RAICHUR UNIVERSITY, RAICHUR

Krishna Tunga Campus, Yeragera-584133, Raichur

DEPARTMENT OF STUDIES IN CHEMISTRY

MASTER OF SCIENCE

Choice Based Credit System

With effect from 2023-2024

RAICHUR UNIVERSITY, RAICHUR

Krishna Tunga Campus, Yeragera-584133, Raichur

Department of Studies in Chemistry

Programme: Master of Science (M.Sc.) in Chemistry

Programme Overview:

Duration: 2 Years (4 semesters)

Master of Science (M.Sc.) in Chemistry programme provides fundamental and applied knowledge in Chemistry with hands-on training through laboratory practicals and foster career in teaching, research or industry.

Program Educational Objectives (PEOs):

- Post graduates will demonstrate capability to understand, analyse, develop, and execute the chemical solutions for the current societal requirements through experimental and experiential learning.
- Post Graduates exhibit professionalism and organizational goals with commitment to ethics, team work and respect for everyone.
- Students will be motivated for continuous learning and career development.
- Students impart educational skills and the knowledge in Chemistry in academia, research and industries .

Program Outcomes (POs):

- Discipline knowledge: Capable to apply knowledge of Chemistry and research to understand and solve the societal requirements.
- Solving of problems: Identify, analyse, interpret and develop solutions for problems related to Chemistry in Society.
- Design and execute chemical systems for different applications
- Apply hands-on training and research knowledge to conduct investigations, interpretation and formulation of solution.
- Application of advanced methodologies in synthesis and analytical techniques for finding solution in various domains.
- Acquire the information on the environmental issues and apply the knowledge to monitor and provide solutions to overcome.
- Able to work individually as well as in teams by institutionalizing the ethical values.
- Motivate for continuous learning and acquire updates in the field.

RAICHUR UNIVERSITY, RAICHUR

Distribution of Courses/Papers in Postgraduate Programme I to IV Semester as per Choice Based Credit System (CBCS) for Chemistry

M.Sc. I-SEMESTER

Semester No.	Paper Code	Title of the Paper	Marks			Teaching hours/week			Credit	Duration of SEE (Hrs)
			IA	SEE	Total	L	T	P		
FIRST	HCT11	Essentials of Inorganic Chemistry	20	80	100	4	-	-	4	3
	HCT12	Concepts in Organic Chemistry	20	80	100	4	-	-	4	3
	HCT13	Fundamentals of Physical Chemistry	20	80	100	4	-	-	4	3
	SCT11	Principles of Analytical Chemistry	20	80	100	4	-	-	4	3
	SCT12	Applied Analytical Chemistry	20	80	100	4	-	-	4	3
	SCT13	Environmental Chemistry	20	80	100	4	-	-	4	3
	HCP11	Inorganic Chemistry Practicals-I	10	40	50	-	-	4	2	4
	HCP12	Organic Chemistry Practicals – I	10	40	50	-	-	4	2	4
	HCP13	Physical Chemistry Practicals-I	10	40	50	-		4	2	4
Total Marks for I Semester					**550**				**22**	

M.SC. CHEMISTRY FIRST SEMESTER

Course Title: ESSENTIALS OF INORGANIC CHEMISTRY	**Course Code: HCT11**
Teaching Hours/Week (L-T-P): 4 - 0 - 0	**No. of Credits:** 04
Internal Assessment: 20 Marks	**Semester End Examination:** 80 Marks

Course Objectives:

1.	To refresh the chemistry knowledge learnt in UG programs and to introduce advanced concepts on related topics**.**
2.	Acquisition of skills in Inorganic Chemistry.
3.	To impart essential theoretical knowledge on atomic structure, periodic properties and chemical bonding.
4.	To develop the ability to correlate the chemical and physical properties of elements and their compounds with their positions in the periodic table.
5.	Understand the theories in Inorganic Chemistry

Unit	Description	Hours
1	**Review of periodic properties and theories of Bonding:** Review of periodic properties- Atomic size, ionization potential, and electron affinity and electro negativity. Ionic Bond: Radius ratio rules, types and structures of simple ionic compounds, lattice energy, Born-Lande equation, Kapustinskii equation, Size effects, polarizing power and polarizability of ions, Fajan's rules, solubility of ionic solids and hydration energy. Covalent Bond and Metallic Bond: VSEPR theory shapes of molecules-ClF_3, ICl_4^-, TeF_5-, I_3-, $TeCl_6^{2-}$, XeF_6, $SbCl^{3-}$, IF_7, XeF_8^{2-}, TaF_8^{3-}Concepts of hybridization, Energetics of hybridization, Bent rules and energetics of hybridization, partial ionic character, covalent-coordinate and multicentre bonding, M.O theory- LCAO approach, σ, δ and π molecular orbits. M.O treatment of homo nuclear and hetero nuclear diatomic molecules, Bond order in delocalized π- bonding systems, Ex: CO_3^{2-} NO_3^- and SO_3. Metallic bonding – electron sea model, VBT. Hydrogen Bonding	15hrs
2	**Structures and Energetics of Ionic Crystals and Covalent Bonds:** Ionic Bond: Properties of ionic compounds, crystal lattices, closed packed structures, coordination number of an ion, radius ratio rule, structures of crystal lattices- NaCl, CsCl, ZnS and rutile. Lattice energy: Born Lande equation, Born-Haber cycle, uses of Born-Haber type of calculations. Covalent character in ionic bonds, Fajan's rules, hydration	15hrs

	energy and solubility of ionic solids. Covalent Bond: Valence bond theory, resonance, hybridization and energetics of hybridization. VSEPR theory: Deduction of molecular shapes. MOT of homo and heteronuclear molecules and MO treatment for the molecules involving delocalized π- bonding (CO_3^{2-}, NO_3^- and CO_2). Walsh diagrams and Bent's rule.	
3	**Coordination Chemistry:** Coordination numbers 2 to 10 and their geometries. Crystal field theory of coordination compounds: octahedral, square planar, tetrahedral, trigonal bipyramidal and square pyramidal fields, measurement of 10 Dq and factors affecting it, CFSE, Spectrochemical series and Jahn-Teller effect. Structural evidences for ligand field splitting: hydration, ligation and lattice energies. Evidences for covalency in M-L bonding. MO theory of coordination compounds: MO energy level diagrams for octahedral and tetrahedral complexes without and with pi-bonding. Electronic Spectra: Spectroscopic ground terms, Orgel diagrams for transition metal complexes (Td &Oh). **Magnetism: Types, spin moment, spin-orbit coupling.**	15hrs
4	**Stability of Complexes and Acid-Base theory:** Stability of Metal Complexes, Concepts of Acids and Bases and Non-aqueous Solvents: Stability of complexes: Step-wise and overall formation constants, factors affecting stability of metal complexes, determination of stability constants of metal complexes by spectrophotometric and polarographic methods. Concept of acids and bases: Theories of acids and bases, Bronsted and Lewis acids and bases, Lux-Flood theory, leveling effect of solvents, hardness and softness, HSAB concept and its applications. Non-aqueous solvents: Classification of solvents, properties of non-aqueous solvents. Reactions in non-aqueous media: Liquid ammonia, anhydrous sulphuric acid, anhydrous HF, liquid sulphur dioxide. Super acids.	15hrs

References:

1. Inorganic Chemistry-Principles of Structure and Reactivity, 4thEdn J. E. Huheey, E.A. Keiter, R. L. Keiter and O.K. Medhi. Pearson Education (2009).
2. Shriver & Atkins' Inorganic Chemistry, 5th Edn-P. Atkins, Tina Overton, J. Rourke, 00 Mark Weller and F.Armstrong.Oxford University Press (2010)
3. Inorganic Chemistry, 2nd Edn. Catherine E. Housecroft and A.G. Sharpe, Pearson Prentice Hall (2005)
4. Concise Inorganic Chemistry-J. D. Lee, 5th Edn, New Age International (1996).

5. Chemical Applications of Group Theory, 2nd Edn-F. A. Cotton, Wiley Eastern Ltd ( ).
6. Symmetry and Spectroscopy of Molecules-K. Veera Reddy, New Age International, (2011).
7. Group Theory in Chemistry-M. S. Gopinathanan and V. Ramakrishnan, Vishal Publishing Co. (2007)
8. Organometallic Chemistry-A unified Approach, R.C. Mehrotra and A. Singh, 2nd Edn. New Age International (2011).
9. F.A.Cotton and G.Wilkinson : Advanced Inorganic Chemistry, Wiley, 1991.
10. Basic Organometallic Chemistry – B D Gupta and A J Elias, Universities Press (2013)

Course outcomes:

1.	Identify the nature of bonding exists between various elements.
2.	Apply fundamental chemical theories in interpretation of complex systems
3.	Interpret and apply the properties of s, p, d and f block elements for different applications.
4.	Apply the theories of acid base in Chemical reactions
5.	Explain selected crystal structures and the parameters that affect the crystal structure of a compound

Course Title: CONCEPTS IN ORGANIC CHEMISTRY	**Course Code: HCT12**
Teaching Hours/Week (L-T-P): 4 - 0 - 0	**No. of Credits:** 04
Internal Assessment: 20 Marks	**Semester End Examination:** 80 Marks

Course Objectives:

1.	To understand basic and fundamental theoretical aspects of organic chemistry.
2.	To study the nature of bonding and aromaticity in organic compounds.
3.	Evaluate the molecular geometry, hybridization and polarity of organic molecules.
4.	To acquire the knowledge of substitution reactions occurring in organic molecules.
5.	To understand electron delocalization and its effect on stability and reactivity

Unit	Description	Hours
1	**Basic Aspects of Organic Structures and Properties:** **Concept of hybridization**: sp, sp^2, sp^3 hybridization with examples, modified hybrid orbitals. **Electron delocalization and Resonance:** Delocalized electron in conjugated systems, resonance hybrid, resonance energy, stability of allylic and benzylic cations and radicals, effect of delocalized electrons on pK_a. **Aromaticity:** Concept of aromaticity, Huckel's rule, aromaticity of benzene, dienes, cyclopentadienyl anion, tropylium cation, cyclopropenyl cation, annulenes, azulene, heterocyclic compounds. Aromatic dications and dianions. Concept of homoaromatic, nonaromatic and antiaromatic compounds. **Aromatic Electrophilic Substitutions**: General mechanism in aromatic electrophilic substitution reaction, Nitration, Sulphonation, Halogenation, Friedel-Crafts alkylation and acylation, Diazo-coupling, Vilsmeir Hack reaction, Gatterman Koch reaction and their applications in organic synthesis. Energy profile diagrams. Orientation and reactivity. Effect of substituent's on aromatic ring system.	15hrs
2	**Intermediates and Substitution Reactions:** **Reactive intermediates:** Gnereation, structure, stability and reactivity of carbocations, carbanions, free radicals, carbenes, nitrenes, arynes, ylides (phosphorous and sulphur ylides) and enamines with representative examples. **Methods of determining reaction mechanisms**: Kinetic method, identification of products, detection of intermediates, study of catalysts, isotopic labeling, cross-over experiments and stereochemical evidences with suitable examples. **Aliphatic Nucleophilic Substitution**: The SN^1 SN^2, SN^i and SET	15hrs

	mechanisms. Classical and nonclassical carbocations, phenonium ions, norbornyl system, common carbocation rearrangements. Reactivity effects of substrate structure, attaching nucleophile, leaving group and reaction medium. **Electrophilic Substitution**: SE1 and SE2 Mechanism and stereochemistry, electrophilic substitution accompanied by double bond shifts. Effect of substrates, leaving group and the solvent polarity on the reactivity.	
3	**Addition And Elimination Reactions:** **Addition Reactions:** Addition to carbon-carbon and carbon-hetero atom multiple bonds. Addition involving electrophiles, nucleophiles and free radicals, concerted addition. Mechanism, orientation and stereochemistry of addition reactions. Addition of hydrogen halides to alkenes. Addition of HCN, bisulphate, Grignard reagent, hydride, amino compounds, alcohols and thioalcohols to C=O. Acid catalyzed hydration and related addition reactions. **Elimination Reactions:** E_1, E_2 and E_{1CB} reactions, regioselectivity in β-elimination reactions (orientation of π-bonds), and stereochemistry requirement in β-elimination reactions. Saytzeff and Hoffmann rules, elimination vs substitution, E_1, E_2 and E_{1CB} comparative study, 1,1-elimination (α-elimination) - dehalogenation of vicinal dihalides, elimination reactions without involving hydrogen like dehalogenations and related reactions decarboxylative eliminations. Pyrolytic eliminations; Chugaev and Cope eliminations.	15hrs
4	**Stereochemistry:** **Stereoisomerism:** Introduction, molecular structure – projection formulas (Fischer, Newmann, Sawhorse and Flying wedge), interconversion of projection formulas. Molecular symmetry and symmetry elements. Chirality and steroisomerism. Enatiomers, diastereomers, epimers, anomers (definition and examples). Racemic mixture, Racemisation involving - carbonanion, carbocation as intermediates, Walden inversion, rotation about carbon-carbon single bond. Resolution (racemic modification) – mechanical separation, preferential crystallization, biochemical, chemical and chromatographic method. D,L-configuration threo, erythro – configuration. R,S-nomenclature for isomers with more than one chirality centre. **Optical isomerism**: Conditions for optical isomerism: Elements of symmetry-plane of symmetry centre of symmetry, alternating axis of symmetry (rotation-reflection symmetry). **Optical isomerism due to**	15hrs

	molecular dissymmetry: Eg. allenes, spiranes, biphenyls, alkylidine and cycloalkanes. **Geometrical isomerism**: Due to C=C, C=N and N=N bonds, *E*, *Z* conventions, determination of configuration by physical and chemical methods. Geometrical isomerism in cyclic systems.	

References::

1. Organic Chemistry, J. Clayden, S. Warren, N. Greeves, P. Wothers, 1st Edition, Oxford University Press, UK, 2001.
2. Organic Chemistry – Solution Mannual, S. Warren, Oxford University Press, UK, 2009.
3. Advanced Organic Chemistry, Part-A: Structure and Mechanisms, 5th Edition, Francis A. Carey, Richard J. Sundberg, Springer, New York, 2007.
4. Principles of Organic Synthesis, R.O.C. Norman, J.M. Coxon, 3rd Edition (First Indian Reprint), Nelson Thrones, UK, 2003.
5. Advance Organic Chemistry – Reactions, mechanisms and structure, Jerry March, 4th Edition, Wiley India Pvt. Ltd., New Delhi, 2008.
6. Organic Reaction Mechanisms, V.K. Ahluwalia, R.K. Parashar, 3rd Edition, Narosa Publishing House, New Delhi, 2009.
7. Pathway to Organic Chemistry – Structure and Mechanism, P. Bhattacharjee, Arunabha Sen Books and Allied Pvt. Ltd., Kolkta, India, 2012.
8. Organic Chemistry, Paula Yurkanis Bruice, 3rd Edition, Pearson Education, Sai Printo Pack Pvt. Ltd., New Delhi, India, 2007.
9. Organic Chemistry (As per UGC Syllabus), S.M. Mukherji, S.P Singh, R.P. Kapoor, R. Dass, Vol. I, New Age International Pvt. Ltd., New Delhi, 2010.
10. Stereochemistry of Organic Compounds – Principles and applications, D. Nasipuri, Revised 2nd Edition, New Age International Pvt. Ltd., New Delhi, 2009.
11. Organic Reactions and their Mechanisms, P.S. Kalsi, 2nd Edition, New Age International Pvt. Ltd., New Delhi, 2007.
12. Organic Chemistry, Solomons, Fryhle, 8th Edition (Wiley Student Edition), Brijbasi Art Press Ltd., Noida, India 2004.
13. Organic Chemistry, G. Marc Loudon, 4th Edition, Oxford University Press, UK, 2000.
14. Organic Chemistry, R.T. Morrison, R.N. Boyd, 6th Edition, Pearson Education (Singapore Pvt. Ltd.), Delhi, Indian, 2005.
15. Organic Chemistry, L.G. Wade, JR., 5th Edition, Pearson Education (Singapore Pvt. Ltd.), Delhi, Indian, 2004.
16. Organic Chemistry, M.A. Fox, J.K. Whitesell, 2nd Edition, Jones and Bartlett Publishers, Sudbury, Massachusetts, London, 1997.
17. Organic Chemistry, M. Jones, Jr., 2nd Edition, W.W. Norton and Company, New York, 2000.
18. Organic Chemistry, Francis A. Carey, 5th Edition, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2004.
19. Modern Methods of Organic Synthesis, W. Carruthers, 3rd Edition, Cambridge University Press, UK, 2004.

course outcomes:

1.	Acquire the basic and fundamental aspects of organic chemistry reactions.
2.	Interpret the molecular geometry, hybridization and polarity of organic molecules
3.	Recognize the existence of stereoisomerism and conformational analysis
4.	Capable to predict the mechanism of substitution reactions
5.	Apply the knowledge in nomenclature, identification of organic compounds

Course Title: FUNDAMENTALS OF PHYSICAL CHEMISTRY	Course Code: HCT13
Teaching Hours/Week (L-T-P): 4- 0 - 0	**No. of Credits:** 04
Internal Assessment: 20 Marks	**Semester End Examination:** 80 Marks

Course objectives:

1.	To understand physical phenomenas like Chemical thermodynamics and Chemical kinetics.
2.	To study the nature of kinetics of reactions and electrochemical reactions.
3.	Evaluate the basics and applications chemical thermodynamics.
4.	To acquire the knowledge of catalysis and electrochemistry in solution state.
5.	To understand basics of corrosion, corrosion control and its applications,

Unit	Description	Hours
1	**Quantum Chemistry:** A brief review of black body radiation, Photoelectric effect, Compton effect, de-Broglie's hypothesis, Heisenberg's uncertainty principle., Concept of operator - Addition, Subtraction, Multiplication of operators, Commutative, Linear, Del, Hermitian operators and their properties , Hamiltonian operators, Eigenvalue and Eigen function. Postulates of quantum mechanics Schrödinger wave equation - wave function and its interpretation, Pauli Exclusion Principle, elementary application to a particle in one dimensional box, particle in a ring and hydrogen atom. One dimensional harmonic oscillator. Conditions for orthogonality and normalization of wave functions, Kroneckers delta.	15hrs
2	**Electro and Supramolecular Chemistry:**Activity and Activity co-efficient, mean activity co-efficient, Debye-Huckle limiting law (qualitative aspect only) and assumptions. Ionic strength, thickness of ionic atmosphere. Concept of acids and bases, buffer action and capacity. Buffer solutions. Handerson Hassalback equation (quantitative) and its application in preparation of buffer. Importance of buffer in biological system. **Supramolecular Chemistry** Definition of supramolecular chemistry. Nature of binding interactions in supramolecularstructures ion-ion, ion-dipole, dipole-dipole, H-bonding, van der Waals interactionsroleof H-bonding and other weak interactionsSelf-assembly molecules:,	15hrs

	catenanes and rotaxanes (qualitatives)	
3	**Polymer Chemistry:** Basic definitions, classification of polymers, Monomer, Repeat units, Linear, Branched, Cross Linked, Straight, Copolymers. Degree of polymerization. Molecular weight-Average molecular weight concepts, Number Average, Weight Average, Viscosity Average molecular weights. Determination of molecular weights, Osmotic pressure method, viscosity method, light scattering (Debye and Zimm plots), Ultra centrifugation method, polydispersity, molecular weight distribution. Definition of glass transition and melting point and their relationships. Factors effecting Tg value, Applications of Polymers.	15hrs
4	**Chemical Kinetics and Thermodynamics:** A brief review of basic concepts and terminology in reaction kinetics. Methods of determining rate laws. Steady state approximation, Arrhenius equation. Collision state theory for bimolecular reaction rates, Transition state theory. Comparison between collision and transition state theories. Lindemann and RRKM theories of unimolecular reaction rates. Concepts and significance of energy of activation. **Dynamics in solution**: Ionic reactions, effect of ionic strength. Primary and secondary salt effects. Dynamics of Fast reactions, Relaxation methods, Flow methods (stopped flow and plugged flow), Flash photolysis methods. Reviews on laws of thermodynamics. Maxwell's relation. Fugacity and its variation withtemperature.	15hrs

References:

1. Molecular Quantum Chemistry P.W Atkins
2. Problems in Quantum Mechanics by G. L. Squires.
3. Introduction to Quantum Chemistry by A. K. Chandra, 4th Edn. TMHNew Delhi.
4. Valence by C. A. Coulson.
5. Physical Chemistry by P. W. Atkins, ELBS London 1990.
6. Quantum Chemistry by Ira N. Levine, Prentiss Hall of India, New Delhi, India.
7. Quantum Chemistry by R. K. Prasad.
8. Electrochemistry by S. Glasstone.
9. Modern Electrochemistry by S. Bockris and A K N Reddy, Vol. 1 and 2,Butterworth London, 2006.
10. Thermodynamics by L. M. Koltz and R. M. Rosenberg.
11. An introduction to Chemical Thermodynamics by R. P. Rastogi and S. S. Mishra,Vikas Publishing house Pvt limited, New Delhi.

12.Chemical Kinetics by K. J. Laidler, Pearson edition.
13.Polymer science by Gowrikar, New Age Pvt Limited publishers, Chennai.
14.Polymer chemistry by Flory.
15. Polymer chemistry by A. Tager.
16. Introduction to polymer chemistry Billmayer(Jr).
17. J.-M. Lehn; Supramolecular Chemistry-Concepts and Perspectives (Wiley-VCH,1995
18. P. D. Beer, P. A. Gale, D. K. Smith; Supramolecular Chemistry (Oxford UniversityPress, 1999

Course outcomes:

1.	Able to analyse Thermodynamic aspects as well as kinetics of reactions.
2.	Evaluate the kinetics of chemical reactions with step wise mechanisms
3.	Able to determine the thermodynamics parameters of ideal and non ideal solutions
4.	Integrate the knowledge of catalysis, multilayer adsorption and surface reactions
5.	Interpret the electrochemical behaviour in solution state and surface
6.	Analyse and solve the problems in corrosion process

Course Title: PRINCIPLES OF ANALYTICAL CHEMISTRY	**Course Code: SCT11**
Teaching Hours/Week (L-T-P): 4- 0 - 0	**No. of Credits:** 04
Internal Assessment: 20 Marks	**Semester End Examination:** 80 Marks

Course objectives:

1.	To understand the concepts of classical methods of analysis like titirmetry, gravimetry.
2.	To gain knowledge of purity and separation techniques
3.	To acquire basics of electroanalytical techniques
4.	To inculcate the skills for chemical analysis and treatment of data

Unit	Description	Hours
1	**Introduction to Analytical Chemistry** Definition and scope of Analytical Chemistry, Importance of Analytical Chemistry in various fields Types of analytical techniques: Classical vs. Instrumental. **Errors and Treatment of Analytical Data:** Classification of errors- determinate and indeterminate errors, minimization of errors. Limitations of analytical methods. **Random errors:** sources, distribution, and the normal curve. Accuracy and precision. **Statistical treatment of finite samples:** measures of central tendency and variability (mean, median, range, standard deviation, and variance). Student's t-test, confidence interval of mean, F-test, t-test, paired t-test, Q-test. Control charts. Propagation of errors, significant figures. Least square method of deriving calibration plots. Correlation and regression. Detection limits. **Sampling and sample handling principles:** sampling step, methods for solid, liquid, and gaseous samples. **Need for quality assurance:** Good laboratory practices (GLP), ISO guide 25, and significance of six sigma concepts.	15hrs
2	**Separation Techniques:** Introduction, Classification of separation techniques and chromatographic techniques. Theories, plate theory, rate theory, band broadening-eddy diffusion, longitudinal diffusion and resistance to mass transfer, column efficiency, Van Deemter's equation and its modern version, interrelationships, capacity factor, selectivity factor, column resolution, distribution constant **Solvent extraction:** General discussion, principles, factors affecting solvent extraction, quantitative treatment, extraction reagents, practical considerations, automation, and applications.	15hrs

	Paper and thin layer Chromatography: General principles and mechanism, classification of chromatographic methods-paper, thin layer, column and liquid chromatography. Selection of stationary and mobile phases, preparation of micro and macro plates, development, spray reagents, identification and detection, reproducibility of Rf values, qualitative, quantitative analysis and applications of TLC. **Ion Exchange methods**: Introduction, definitions, principles, cation exchangers, anion exchangers, regeneration, ion exchange columns, batch method, column method, and applications. **Column chromatography:** Principle, Criteria for the selection of adsorbents and mobile phase, characteristics of adsorbents, Preparation of column and applications	
3	**Titrimetric analysis:** **Acid base titrations:** Principle, role of solvent in acid-base titrations, effect of concentration. Titration curves for strong acid-strong base, weak acid – strong base, weak base –strong acid, polyprotic acids, poly equivalent bases, determination of equivalence point – theory of acid base indicators, and colour change range of indicators. Applications for nitrogen, nitrates and carbonates. **Oxidation –Reduction Titrations:** Redox process-balancing redox equations, titration curves. Redox indicators, detection of end point, visual indicators and potentiometric end point detection. Quantitative applications-adjusting the analyte's oxidation state, determination of chemical oxygen demand (COD) in natural and waste waters and other applications. Titrations of mercaptans and ascorbic acid with I_3^- and titration of organic compounds using periodate. **Precipitation Titration:** Principle, Formation constant, Indicators, Mohr's, Volhard and Fajan's method, Applications **Complexometric Titrations:** Introduction, a simple complexation titration, titration curves, types of EDTA titrations, titrations of mixtures, selectivity, masking and demasking agents, metal ion indicators, some practical considerations. **Organic Reagents in Inorganic Analysis:** Organic precipitants, general properties, reagents asprecipitants.	15hrs
4	**Electroanalytical Techniques** **Potentiometry:** Basic principles, types of electrodes (reference electrodes, glass electrodes, membrane electrodes), applications. **Conductometry:** Theory, measurements of conductivity, conductometric titrations, applications. **Coulometry:** Basic principles, constant current and control potential Coulometry, applications. **Voltammetry:** Polarography theory, dropping mercury electrode, quantitative applications, measurement of wave heights, pulse polarography, rapid scan polarography, stripping voltammetry, cyclic voltammetry.	15hrs

	Amperometry: Pricnciples, amperometric titrations with examples. Biamperometry. **Electrogravimetry:** Theory, completeness and nature of the deposit, instrumentation, electrolytic separation of metals and applications.	

References:

1. Fundamental of Analytical Chemistry, D.A. Skoog, D.M. West, Holler and Crouch, 8th edition, 2005, Saunders College Publishing, New York.
2. Analytical Chemistry, G.D. Christian, 5th ed., 2001 John Wiley & Sons, Inc, India.
3. Quantitative Analysis, R.A. Day and A.L. Underwood, 6th edition, 1993 Prentice Hall, Inc. New Delhi.
4. Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R.C. Denney, J.D. Barnes and M.J.K. Thomas, 6th edition, Third Indian Reprint. 2003 Pearson Education Pvt. Ltd., New Delhi.
5. Analytical Chemistry Principles, John H. Kennedy, 2nd edition, Saunders College Publishing, California, 1990.
6. Instrumental Methods of Chemical Analysis, Chatwal and Anand, 5th Edn.
7. Chromatography, E. Heftman (ed). 5th Edition, Part A. and Part B. Elsevier Science Publishers, 1992.
8. Chromatography Today, C. F. Poole & S. K. Poole, Elsevier Science Publishers (1991).
9. Analytical Chemistry by Alka L. Guptha, A, Pragathi edition. Fourth edition.
10. Separation Methods by M. N. Sastri, Himalaya Publisher.
11. Modern Analytical Chemistry, Harvey, Harcourt Publishers.
12. An Introduction to Chromatography: Theory and Practical, V. KSrivastav and K. K. Srivastav.
13. Instrumental Methods of Chemical Analysis, Gurudeep R Chatwal, Sharma K Anand. Himalaya publishers.
14. Chromatography by B. K. Sharma, GOEL publishers.
15. Basic Concepts of Analytical chemistry, S. M. Khopakr, New Age International publications, 3rd edition.

Course outcomes:

1.	Apply basic analytical methods for chemical analysis
2.	Evaluate and treat the analytical data
3.	Apply the separation techniques in separation and purification
4.	Design and interpret the analytical data

Course Title: APLLIED ANALYTICAL CHEMISTRY	Course Code: SCT12
Teaching Hours/Week (L-T-P): 4- 0 - 0	**No. of Credits:** 04
Internal Assessment: 20 Marks	**Semester End Examination:** 80 Marks

Course objectives:

1.	To understand the applications of analytical chemistry.
2.	To gain knowledge on environmental analysis, pharmaceutical analysis
3.	To inculcate the skills for chemical analysis

Unit	Description	Hours
1	**Environmental Analysis:** Analytical techniques for environmental monitoring,studies on air, water, and soil analysis, Regulatory aspects and compliance.Chemical and physical examination and measurement of quality of water, chemical substances affecting portability, odour, taste, temperature and electrical conductivity of water, suspended and dissolved solids, acidity and alkalinity of water, free carbon dioxide and chlorine. Chlorine demand. Analysis of calcium, magnesium, iron, manganese, silver and zinc in water. Determination of ammonia, nitrate cyanide, sulphate and fluoride. Determination of arsenic, beryllium, chromium, lead, selenium and mercury	15hrs
2	**Pharmaceutical Analysis:** Application of analytical chemistry in the pharmaceutical industry, Quality control and assurance, Drug formulation analysis **Clinical and Biochemical Analysis:** Composition of blood collection, and preparation of samples, clinical analysis – serum electrolytes, blood glucose, blood urea nitrogen , uric acid , albumin , globulin , barbiturates, acidic and alkaline phosphates, Immunoassay , principles of radioimmunoassay and applications . **Blood analysis**: trace elements in the body. Applications in clinical laboratories, Analysis of biomarkers and diagnostic substances, Biochemical analysis techniques.	15hrs
3	**Food and Beverage Analysis:** Detection and determination of sugars and starch. Methods for protein determination. Oils and fats and their analysis – iodine value, saponification value and acid value. Rancidity - detection and determination (peroxide number). Tests for common edible oils. Analysis of foods for minerals - phosphorus, sodium, potassium and calcium. General methods for the determination of moisture, crude fibre and ash contents of food. Analysis of milk for fat and added water. **Non-alcoholic beverages**: determination of chicory and caffeine in coffee;	15hrs

	caffeine and tannin in tea. Alcoholic beverages -methanol in alcoholic drinks and chloral hydrate in toddy. **Food additives**: chemical, preservatives - inorganic preservatives - sulphur dioxide and sulphites, their detection and determination. Organic preservatives - benzoic acid and benzoates, their detection and determination. Flavouring agents - detection and determination of vanilla and vanillin. Colouring matters in foods - classification, certified colours, detection of water soluble dyes, colour in citrus fruits, beet dye in tomato products, mineral colour. Pesticide residues in foods - determination of chlorinated organic pesticides.	
4	**Chemical analysis in Industries:** Parameters of analysis of the end products in the pharmaceutical industries, Different Experimental methods used in the analysis of following drugs: aspirin, nimesulide, metformin, andglimepiride. **Drug analysis:** Narcotics and dangerous drugs, classification of drugs, screening by gas and thin layer chromatography and spectrophotometric analysis. **Techniques for optimizing industrial processes:** Principles of quality control in manufacturing, Statistical tools for quality assurance. Application of analytical chemistry in ensuring product quality, Overview of sensors used in industrial processes, Automation and its role in analytical chemistry	15hrs

References:

1. Hage, P., &Carr, J. Analytical Chemistry: Principles and Techniques. (Latest edition).
2. Skoog, D. A., Holler, F. J., & Crouch, S. R. (Year). Principles of Instrumental Analysis. (Latest edition).
3. Schwarzenbach, R. P., Fenter, P. R. B., & Hofstetter, T. B. Environmental Analytical Chemistry. (Latest edition).
4. Baird, C., &Cann, M. Environmental Chemistry. (Latest edition).
5. Watson, D. G. (Year). Pharmaceutical Analysis: A Textbook for Pharmacy Students and Pharmaceutical Chemists. (Latest edition).
6. Nielsen, S. S. Food Analysis. (Latest edition).
7. Belitz, H.-D., Grosch, W., &Schieberle, P. (Year). Food Chemistry. (Latest edition).
8. Bishop, M. L., Fody, E. P., &Schoeff, L. E. Clinical Chemistry: Techniques, Principles, Correlations. (Latest edition).
9. Skoog, D. A., Holler, F. J., & Crouch, S. R. (Year). Process Analytical Chemistry. (Latest edition).
10. Fundamental of Analytical Chemistry, D.A. Skoog, D.M. West, Holler and Crouch 8th edition, 2005, Saunders College Publishing, New York.
11. Analytical Chemistry, G.D. Christian, 5th ed., 2001 John Wiley & Sons, Inc, India.
12. Quantitative Analysis, R.A. Day and A.L. Underwood, 6th edition, 1993 Prentice Hall, Inc. New Delhi.
13. Vogel's Textbook of Quantitative Chemical Analysis, J. Mendham, R.C. Denney, J.D. Barnes and M.J.K. Thomas, 6th edition, Third Indian Reprint.2003 Pearson Education Pvt.

Ltd., New Delhi.
14. Analytical Chemistry Principles, John H. Kennedy, 2nd edition, Saunders College Publishing, California, 1990.
15. Instrumental Methods of Chemical Analysis, Chatwal and Anand - 5th Edn.
16. Chromatography, E. Heftman (ed). 5th Edition, Part A. and Part B. Elsevier Science Publishers, 1992.
17. Chromatography Today, C. F. Poole & S. K. Poole, Elsevier Science Publishers (1991).
18. Analytical chemistry by Alka L. Guptha, A pragathi edition.
19. Separation methods by M. N. Sastri, Himalaya publisher.
20. Modern analytical chemistry, Harvey, Harcourt publishers.

Course outcomes:

1.	Apply basic analytical methods for chemical analysis
2.	Able to understand the applications in environmental and pharmaceutical analysis
3.	Design and interpret the analytical data

Course Title: ENVIRONMENTAL CHEMISTRY	Course Code: SCT13
Teaching Hours/Week (L-T-P): 4- 0 - 0	**No. of Credits:** 04
Internal Assessment: 20 Marks	**Semester End Examination:** 80 Marks

Course objectives:

1.	To understand the environment and its importance.
2.	To gain knowledge on environmental sample analysis
3.	To understand the theory and importance of environmental pollution
4.	To inculcate the skills for chemical analysis and treatment of data

Unit	Description	Hours
1	**Introduction to Environmental Chemistry:** Environmental Compounds and their Characteristics, Chemical Equilibria in Environmental Systems, pH and Redox Potential in Environmental Chemistry, Chemical Kinetics in Environmental Systems. **Water Analysis:** Water Quality Parameters and Standards,Safe drinking water, public health significance and measurement of colour, turbidity, total solids, acidity, alkalinity, hardness, sulphate, fluoride, phosphate and different forms of nitrogen in natural and polluted water, Methods for Water Quality Analysis, Analysis of Heavy metals such as Pb, Cd, Cr, Hg, As, Cu, Zn and Mn in Water, Nutrient Analysis in Water Samples. **Air Analysis:** Air Quality Parameters and Standards, Sampling and Analysis of Air Pollutants, Gas Chromatography in Air Quality Monitoring, Particulate Matter Analysis. .	15hrs
2	**Soil and Sediment Analysis:** Soil and Sediment Characteristics, Soil Sampling and Sample Preparation, Analysis of Soil Contaminants (Heavy Metals, Organic Compounds), Methods for Sediment Analysis. **Biomonitoring and Bioanalytical Techniques:** Introduction to Biomonitoring, Biological Indicators in Environmental Analysis, Bioanalytical Techniques (Enzyme Assays, Immunoassays) in Environmental Monitoring, Significance and measurement of DO, BOD, COD, TOD, and TOC, phenols, pesticides, surfactants and tannin and lignin as water pollutants and their determination. **Forensic analysis:** General discussion of poisons with special reference to	15hrs

	mode of action of cyanide, organophosphates and snake venom. Estimation of poisonous materials such as lead, mercury and arsenic in biological materials.	
3	**Quality Assurance and Quality Control (QA/QC):** QA/QC Principles in Analytical Chemistry, Calibration and Standardization, Method Validation and Verification, Data Quality Assessment and Reporting **Emerging Trends in Environmental Analysis:** Green Analytical Chemistry, Sensors and Biosensors for Environmental Monitoring, Remote Sensing and GIS Applications in Environmental Analysis. **Case Studies and Practical Applications:** Case Studies in Environmental Analysis, Interpreting Analytical Results in Real-world Context, Ethical Considerations in Environmental Analysis	15hrs
4	**Overview of Analytical Chemistry:** Techniques and Applications, Importance of Analytical Chemistry in Environmental Sciences, Sampling Techniques in Environmental Analysis, Basics of Environmental Sampling and Sample Preparation. **Instrumental Analysis Techniques:** Chromatographic Techniques (GC, HPLC) and their principles, theory and Applications, Mass Spectrometry in Environmental Analysis, Atomic Spectroscopy (AAS, ICP-MS) and its Applications, Introduction to NMR Spectroscopy in Environmental Chemistry.	15hrs

References:

1. Quantitative Chemical Analysis by Daniel C. Harris (Publisher: W. H. Freeman; Year: 2015)
2. Environmental Chemistry by Colin Baird and Michael Cann (Publisher: W. H. Freeman; Year: 2012)
3. Principles of Instrumental Analysis by Douglas A. Skoog, F. James Holler, and Stanley R. Crouch (Publisher: Cengage Learning; Year: 2017)
4. Environmental Analysis by Kenneth A. Hunter (Publisher: CRC Press; Year: 1998)
5. Analytical Chemistry: An Introduction by Douglas A. Skoog, Donald M. West, F. James Holler, and Stanley R. Crouch (Publisher: Cengage Learning; Year: 2013)
6. Environmental Analytical Chemistry by René P. Schwarzenbach, Philippe R. B. Fenter, and Thomas B. Hofstetter (Publisher: John Wiley & Sons; Year: 1999)
7. Introduction to Environmental Chemistry by Julian E. Andrews, Peter Brimblecombe, and Tim D. Jickells (Publisher: Wiley; Year: 2004)
8. Analytical Chemistry for Technicians by John Kenkel (Publisher: CRC Press; Year: 2017)
9. Handbook of Environmental Analysis: Chemical Pollutants in Air, Water, Soil, and Solid Wastes by Pradyot Patnaik (Publisher: CRC Press; Year: 1997)
10. Environmental Chemistry: A Global Perspective by Gary W. VanLoon and Stephen J. Duffy (Publisher: Oxford University Press; Year: 2019)
11. Environmental Monitoring Handbook by Frank R. Spellman and Nancy E. Whiting

(Publisher: McGraw-Hill Education; Year: 2004)
12. Analytical Chemistry in a GMP Environment: A Practical Guide by James M. Miller and Jonathan B. Crowther (Publisher: Wiley; Year: 2005)
13. Introduction to Environmental Engineering and Science by Gilbert M. Masters and Wendell P. Ela (Publisher: Pearson; Year: 2008)
14. Practical Environmental Analysis by Jerry A. Nathanson and Donald A. Sweitzer (Publisher: Wiley; Year: 1998)
15. Analytical Chemistry in a Changing World by D. W. Oxtoby, H. P. Gillis, and L. J. Butler (Publisher: W. H. Freeman; Year: 1991)

Course outcomes:

1.	Apply basic analytical methods for environmental sample analysis
2.	Evaluate and treat the analytical data
3.	Design and interpret the analytical data
4.	Able to handle and interpret the various environmental analysis techniques

Course Title: INORGANIC CHEMISTRY PRACTICALS-I	**Course Code: HCP11**
Teaching Hours/Week (L-T-P): 0 - 0 - 4	**No. of Credits:** 02
Internal Assessment: 10 Marks	**Semester End Examination:** 40 Marks

Course objectives:

1.	Hands-on training for quantitative estimation using volumetric and gravimetric analysis.
2.	Understand the importance of determination of common metallic traces affecting the biological system.
3.	Understand and appreciate common useful methods of detection of traces of elements.

List of Experiments: **60 hrs**

1.	Semimicro qualitative inorganic analysis of a mixture. Mixture containing three cations and three anions including one less common cations such as Mo, Ti, Zr, Ce, V and Li and one interfering anion.
2.	Analysis of sodium carbonate and sodium bicarbonate in baking soda by acid- base titration.
3.	Determination of acid content of vinegar.
4.	Preparation of hexamine nickel (II) chloride complex.

Books Recommended:

1.	Chemical Semi micro analysis- V.N.Alexeyev Mir Publishers (Mascow)
2.	Vogel's Qualitative Inorganic analysis, Revised by G.Suchla Longarman group ltd.
3.	Vogel's Text book of Quantitative Inorganic Analysis – J.Basett, R.C.Denney, G.H.Jeffery and J.Mendhaman, Longamans Green and Company Ltd.
4.	Advanced Inorganic Analysis by Agarwal and Keemtilal, A Pragati Edition, Eleventh Revised edition, 2011.

Course Outcomes:

1.	Analyse binary and complex mixtures of metallic ions by volumetric and gravimetric methods
2.	Design procedure for the quantification of inorganic compounds in various samples
3.	Identification of different radicals
4.	Interpret the analytical data to comply with regulatory standards

Course Title: ORGANIC CHEMISTRY PRACTICALS-I	**Course Code: HCP12**
Teaching Hours/Week (L-T-P): 0- 0 - 4	**No. of Credits:** 02
Internal Assessment: 10 Marks	**Semester End Examination:** 40 Marks

Course objectives:

1.	Expose to simple synthetic procedures in the laboratory.
2.	Correlate theoretical concepts for preparing, purifying, and identifying organic molecules.
3.	Comply with safety rules in conducting laboratorial experiments.
4.	To identify the components through various steps, derivative preparation, checking the purity of components.

List of Experiments: **60 hrs**

1.	**Qualitative analysis** Systematic separation of organic binary mixtures of solid type using chemical and physical methods. At least six experiments from the following combinations, Acid + Phenol Phenol + Base Base + Neutral Acid + Base Phenol + Neutral Acid + neutral

References:

1.	Advanced Practical Organic Chemistry, N K Vishnoi , Second edition, Vikas Publishing House Pvt. Ltd, 1996
2.	Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis
3.	Renu Aggarwal, V. K. Ahluwalia, Universities press (India), 2001
4.	Systematic Laboratory Experiments in Organic Chemistry, Arun Sethi, New Age International, 2003.
5.	Comprehensive Practical Organic Chemistry: Qualitative Analysis, Ahluwalia V.K. Sunitha Dhingra, First edition, Orient Longman, 2004
6.	Practical Organic Chemistry: Qualitative Analysis, Bhutani S.P. Chhikara A, First edition, ANE books-new Delhi, 2009
7.	Vogel's Textbook of Practical Organic Chemistry, Brian S. Furniss, 5th Edition, Pearson India, 2005.
8.	Laboratory techniques in Organic chemistry, V.K. Ahluwalia , Pooja Bhagat & Renu

	Aggarwal, I.K. International Publishing House Pvt.Ltd.
9.	Laboratory Manual of Organic Chemistry, Raj K. Bansal. 5th edition, New Age international, 2008

Course outcomes:

1.	Analyse and separate complex organic mixtures
2.	Design experimental approach for purification of organic compounds
3.	Develop methodology for synthetic reaction and characterization
4.	Hands on training in determining melting point , boiling point, TLC etc

Course Title: PHYSICAL CHEMISTRY PRACTICALS-I	**Course Code: HCP13**
Teaching Hours/Week (L-T-P): 0- 0 - 4	**No. of Credits:** 02
Internal Assessment: 10 Marks	**Semester End Examination:** 40 Marks

Course objectives:

1.	Study Kinetics of chemical reactions
2.	To understand varied solvents interaction by phase formation mechanism
3.	Analysis of samples using conductometric techniques

List of Experiments: **60 hrs**

1.	Study of kinetics of hydrolysis of an ester using HCl/H_2SO_4 at two different temperatures, determination of rate of constants and energy of activation.
2.	Study of kinetic reactions between $K_2S_2O_8$ and KI, first order, determination of rate constants at two different temperatures and Energy of activation.
3.	Conductometric titration of mixture of HCl and CH_3COOH against NaOH.
4.	Conductometric titration of mixture of HCl and CH_3COOH and $CuSO_4$ against NaOH.
5.	Conductometry-To determine the degree of hydrolysis and hydrolysisconstant of aniline hydrochloride.
6.	Conductometric titration of potassium iodide with mercuric perchlorate.
7.	Phase diagram for Three component liquid system, acetic acid, benzene and water.
8.	Kinetics of dissociation of trichloroacetic acid

References:

1.	Experimental Physical Chemistry: A Laboratory Textbook, A. Halpern & G. McBane III Ed. W. H. Freeman (2006)
2.	Practical Physical Chemistry- A.J.Findlay (2007).
3.	Experimental Physical Chemistry-F.Daniel et el (2006).
4.	Selected Experiments in Physical Chemistry- Latham (1974).
5.	Experimental Physical Chemistry- Janes and Parichard 3rd edition (1974).
6.	Experimental Physical Chemistry- Shoemaker 5th edition (1989).
7.	Experimental Physical Chemistry- Yadav, Goel Publishing House.
8.	Experimental Physical Chemistry- Das R.C and Behera B., Tata Mc Graw Hill.

Course outcomes:

1.	Skills in analysis of physical properties of materials and reactions
2.	Analyse and interpretation of physical properties
3.	Designing of methods for ionic substances
4	Evaluate the kinetics of reaction