer by turbidimetry. To study the rate of reaction between ethyl bromoacetate and sodium thiosulphate kinetically. To determine the percentage composition of a given mixture of two liquids by stalagmometer method. To study the kinetics of hydrolysis of methyl acetate and to determine a) Energy of activation b) Entropy of activation and c) Free energy change. To study the kinetics of the reaction between potassium persulphate ($K_2S_2O_8$), and potassium iodide (KI), and to determine a) Energy of activation b) Entropy of activation and c) Free energy change. To determine the order of reaction for hydrolysis of ethyl acetate by graphical, fractional change and differential methods. To determine the molecular weight of polystyrene by viscosity measurement. | 36 | CO1, CO3, CO4 | K1, K2, K3, K4, K5 |
| Module 2: | 2. Instrumental Experiments <ol style="list-style-type: none"> To determine the relative strength of chloroacetic acid and acetic acid by conductometry. To determine the degree of hydrolysis of salt of weak base and strong acid using conductometry. To determine the composition of a mixture of acetic acid, dichloroacetic acid and hydrochloric acid by conductometric titration. To determine the dissociation constants of monobasic acid and dibasic acid and obtain derivative plot to get equivalence point. | 24 | CO2, CO3, CO4 | K2, K3, K4, K5 |

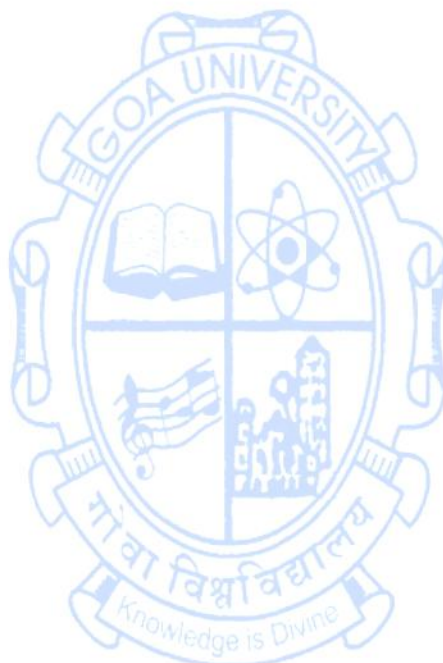
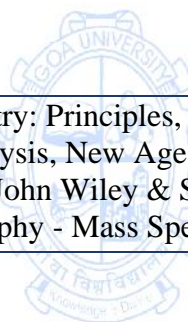
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| | 5. To determine the redox potential of $\text{Fe}^{2+}/\text{Fe}^{3+}$ system by titrating it with standard $\text{K}_2\text{Cr}_2\text{O}_7$ solution. 6. To study the electrodeposition of metal. | | | |
| Pedagogy: | Students will be given pre-lab and post-lab assignments on theoretical aspects of laboratory experiments prior to the conduct of each experiment. Exams will be in the form of ISA, SEA which will involve performing given experiments and conduct of viva, systematic reporting of experiments, results and observations in laboratory report. Sessions can preferably be interactive in nature to enable peer group learning. | | | |
| Texts: | 1. V. D. Athawale, P. Mathur, Experimental Physical Chemistry, New Age International Publishers, 1st ed., New Delhi, 2001. 2. J.N. Gurtu, A. Gurtu, Advanced Physical Chemistry Experiments, Pragati Publications, 1st ed., Meerut, 2008. 3. A. Findlay & J. A. Kitchener, Practical Physical Chemistry, Longmans, Green and Co., 1st ed., London 1954. 4. F. Daniels & J. H. Mathews, Experimental Physical Chemistry, McGraw-Hill, 1st ed., New York, 1941. | | | |
| References/ Readings: | 1. A. M. James, Practical Physical Chemistry, Prentice Hall Press, USA 3rd ed., 1974. 2. D.P. Shoemaker & C. W. Garland, Experiments in Physical Chemistry, McGraw-Hill, 1st ed., New York, 1962. 3. T. Kadow & F. Mafune, Progress in experimental and theoretical studies of clusters, World Scientific publishers, 1st ed., New Jersey, 2002. 4. C. Arora & S. Bhattacharya, Advanced Physical Chemistry Practical Guide, Bentham Science Publishers, 1st ed., UAE, 2022. 5. A. K. Hagi, L. Pogliani, A. C. F. Ribeiro, Practical applications of Physical Chemistry in food science and technology, 1st ed., Apple Academic Press, USA, 2021. | | | |

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| Title of the Course | Analytical Chemistry Practical - I | |
| Course Code | CHA-5201 | |
| Number of Credits | 2 | |
| Theory/Practical | Practical | |
| Level | 400 | |
| Effective from AY | 2025-26 | |
| New Course | Yes | |
| Bridge Course/ Value added Course | No | |
| Course for advanced learners | No | |
| Pre-requisites for the Course: | Nil | |
| Course Objectives: | <ul style="list-style-type: none"> • To perform various experimental techniques for analysis. • To learn data analysis, handling and interpretation of spectra. • To determine concentration of solutions. • To use techniques for qualitative and quantitative estimation. | |
| Course Outcomes: | Students will be able to: | Mapped to PSO |
| | CO 1. Explain data analysis, handling and interpretation of spectra. | PSO1, PSO3, PSO4 |
| | CO 2. Apply different techniques for qualitative and quantitative estimation. | PSO1, PSO2, PSO6 |
| | CO 3. Determine concentration of solutions. | PSO1, PSO6 |
| | CO 4. Perform various experimental techniques for analysis. | PSO1, PSO2, PSO6 |

| Content: | This course consists of 8 units of experiments in various areas of Analytical chemistry. Minimum 15 experiments which include at least 01 experiment from each unit to be performed. | No of hours | Mapped to CO | Cognitive Level |
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| Module 1: | Statistics: i. Calibration of selected Volumetric apparatus ii. Calibration of selected Laboratory instruments iii. Preparation of standard solutions and standardisation. | 4 | CO3 | K5 |
| Module 2: | Colorimetry/ UV-Visible Spectrophotometry: i. Estimation of Iron from Pharmaceutical sample (Tablet/capsule) by thiocyanate method ii. Estimation of phosphoric acid in cola drinks by molybdenum blue method. iii. Estimation of KNO_3 by UV spectroscopy and $\text{K}_2\text{Cr}_2\text{O}_7$ by Visible spectroscopy iv. Simultaneous determination and Verification of law of additivity of absorbances ($\text{K}_2\text{Cr}_2\text{O}_7$ and KMnO_4). | 8 | CO4, CO2 | K6, K3 |
| Module 3: | Flame Spectrophotometry and AES/AAS/ICP Spectroscopy i. Estimation of Na and K in food supplements or cosmetic products. ii. Estimation of Pb in water sample by AES/AAS/ICP. iii. Estimation of Fe and Al in Iron ore sample by AES/AAS/ICP. | 8 | CO1, CO2 | K2, K3 |
| Module 4: | Ion Exchange Chromatography and High Performance Liquid Chromatography (HPLC): i. Separation and Estimation of chloride and bromide using Ion exchange chromatography. ii. Separation of anthracene and naphthalene using reverse phase chromatography iii. Separation of benzaldehyde and benzyl alcohol using normal phase chromatography | 8 | CO4, CO2 | K6, K3 |
| Module 5: | Volumetric Titrations: i. Estimation of Ca in pharmaceutical tablet. ii. Estimation of Al and Mg in antacid tablet. | 8 | CO4, CO3 | K6, K5 |

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| | iii. Estimation of CaO in cement. | | | |
| Module 6: | Solvent Extraction and spectrophotometry: <ol style="list-style-type: none"> Extraction of Cu as copper dithiocarbamate (DTC) using solvent extraction and estimation by spectrophotometry. Determination of Ni as dimethylglyoxime complex by spectrophotometry. Determination of silver as ion association complex with 1,10-phenanthroline and bromopyrogallol red. | 8 | CO4, CO3 | K6, K5 |
| Module 7: | Demonstration and Interpretation Exercises: <ol style="list-style-type: none"> Thermal studies: TG/DTA and Isothermal weight loss studies of various hydrated solids like $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$, $\text{CaC}_2\text{O}_4 \cdot \text{H}_2\text{O}$, $\text{FeC}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$. X-ray powder diffractometry: Calculation of lattice parameters from X-ray powder pattern of cubic system such as NiMn_2O_4, CoFe_2O_4. IR spectra of urea, benzoic acid, copper sulphate pentahydrate etc. | 8 | CO1, CO2 | K2, K3 |
| Module 8: | Demonstration: <ol style="list-style-type: none"> Turbidimeter. KF instrument. Polarimeter. LCMS. NMR. | 8 | CO1, CO2 | K2, K3 |
| Pedagogy: | Prelab exercises / assignments / presentations / lab hand-out or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning. | | | |
| Texts: | <ol style="list-style-type: none"> J. Mendham, R. C. Denney, J. D. Barnes, M. Thomas, B. Sivasankar, Vogel's Text Book of Quantitative Chemical Analysis, 6th ed., Pearson, New Delhi, 2009. R. A. Day & A.L. Underwood, Quantitative Analysis, 6th ed., Pearson Education India, 2015. J. Kenkel, Analytical Chemistry for Technicians, 3rd ed., Lewis publishers, USA, 2002. R. M. Silverstein, F. X. Webster, D. Kiemle, D. Bryce, S. Samant, V. S. Nadkarni, Spectrometric Identification of Organic compounds, An Indian Adaptation, Wiley, India, 8th ed., 2022 A. J. Elias, Collection of interesting chemistry experiments, University press, Hyderabad, 2002. | | | |
| References/ | <ol style="list-style-type: none"> G. D. Christian, Analytical chemistry, 5th ed., John Wiley and Sons, USA, 1994 | | | |

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| Readings: | <ol style="list-style-type: none"> 2. J. H. Kennedy, Analytical Chemistry: Principles, 2nd ed., Saunders College Publishing, Philadelphia, 1990. 3. A. Kar, Pharmaceutical Drug Analysis, New Age International, India, 2005 4. M. Asadi, Beet-Sugar Handbook, John Wiley & Sons, USA, 2006 5. R. E. Ardrey, Liquid Chromatography - Mass Spectrometry: An Introduction, John Wiley & Sons, England, 2003 |
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| Title of the Course | Analytical Chemistry Practical - II | |
| Course Code | CHA-5202 | |
| Number of Credits | 2 | |
| Theory/Practical | Practical | |
| Level | 400 | |
| Effective from AY | 2025-26 | |
| New Course | Yes | |
| Bridge Course/ Value added Course | No | |
| Course for advanced learners | No | |
| Pre-requisites for the Course: | Nil | |
| Course Objectives: | <ul style="list-style-type: none"> • To perform various experimental techniques for analysis. • To learn data analysis, handling and interpretation of spectra. • To determine concentrations of solution. • To use techniques for qualitative and quantitative estimation. | |
| Course Outcomes: | Students will be able to: | Mapped to PSO |
| | CO 1. Explain data analysis, handling and interpretation of spectra. | PSO1, PSO3, PSO4 |
| | CO 2. Apply different techniques for qualitative and quantitative estimation. | PSO1, PSO2, PSO6 |
| | CO 3. Determine concentration of solutions. | PSO1, PSO6 |
| | CO 4. Perform various experimental techniques for analysis. | PSO1, PSO2, PSO6 |

| Content: | This course consists of 8 units of experiments in various areas of Analytical chemistry. Minimum 15 experiments which include at least 01 experiment from each unit to be performed. | No of hours | Mapped to CO | Cognitive Level |
|------------------|---|--------------------|---------------------|------------------------|
| Module 1: | Statistics: i. Calibration of selected Volumetric apparatus ii. Calibration of selected Laboratory instruments iii. Preparation of standard solutions and standardisation. | 4 | CO3 | K5 |
| Module 2: | Titrimetric Analysis: i. Standardisation and estimation of Chloride using precipitation titration (Mohr's method) ii. Analysis of commercial caustic soda by neutralisation method. iii. Determination of sulphates by complexometric titration. | 8 | CO4, CO2 | K6, K3 |
| Module 3: | Flame Spectrophotometry and AES/AAS/ICP Spectroscopy i. Estimation of sodium and potassium in food supplements or cosmetic products using flame photometer. ii. Estimation of chromium in water sample by AES/AAS/ICP. iii. Estimation of nickel, molybdenum in Hastelloy C-22 using AES/AAS/ICP. | 8 | CO1, CO4 | K2, K6 |
| Module 4: | Natural product isolation and Ion Exchange Chromatography. i. Isolation of cinnamaldehyde from cinnamon. ii. Isolation of caffeine from tea powder. iii. Separation and estimation of cadmium and zinc. | 8 | CO4, CO2 | K6, K3 |
| Module 5: | UV-Visible Spectrophotometry and High Performance Liquid Chromatography (HPLC). i. Estimation of KNO_3 and $\text{K}_2\text{Cr}_2\text{O}_7$ using UV- Visible spectroscopy. ii. Separation of benzaldehyde and benzoic acid using reverse phase HPLC. iii. Quantification of naphthalene in a sample using reverse phase HPLC. | 8 | CO4, CO3 | K6, K5 |
| Module 6: | Solvent Extraction and spectrophotometry i. Spectrophotometric determination of aspirin/phenacetin/caffeine in APC tablet | 8 | CO4, CO3 | K6, K5 |

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| | using solvent extraction. ii. Colorimetric determination of iron with salicylic acid. iii. Determination of copper in brass sample by colorimetry. | | | |
| Module 7: | Data Interpretation Exercises: i. NMR/Mass spectra ii. HPLC and GC chromatograph iii. XRD powder pattern of cubic systems iv. Thermogram of coordination compounds | 8 | CO1, CO2 | K2, K3 |
| Module 8: | Demonstration: i. Turbidimeter. ii. KF instrument. iii. Polarimeter. iv. LCMS. v. NMR. | 8 | CO1, CO2 | K2, K3 |
| Pedagogy: | Prelab exercises / assignments / presentations / lab hand-out or a combination of some of these. Sessions shall be interactive in nature to enable peer group learning. | | | |
| Texts: | 1. J. Mendham, R. C. Denney, J. D. Barnes, M. Thomas, B. Sivasankar, Vogel's Text Book of Quantitative Chemical Analysis, 6th ed., Pearson, New Delhi, 2009. 2. R. A. Day & A.L. Underwood, Quantitative Analysis, 6 th ed., Pearson Education India, New-Delhi, 2015. 3. J. Kenkel, Analytical Chemistry for Technicians, 3 rd ed., Lewis publishers, USA, 2002. 4. R. M. Silverstein, F. X. Webster, D. Kiemle, D. Bryce, S. Samant, V. S. Nadkarni, Spectrometric Identification of Organic compounds, An Indian Adaptation, Wiley, India, 8th ed., 2022 5. A. J. Elias, Collection of interesting chemistry experiments, University press, Hyderabad, 2002. 6. A. Kar, Pharmaceutical Drug Analysis, New Age International, India, 2005 | | | |
| References/ Readings: | 1. G. D. Christian, Analytical chemistry, 5 th ed., John Wiley and Sons, USA, 1994 2. J. H. Kennedy, Analytical Chemistry: Principles, 2nd ed., Saunders College Publishing, Philadelphia, 1990. 3. M. Asadi, Beet-Sugar Handbook, John Wiley & Sons, USA, 2006 4. R. E. Ardrey, Liquid Chromatography - Mass Spectrometry: An Introduction, John Wiley & Sons, England, 2003 | | | |