Central University of Punjab, Bathinda

M.Sc. Chemistry
(Specialization: Applied Chemistry)

Session: 2019-21

Department of Chemistry

Program Outcomes

Department of Chemical Sciences was established in Jul, 2015. The department offers M.Sc. Chemistry, M.Sc. Chemistry (Specialization: Applied Chemistry) and Ph.D. in Chemistry.
Upon successful completion of the graduate program student should achieve the following

- Demonstrate an understanding and applications of major concepts in all disciplines of chemistry.
- Instrumentation in chemistry and its application in proof of scientific concepts at an advanced level.
- Design and execute experiments with proper use of good laboratory practices and proper handling of waste generated in the laboratory.
- Critical think and design, carry out, record and analyze the results of chemical experiments as per the industrial and scientific quality standards.
- Work effectively in group across disciplines and should be able to lead in chemical perspective on Environment and Industry.
- Identify, formulate research out literature and analyze complex problems reaching substantial conclusions using principles of chemical sciences

SEMESTER 1

S. No.	Paper Code	Course Title	Course Type	L	T	P	Cr
1	CHM.506	Fundamental Biology (Non-medical group)	CF	2	-	-	2
	CHM507	Fundamental Mathematics (Medical group)					
2	CHM.508	Analytical Chemistry and Instrumental Methods	CF	3	-	-	3
3	CHM.509	Inorganic Chemistry-1	CC	3	-	-	3
4	CHM.510	Organic Chemistry-I	CC	3	-	-	3
5	CHM.511	Physical Chemistry-I	CC	3	-	-	3
6	CHM.512	Quantum Chemistry	CC	3	-	-	3
7	CAC.513	Applied Practical Inorganic Chemistry-1 (P)	CC	-	-	4	2
8	CAC.514	Applied Practical Organic Chemistry-I (P)	CC	-	-	4	2
9	XXX	Inter-Disciplinary Course (ID) (Opt any one from other Departments)	EC	2	-	-	2
10.	CAC.541	Seminar	EC	1			1
		Total		**20**	**0**	**8**	**24**

CC: Core Course, **EC**: Elective Course,**CF**: Compulsory Foundation

L: Lectures T: Tutorial P: Practical Cr: Credits

Mode of Transaction: Lecture, Demonstration, Lecture cum demonstration, Dialogue Mode, Experimentation, Brain storming, Problem solving, Seminar.

SEMESTER 2

S. No.	Paper Code	Course Title	Course Type	L	T	P	Cr
1	CHM.521	Inorganic Chemistry-II	CC	3	-	-	3
2	CHM.522	Organic Chemistry-II	CC	3	-	-	3
3	CHM.523	Physical Chemistry-II	CC	3	-	-	3
4	CHM.524	Spectroscopic Analysis	CF	3	-	-	3
5.	CHM.525	Molecular Spectroscopy	CC	3	-	-	3
6	CAC.526	Applied Practical Inorganic Chemistry-II (P)	CC	-	-	4	2
7	CAC.527	Applied Practical Physical Chemistry- II (P)	CC	-	-	4	2
8	CAC.542	Seminar	EC	-	1	-	1
9	XXX	Inter-Disciplinary Course (ID) (Opt any one from other Departments)	EC	2	-	-	2
10.	XXX	Value Based Course	EF	1	-	-	1
		Total		**18**	**1**	**8**	**23**

CC: Core Course, **EC**: Elective Course, **CF**: Compulsory Foundation, **EF**: Elective Foundation

Mode of Transaction: Lecture, Demonstration, Lecture cum demonstration, Dialogue Mode, Experimentation, Brain storming, Problem solving, Seminar.

SEMESTER 3

S. No.	Paper Code	Course Title	Course Type	L	T	P	Cr
1	CHM.556	Research Methodology	CC	4	-	-	4
2	CHM.551	Inorganic Chemistry-III	CC	3	-	-	3
3	CHM.552	Organic Chemistry-III	CC	3	-	-	3
4	CAC.551	Quality Control in Laboratory	CC	2	-	-	2
5	CAC.552	Applied Chemistry Practical –I (P)	CC	-	-	4	2
6	CAC.553	Applied Chemistry Practical –II (P)	CC	-	-	4	2
7.	XXX	Value Based Course	EF	1	-	-	1
8.	CAC.599	Project	EC	-	-	12	6
Opt any one of the following courses:							
9	CAC.554	Applied Electrochemistry	EC	2	-	-	2
	CAC.560	Aerosol Chemistry and Air Pollution Control					
	CAC.557	Chemo and Biosensor					
	CAC.559	Food Chemistry					
	CAC.558	Pharmaceutical Products					
	Total			**15**	**0**	**20**	**25**

CC: Core Course, **EC**: Elective Course, **CF**: Compulsory Foundation, **EF**: Elective Foundation

Mode of Transactions: Lecture, Demonstration, Lecture cum demonstration, Experimentation, Problem solving, Brain storming, Tutorial, Case study, Dialogue Mode, Project.

SEMESTER 4

S. No.	Paper Code	Course Title	Course Type	L	T	P	Cr
1.	CAC.571	Applied Polymer Chemistry	CC	4	-	-	4
2.	CHM.572	Concepts in Chemistry-I	CC	2	-	-	2
3.	CHM.573	Concepts in Chemistry-II	CC	2	-	-	2
4.	CAC.599	Project	EC	-	-	12	6
Opt any one of the following courses:							
5.	CAC.572	Green and Industrial Organic Chemistry	EC	4	-	-	4
	CHM.577	Environmental Chemistry					
	CAC.573	Industrial Inorganic Chemistry					
	CHM.581	Material Chemistry					
Opt any one of the following courses:							
6.	CAC.574	Fuel and Energy	EC	2	-	-	2
	CAC.575	Dyes and Pigments					
	CAC.576	Petroleum Chemistry					
	CAC.577	Advanced Instrumental Analysis					
		Total		**14**	**-**	**12**	**20**

CC: Core Course, **EC**: Elective Course, **CF**: Compulsory Foundation

Mode of Transactions: Lecture, Demonstration, Lecture cum demonstration, Experimentation, Problem solving, Brain storming, Tutorial, Case study, Dialogue Mode, Project.

SEMESTER - I

Course Title: Fundamental Biology (Non-medical group)
Paper Code: CHM.506
Total Contact Hours: 30

L	T	P	Cr
2	0	0	2

Course Outcome: After this course completion, the students will be able to analyze and apply the knowledge of

1. Molecular structure and interactions present in various biomolecules like proteins, nucleic acids, lipids etc.
2. Organization and working principles of various components present in living cell.
3. Physical principles of structure, function, and folding of biomolecules.

Unit 1 **7 Hrs**

Introduction: Cell structure and functions, thermodynamics and kinetics of biological processes, ATP. Interactions in aqueous solutions, Role of water in life, pH, Acidic and basic buffers, Biological buffers, solution equilibria, Henderson-Hasselbalch equation, Hofmeister series, Chaotropic and kosmotropic ions/co-solvents.

Unit 2 **7 Hrs**

Amino Acids and Peptides: Classification and properties of amino acids, peptide and polypeptides, primary structures, structure of peptide bond, synthesis of peptides, different protecting groups in peptide chemistry, N-terminal, C-terminal and sequence determination.

Carbohydrates: Biologically important monosaccharides, disaccharides and polysaccharides, glycoproteins, role of sugars in biological recognition.

Unit 3 **8 Hrs**

Proteins: Secondary structure of proteins with emphasize on supramoelcular characteristics of □-helix, □-sheets, supersecondary structure and triple helix structure of collagen, tertiary structure of protein-folding, quaternary structure of protein, in-vivo and in-vitro protein folding, protein misfolding and conformational diseases.

Unit 4 **8 Hrs**

Nucleic Acids: Purine and pyrimidine bases, nucleotides, nucleosides, base pairing via H-bonding, structure of ribonucleic acids (RNA) and deoxyribonucleic acids (DNA), double helix model of DNA, different types of RNA and their functions, the chemical basis for heredity, overview of replication of DNA, transcription, translation and genetic code.

Lipids: Lipid classification, lipid bilayers, liproproteins-composition.high density (HDL) and low-density (LDL) lipoproteins and function, membrane proteins - integral membrane proteins.

Suggested Readings

1. Voet, D., Voet, J. G., and Pratt, C. W. (2008). *Principle of Biochemistry*. John Wiley andSons .
2. Berg, J. M., Stryer, L., and Tymoczko, J. L. (2015). *StryerBiochemie*. Springer-Verlag.
3. Garrett, R. H., and Grisham, C. M. (2013). *Biochemistry*, Brooks/Cole, Cengage Learning.
4. Conn, E., and Stumpf, P. (2009). *Outlines of Biochemistry*. John Wiley and Sons.

Course Title: Fundamental Mathematics (Medical group)
Paper Code: CHM.507
Total Contact Hours: 30

L	T	P	Cr
2	0	0	2

Course Outcome: The students should be able to demonstrate and apply the various mathematical operations including matrix operations, differentiation, integration, complex, quadratic and differential equations.

Unit 1 **7 Hrs**

Trigonometry and Algebra

Trigonometric functions of sum and differences of angles, addition and subtraction formulas.

Polynomial equations and their solutions: binomial theorem and expansion. Common series and expansions used in chemistry.

Complex Algebra:complex numbers, the graphical interpretation of complex numbers, characterizations of the exponential function, the trigonometric functions of complex argument ($e^{i\theta}$, $e^{-i\theta}$).

Unit 2 **8 Hrs**

Differential Calculus

Functions, limits, differentiation, basic rules of differentiation, maxima and minima, exact and inexact differentials, partial differentiation.

Marix Algebra: Addition and multiplication; inverse, adjoint and transpose of matrices, matrix equation, Introduction to vector spaces, matrix Eigen values and Eigen vectors, diagonalization, determinants (examples from Huckel theory).

Unit 3 **8 Hrs**

Integral Calculus

Basic rules for integration, integration by parts, partial fraction and substitution, definite integrals, evaluation of definite and some standard integrals related to chemistry

Unit 4 **7 Hrs**

Elementary Differential Equations

Variables-separable and exact, first-order differential equations, homogenous, exact and linear equations. Applications to chemical kinetics, quantum chemistry, etc. solutions of differential equations by the power series method, spherical harmonics, second order differential equations and their solutions.

Suggested Readings

1. Steiner, E. (2008). *The Chemistry Maths Book*. Oxford University Press.
2. Doggett, G., and Sutcliffe, B. T. (1995). *Mathematics for Chemistry*. Longman Pub Group.
3. Daniels, F. (2003). *Mathematical Preparation for Physical Chemistry*. McGraw Hill Publishers.
4. Tebbutt, P. (1998). *Basic Mathematics for Chemists*. Chichester: Wiley.

Course Title: Analytical Chemistry and Instrumental Methods
Paper Code: CHM.508
Total Contact Hours: 45

L	T	P	Cr
3	0	0	3

Course Outcome: The students should be able to choose the method of analysis based on the sample amount/volume, accuracy and precision required for analysis and interference. The student should be able to able to demonstrate the understanding and application of the principles of instrumental analysis.

Unit 1 **11 Hrs**

Errors in Quantitative Analysis: Accuracy, precision, sensitivity, specificity, mean and standard deviation, classification of errors and their minimization, significant figures, linear regression, covariance and correlation coefficient. Standard reference materials, criteria for selection of analytical method.

Quantitative Analysis: Concepts important to quantitative analysis, classification of methods for quantitative analysis, choice of method for analysis, theory of volumetric and gravimetric methods of analysis.

Unit 2 **11 Hrs**

Analytical Spectroscopy: Principle, applications and limitations of spectrophotometery, Beer-Lambert law, analysis of mixtures, sources and treatment of interferences and detection limits to be considered in each of the techniques, fluorescence spectrometry, atomic absorption spectrometry (AAS); flame AAS, electrothermal AAS (ETAAS).

Unit 3 **12 Hrs**

Potentiometry – General principles, reference electrodes, ion selective electrodes, ion selective electrode construction, membrane electrode, glass electrodes, liquid membrane electrodes, biosensors ISFET and MOSFETS.

Coulometry: Basic principles of electrogravimetry, ohmic potential, kinetic and concentration polarization, overpotential, constant current and constant potential coulometry. coulometric titrations and application.

Voltammetry: Principles, dropping mercury electrode (DME), polarography, half-wave potential, diffusion current and Illkovic equation, different wave forms–linear scan, square scan and triangular scan, cyclic voltammetry, voltammograms. Anion/cation striping voltametry and its applications.

Unit 4 **11 Hrs**

Chromatography: Partition and distribution, principles of chromatography, plate and rate theory. retention time and retention factor, resolution and separation factor; general idea about adsorption, partition and column chromatography, paper and thin layer chromatography, gas chromatography (GC) and high performance liquid chromatography (HPLC) - instrumentation, methodology and applications. SFC LC, hyphenated techniques. Ion exchange resins and extraction, Ion Chromatography, anion supressors and ion speciation analysis.

SUGGESTED READINGS

1. Skoog, D. A., Holler, F. J., and Crouch, S. R. (2017). *Principles of Instrumental Analysis*. Cengage learning.
2. Willard, H. H., Merritt Jr, L. L., Dean, J. A., and Settle Jr, F. A. (1988). *Instrumental Methods of Analysis*.CBS Publishers.
3. Mendham, J., Denney, R. C., Barnes, J. D., and Thomas, M. J. K. (2008). *Vogel's Textbook of Quantitative Chemical Analysis*, Dorling Kindersley.
4. Skoog, D. A., West, D. M., Holler, F. J., and Crouch, S. (2013). *Fundamentals of Analytical Chemistry*. Nelson Education.
5. Christian, G. D. (1994). *Analytical Chemistry*. John Wiley and Sons, USA, 331.
6. Bard, A. J., and Faulkner, L. R. (2001). *Electrochemical Methods*, 2nd. John Wiley New York, *669*.
7. Rouessac, F., and Rouessac, A. (2013). *Chemical Analysis: Modern Instrumentation Methods and Techniques*. John Wiley and Sons.
8. Danzer, K. (2007). *Analytical Chemistry: Theoretical and Metrological Fundamentals*. Springer Science and Business Media.

Course Title: Inorganic Chemistry - I
Paper Code: CHM.509
Total Contact Hours: 45

L	T	P	Cr
3	0	0	3

Course Outcome: The completion of this course will endow

1. To predict the reaction mechanism, formation constant and stability of the coordination complexes.
2. Interpretation of the electronic and magnetic properties.

Unit 1 **11 Hrs**

Metal-Ligand Equilibria in Solution

Stepwise and overall formation constant and their interaction, trends in stepwise constants, factors affecting the stability of metal complexes with reference to the nature of metal ion and ligand, chelate effect and its thermodynamic origin, determination of binary formation constants by spectrophotometry and potentiometric (pH) methods.

Unit 2 **11 Hrs**

Reaction Mechanisms of Transition Metal Complexes

Introduction, potential energy diagram and reactivity of metal complexes, ligand substitution reactions, labile and inert metal complexes, acid hydrolysis, factors affecting acid hydrolysis, base hydrolysis, conjugate base mechanism, anation reaction, substitution reactions in square planar complexes, trans effect, mechanism of the substitution reaction reactions without metal ligand bond cleavage, electron transfer processes outer and inner sphere.

Unit 3 **12 Hrs**

Ligand field theory and molecular orbital theory; nephelauxetic series, structural distortion and lowering of symmetry, electronic, steric and Jahn-Teller effects on energy levels, conformation of chelate ring, structural equilibrium, magnetic properties of transition metal ions and free ions presentive, effects of L-S coupling on magnetic properties, quenching of orbital angular momentum by crystal fields in complexes in terms of splitting. effect of spin-orbit coupling and A, E and T states mixing.

Unit 4 **11 Hrs**

Crystal Fields Splitting

Spin-spin, orbital-orbital and spin orbital coupling, LS and J-J coupling schemes, determination of all the spectroscopic terms of p^n, d^n ions, determination of the ground state terms for p^n, d^n, f^n ions using L.S. scheme, determination of total degeneracy of terms, order of interelectronic repulsions and crystal field strength in various fields, spin orbit coupling parameters (λ) energy separation between different j states, the effect of octahedral and tetrahedral fields on S, P, D and F terms. Splitting patterns of and G, H and I terms. selection rules of electronic transitions in transition metal complexes, relaxation of the selection rule in centrosymmetric and non-centrosymmetric

molecules, Orgel diagrams, Tanabe Sugano diagrams, spectrochemical series, band intensities, factors influencing band widths.

Suggested Readings

1. Cotton, F. A., and Wilkinson, G. (1988). *Advanced Inorganic Chemistry* (Vol. 545). New York: Wiley.
2. Huheey, J. E., Keiter, E. A., Keiter, R. L., andMedhi, O. K. (2006). *Inorganic Chemistry: Principles of Structure and Reactivity*. Pearson Education India.
3. Greenwood, N. N., and Earnshaw, A. (2012). *Chemistry of the Elements*. Elsevier.
4. Miessler, G. L. andTarr, D. A. (2011) *Inorganic Chemistry*, Pearson Education.
5. Atkins, P. (2010). *Shriver and Atkins' Inorganic Chemistry*. Oxford University Press, USA.
6. Dutta, R. L., and Syamal, A. (1993). *Elements of Magnetochemistry*. Affiliated East-West Press.
7. Drago, R. S. (1992) *Physical Methods for Chemists*. Saunders College Publishing.

Course Title: Organic Chemistry-I
Paper Code: CHM.510
Total Contact Hours: 45

L	T	P	Cr
3	0	0	3

Course Outcome: Students will apply the knowledge of

1. Structure activity relationship and predict the mechanism of various organic reactions.
2. Mechanistic and synthetic aspects of nucleophilic and electrophilic substitution for various organic reactions.
3. Mechanistic and synthetic aspects of addition and elimination for various organic reactions.

Unit 1 **11 Hrs**

Reaction mechanism, structure and reactivity: Classification and determination of reaction mechanisms, kinetic and thermodynamic control, Hammond's postulate, Curtin-Hammett principle, methods of determining mechanisms, isotope effects, effect of structure on reactivity: Hammett equation, Taft equation.

Reactive intermediates: Generation, structure and reactions of carbocations, carbanions, free radicals, carbenes, nitrenes and benzynes. Neighbouring group participation, classical and non-classical carbocations, phenonium ions and norbornyl system.

Aromaticity: Aromaticity in benzenoid and non-benzenoid compounds, antiaromaticity, homoaromatic compounds.

Unit 2 **11 Hrs**

Aliphatic nucleophilic substitution reaction: The S_N2, S_N1, mixed S_N2 and S_N1, the S_Ni mechanism. Energy profile diagram, nucleophilic substitution at an allylic, aliphatic and vinylic carbon. reactivity effects of substrate structure, attacking nucleophile, leaving group and reaction medium, ambident nucleophile, regioselectivity, effect of solvent in substitution reaction, competition betweenS_N2 and S_N1 mechanisms.

Aromatic nucleophilic substitution: The S_NAr, bimolecular displacement mechanism and benzyne mechanism, reactivity effect of substrate structure, leaving group and attacking nucleophile.

Aromatic electrophilic substitution: The arenium ion mechanism, orientation and reactivity, energy profile diagrams, *ortho/para* ratio, *ipso* attack, orientation in other ring systems, quantitative treatment of reactivity in substrates and electrophiles.

Unit 3 **12 Hrs**

Elimination reactions: E2, E1 and E1cB mechanisms and their spectrum, orientation of the double bond, effects of substrate structures, attacking base, the leaving group and the medium, mechanism and orientation in pyrolytic elimination.

Addition to carbon-carbon multiple bonds: Mechanistic and stereochemical aspects of addition reactions involving electrophiles, nucleophiles and free radicals, addition of halogen polar reagents to alkenes, Regio- and chemoselectivity, orientation and reactivity, hydroboration, epoxidation and hydroxylation.

Unit 4 **11 Hrs**

Addition to carbon-hetero multiple bonds: Structure and reactivity of carbonyl group towards nucleophilic addition: addition of CN, ROH, RSH, H_2O, hydride ion, ammonia derivatives, $LiAlH_4$, $NaBH_4$, organozinc and organolithium reagents to carbonyl and conjugated carbonyl compounds, Arndt-Eistertsynthesis. Mechanism of condensation reactions involving enolates: Aldol, Knoevenagel, Claisen, Dieckmann, Mannich, Benzoin, Perkin and Stobbereactions. Carboxylic acids and derivatives, hydrolysis of esters and amides, ammonolysis of esters.

Suggested Readings

1. Clayden, J., Greeves, N., Warren, S. and Wothers, P. (2012) *Organic Chemistry,*Oxford University Press.
2. Finar, I. L. (1996). *Textbook OfOrganic Chemistry*. ELBS, Pearson Education UK.
3. McMurry, J. (1996). *Organic Chemistry*, Brooks. Cole, New York, 657.
4. Smith, M. B., and March, J. (2013). *March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure*. John Wiley and Sons.

5. Ahluwalia, V. K., and Parashar, R. K. (2011). *Organic Reaction Mechanisms*. Narosa Publishing House (P) Ltd.
6. Bansal, R. K. (2012). *A Textbook of Organic Chemistry*. New Age International.
7. Bansal R.K. (2010) *Organic Reaction Mechanism.* New Age International (P) Ltd.
8. Kalsi, P.S. (2010) *Organic Reactions and Their Mechanisms.* New Age International, New Delhi.
9. Lowry, T. H. and Richardson K. S. (1998) *Mechanism and Theory in Organic Chemistry,* Addison-Wesley Longman Inc., New York.
10. Morrison, R.T. and Boyd, R.N. (2011) *Organic Chemistry,* Prentice- Hall of India.
11. Mukherjee, S.M. and Singh, S.P. (2009) *Reaction Mechanism in Organic Chemistry.* Macmillan India Ltd., New Delhi.
12. Robert, J. D. And Casereo, M.C. (1977) *Basic Principle of Organic Chemistry***.** Addison-Wesley.
13. Solomon, T.W.G, Fryhle, C.B. and Snyder, S. A. (2013) *Organic Chemistry*. John Wiley and Sons, Inc.
14. Sykes, P. A. (1997) *Guide Book to Mechanism in Organic Chemistry,* Prentice Hall.

Course Title: Physical Chemistry-I
Paper Code: CHM.511
Total Contact Hours: 45

L	T	P	Cr
3	0	0	3

Course Outcome: The students will acquire knowledge of

1. Classical thermodynamics and understanding thermodynamic phenomenon in a chemical system
2. Statistical thermodynamics and understanding thermodynamic properties in terms of partition functions,
3. Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics, theories of specific heat for solids.

Unit 1 **11 Hrs**

Partial Molar Properties and Fugacity: Partial molar properties. Chemical potential of a perfect gas, dependence of chemical potential on temperature and pressure, Gibbs- Duhem equation, fugacity, its importance and determination, standard state for gases.

Thermodynamics of Simple Mixtures: Thermodynamic functions for mixing of perfect gases. Chemical potential of liquids. Raoult's law, thermodynamic functions for mixing of liquids (ideal solutions only). Real solutions and activities. Activity coefficient; determination of activity and activity coefficients.

Unit 2 **11 Hrs**

Solid-Liquid Solutions: Solutions of nonelectrolytes and electrolytes. Colligative properties of solutions, such as osmotic pressure, depression of the freezing point and elevation of the boiling point.

Phase transition: Phase rule, water, CO_2 phase transition, binary and ternary component phase transitions. Clausius-Clapeyron equation and its application to solid-liquid, liquid-vapour and solid-vapour equilibria.

Unit 3 **12 Hrs**

Statistical Thermodynamics: Statistical concepts and examples, Thermodynamic probability and entropy, Partition function, molar partition function, thermodynamic properties in term of molecular partition function for diatomic molecules, monoatomic gases, rotational, translational, vibrational and electronic partition functions for diatomic molecules, calculation of equilibrium constants in term of partition function.

Unit 4 **11 Hrs**

Theories of Statistical Thermodynamics: Concept of Maxwell-Boltzmann, Bose-Einstein and Dermi-Dirac statistics, Difference between Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics, Applications of Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics., Monoatomic solids, theories of specific heat for solids.

Suggested Readings

1. Barrow, G. M. (2007) *Physical Chemistry*. Tata McGraw-Hill Publishers.
2. Kapoor, K. L. (2011) *Text Book of Physical Chemistry*.3/5, Macmillan Publishers.
3. Atkins, P. and De Paula, J. (2009) *Atkins' Physical Chemistry*. Oxford University Press.
4. McQuarrie, D. A. and Simon, J. D. (1998) *Physical Chemistry: A Molecular Approach*. Viva Books.
5. Moore, J. W. and Pearson, R. G.(1981)*Kinetics and Mechanism.* John Wiley and Sons.
6. Silbey, R. J. Alberty, R. A. and Bawendi, M. G. (2004) *Physical Chemistry*. Wiley-Interscience Publication.
7. Engel, T., Reid, P. and Hehre, W. (2012) *Physical Chemistry*. Pearson Education.
8. Puri, B.R., Sharma L.R. and Pathania, M.S. (2013) *Principles of Physical Chemistry*. Vishal Publishing Company.
9. Rastogi, R. P. and Mishra, R. R. (2013) *An Introduction to Chemical Thermodynamics.* Vikas Publishing
10. Rajaram, J. and Kuriacose, J. C.(2013) *Chemical Thermodynamics, Classical, Statistical and Irreversible Thermodynamics*. Pearson Education.

11. Laurendeau N. M.(2005) *Statistical Thermodynamics: Fundamentals and Applications*. Cambridge University Press.
12. Nash, L. K. (2012) *Elements of Statistical Thermodynamics*. Dover Publication Inc.
13. Hill, T. L. (1986) *An Introduction to Statistical Thermodynamics*. Dover Publications Inc.

Course Title: Quantum Chemistry
Paper Code: CHM.512
Total Contact Hours: 45

L	T	P	Cr
3	0	0	3

Course Outcome: The students will be able to Interpret and solve the Schrodinger equation various particle in a boundary model, Electronic and Hamiltonian operators for molecules.

1. Interpret and demonstrate the Quantum chemical description of angular momentum and term symbols for a one and many-electron systems.
2. Relate the Born-Oppenheimer approximation, the Pauli principle, Hund's rules, Hückel theory and the variation principle with the atomic and molecular phenomena.

Unit 1 **11 Hrs**

Fundamental Background: Review of essential mathematical concepts required for quantum chemistry, Postulates of quantum mechanics, Eigen values and Eigen functions, operators, Schrodinger equation.

Unit 2 **11 Hrs**

Translational, Rotational and Vibrational Motions: - Free particle and particle in a box and its application (*i.e.,* quantum tunnelling effect), one-dimensional harmonic oscillator and rigid rotor, particle in a ring, particle on a sphere, hydrogen like atoms

Variation Methods: The variation theorem and its application, linear variation principle, perturbation theory up to second order in energy and its applications.

Unit 3 **12 Hrs**

Angular Momentum: Ordinary angular momentum, generalized angular momentum, Eigen functions and Eigen values for angular momentum, Ladder operator, addition of angular momenta, spin, antisymmetry and Pauli exclusion principle, Slatter determinantal wave functions.

Electronic Structure of Atoms: Electronic configuration, term symbols and spectroscopic states, Russell-Saunders terms and J-J coupling schemes, Term

separation energies of pn and dn configurations, Magnetic effects: spin-orbit coupling and Zeeman splitting.

Unit 4 **11 Hrs**

Born-Oppenheimer Approximation: LCAO-MO and VB treatments of the H_2^+ and H_2, hybridization and valence MOs of H_2O and NH_3. Huckel Theory of acyclic and cyclic conjugated systems, bond order and charge density calculations.

Suggested Readings

1. Levine, I.N. (2000) *Quantum Chemistry*. Pearson Education Inc.
2. Chandra, A.K. (1994) *Introductory Quantum Chemistry*. Tata Mcgraw-Hill.
3. Prasad, R.K., (2009) *Quantum Chemistry*. New Age Science.
4. McQuarrie, D. A. and Simon, J. D. (1998) *Physical Chemistry: A Molecular Approach.* Viva Books.
5. Murrell, J.N., Kettle S.F.A. and Tedder, J. M. (1965) *Valence Theory*. John Wiley Publishers.
6. Lowe, J. P. and Peterson, K., (2006). *Quantum Chemistry*. Academic Press.

Course Title: Applied Practical Inorganic Chemistry-I (P)

L	T	P	Cr
0	0	4	2

Paper Code: CAC.513
Contact Hrs: 60
Course Outcome: The students will be updated to analyse of

1. Volumetric and gravimetric analysis of cations and anions within reaction mixtures.
2. Standardization and titrations of various inorganic compounds.

Experiments:

Introduction to good laboratory practices in chemistry.

Gravimetric Estimation

1. Determination of Ba^{2+} as its Sulphate / chromate.
2. Estimation of lead as its lead sulfate.
3. Estimation of Nickel (II) as its nickel dimethyl glyoximate.
4. Estimation of Cu^{2+}as cuprousthiocyanate.

Complexometric Titrations

1. Determination of Water Hardness using complexometric titrations.
2. Determination of aluminium and Magnesium ions using EDTA titration
3. Complexometric Titration of Zn(II) with EDTA

Precipitation Titrations

1. $AgNO_3$ standardization by Mohr's method.
2. Volhard's method for Cl^- determination.

Oxidation-Reduction Titrations

1. Standardization of $KMnO_4$with sodium oxalate and determination of Ca^{2+} ion.
2. Standardization of ceric sulphate with Mohr's salt and determination of Cu^{2+}, NO_2 and $C_2O_4^{-2}$ ions.
3. Standardization of $K_2Cr_2O_7$ with Fe^{2+} and determination of Fe^{3+} (Ferric alum)
4. Standardization of hypo solution with potassium iodate / $K_2Cr_2O_7$ and determination of available Cl_2 in bleaching powder, Sb^{3+} and Cu^{2+}.
5. Determination of hydrazine with KIO_3 titration.

Suggested Readings

1. Pass, G. and Sutcliffe H. (1979) *Practical Inorganic Chemistry*. Chapman and Hall Ltd.
2. Jolly, W.L. (1961) *Synthetic Inorganic Chemistry*. Prentice Hall, Inc.
3. Nakamoto, K. (1997) *Infrared and Raman Spectra of Inorganic and Coordination Compounds: Part A and B*. John Wiley and Sons,.
4. Mendham, J., Denney, R.C., Barnes, J.D. and Thomas, M. J. K.(2000) *Vogel's Textbook of Quantitative Chemical Analysis*. Pearson Education Ltd.
5. Svehla,G. and Sivasankar,B. (1996) *Vogel's Qualitative Inorganic Analysis*. Pearson Education Ltd.
6. Skoog, D.A., Holler, F.J. and Crouch, S.R.(2007) *Principles of Instrumental Analysis*. Thomson Learning.

Course Title: Applied Practical Organic Chemistry-I (P)
Paper Code: CAC.514

L	T	P	Cr
0	0	4	2

Total Contact Hrs: 60

Course Outcome: At the end of this course student will

(i) Demonstrate and practice good laboratory practices including safe handling of hazardous chemicals, laboratory glassware and equipment(s).
(ii) Apply various experimental skills for purification, isolation and recrystallization of organic molecules.
(iii) Analyse the progress of a given reaction on thin layer chromatography.

Experiments:
Safety and Handling of hazardous chemicals:

(i) Good laboratory practices, handling and disposal of hazardous chemicals.
(ii) Awareness about different types of glassware, heating devices, equipment(s), how to conduct organic reaction etc.

A. **Techniques**:

Chromatography: Thin layer chromatography (TLC): Monitoring the progress of chemical reactions, R_f values: identification of unknown organic compounds by comparing the R_f values with known standards. Column chromatography.

Purification Techniques: crystallization, distillation, sublimation.

Determination of melting point and mixed melting point.

B. **Single Stage Synthesis**: Synthesis of compounds and their purification, aspects such as conversion, theoretical yield and percentage yield should be paid attention. (Attempt any six)

1 Synthesis of chalcones *via* Claisen-Schmidt condensation.
2 Reduction of benzophenone to benzhydral using $NaBH_4$.
3 Conversion of benzaldehyde to cinnamic acid (Knoevenagel condensation)
4 Conversion of benzaldehyde to dibenzylidene acetone (Aldol condensation)
5 To prepare phenylpropene *via* dehydration of corresponding phenylpropanol.
6 To prepare ethyl cinnamate *via* acid catalyzed esterification of cinnamic acid.
7 Conversion of phthalic anhydride to phthalimide
8 To synthesize acylinide analogue of Meldrum acid.
9 Synthesis of alcohol *via* addition of Grignard reagent to an aldehyde.

C. ChemDraw-Sketch: Draw the structure of simple aliphatic, aromatic, heterocyclic organic compounds with substituents. Get the correct IUPAC name.

Suggested Readings

1. Harwood, L.M. and Moody, C.J. (1989) *Experimental Organic Chemistry*. Blackwell Scientific Publishers.
2. Vogel, A.I. (1978) *Textbook of Practical Organic Chemistry*. ELBS, Longman Group Ltd.
3. Mann, F.G. and Saunders, B.C. (1975) *Practical Organic Chemistry*. Orient Longman Pvt. Ltd.
4. Leonard, J. and Lygo, B. (1995) *Advanced Practical Organic Chemistry*. Chapman and Hall,.
5. Armarego, W.L. and Chai, C. (2012) *Purification of Laboratory Chemicals*. Butterworth-Heinemann.
6. Young, J.A. (1991) *Improving Safety in the Chemical Laboratory: A Practical Guide.* Wiley Publishing.

Course Title: Seminar
Paper Code: CAC.541
Total Contact Hours: 15

L	T	P	Cr
1	0	0	1

Course Outcome: The student should elucidate and demonstrate the technical writing and present the problem in hand highlighting the various ways the problem is addressed in the literature.

The seminar must include discussion on topics such as awareness about weapons of mass destruction (chemical, biological, radiological, and nuclear weapons), disarmament, peaceful uses of chemistry, International Regulation of Biological and Chemical or Weapons of Mass Destruction.

SEMESTER 2

Course Title: Inorganic Chemistry-II
Paper Code: CHM.521
Total Contact Hours: 45

L	T	P	Cr
3	0	0	3

Course Outcome: The students will be able to

1. Elaborate the point group within any chemical structure, character tables and projection operator techniques.
2. Relate and apply symmetry and group theory in spectroscopy.
3. Demonstrate and explain the structural properties of organometallic complexes and their uses.

Unit 1 **11 Hrs**

Symmetry

Symmetry elements, symmetry operations and their matrix representation, group postulates and types, multiplication tables, point group determination.

Unit 2 **11 Hrs**

Group theory

Determination of reducible and irreducible representations, character tables, construction of character tables for C_2v, C_3v, use of symmetry in obtaining symmetry of orbitals in molecules.

Unit 3 **12 Hrs**

Metal Complexes

Organic-transition metal chemistry, complexes with π-acceptor and σ-donor ligands, 18-electron and 16-electron rules, isolobal analogy, Synthesis and important reaction of metal carbonyls. Structure and bonding of metal carbonyls, metal nitrosyl, dinitrogen and dioxygen complexes, tertiary

phosphine as ligand and vibrational spectra of metal carbonyls for bonding and structure elucidation.

Unit 4 **11 Hrs**

Inorganic cages

Metallocenes, metal cluster compounds, metal-metal bond, metal carbenes, carbonyl and non-carbonyl clusters, fluxional molecules, application of organometallic compounds as catalysts in organic synthesis.

Cage compounds of boron: boron cage
compounds, boranes, carboranes and metallocene carboranes.

Suggested Readings

1. Cotton, F. A., and Wilkinson, G. (1988). *Advanced inorganic chemistry* (Vol. 545). New York: Wiley.
2. Huheey, J. E., Keiter, E. A., Keiter, R. L., andMedhi, O. K. (2006). *Inorganic chemistry: principles of structure and reactivity*. Pearson Education India.
3. Greenwood, N. N., and Earnshaw, A. (2012). *Chemistry of the Elements*. Elsevier.
4. Lever, A.B.P. (1984) *Inorganic Electronic Spectroscopy*. Elsevier Science Publishers B.V.
5. Atkins, P. (2010). *Shriver and Atkins' inorganic chemistry*. Oxford University Press, USA.
6. Dutta, R. L., and Syamal, A. (1993). *Elements of magnetochemistry*. Affiliated East-West Press.

Course Title: Organic Chemistry-II
Paper Code: CHM.522
Total Contact Hours: 45

L	T	P	Cr
3	0	0	3

Course Outcome: The students to be able to

1. Interpret and predict the energetically favoured Conformation of cyclic and acyclic compounds, chirality and reactivity.
2. Demonstrate, explain and apply basic photochemical reactions, photochemistry of carbonyl and aromatic compounds, various thermally or photochemically driven pericyclic reactions and explain their stereochemical aspects.
3. Explain and apply various molecular rearrangements in organic synthesis for the conversion of different functional group.

Unit 1 **11 Hrs**

Stereochemistry: chirality, projection formulae, configurational and conformational isomerism in acyclic and cyclic compounds; stereogenicity, stereoselectivity, diastereoselectivity, D/L, R/S, *E*/*Z* and *cis*/*trans* configurational notations, *threo* and *erythro* isomers, optical purity, enantiotopic and diastereotopic atoms, groups and faces, stereospecific and

stereoselective synthesis, optical activity in the absence of chiral carbon (biphenyls, allenes and spiranes), chirality due to helical shape, conformational analysis of acyclic compounds and cyclic compounds such as cyclopentane, cyclohexane, cyclohexanone derivatives, decalins, 1,2, 1,3-, 1,4-disubstituted cyclohexane derivatives and D-Glucose, effect of conformation on reactivity,

Unit 2 **11 Hrs**

Photochemistry: Jablonski diagram, singlet and triplet states, photosensitization, quantum efficiency, photochemistry of carbonyl compounds, Norrish type-I and type-II cleavages, Paterno-Buchi reaction, Photoreduction, Di π – methane rearrangement.

Photochemistry of aromatic compounds, Photo-Fries reactions of anilides, Photo-Fries rearrangement, Barton reaction, Singlet molecular oxygen reactions.

Unit 3 **12 Hrs**

Pericyclic chemistry:

Introduction, Phases, nodes and symmetry properties of molecular orbitals in ethylene, 1,3-butadiene, 1,3,5- hexatriene, allyl cation, allyl radical, pentadienyl cation and pentadienyl radical.

Electrocyclic reactions: Conrotation and disrotation, 4n and 4n+2 systems. Woodward-Hoffmann rules.(i) Symmetry properties of HOMO of open chain partner (ii) Conservation of orbital symmetry and correlation diagrams.

Cycloaddition reactions: Suprafacial and antarafacial interactions. $\pi^2 + \pi^2$ and $\pi^4 + \pi^2$ cycloadditions and stereochemicalaspects.Diels-Alder reaction.Woodward-Hoffmann Selection rules. Explanation for the mechanism by (i) Conservation of orbital symmetry and correlation diagrams (ii) FMO theory

Sigmatropic reactions: [1,j] and [i,j] shifts; suprafacial and antarafacial, selection rules for [l, j] shifts; Cope and Claisen rearrangements; explanation for the mechanism by (i) symmetry properties of HOMO (ii) Introduction to cheletropic reactions and the explanation of mechanism by FMO theory.

Unit4 **11 Hrs**

Rearrangements: General mechanistic considerations-nature of migration, migratory aptitude, mechanistic study of the following rearrangements: Pinacol-pinacolone, Wagner-Meerwein, Benzil-Benzillic acid, Favorskii, Neber, Beckmann, Hofmann, Curtius, Lossen, Schmidt, Carroll, Claisen, Cope, Gabriel–Colman, Smiles and Sommelet–Hauser rearrangements.

Selective Name Reactions: Ene/Alder-ene reaction, Dakin reaction, Reformatsky, Robinson annulation, Michael addition,Hofmann-Loffler Fretag,Chichibabin reaction.

Suggested Readings

1. Clayden, J., Greeves, N., Warren, S. andWothers, P. (2012). *Organic Chemistry.* Oxford University Press.
2. Bansal, R. K. (2012). *A Textbook of Organic Chemistry*. New Age International.
3. Carey, F. A., and Sundberg, R. J. (2007). *Advanced Organic Chemistry: Part A: Structure and Mechanisms.* Springer Science and Business Media.
4. Kalsi, P. S. (2010). *Stereochemistry Conformation and Mechanism*. New Age International.
5. Eliel, E. L., and Wilen, S. H. (2008). *Stereochemistry of Organic Compounds*. John Wiley and Sons.
6. Carey, F. A., and Sundberg, R. J. (2007). *Advanced Organic Chemistry: PartB*. Springer Science and Business Media.
7. Finar, I. L. (1996). *Textbook of Organic Chemistry*. *ELBS*, Pearson Education UK.
8. Katritzky, A. R., Ramsden, C. A., Joule, J. A., andZhdankin, V. V. (2010). *Handbook of Heterocyclic Chemistry*. Elsevier.
9. Norman, R.O.C. and Coxon, J.M. (1998). *Principles of Organic Synthesis*. Blackie Academic and Professional.
10. Fleming, I. (2015). *Pericyclic Reactions*. Oxford University Press.
11. Singh, J. (2005). *Photochemistry and Pericyclic Reactions*. New Age International.
12. McMurry, J. (1996). *Organic Chemistry*, Brooks. *Cole, New York*, 657.

Course Title: Physical Chemistry-II
Paper Code: CHM.523
Total Contact Hours: 45

L	T	P	Cr
3	0	0	3

Course Outcome: The students should be able to

1. Evaluate and predict the spontaneity of a redox processes in electrochemical systems
2. Evaluate and apply activity coefficient calculated from Debye-Huckel theory in real chemical solutions.
3. Establish and evaluate the kinetics and Mechanism for chemical reactions including fast reactions, homogenous and heterogeneous catalysis reactions.
4. Understanding of techniques for fast reaction monitoring.

Unit 1 **12 Hrs**

Electrochemistry: Ionic equilibria, electrolytic conductance –Kohlrausch's Law, activity-coefficients, mean activity coefficients; Debye-Huckel treatment of dilute electrolyte solutions, derivation of Debye-Huckel limiting law, extended Debye-Huckel law and conductometric titrations.

Electrochemical Cells: Nernst equation, redox systems, electrochemical cells, application of electrochemical cell, concentration cells with and without liquid junction, thermodynamics of reversible electrodes and reversible cells, potentiometric titration.

Unit 2 **11 Hrs**

Reaction Kinetics: Introduction, rates of chemical reactions, complex reactions, steady state approximation, determination of mechanisms of chemical reactions, temperature dependence of rate constant, Arrhenius and Eyring equations and their applications, collision and transition state theories of rate constant, treatment of unimolecular reactions, steric factor, ionic reactions: salt effect,.

Unit 3 **11 Hrs**

Photochemical Reactions and Processes: Laws of photochemistry and kinetics of photochemical reactions, measurement of fluorescence and phosphorescence lifetimes and photoinduced electron transfer rates, photosensitization, quenching and photodimerization.

Fast Reaction Kinetics: Introduction to time-resolved techniques for absorption and emission measurements, relaxation method, study of kinetics of fast reactions by millisecond stopped-flow, nanosecond flash photolysis techniques, detection and kinetics of reactive intermediates,

Unit 4 **11 Hrs**

Adsorption and Catalysis: Adsorption of solids, Gibbs adsorption isotherm, BET adsorption isotherm, Langmuir and Fredulich Isotherms. Homogeneous catalysis and heterogeneous catalysis, enzyme catalysis. Michealis-Menten mechanism, Lineweaver-Burk Plot, competitive, non-competitive and uncompetitive bindings, kinetics of catalytic reactions.

Suggested Readings

1. Laidler, K. J. (1987). *Chemical Kinetics*. Pearson Education Ltd.
2. Atkins, P. and De Paula, J. (2009) *Atkins' Physical Chemistry.* Oxford University Press.
3. Silbey, R. J. Alberty, R. A. and Bawendi, M. G. (2004)*Physical Chemistry*. Wiley-Interscience Publication.
4. Engel, T.andReid, P. (2012). *Thermodynamics, Statistical Thermodynamics, and Kinetics*. Pearson Education.
5. Lakowicz, J. R. (2006). *Principles of Fluorescence Spectroscopy*. Springer.
6. Barrow, G. M. (2007) *Physical Chemistry*. Tata McGraw-Hill Publishers.
7. Kapoor, K. L. (2011) *Text Book of Physical Chemistry*.3/5, Macmillan Publishers.

8. McQuarrie, D. A. and Simon, J. D. (1998) *Physical Chemistry: A Molecular Approach*. Viva Books.
9. Moore, J. W., and Pearson, R. G. (1981). *Kinetics and Mechanism*. John Wiley and Sons.
10. Raj, G. (2002). *Surface Chemistry (Adsorption)*. Goel Publishing House.
11. Moore, J. W. and Pearson, R. G. (1981) *Kinetics and Mechanism.* John Wiley and Sons.
12. Puri, B.R., Sharma L.R. and Pathania, M.S. (2013) *Principles of Physical Chemistry.* Vishal Publishing Company.

Course Title: Spectroscopic Analysis
Paper Code: CHM.524
Total Contact Hours: 45

L	T	P	Cr
3	0	0	3

Course Outcome: At the end of this course student will be able to

(i) Elucidate and demonstrate the application of various spectroscopic techniques (UV, IR, NMR and MS) in organic synthesis.
(ii) Predict NMR spectra and various fragment-ions/peaks in MS of a given molecular structure.
(iii) Analyse and interpret the combined spectroscopic data (UV-Vis, IR, ^{1}H &^{13}C NMR) for structural elucidation of unknown organic molecules.

Unit 1 **11 Hrs**

UV-Visible spectroscopy: Introduction, role of solvents, chromophores and their interaction with UV-visible radiation. Woodward-Fieser rule for conjugated dienes and carbonyl compounds

Infrared Spectroscopy: Infrared radiation and its interaction with organic molecules, vibrational mode of bonds, effect of hydrogen bonding and conjugation on absorption bands, interpretation of IR spectra. FTIR.

Unit 2 **12 Hrs**

Nuclear magnetic resonance spectroscopy: Introduction, chemical shift and factors influencing chemical shift, reference standards and solvents. spin-spin coupling, effect of deuteration, coupling constants, integration of signals, interpretation of spectra, spin decoupling, double resonance and shift reagent methods, long range coupling, resonance of other nuclei e.g. ^{19}F, ^{15}N, ^{31}P.

Unit 3 **11 Hrs**

^{13}C NMR: Introduction, Proton coupled and proton decoupled ^{13}C NMR, nuclear overhauser enhancement (NOE), DEPT techniques, 2D NMR Correlation spectroscopy (COSY), Homo COSY (^{1}H-^{1}H COSY), Hetro COSY (^{1}H-^{13}C COSY, HMQC), long range ^{1}H-^{13}C COSY (HMBC), NOESY.

Unit 4 **11 Hrs**

Mass spectrometry: Basic principles and brief outline of instrumentation. Ion formation: EI, CI, FAB, MALDI, ESI, metastable ion, □-cleavage, McLafferty rearrangement, Retro-Diels-Alder Cleveage, nitrogen rule, fragmentation process of organic molecules in relation to molecular structure determination. Relative abundance of isotopes, High resolution mass spectrometry (HRMS) and recent advances in mass spectrometry.

Problems for structure elucidation using the above spectroscopic techniques.

Suggested Readings

1. Banwell, C. N., and McCash, E. M. (1994). *Fundamentals of Molecular Spectroscopy*(Vol. 851). New York: McGraw-Hill.
2. Dyer, J. R. (1965). *Applications of Absorption Spectroscopy of Organic Compounds*. Phi Learning.
3. Kalsi, P. S. (2007). *Spectroscopy of Organic Compounds*. New Age International.
4. Kemp, W. (1998). *Organic Spectroscopy*, ELBS.
5. Khopkar, S. M. (1998). *Basic Concepts of Analytical Chemistry*. New Age International.
6. Melinda, J.D. (2010). *Introduction to Solid NMR Spectroscopy*. Wiley India Pvt Ltd.
7. Mendham, J., Denney, R. C., Barnes, J. D., and Thomas, M. J. K. (2008). *Vogel's Textbook of Quantitative Chemical Analysis*, Dorling Kindersley.
8. Pavia, D. L., Lampman, G. M., Kriz, G. S., and Vyvyan, J. A. (2008). *Introduction to Spectroscopy*. Cengage Learning.
9. Silverstein, R. M., Webster, F. X., Kiemle, D. J., and Bryce, D. L. (2014). *Spectrometric Identification of Organic Compounds*. John wileyand sons.
10. Gross, J. H. (2006). *Mass Spectrometry: A Textbook*. Springer Science and Business Media.

Course Title: Molecular Spectroscopy
Paper Code: CHM.525
Total Contact Hours: 45

L	T	P	Cr
3	0	0	3

Course Outcome: The students will be able to apply microwave, infrared-vibration-rotation Raman and infra-red Spectroscopy for chemical analysis and prediction of molecular structure

1. Demonstrate and apply electronic spectroscopy of different elements and simple molecules.
2. Demonstrate and elucidate the physical principles of nuclear magnetic and electron spin resonance spectroscopy.

Unit 1 **11 Hrs**

Electronic Spectroscopy: Electronic transition, energy of electronic transition, selection rules, the Franck-Condon principle.

Microwave Spectroscopy: Classification of molecules, rigid rotor model, effect of isotopic substitution on the transition frequencies, intensities of spectral lines, non-rigid rotor, Stark effect, applications.

Unit 2 **12 Hrs**

Vibrational Spectroscopy: Review of harmonic oscillator, Selection rules, vibrational energies of diatomic molecules, zero point energy, force constant and bond strength, anharmonicity, vibration-rotation spectroscopy, Morse potential energy diagram, P, Q, R branches, vibrations of polyatomic molecules, overtones, hot bands and applications.

Raman Spectroscopy - Classical and quantum theories of Raman Effect, vibrational-rotational Raman spectra, selection rules, mutual exclusion principle, resonance Raman Spectroscopy, surface enhanced Raman spectroscopy, coherent anti stokes Raman spectroscopy.

Unit 3 **11 Hrs**

Magnetic Resonance Spectroscopy: Basic principles of NMR and ESR, instrumentation of NMR and ESR, magnetization vector and relaxation, NMR transitions, Bloch equation, relaxation effects and mechanism, effect of quadrapole nuclei, nuclear overhauser effect (NOE), multiple pulse methods, Hyperfine splitting in ESR.

Unit 4 **11 Hrs**

Lasers and Laser Spectroscopy: Principles of laser action, pulsed lasers, examples of lasers: He-Ne, Nd-YAG, dye lasers.

Photoelectron spectroscopy: The photoelectric effect, UV photoelectron spectroscopy UPES, X-ray photoelectron spectroscopy XPES.

Suggested Readings

1. Hollas, J. M. (2004). *Modern Spectroscopy*. John Wiley and Sons.
2. Lakowicz, J. R. (2006). *Principles of Fluorescence Spectroscopy*. Springer.
3. Barrow, G. M. (2007) *Physical Chemistry*. Tata McGraw-Hill Publishers.
4. Banwell, C. N., and McCash, E. M. (1994). *Fundamentals of Molecular Spectroscopy* (Vol. 851). New York: McGraw-Hill.
5. Carrington, A., and McLachlan, A. D. (1967). *Introduction to Magnetic Resonance: With Applications to Chemistry and Chemical Physics.*Chapman and Hall, London.
6. Lynden-Bell, R. M., and Harris, R. K. (1969). *Nuclear Magnetic Resonance Spectroscopy*. Appleton-Century-Crofts.
7. Reilley, C. N., Everhart, D. S., and Ho, F. F. L. (1982). *Applied Electron Spectroscopy for Chemical Analysis. Chemical Analysis, 63, 105.*John Wiley.

8. Chang, R. (1971). *Basic Principles of Spectroscopy*. McGraw-Hill.
9. Ghosh, P. K. (1983). *Introduction to Photoelectron Spectroscopy*. John Wileyand Sons, New York.
10. Günther, H. (2013). *NMR Spectroscopy: Basic Principles, Concepts and Applications in Chemistry*. John Wiley and Sons.

Course Title: Applied Practical Inorganic Chemistry –II (P)
Paper Code: CAC.526
Total Lectures: 60

L	T	P	Cr
0	0	4	2

Course Outcome: The students will acquire knowledge of

1. Preparation and purification of different inorganic complexes.
2. Application of UV-Vis, FT-IR, Magnetic moment measurement, Conductivity measurements, NMR and Thermogravimetric analysis for characterization of coordination complexes.
3. Preparation of Chloropentaammine cobalt (III) Chloride and its IR measurements.
4. Preparation of $[Co(en)_2Cl_2]$ Cl, $Na_2[Fe(CN)_5NH_3]$. H_2O, $[UO_2(NO_3)_2Py_2]$, $Cu_2(CH3COO)_4(H_2O)_2$.
5. Preparation of $Hg[Co(CNS)_4]$ and used as standard for the magnetic moment measurement
6. Preparation of cis-and trans-K $[Cr(C_2O_4)_2(H_2O)_2$ and its IR study.
7. Preparation of bis(2,4-pentanedione)vanadium(IV) acetate and its piperidine or pyridinecomplex. Study of both the complexes with the help of infrared, UV-vis spectroscopy andmagnetic susceptibility.
8. Preparation of lead tetraacetate.
9. Preparation and separation of isomers of $K_3[Fe(C_2O_4)_3]$, Cu(II) and Ni(II) complexes of Schiff base.
10. Determination of the acid value and saponification value fat/oil.
11. Determination of Chlorophyll content
12. Determination of gross calorific value (GCV) for fuels.
13. Determination of pour point, flash point and cloud point of liquid fuel.

Suggested Readings

1. Pass, G. and Sutcliffe H. (1979).*Practical Inorganic Chemistry*. Chapman and Hall Ltd.
2. Nakamoto, K. (1997).*Infrared and Raman Spectra of Inorganic and Coordination Compounds: Part A and B*. John Wiley and Sons,.
3. Mendham, J., Denney, R.C., Barnes, J.D. and Thomas, M. J. K. (2000).*Vogel's Textbook of Quantitative Chemical Analysis,* Pearson Education Ltd.
4. Kolthoff, I. M., andSandell, E. B. (1944). *Text Book of Quantitative Inorganic Analysis*. The Macmillan; New york.
5. Marr, G., andRockett, B. W. (1960). *Practical Inorganic Chemistry*. John Wiley and Sons.

6. Jolly, W.L. (1961).*Synthetic Inorganic Chemistry*. Prentice Hall, Inc.

Course Title: Applied Practical Physical Chemistry-II (P)
Paper Code: CAC.527
Total Contact Hrs: 60

L	T	P	Cr
0	0	4	2

Course Outcome: The students should demonstrate and apply potentiometer, viscometer, refractometer CD, UV-Visible and fluorescence spectrometer for different physicochemical parameter of chemical system.

1. Determination of strength of a given base by titrating with an acid conductometrically.
2. Determination of solubility and solubility product of sparingly soluble salts (e.g., $PbSO_4$, $BaSO_4$) conductometrically.
3. Determination standard electrode potential of Fe^{2+}/Fe^{3+} system by potentiometer using potassium permanganate solution.
4. Determination of pKa of acetic acid and glycine by pH meter using NaOH.
5. Determination of relative and absolute viscosity of a given liquid.
6. Determination of surface tension of alcohols.
7. Determination of refractive indices of given liquids.
8. Determination of concentrations of heme proteins using spectrophotometer
9. Preparation of buffers and measurement of their pH
10. Verificationof the Lambert Beer's law.
11. Structural analysis of amino acids and proteins using CD spectrometer.
12. Structural analysis of amino acids and proteins using CD and Fluorescence spectrometer.
13. Study of chemical and thermal denaturation (T_m and ΔH_m) of proteins using UV-Visible, CD spectrometer and Differential Scanning Calorimeter (DSC).
14. Determination of stability constant of Fe(III)-salicyclic acid complex by spectrophotometer.
15. Determination of mean, median, standard errors, standard deviation, coefficient of variance using software.

Suggested Readings

1. Nad, A. K., Mahapatra, B. and Ghoshal, A. (2014). *An Advanced Course in Practical Chemistry*. New Central Book Agency (P) Ltd.
2. Maity S., and Ghosh, N.(2012). *Physical Chemistry Practical*. New Central Book Agency (P) Ltd.
3. Elias, A. J. (2002). *A Collection of Interesting General Chemistry Experiments*. Universities Press.
4. Khosla, B.D., Garg, V.C., and Gulati A.R. (2007). *Senior Practical Physical Chemistry*. S. Chand and Sons.
5. Yadav, J. B. (2006). *Advanced Practical Physical Chemistry*. Krishna Prakashan Media.

6. Das, R. C., and Behera, B. (1983). *Experimental Physical Chemistry*. Tata McGraw-Hill.
7. Das, R.C., and Behra, B. (1983). *Experimental Physical Chemistry*. 1983, Tata McGraw-Hill.
8. James, A. M., and Prichard, F. E. (1974). *Practical Physical Chemistry*. New York: Longman.
9. Ghosh, J.C. (1990). *Experiments in Physical Chemistry*, Bharati Bhavan.

Course Title: Seminar
Paper Code: CAC.542
Total Contact Hours: 15

L	T	P	Cr
0	1	0	1

Course Outcome: The student would be able to demonstrate the investigation of various aspects related to the chemistry problem with introduction to the problem, what the literature has to say about the problem with proper bibliographic content arrangement and apply the same for the analysis of research gap.

Seminar would emphasize on problem solving approach and use of various techniques to prove a chemical process /techniques. The seminar would emphasize upon the writeup of introduction, review of literature and cited references. The presentation would promote the use of Office Suites and Chemical drawing tools apart from spreadsheets and imaging software.

SEMESTER 3

Course Title: Research Methodology
Paper Code: CHM.556
Total Lecture: 60

L	T	P	Cr
4	-	-	4

Course Outcome: At the end of this course student will

(i) Identify the overall process of a research design.
(ii) Familiar with various e-resources.
(iii) Understand the importance of Intellectual Property Rights and various ethical issues in research.

Unit 1 **15 Hrs**

General principles of research: Meaning and importance of research, Critical thinking, Formulating hypothesis and development of research plan, Review of literature, Interpretation of results and discussion.

Bibliographic index and research quality parameters- citation index, impact factor, *h* index, i10 index, etc. Research engines such as google scholar, Scopus, web of science, etc

Unit-2 **15 Hrs**

Technical and scientific writing: Technical and Scientific writing - theses, technical papers, reviews, electronic communication, research papers, etc., Poster preparation and Presentation and Dissertation. Reference Management using various softwares such as Endnote, reference manager, Refworks, etc. Communication skills–defining communication; type of communication; technicques of communication, etc.

Unit-3 **15 Hrs**

Library: Classification systems, e-Library, Reference management, Web-based literature search engines.

Plagiarism: Plagiarism, definition, Search engines, regulations, policies and documents/thesis/manuscripts checking through softwares, Knowing and Avoiding Plagiarism during documents/thesis/manuscripts/ scientific writing.

Unit-4 **15 Hrs**

Intellectual Property Rights: Intellectual Property, intellectual property protection (IPP) and intellectual property rights (IPR), WTO (World Trade Organization), WIPO (World Intellectual Property Organization), GATT (General Agreement on Tariff and Trade), TRIPs (Trade Related Intellectual Property Rights), TRIMS (Trade Related Investment Measures) and GATS (General Agreement on Trades in Services).

Suggested Readings

1. Gupta, S. (2005) *Research Methodology and Statistical Techniques*, Deep and Deep Publications (p) Ltd. New Delhi.
2. Kothari, C. R. (2008) *Research Methodology(s)*, New Age International (p) Limited.
3. Web resources: www.sciencedirect.com for journal references, www.aip.org and www.aps.org for reference styles.
4. Web resources: www.nature.com, www.sciencemag.org, www.springer.com, www.pnas.org, www.tandf.co.uk, www.opticsinfobase.org for research updates.

Course Title: Inorganic Chemistry-III
Paper Code: CHM.551
Total Lectures: 45

Course Outcome: The students will be able to do

1. Workout chemistry of f-block elements
2. Structural analysis of inorganic compounds through spectroscopic techniques

L	T	P	Cr
3	0	0	3

Unit 1 **11 Hrs**

Lanthanides, actinides and super-heavy elements

Coordination chemistry, magnetic and spectral properties, comparison of general properties of lanthanides and actinides, comparison with d-block elements, organo lanthanides and actinides, analytical application of lanthanides and actinides-lanthanides as shift reagents and high temperature super conductors.

Unit 2 **12 Hrs**

Nuclear Magnetic Resonance (NMR) and Electron Spin Resonance (ESR) Spectroscopy:

NMR: The contact and pseudocontact shofts, factors affecting nuclear relaxation, some application including biochemical systems, an overview of NMR of metal nuclides with emphasis on ^{195}Pt and ^{119}Sn NMR**.**

ESR: Hyperfine coupling, spin polarization for atoms and transition metal ions, spin orbit coupling and significance of *g*-tensors, application of transition metal complexes (having one unpaired electron) including biological systems.

Unit 3 **11 Hrs**

Mossbauer Spectroscopy

Basic principles, spectral parameters and spectrum display,application of the technique to the studies of (1) bonding and structures of Fe^{+2} and Fe^{+3} compounds including those of intermediate spin, (2) Sn^{+2} and Sn^{+4} compounds-nature of M-L bond, coordination number, structure and (3) detection of oxidation state and non-equivalent MB atoms.

Unit 4 **11 Hrs**

Nuclear Chemistry: Classification of nuclides, nuclear stability, atomic energy, types of nuclear reactions-fission and fusion, nuclear decay laws, radioanalytical techniques.

Metal Ions in Biological Systems: Metal Complexes for therapeutic uses (cisplatin, carboplatin, non-platinum complexes). The Fenton reaction, free radical chemistry and metal poisoning.

Suggested Readings

1. Cotton, F.A. and Lippard, S.J., *Progress in Inorganic Chemistry*. Wiley Internationals.
2. Lever, A.B.P.,(1984). *Inorganic Electronic Spectroscopy*. Elsevier Science Publishers B.V.
3. Parish, R.V.,(1990). *NMR, NQR, EPR and Mossbauer Spectroscopy in Inorganic Chemistry*. Ellis Harwood.
4. Silverstein, R.M., Bassler, G.C. and Morrill, T.C. (2002). *Spectrometric Identification of Organic Compounds*. John Wiley and Sons.

5. Abraham, R. J., Fisher, J. and Loftus, P. (1988). *Introduction to NMR spectroscopy*. Wiley.
6. Martin, M. L., Delpuech, J. J. and Martin, G. J. J. (1980).*Practical NMR spectroscopy*. Heyden.
7. Williams, D. H. and Fleming, I. (1980). *Spectroscopic Methods in Organic Chemistry*. McGraw-Hill.
8. Greenwood, N. N. and Earnshaw, A. (2012). *Chemistry of the Elements*. Elsevier.

Course Title: Organic Chemistry-III
Paper Code: CHM.552
Total Contact Hours: 45

L	T	P	Cr
3	0	0	3

Course Outcome: At the end of this course student will be able to

(i) Apply retrosynthetic methods for logical dissection and hence to design a strategy for the synthesis of target molecule.
(ii) Use various reagents (oxidising and reducing) in a logical manner for their application in functional group conversion in organic synthesis.
(iii) Compare the reactivity of various heterocyclic compounds besides knowing about their nomenclature.

Unit 1 **11 Hrs**

Retrosynthesis: Synthon, synthetic equivalent, functional group interconversion (FGI), functional group addition, functional group elimination, criteria for selection of target, linear and convergent synthesis, retrosynthetic analysis involving chemoselectivity, reversal of polarity (umpolung), importance of the order of events in organic synthesis. One group and two group C-X disconnections, two group C-C disconnections; Diels-Alder reaction, control in carbonyl condensation.

Unit 2 **12 Hrs**

Metal and non-metal mediated oxidation: Mechanism, selectivity, stereochemistry and applications of oxidation reactions, Baeyer-Villiger, Oppenauer oxidation, oxidation reactions using DDQ, NBS, $Pb(OAc)_4$, Selenium dioxide, PCC, PDC, Cr and Mnreagents,phase transfer catalysis, Periodic acid, Ceric ammonium nitrate,OsO_4, Swern oxidation, hydroboration, Sharpless asymmetric epoxidation, epoxidations using peracids.Recent approaches for oxidation using green oxidants.

Unit 3 **11 Hrs**

Metal and non-metal mediated reduction: Mechanism, selectivity, stereochemistry and applications of catalytic hydrogenations using Pd, Pt and Ni catalysts (Lindlar, Rosenmund, Adam's catalysts), Clemmensen reduction, Wolff-Kishner reduction, Meerwein-Pondorff-Verley reduction, dissolving metal reductions (Li/Na in liquid ammonia), metal hydride reductions using $NaBH_4$, Luche reduction, $NaBH_3CN$, $NaBH(OAc)_3$, L-Selectride, K-Selectride, $LiAlH_4$, DIBAL. Wilkinson's catalysis, Birch reduction.

Unit 4 **11 Hrs**

Heterocyclic Chemistry: Systematic nomenclature (Hantzsch-Widman system) and replacement nomenclature for monocyclic, fused and bridged heterocycles, aromatic heterocycle, non-aromatic heterocycle: bond angle and torsional strains and their consequences in small ring heterocycles, conformation of six-membered heterocycles.

Three-membered and four-membered heterocycles: aziridines, oxiranes, thiranes, azetidines, oxetanes.

Five membered heterocycles containing two heteroatoms (S,N,O): Diazoles (imidazole, pyrazole), triazoles, oxazoles and thiazoles.

Benzo-fused five-membered heterocycles:Indoles, benzofurans and benzimidazoles.

Six-membered heterocycles: Synthesis and reactions of coumarins, chromones.

Suggested Readings

1. Ahluwalia, V. K., and Parasar R. K., (2011). *Organic Reaction Mechanism***.** Narosa Publishing House (P) Ltd., New Delhi.
2. Bansal, R. K. (2012). *A Textbook of Organic Chemistry*. New Age International.
3. Carey, F. A., andSundberg, R. J. (2007). *Advanced Organic Chemistry: Part B*. Springer Science and Business Media.
4. Finar, I. L. (1996). *Textbook of Organic Chemistry*. *ELBS*, Pearson Education UK.
5. Gilchrist, T.L., (1997). *Heterocyclic Chemistry*. Addison Wesley Longman Publishers, US.
6. Gupta R.R., Kumar M., and Gupta V., (2010). *Heterocyclic Chemistry-II Five Membered Heterocycles*. Vol. 1-3, Springer Verlag, India.
7. Joule, J.A., and Mills, K., (2010). *Heterocyc1ic Chemistry*. Blackwell Publishers, New York.
8. Smith, M. B., (2013). *March's Advanced Organic Chemistry: Reactions, Mechanisms and Structure*. John Wiley and Sons.
9. Warren, S., (2010). *Organic synthesis: The Synthon Approach*. John Wileyand Sons.
10. Warren, S., and Wyatt, P., (2010). *Designing Organic synthesis: A Disconnection Approach*. John Wiley and Sons.

11. Corey, E.J., and Cheng X.-M., (1989). *The Logic of Chemical Synthesis*. John Wiley and Sons.

Course Title: Quality Control in Laboratory
Code: CAC.551
Total Lectures: 30

L	T	P	Cr
2	0	0	2

Course Outcome: The students will be able to

1. Demonstrate and apply the various statistical tools for the quality control of the analytical results and its implications to regulatory approvals.
2. Elucidate the good laboratory and manufacturing practices.

Unit I **8 Hrs**

Statistical. Method of Least squares and weighted least squares formalism. Use of certified reference materials and procedures for interlaboratory comparisons. Definition of limits of detection and sensitivity, and concept of standard addition to assess matrix effects. Uncertainity Calculations.

Unit II **7 Hrs**

Concept of Total Quality Management, philosophy of GMP's and GLPS, ISO 9000 and ISO 14798 (NABL Accreditation). Organization and personnel, responsibilities, training, hygiene, personnel records. **Premises:** Location, design, plan layout, construction, maintenance of sterile areas, control of contamination. Equipment, selection purchase specifications, preventive maintenance of equipment, cleaning of equipment.
Raw materials: purchase specifications stores selection of vendors, control on raw materials. Warehousing, good warehousing practices, materials management.

Unit III **7 Hrs**

Quality control laboratory, responsibilities, good laboratory practice, routine controls, instruments reagents, sampling plans, standard test procedures, protocols, non-clinical testing, controls on animal house, data generation and storage, quality control documentation, retention samples, records. Complaints and recalls, evaluation of complaints, recall procedures, related records and documents.

Unit IV **7 Hrs**

Regulatory aspects of pharmaceutical and bulk drug manufacture. DRA, FDA, CPMP, ICH guidelines. Regulatory Aspects of Environmental and Food Testing USEPA, MoEF, MoFPI, AOAC guidelines. Validation: Qualification (IQ/PQ/OQ), validation and calibration of equipment's, Evaluation of Analytical data. Drug approval process, patent application and WHO certification.

Suggested Readings

1. Miller, J. C., and Miller, J. N. (2010). *Statistics for Analytical Chemistry*. Pearson Education Ltd.
2. http://www.who.int/water_sanitation_health/resourcesquality/wqmchap9.pdf
3. https://www.unece.org/fileadmin/DAM/env/water/publications/documents/guidancela boratories.pdf.

Course Title: Applied Chemistry Practical-I (P)
Paper Code: CAC.552
Total Contact Hrs: 60

L	T	P	Cr
0	0	4	2

Course Outcome: At the end of this course student will

i. Know about various reagents used for drying of solvents and their disposal.
ii. Demonstrate various analytics for quality assessment of oils and fats.
iii. Demonstrate and apply current organic synthesis and its workup.
iv. Elucidate the characterization of the synthesized organic compounds using various spectroscopic techniques

1. **Solvent Drying:** Use of sodium metal for drying of toluene and precautions while quenching the residual sodium. Drying of DCM using P_2O_5 and safe disposal of residual P_2O_5.
2. **Synthesis:** Separation and purification of organic compounds by column chromatography, percentage yield calculation

1. Preparation of dyes: Preparation of azo dyes, Fluoroscein, Malachite green, Crystal violet etc and their TLC and melting point(any one)
2. Estimation of Oils and Fats: (i) Saponification value of the given oil or fat samples (ii) Iodine value of a given oil or fat samples.
3. Extraction of essential oil: To extract the essential oils from some common plant parts.
4. To study the saponification reaction for preparation of soap.
5. Synthesis of aromatics and perfumery compounds:Camphor, Methlcinnamate, Methyl anthranilate. Benzyl acetate. Amyl benzoate, Coumarin (any two)
6. Green Synthesis of antipyretic drug paracetamol.
7. To study Buchwald-Hartwig reaction of aryl halide with an amine using Cu-based catalyst.
8. To study decarboxylation of Ferulic acid under microwave irradiation.
9. To study dehydration of benzylic alcohols using imidazolium based ionic liquid.
10. Preparation of allylic alcohols *via* Baylis-Hillman reaction using DABCO as a catalyst and characterization through various spectroscopic techniques.
11. Synthesis of stilbenes *via* Heck coupling Strategy.

12. Synthesis of triazole *via* reaction of phenylacetylene with azide in water (Huisgen cycloaddition).
13. Synthesis of a FEMA-GRAS approved flavoring agent 4-vinylguaiacol via Knoevenagel-Doebner decarboxylation strategy.
14. To study the synthesis of Dialntin via benzylic acid rearrangement.
15. To study the rearrangement of benzopinacol into benzopinacolone.
16. To study the tree component coupling reaction for the synthesis of (any one)

    (i) dihydropyrimidinone (*via* Bignelli reaction) (ii) propargylamine (*via* A^3-coupling)

SUGGESTED READINGS:

1. Harwood, L.M.,and Moody, C.J., (1989).*Experimental Organic Chemistry*. Blackwell Scientific Publishers.
2. Vogel, A.I. (1978) *Textbook of Practical Organic Chemistry*. ELBS, Longman Group Ltd.
3. Mann, F.G.,and Saunders, B.C. (1975) *Practical Organic Chemistry*. Orient Longman Pvt. Ltd.
4. Leonard, J., and Lygo, B.(1995) *Advanced Practical Organic Chemistry*. Chapman and Hall.
5. Tewari, K.S. Vishnoi, N.K., and Mehrotra, S.N. (1976) *A Textbook of Organic Chemistry*. Vikas Publishing House.
6. Reineccius, G., (2005). *Flavour Chemistry and Technology.* Taylor and Francis Group.
7. Guenther, E., (2007). *The Essential Oils-Vol.1*: *History –Origin of Plants-Production-Analysis*. Jepson Press.

Course Title: Applied Chemistry Practical-II (P)
Paper Code: CAC.553
Total Contact Hrs: 60

L	T	P	Cr
0	0	4	2

Course Outcome: The students will proficient for

1. Preparation and purification of different inorganic complexes and their spectroscopic characterizations.
2. Determination of stability constant, fluoride and silica in water samples, estimation of boron in water.
3. Measurement of various physical (order and activation energy of reaction, partition coefficient etc) and chemical properties.
4. Preparation of any four coordination complexes, purity, magnetism and their characterization by different spectroscopic techniques

    a. Tetraamminecopper(II) Sulphate
    b. Hexaaminechromium(III) Nitrate
    c. Hexaureachromium(III) Chloride
    d. Tris(ethylendiamine) nickel(II) Chloride
    e. Tris(ethylenediamine) chromium(III) Chloride

f. Potassium tris(oxalato)ferrate(III)
g. Potassium tris(oxalato)chromate(III)
h. Potassium tris(oxalato)cuprate(II)
i. Potassium hexathiocyanatochromate(III)
j. Potassium tetrathiocyanatodiamminechromate(III)
k. Hexathiourealead(II) nitrate
l. Tris (thiourea)copper(I) complex
m. Potassium tris (oxalate) aluminate
n. Hexammine cobalt (III) chloride.
o. Schiff base complexes of various divalent metal ions.

1. Spectrophotometry:
   a. Determination of Fluoride in water samples using SPANDS method.
   b. Estimation of boron in water using Curcumin method.
   c. Determination of Cation Exchange Capacity(CEC) of soil using versenate method.
   d. Determination of half wave potential for
   e. Stripping voltametric analysis for heavy metals.

2. Chemical Kinetics:
   a. Determination of order of $S_2O_8^{2-} + I^- \rightarrow SO_4^{2-} + I_2$ reaction
   b. Determination of energy of activation of $S_2O_8^{2-} + I^- \rightarrow SO_4^{2-} + I_2$ reaction

3. Determination of partition coefficient of benzoic acid between organic solvent and water.

Suggested Readings:

1. Ramanujam, V.V., (1990). *Inorganic Semi-Micro Qualitative Analysis*. The National Publishing House.
2. Palmer, W.G., (1965).*Experimental Inorganic Chemistry*. Cambridge University Press.
3. Mendham, J., Denney, R.C., Barnes, J.D. and Thomas, M. J. K. (2000). *Vogel's Textbook of Quantitative Chemical Analysis,* Pearson Education Ltd.
4. Vogel, A. I. (2013). *A Text-Book of Quantitative Inorganic Analysis-Theory and Practice*. Longmans, Green And Co.; London; New York; Toronto.
5. Kolthoff, I. M., andSandell, E. B. (1944). *Text Book of Quantitative Inorganic Analysis*. The Macmillan; New york.
6. Khosla, B.D., Garg, V.C., and Gulati A.R. (2007). *Senior Practical Physical Chemistry*. S. Chand and Sons.
7. Yadav, J. B. (2006). *Advanced Practical Physical Chemistry*. Krishna Prakashan Media.

Course Title: Applied Electrochemistry
Paper Code: CAC.554
Total Lectures: 30

L	T	P	Cr
2	0	0	2

Course Outcome: Upon completion of the course the student would be able to

1. Elucidate the working and efficiency of Commercial electrochemical cells and Mechanism of Corrosion.
2. Demonstrate and apply electrochemistry of bio/chemical origin in analysis of important analytes of biological relevance.

Unit I **8 Hrs**

Conversion and storage of electrochemical energy, maximum intrinsic efficiency of an electrochemical converter. physical interpretation of the Carnot efficiency factor in electrochemical energy converters. power outputs. Electrochemical generators (fuel cells): hydrogen oxygen cells, hydrogen air cell, hydrocarbon air cell, alkaline fuel cell, applications of fuel cells.

Unit II **7 Hrs**

Electrochemical energy storage. Properties of electrochemical energy storage: measure of battery performance, charging and discharging of a battery, Classical batteries: (i) lead acid (ii) nickel-cadmium. Modernbatteries : (i) nickel-metal hydride, (ii) lithium battery.

Unit III **7 Hrs**

Corrosion and stability of metals. Mechanism of the corrosion of the metals; thermodynamics and the stability of metals, corrosion current and corrosion potential -Evans diagrams. Measurement of corrosion rate: Inhibiting corrosion, Passivation. Structure of passivation films, mechanism of passivation.

Unit IV **8 Hrs**

Bioelectrochemistry. Bioelectrodics, membrane potentials, simplistic theory, modern theory, electrical conductance in biological organism: enzymes as electrodes. kinetic of electrode process. Essentials of electrode reaction. Current density, overpotential, Tafel equation, Butler Volmer equation.

Suggested Readings:

1. Bockris, J. O. M., and Reddy, A. K. (1998). *Modern Electrochemistry 2B: Electrodics in Chemistry, Engineering, Biology and Environmental Science*(Vol. 2). Springer Science and Business Media.
2. Srinivasan, S., (2006). *Fuel Cells: From Fundamentals to Applications*. Springer Science + Business Media LLC.
3. Bond, A. M. (1980). *Modern Polarographic Methods in Analytical Chemistry*(Vol. 4). CRC Press.
4. Zutshi, K. (2006). *Introduction to Polarography and Allied Techniques*. New Age International.

5. Monk, P. M. S., (2001). *Fundamentals of Electroanalytical Chemistry*. Wiley and Sons.
6. Vassos, B. H., andEwing, G. W., (1983).*Electroanalytical Chemistry*. Wiley Interscience.

Course Title: Aerosol Chemistry and Air Pollution Control
Paper Code: CAC.560
Total Lectures: 30

L	T	P	Cr
2	0	0	2

Course Outcome: The students should be able to

1. Elucidate the importance of the aerosol to environment and control of pollutants.
2. Demonstrate the analysis of pollutant in ambient and stationary sources and its modeling in the immediate environment.
3. Elucidate and apply the various air pollution control device and their selections based on the nature of processes.

UNIT – I **7 Hr**

Atmospheric Aerosols: Size distribution, lognormal number, surface area, volume and mass distribution, dynamics, thermodynamics of aerosol and nucleation phenomenon.

Laws, Rules and Convention: The Air (Prevention and Control of Pollution) Act – 1981 and its Amendments, Geneva Convention on long range transport of atmospheric pollutants.

UNIT- II **8 Hrs**

Ambient air sampling using impactor, cyclone, dichotomous and impingement devices, filter media selection. adsorption and adsorption based sampling, Indoor environment monitoring.

Industrial Monitoring: Flow velocity and temperature monitoring, isokinetic sampling and compositional analysis, flue gas analyzer principles for monitoring COx, NOx, SOx, hydrocarbon.

Air dispersion and Modelling: Plume behaviour and principles of air pollutants dispersion (Gaussian dispersion model) Plume rise estimation, Effluent dispersion theories and Atmospheric and Indoor chemical modeling.

Unit - III **8 Hrs**

Particulate: Designs and control of filters, gravitational, centrifugal-multiple type cyclones, scrubbers and electrostatic precipitators: equipment descriptions prediction of collection efficiency and pressure drop. adsorbents, PSA, adsorption cycle, rotary bed/fluidized bed, condensation - contact condensers, shell and tube condenser, flaring.

UNIT - IV **7 Hrs**

Gaseous Pollutants: Absorption: packed and plate columns. Wellman-Lord process, fuel desulphurization and denitrogenation, low NO_x burner.

Vehicular Pollution Control: Combustion cycle, fuel/air ratio and catalytic convertor; selective catalytic and selective non-catalytic reduction. Application of nanotechnology in catalytic convertor.

Suggested Readings:

1. Tiwary, A., and Colls, J. (2009). *Air Pollution: Measurement, Modelling And Mitigation*. Taylor and Francis.
2. Clarke, A. G. (Ed.). (2012). *Industrial Air Pollution Monitoring*. Springer Science and Business Media.
3. Kenneth Jr., W., Davis, W. T., Warner C. F. (1998). *Air Pollution and its Origin and Control*. Prentice Hall, USA.
4. Cheremisinoff N. P. (2002). *Handbook of Air Pollution Prevention and Control*. Butterworth-Heinemann Publishers, UK.
5. Rao, C.S. (2006). *Environmental Pollution Control Engineering*. New Age International Publishers, New Delhi.
6. Vallero, D. A. (2007). *Fundamentals of Air Pollution*. Academic Press, USA
7. Wang, L. K. Wang, L. K. and Pereira N. C. (2004). *Advanced Air and Noise Pollution Control*. Humana Press.

Course Title: Chemo and Biosensors
Paper Code: CAC.557
Total Lectures: 30

L	T	P	Cr
2	0	0	2

Course Outcome: The students will be able to

1. Elucidate the principles behind sensor designing.
2. Demonstrate and elucidate the design of physical transducer based sensors.
3. Should be able to construct and design sensors based on the principles of sensor designing for a given chemo/bio recognition units.

UNIT – I **8 Hrs**

Introduction, Host-guest chemistry, receptor theory, supramolecular forces, binding constant, chelate effect, co-operativity, preorganization, complimentarity, Themodynamic and kinetic aspects of supramolecular interactions. cation and anion recognition events, ion pair receptors, inclusion phenomenon, self-assembly. molecular approaches for designing of molecular-guest recognition event.

UNIT-II **7 Hrs**

Fundamentals of chemical sensors, selectivity and role of flow injection in chemical sensing.

Chemical sensors based on mode of transduction; mass sensors, optical sensors, nanoparticles and sensors, electrochemical sensors and thermal sensors. chemical sensors based on chemically sensitive layer; sensors arrays and micro total analysis system,molecular imprinting polymer (MIP) sensors

UNIT – III **7 Hrs**

Biosensors: Basics and applications, relevant biology, enzymes and kinetics, design considerations. optical spectroscopy for biosensing, optical glucose sensing, optical biosensors, Surface Plasmon Resonance (SPR) and SPR based sensor, luminescence and luciferase biosensors.

UNIT – IV **8 Hrs**

Electrochemical chemo/biosensors: semi-conductor gas sensors, solid electrolyte gas sensors, ion-selective electrode sensors, potentiometric biosensors, humidity sensors, FET sensors and bio-sensors, amperometric biosensors. calorimetric biosensors.Affinity biosensors: antibodies and immunosensors, DNA sensors, aptamer sensors.

Suggested Readings:

1. Grimes, C. A. (2006). *Encyclopedia of Sensors,* American Scientific Publisher.
2. Ligler, F. S., andTaitt, C. A. R. (Eds.). (2002). *Optical Biosensors: Present and Future*. Gulf Professional Publishing.
3. Turner, A., Karube, I., and Wilson, G. S. (1987). *Biosensors: Fundamentals and Applications*. Oxford university press.
4. Skoog, D. A., Holler, F. J., and Crouch, S. R. (2017). *Principles of Instrumental Analysis*. Cengage learning.
5. Janata, J. (2010). *Principles of Chemical Sensors*. Springer Science and Business Media.
6. Cattrall, R. W. (1999). *Chemical Sensors*. Oxford University Press.
7. Mulchandani, A., Rogers, K., (2010). *Enzyme and Microbial Biosensors: Techniques and Protocols.* Humana Press, Totowa.

Course Title: Food Chemistry
Paper Code: CAC.559
Total Lectures: 30

L	T	P	Cr
2	0	0	2

Course Outcome: The students will be able to:

1. Understand and on various industrial food processing technologies
2. Different additives permitted and used in food processing industries and their physicochemical properties.

Unit-I **8 Hrs**

Water in foods: Function; Types; Structure; Association and dissociation of water; Phase diagram; Relevance to deteriorative processes in foods. Carbohydrates-Mono, Oligo and Polysaccharides: Occurrence; Structure;

Chemical properties; Properties and food applications of important polysaccharides e.g. starch, cellulose, guar gum, xanthan gum, dextran, pectin, alginate, etc.; Starch digestibility and Glycaemic Index; Modified starches; Forms and derivatives of cellulose (MCC, CMC, MC and HPMC).

Unit-II **7 Hrs**

Proteins: Functional properties; Major source of food proteins; Methods of protein characterization and analysis; Protein quality/Biological value of proteins; Chemical and biological methods for evaluation of protein quality; Processing induced physicochemical changes in proteins; Chemical and enzymatic modification of proteins.

Unit-III **7 Hrs**

Lipids: Rancidity and flavour reversion; Mechanism of lipid oxidation; Pro-oxidants; Measurement of lipid oxidation; Role of fats in body; Health problems associated with fats; Trans fats; Bioactivity of fatty acids; Recommendations for fat intake; Fat replacement strategies

Vitamins: Sources, requirements and functions of different vitamins

Unit-IV **8 Hrs**

Minerals: General functions of minerals; Specific functions and requirements of Ca, P, Mg, Fe, Cu, Pb, Zn, Se and As Pigments: Myoglobin; Chlorophyll; Anthocyanins; Carotenoids; Betalains Browning reactions: Enzymatic and Non-enzymatic browning of foods.

Antioxidants: Natural antioxidants; Mechanisms of action; Techniques of evaluation of antioxidant activity Flavour: Nature of flavour components, Applications, Importance of aroma compound

Suggested Readings:

1. Damodaran, S., andParkin, K. L. (2017). *Fennema'sFood Chemistry*. CRC press.
2. Chopra, H.K., andPanesar, P.S., (2010). *Food Chemistry*. Narosa Publishing.
3. Potter, N. N., and Hotchkiss, J. H. (2012). *Food Science*. Springer Science and Business Media.
4. Chakraborty, M.M.,(2003). *Chemistry and Technology of Oils and Fats*. Prentice Hall.
5. Vaclavik, V. A., and Christian, E. W., (2014). *Essentials of Food Science*. Springer.
6. Mehthani, S. and Ingle, P.K., (1999) *Plant Food Flavors*. National Institute Science Communication.
7. Marsili, R., (2011). *Flavor, Fragrance and Odor Analysis,* CRC Press.

Course Tile: Pharmaceutical Products
Paper Code: CAC.558
Credits Hrs: 30

L	T	P	Cr
2	0	0	2

Course Outcome: The students be able to rationalize the importance of pharmaceutical products.

Unit 1 **8 Hrs**

Herbal Products:

General Properties, Chemistry, Phytoconstituentsand bioactive constituents and medicinal importance

Alkaloids Containing Herbal Drugs: *Papaversomniferium* (morphine), *Rauvolfiaserpentina* (reserprine), *Atropabelladona* (atropine), *Ephedra gerardiana* (ephedrine), biosynthesis of alkaloids.

Terpenes Containing Herbal Drugs: Lemon grass oil (citral and geraneol), *Artemesiaannua* (artemisinin) and Taxusbaccata, biosynthesis of terpenoids

Phenolics containing Herbal Drugs: *Vitisvinifera* (reservertrol), *Pterocarpusmarsupium*(Pterostilbene)

Various Berry fruits (strawberry, cherry, raspberry etc.).

Unit 2 **8 Hrs**

Edible Oils and Fats: General study of the quality assessment, hydrogenation of oils, rancidity, iodine value, acid value, saponification value, Reichert-Meissel value, Polenski value and Kirschner value, adulteration of oils and fats, modifications to produce specialty fats (structured fats, nutraceuticals). Essential fatty acids: ω-3 and ω-6 fatty acids.

Unit 3 **7 Hrs**

Soap: Introduction, manufacturing process different types of soap and their composition, Recovery of glycerin from soap spent lye. Metathesis and co metathesis reactions of fats and oils and their application in oleo chemical industry. hydroformylation reaction, cracking of fatty acids and fatty acid esters.

Unit 4 **7 Hrs**

Chemistry of Cosmetics and Perfumes: Cosmetic necessities: Acids, bases, buffers, topical agents. protective and antimicrobials, Astringents; Chemistry of emulsions in cosmetic formulation; safety issues of cosmetics. Storage and preparation of herbal drugs for commercial market. Essential oils and their importance in cosmetic industries.

Antiperspirants, artificial and natural flavors, colors and preservatives, artificial sweeteners.

Suggested Readings:

1. Gunstone,F., (2004).*The Chemistry of Oils and Fats*. Blackwell Publishing Ltd, UK.

2. Rahman, A. U. (Ed.). (2006). *Studies in Natural Products Chemistry*(Vol. 33). Elsevier.
3. Jain, P.C. and Jain M. (2007).*Engineering Chemistry*. Dhanpat Rai and Sons.
4. Sharma, B. K. (1991). *Industrial Chemistry*. Krishna Prakashan Media.
5. Patrick, G. L. (2013). *An Introduction to Medicinal Chemistry*. Oxford university press.
6. Singh, H., andKapoor, V.K., (2007).*Medicinal and Pharmaceutical Chemistry*.VallabhPrakashan, Pitampura, New Delhi.
7. Foye, W. O. (2008). *Foye'sPrinciples of Medicinal Chemistry*. Lippincott Williams and Wilkins.
8. Poucher, W. A. (2012). *Poucher's Perfumes, Cosmetics and Soaps: Volume 3: Cosmetics*. Springer Science and Business Media.
9. Edwards, S. E., da Costa Rocha, I., Heinrich, M., and Williamson, E. M. (2015). *Phytopharmacy: An Evidence-Based Guide to Herbal Medicinal Products*. John Wiley and Sons.

Course Title: Project
Paper Code: CAC.599
Total Contact Hrs:

L	T	P	Cr
0	0	32	16

Course Outcome: The student would be able to

1. Investigate various aspects related to the chemistry problem.
2. Appreciate the literature and its relevance to his topic of interest
3. Write synopsis independently
4. Would generate interest in current topics of research.

Project supervisor would be allocated at the start of the semester and research project would be undertaken in discussion with the project supervisor. At the end of the semester the student has to prepare a project report as per the university guidelines. Upon submission of the project report, the projects would be evaluated based on a project presentation.

SEMESTER 4

Course Title: Applied Polymer Chemistry
Paper Code: CAC.571
Total Lectures: 60

L	T	P	Cr
4	0	0	4

Course Outcomes: The student upon completion of the course would be able to

1. Elucidate the different mechanisms of polymerization.

2. Apply the various methods for determination of Number, weight and viscosity averaged molecular weights.
3. Elucidate and demonstrate the processing of thermoplastic and thermosetting polymers.
4. Apply the polymers for their use in biological and lifestyle applications.

UNIT I **15 Hrs**

Polymers synthesis and Characterisation: Repeating units, degree of polymerisation, linear, branched and network polymers. Classification of polymers. Addition, radical, ionic, coordination and condensation polymerisation; their mechanism and examples. Polymerisation conditions and polymer reactions. Polymerisation in homogeneous and heterogeneous systems.

UNIT II **15 Hrs**

Polymer: Significance of molecular weight of polymer. Polydispersive average molecular weight. number, weight and viscosity average weights. Measurement of molecular weights. End group, viscosity, light scattering, osmotic and ultracentrifugation methods. Chemical and spectroscopic analysis of polymers. X-ray diffraction study.

UNIT III **15 Hrs**

Structure and properties: Configuration of polymer chains. Crystal structure of polymers,morphology of crystalline polymers. Thermal analysis, tensile strength, fatique, impact, tear resistance, hardness and abrasion resistance. Polymer structure and physical properties; crystalline melting point T_m, melting points of homogeneous series, effect of chain flexibility and other steric factors, entropy and heat of fusion. The glass transition temperature, T_g relationship between T_m and T_g, effects of molecular weight, diluents, chemical structure, chain topology, branching and cross linking.

Polymer Processing. Plastics, elastomers and fibres. Compounding. Processing techniques, calendering, die casting, rotational casting, film casting, injection moulding, blow moulding, extrusion moulding, thermoforming, foaming, reinforcing and fibre spinning.

UNIT IV **15 Hrs**

Applications of Polymers: Properties of polyethylene, polyvinyl chloride, polyamides, polyesters, phenolic resins, epoxy resins and silicone polymers. Functional polymers,fire retarding polymers and electrically conducting polymers. Biomedical polymers, contact lens, dental polymers, artificial heart, kidney, skin and blood cells.

Biopolymers: The structure, function, and properties of synthetic (dextran, ficoll) and natural biopolymers (DNA, nucleic acids, nucleotides, proteins), conformation of nucleic acids (DNA, t-RNA, micro-RNA),molecular architecture for some biological structures such as collagen, tissue, silk, wool, and shell. Introduction to biomedical materials and drug delivery formulations.

Suggested Readings

1. Billmeyer, Jr., F.W. (2007). *Textbook of Polymer Science*. Wiley.
2. Gowariker, V. R., Viswanathan, N. V., andSreedhar, J. (1986). *Polymer Science*. New Age International.
3. Takemoto, K. Inaki Y. andOttanbrite R.M. (1997). *Functional Monomers and Polymers,* CRC Press.
4. Alcock H.R., Lambe, F.W., and Mark, J. E., (2003). *Contemporary Polymer Chemistry*, Prentice Hall.
5. Cowie, J. M. G., andArrighi, V. (2007). *Polymers: Chemistry and Physics of Modern Materials*. CRC press.
6. Odian, G. (2004). *Principles of Polymerization*. John Wiley and Sons.
7. Peacock, A., and Calhoun, A. (2012).*Polymer Chemistry-Properties and Applications*.HanserPublishers,Munich.
8. Chandra, R., and Adab, A., (1994).*Rubber and Plastic Waste*. CBS Publishers and Distributors, New Delhi,
9. Bahadur, P., and Sastry, N. V., (2002). *Principles of Polymerisation*, Narosa Publishing House, New Delhi.

Course Title: Concepts in Chemistry-I
Paper Code: CHM.572
Total Contact Hours: 30

L	T	P	Cr
2	0	0	2

Course Outcome: This course is designed to exercise various problems in organic synthesis so that students can compete for National level competitive examinations such as UGC-CSIR-NET, GATE etc. After completion of this course student will be able to

(i) Solve various problems of structure elucidation via interpretation of spectroscopic data.

(ii) Identify the product of various pericyclic reactions besides mechanism and stereoslective aspects of various organic transformations.

(iii) Compare the reactivity of various heterocyclic compounds and utility of natural products.

Unit 1 **8 Hrs**

Combined Structure problems: Exercises of structure elucidation of unknown compounds *via* combined spectral interpretation of IR, UV-vis, ^{1}H and ^{13}C NMR and mass spectra, along with two-dimensional NMR spectroscopy.

IUPAC nomenclature of organic molecules including regio- and stereoisomers.

Unit 2 **7 Hrs**

Organic reaction mechanisms: involving addition, elimination and substitution reactions with electrophilic, nucleophilic or radical species. Determination of reaction pathways.

Various strategies for asymmetric synthesis and its applications in natural products and drug molecules.

Unit 3 **7 Hrs**

Organic transformations and reagents: Functional group interconversion including oxidations and reductions; common catalysts and reagents: organic, inorganic, organometallic and enzymatic. Chemo, regio and their applications in organic synthesis. stereoselective transformations. Green catalysts in organic synthesis.

Exercises on stereochemical aspects of various pericyclic reactions.

Unit 4 **8 Hrs**

Reactivity of common heterocyclic compounds containing one or two heteroatoms (O, N, S) and their utility in organic synthesis.

Chemistry of natural products: Carbohydrates, proteins and peptides, fatty acids, nucleic acids, terpenes, steroids and alkaloids.

Suggested Readings

1. Pavia, D.L., Lampman, G. M., Kriz, G. S., and Vyavan, J. R., (2010).*Introduction to Spectroscopy***.** Harcourt College, NY.
2. Dewick, P.M., (2009). *Medicinal Natural Products: A Biosynthetic Approach*. Wiley and Sons,UK.
3. Finar, I.L. (2006). *Organic Chemistry: Stereochemistry and the Chemistry of Natural Products*. Dorling Kindersley Pvt. Ltd., India.
4. Claydon, J., Gleeves, N., Warren, S. And Wother, P., (2001).*Organic Chemistry*. Oxford University Press, UK.
5. Fleming, I.,(2015). *Pericyclic Reactions*. Oxford University Press.
6. Carey B. F. A., and Sundberg R.J., (2007). *Advanced Organic Chemistry Part B*. Springer Science and Business Media Ltd.

Course Title: Concepts in Chemistry-II
Paper Code: CHM.573
Total Contact Hours: 30

L	T	P	Cr
2	0	0	2

Course Outcomes: The student will be able to Recollect demonstrate and apply various physical and inorganic concept involving errors, kinetics, thermodynamics, photochemistry and electrochemistry.

Unit 1 **7 Hrs**

Structure and bonding

Electronic configuration of atoms(L-S coupling) and the periodic properties of elements; Ionic radii, Ionisation potential, electron affinity, electronegativity; concept of hybridisation. Molecular orbitals and electronic configuration of homo- and hetero-nuclear diatomic molecules. Shape of polyatomic molecules; VSEPR theory, Symmetryelements and point groups for simple molecules. Acid and bases concepts, pH and pKa, HSAB concept, Buffer solution. Properties of solid state and solution phase.

Unit 2 **8 Hrs**

Aspects of *s*, *p*, *d* and *f*-block elements

General characteristics of each block. Chemistry of representative (*s* and *p*-block) elements, Coordination chemistry of transition elements. Chemistry of lanthanide and Actinides.

Unit 3 **7 Hrs**

Thermodynamics: Concepts involved in first, second and third law of thermodynamic, Maxwell relations, Helmholtz and Gibbs Energies, equilibrium constant, temperature-dependence of equilibrium constant and Van't Hoff equation, Colligative properties of solutions.

Unit 4 **8 Hrs**

Electrochemistry: Ionic equilibria, ion conduction mechanism, solutions of nonelectrolytes and electrolytes, electrolytic conductance –Kohlrausch's Law, transport number and its determination, Nernst equation, redox systems, electrochemical cells.

Basics of Photochemistry: Absorption, excitation, laws of photochemistry, quantum yield, lifetime of excited states, photochemical stages-primary and secondary process.

Kinetics: Introduction, rates of chemical reactions, Kinetics of photochemical reactions.

Suggested Readings:

1. Cotton, F. A., and Wilkinson, G. (1988). *Advanced Inorganic Chemistry* (Vol. 545). New York: Wiley.
2. Huheey, J. E., Keiter, E. A., Keiter, R. L., andMedhi, O. K. (2006). *Inorganic Chemistry: Principles of Structure and Reactivity*. Pearson Education India.
3. Greenwood, N. N., and Earnshaw, A. (2012). *Chemistry of the Elements*. Elsevier.
4. Miessler, G. L. andTarr, D. A. (2011) *Inorganic Chemistry*, Pearson Education.
5. Atkins, P. (2010). *Shriver and Atkins' Inorganic Chemistry*. Oxford University Press, USA.
6. Barrow, G. M. (2007) *PhysicalChemistry*. Tata McGraw-Hill Publishers.
7. Kapoor, K. L. (2011) *Text Book of Physical Chemistry*. 3/5, Macmillan Publishers.
8. Atkins, P. and De Paula, J. (2009) *Atkins' Physical Chemistry.* Oxford University Press.
9. Moore, J. W. and Pearson, R. G.(1981) *Kinetics and Mechanism.* John Wiley and Sons.
10. Puri, B.R., Sharma L.R. andPathania, M.S. (2013) *Principles of Physical Chemistry.* Vishal Publishing Company.
11. Laidler, K. J. (1987). *Chemical Kinetics*. Pearson Education Ltd.
12. Rohatgi-Mukherjee, K. K., (1986). *Fundamentals of Photochemistry*. New

Age International.

Course Title: Green and Industrial Organic Chemistry
Paper Code: CAC.572
Total Lectures: 60

L	T	P	Cr
4	0	0	4

Course Outcomes: At the end of the course student will be able to

(i) Understand the concept and application of Green Chemistry
(ii) Assess the green aspects of various commercial manufacturing processes for important chemicals.
(iii) Realise the importance of green chemistry and to apply various tools of green chemistry in their future research.

Unit 1 **15 Hrs**

Green Chemistry: Principles of green chemistry, atom economy, tools of green chemistry: green solvents (ionic liquids, supercritical fluids), abundant natural feedstocks/starting precursor, multicomponent reactions (MCRs), tandem/domino reactions, microwave assisted organic synthesis (MAOS), solid phase synthesis, aqueous media reactions, General introduction to Combinatorial Chemistry.

Unit 2 **15 Hrs**

Applications of Green Chemistry: Green synthesis of ibuprofen, design and use of CO_2-surfactants for precision cleaning in industries, environmentally preferable marine antifoulant, use of molting accelerators in place of toxic and harmful insecticides, oxidant activators to replace chlorine-based delignification process in paper and pulp industry, green chemistry process for polyester regeneration, Biocatalytic promiscuity of enzymes for C-C bond formation. Recent applications of ionic liquids as solvent and catalysts in chemical industry.

Unit 3 **15 Hrs**

Industrial Organic Syntheses: The raw material and basic processes, chemical processes used in industrial organic synthesis: production of methanol, ethanol, ethyl acetate,ammonia, sulfuric acid, acetaldehyde, acetic acid, ethylene glycol, glycerine, acetone, phenol, formaldehyde, 1,3-butadinene and styrene.

Unit 4 **15 Hrs**

Detergent: Introduction, Principal groups of synthetic detergents, Classification of surfactants;anionic, cationic, amphoteric and non-ionic detergents, alkyl/aryl/ amide sulphonates, binders and builders; ecofriendly detergents: detergents containing enzymes and zeolites.

Suggested Readings:

1. Anastas, P. T., and Warner, J. C. (2000). *Green chemistry: theory and practice*. Oxford university press.
2. Sauer, N. N. (2000). *Green Chemistry: Frontiers in Benign Chemical Syntheses and Processes* Ed. Anastas P. T., and Williamson T. C., (US Environmental Protection Agency). Oxford University Press: New York, NY.
3. Malhotra, S. V. (2007). *Ionic Liquids in Organic Synthesis*, Oxford University Press, US.
4. Howard, W.L., (1986). *Introduction to Industrial Chemistry*. Wiley-Interscience.
5. Weissermel, K., andArpe, H.J., (1997) *Industrial Organic Chemsitry*.Wiley-VCH.
6. Sheldon, R.A., Arends, I., and Hannefed, U., (2007). *Green Chemistry and Catalysis*. Wiley-VCH Verlag GmbH and Co.
7. Ahluwalia, V. K. and Kidwai, M., (2004). *New Trends in Green Chemistry*. Anamaya Publishers.
8. Scragg, A.H. (2009) *Biofuels: Production, Application and Development*, CAB International, UK.

Course Title: Environmental Chemistry
Paper Code: CHM.577
Total Lectures: 60

L	T	P	Cr
4	0	0	4

Course Outcome: The student will be able to

1. Elucidate the understanding of the various physiochemical processes in air, water and soil environment.
2. Application of various physicochemical parameters in the modelling and predicting the movement of a pollutant in environment.
3. Elucidate the understanding of the various policies in environment.
4. Elucidate and apply chemistry in water/wastewater treatment.

Unit 1 **15 Hrs**

Aquatic chemistry: Surface, ground water, marine and brackish water resources - assessment and utilization; Rivers and Lakes in India; hydrological cycle; Structure and properties of water, Water quality parameters, Physicochemical concepts of color, odour, turbidity, pH, conductivity, DO, COD, BOD and its kinetics, Carbonates and alkalinity, redox potential, Pourbiax diagram, pH-pE diagrams for Iron, oxoanions and anions, Environmental Issues: Ground water depletion; Water logging and salinity; Water Conservation and management techniques; Rain water harvesting; Watershed management; Eutrophication; Restoration of Lakes, transboundary river water sharing and interlinking of rivers.

Interfacial Interactions: Environmental chemistry of arsenic, chromium, Chemical potential, fugacity and its application to fugacity model.

Unit 2 **15 Hrs**

Water treatment Technologies: Chemical and Physical Methods of wastewater treatment with emphasis on sedimentation, coagulation, adsorption, water softening, defluoridation and ion exchange process.

Membrane Processes: Reverse Osmosis, Types of membrane, characterization of membranes, nano-membranes and their formation, efficiency of different membranes in removal of different elements.

Biological wastewater treatment including Activated sludge process, trickling filter and Membrane bioreactor, biological treatment processes - process description, design and application.

Unit 3 **15 Hrs**

Atmospheric chemistry: Composition of air, Chemical speciation, particles, ion and radicals, Formation of particulate matter, Photochemical reactions in the atmosphere, Chemistry of air pollutants, Photochemical smog, Acid rain, Ozone Chemistry and Montreal Protocol, Greenhouse gases and Global warming, Clean Development Mechanism and Kyoto Protocol, Persistant Organic Pollutants (POP) and Stockholm Convention……..

Sources of Natural and Artificial Radiations: Dosimetry, types of dosimeters, radioactive substances, applications and handling of isotopes and other radionuclides in environment.

Biochemical and Toxicological aspects of arsenic, cadmium, lead, mercury, carbon monoxide, O_3, PAN, MIC and other carcinogens.

Unit 4 **15 Hrs**

Chemistry of Soil: Physio-chemical composition of soil, humus, inorganic and organic components of soil, nutrients (NPK) in soil, significance of C:N ratio, cation exchange capacity (CEC), reactions in soil solution, ion exchange (physiosorption), ligand exchange (chemisorption), complexations, chelation; precipitation / dissolution.

Environmental Geochemistry: Concept of major, trace and REE. classification of trace elements, mobility of trace elements, geochemical cycles.

Waste Management: Biomass waste management, biomedical waste management and chemical waste management, design and construction of waste management site. Regulations for waste management.

Suggested Readings

1. Baird, C., andCann, M., (2008). *Environmental Chemistry*. W.H. Freeman, USA
2. Manahan, S. E., (2008). *Fundamentals of Environmental Chemistry*. CRC Press, USA

3. Connell D. W. (2005). *Basic concepts of Environmental Chemistry*, CRC Press, USA
4. Girard, J., (2010). *Principles of Environmental Chemistry*. Barlett Publishers, USA.
5. Harrison, R. M., (2007). *Principles of Environmental Chemistry*. RSC Publishing, UK
6. Hillel, D., (2007). *Soil in the Environment: Crucible of Terrestrial Life*. Academic Press, USA.
7. Manahan, S. E., (2010). *Water Chemistry: Green Science and Technology of Natures Most Renewable Resource*. CRC Press, USA.
8. Tchobanoglous, G., Burton, F. L., andStensel, H. D., (2003). *Wastewater Engineering: Treatment and Reuse*. McGraw-Hill Science, USA.
9. American Public Health Association, American Water Works Association and Water Environment Federation, (2005). *Standard Methods for the Examination of Water and Wastewater*. American Public Health Association.
10. Eckenfelder, Jr., W.W., Ford, D.L., and Englande, A.J., Jr. (2009). *Industrial water quality*. McGraw-Hill.
11. Crittenden, J. C., Trussell, R. R., and Hand, D. W., (2005). *Water treatment: principles and design*. Wiley Publishers, USA.
12. Grady Jr, C. L., Daigger, G. T., Love, N. G., and Filipe, C. D. (2011). *Biological Wastewater Treatment*. CRC Press.

Course Title: Industrial Inorganic Chemistry
Paper Code: CAC.573
Total Lectures: 60

L	T	P	Cr
4	0	0	4

Course Outcome: The students will be able to

1. Elucidate the understanding of the semiconductors and electronics made from inorganic materials.
2. Elucidate the manufacturing of various fertilizers, electroplating processes and glasses and ceramics.

Unit-I **15 Hrs**

Special Materials for Electronic Industry Recent trends in sensor technology, film sensors, Semiconductor IC technology, micro-electro mechanical systems (MEMS), nanosensors. Applications of Sensors: automobile sensors, home appliance sensor, aerospace sensors, sensors for manufacturing medical diagnostic sensors, sensors for environmental monitoring. High purity silicon, germanium, gallium arsenide (GaAs), indium phosphide (InP) etc. Preparation using zone refining, crystal growth and there use in electronic industry. High temperature materials, SiC, chromite, alumina, zirconia, magnesite etc. Ionic and superionic conductors, β alumina oxide ion conductors, halide conductors superionic, fastion conductors- $RbAg_4I_5$.

Unit-II **15 Hrs**

Fertilizer Industries. General principles of plant nutrition: essential plant nutrients, functions of the essential elements, classification of commercial nitrogenous fertilizers. Manufacturing of ammonium sulphate, urea, ammonium nitrate, commercial phosphatic fertilizers. Manufacturing process and properties of phosphatic fertilizers, single super phosphate, triple super phosphate. Commercial potassic fertilizers: chemicals of potassium compounds, classification, manufacturing process and properties of potasium fertilizer, potassium sulphate, mixed fertilizer. Micronutrients: role and deficiency symptom of micronutrients. Biofertilizers: classification, demands and production, present status of fertilizer industries in India.

Unit-III **15 Hrs**

Metal Finish Technology. Basics of electrodeposition, electroplating principles and practice, electrochemistry applied to electroplating, electroplating of metals chromium, cadmium, nickel, copper, silver, gold, purpose of metal electroplating composition and condition of plating bath, applications waste treatment and metal recovery.

Unit-1V **15 Hrs**

Glass and Ceramics. Physical and chemical properties of glasses, raw materials, manufacturing of special glasses.Ceramics and their properties, raw materials, manufacturing of ceramics, applications of colours to pottery, use of ceramics. Industrial gases: manufacturing and industrial uses of H_2, O_2, N_2, CO_2, $Cl_2$and acetylene gases. Liquefaction of gases, production of low temperature. Chemicals of utility: inorganic fine chemicals, magnesia, alumina, $AlCl_3$, calcium carbonate, sodium silicate, MnO_2, $FeSO_4$, PbO_2 and NaOH.

Suggested Readings

1. Keer, H. V. (1993). *Principles of the solid state*. New Age International.
2. West, A. R. (2003). *Solid State Chemistry and its applications*. John Wiley and Sons.
3. Sharma, B. K. (2014). *Engineering chemistry*. Krishna Prakashan Media.
4. Lowenheim, F. A., (1978).*Electroplating,* MC Graw-Hill Book Company.
5. Gable, D.,(1978). *Principal of metal Treatment and protection*. Pergaman Press Oxford
6. Burke, J. E., (1966). *Progess in ceramic scienceVol. IV*. Pergamon Press.
7. Ash, M. and Ash I., (2000). Formulary of paints and other coating. Vol. I, Chemical Punlising Press.
8. Sharma, B. K., (1997). Industrial Chemistry, Goel Publishing House.
9. Shukla S. D. and Pandey, G. N. (1979). *A text book of chemical technology*. Vikas Publishing House.
10. Henglein, F. A. (2013). *Chemical technology*. Elsevier.
11. Patranabi, D. (2003). *Sensors and Tranducers*. PHI Learning Pvt. Ltd
12. Basak, R. K. (2009). *Fertilizers: A Textbook*, Kalyani Publishers.
13. Balasubramaniam, R. (2009). *Callister's Materials Science and Engineering: Indian Adaptation (W/Cd)*. John Wiley and Sons.

Course Title: Material Chemistry
Paper Code: CHM.581
Total Lectures: 60

L	T	P	Cr
4	0	0	4

Course Outcome: The students will be able to

1. Elucidate the magnetic materials and their properties based on their solid state structures.
2. Elucidate and apply various methods of characterizations for the elucidation of the material structure and properties.

Unit I **15 Hrs**

Magnetic Materials (Ferrites): Introduction, structure and classification, hard and soft ferrites, synthesis of ferrites by various methods and characterization of ferrites, significance of hysteresis loop and saturation magnetization in ferrites, magnetic properties of ferrites, applications of ferrites.

Glasses, Ceramics, Composites and Nanomaterials

Glassy state, glass formers and glass modifiers, applications. Ceramic structures, mechanical properties, clay products. Microscopic composites; dispersion-strengthened and particle-reinforced, fibre-reinforced composites, macroscopic composites, nanocrystalline phase, preparation procedures, special properties, applications.

Unit II **15 Hrs**

Mesmorphic behaviour, thermotropic liquid crystals, positional order,bond orientational order, nematic and smectic mesophases; smectic - nematic transition and clearing temperature -homeotropic, planar and schlieren textures, twisted nematics, chiral nematics, molecular arrangement in smectic A and smectic C phases, optical properties of liquid crystals. Dielectric susceptibility and dielectric constants. Lyotropic phases and their description of ordering in liquid crystals.

Thin Films

Prepartion techniques; evaporation/sputtering, chemical process, sol gel etc. Langmuir – Blodgett (LB) films, growth technique, photolithography, properties and applications of thin films.

Materials for Solid State Devices

Rectifiers, transistors, capacitors IV-V compounds, low–dimensional quantum structure; optical properties.

Unit III **15 Hrs**

Diffraction Methods: X-ray, electron and neutron diffraction methods, structure of simple lattices and X-ray intensities, structure factor and its relation to intensity and electron density, phase identification, X-ray structure analysis, XRD and its applications, polymorphism and cocrystallization.

Ionic conductors: mechanism of ionic conduction, interstitial jumps (Frenkel); vacancy mechanism, diffusion superionic conductors; phase transitions and mechanism of conduction in superionic conductors, examples and applications of ionic conductors.

Molecular Conductor: Oligo (phenylenevinylene)s, oligo(phenyleneethynylene)s, oligo (eneyne)s, oligo(thiophenevinylene), oligo (thipheneethynylene) etc. and their applications

Unit IV **15 Hrs**

Fullerenes, Carbon Nanotubes and Graphene: Types and properties, methods of preparation and separation of carbon nanotubes, applications of fullerenes, CNTs and graphene.

Nonlinear Optical Materials: Nonlinear optical effects, second and third order – molecular
hyperpolarisability and second order electric suspceptibility – materials for second and third harmonic generation.

Preparation and characterization of silica and zirconia based stationary phases by (a) dynamic chemical modification, in which chiral selector is adsorbed on the surface of the zirconia by physical forces, (b) permanent chemical modification, in which a CS is chemically bonded onto the zirconia surface, and (c) physical screening, in which zirconia surface is coated with a polymer or carbon layer, and their application in chiral separations by LC

Suggested Readings

1. Ashcroft, N. W., andMermin, N. D. (1976). *Introduction to Solid State Physics*. *Saunders.*.
2. Callister Jr, W. D., andRethwisch, D. G. (2012). *Fundamentals of Materials Science and Engineering: An Integrated Approach*.John Wiley and Sons.
3. Anderson, J. C., Leaver, K. D., Rawlings, R. D., andLeevers, P. S. (2004). *Materials Science for Engineers*. CRC Press.
4. Keer, H. V. (1993). *Principles of the Solid State*. New Age International.

Course Title: Fuel and Energy
Paper Code: CAC.574
Total Lectures: 30

L	T	P	Cr
2	0	0	2

Learning objective:

Unit-I **7 Hrs**

Fuels Energy: Solid Fuels: Origin, classification and analysis of coal; gasification; oxidation; hydrogenation and liquefaction of coal; solid fuel handling and storage

Liquid Fuels: Origin and classification and properties of petroleum, liquid fuels from other sources; storage and handling of liquid fuels.

Gaseous Fuels: Natural gases, methane from coal mines, manufactured gases, producer gas, water gas, refinery gas, LPG; cleaning, purification and handling of gaseous fuels

Unit-II **8 Hrs**

Renewable Energy Sources and Devices: Solar Energy: Principles of conversion of solar radiation into heat, solar collectors, solar energy storage system, solar photovoltaic cell, solar hydrogen energy, solar pumps, heaters, dryers, cookers and refrigerators.

Unit-III **8 Hrs**

Hydrogen Energy: Hydrogen: Its merit as a fuel; applications hydrogen production methods. - production of hydrogen from fossil fuels, electrolysis, thermal decomposition, photochemical and photo-catalytic methods. Hydrogen storage methods - metal hydrides, metallic alloy hydrides, carbon nano-tubes, sea as source of deuterium

Unit-IV **7 Hrs**

Nuclear Fuel: Basic principles, elements of nuclear power plant, nuclear reactor and fuels, advantage and disadvantages of nuclear power plants.

Biomass Energy: Type of biogas plants, construction details, applications, thermal gasification of biomass.

Course Outcomes: The student will have knowledge for

1. Identifying energy sourcesand use of mankind
2. Workout on renewable sources of energy and sources.
3. Address the issues related to various energy alternatives.

Suggested Readings

1. Curley, R., (2011). *Fossil Fuels Energy: Past, Present, and Future*. Rosen Education Service.
2. Richards, J. (2009). *Fossil Fuels*. Benchmark Books.
3. Solway, A.,(2007). *Hydrogen Fuel Energy for the Future and Global Warming*. Gareth Stevens Publishing.

4. Scheer, H., (2012). *Energy Autonomy: The Economic, Social and Technological Case for Renewable Energy*.Routledge.
5. Simon, C. A., (2007). *Alternative Energy: Political, Economic, and Social Feasibility*. Rowman and Littlefield Publishers Inc.
6. Karim, G. A., (2013). *Fuels, Energy, and the Environment*. CRC Press.
7. Ahmed, S. B., (1979). *Nuclear Fuel and Energy Policy*. Houghton Mifflin Harcourt.
8. Luque, R., andMelero J. A., (2012). *Advances in Biodiesel Production: Processes and Technologies*. Woodhead Publishing.
9. Basu, P., (2013). *Biomass Gasification and Pyrolysis: Practical Design and Theory*. Academic Press.
10. Klass, D. L. (1998). *Biomass for Renewable Energy, Fuels, and Chemicals*. Academic Press.
11. Pajares, J.A., andTascón, J.M.D., (1995). *Coal Science*. Elsevier.
12. Fahim, M., Al-Sahhaf, T., andElkilani, A. (2009). *Fundamentals of Petroleum Refining*. Elsevier.
13. Luque, R., Campelo, J., and Clark, J., (2010). *Handbook of Biofuels Production: Processes and Technologies*. Woodhead Publishing.
14. Holmen, A., Jens K.-J., andKolboe S., (1991). *Natural Gas Conversion*. Elsevier.

Course Title: Dyes and Pigments
Paper Code: CAC.575
Total Lectures: 30

L	T	P	Cr
2	0	0	2

Course Outcome: upon successful completion of the course the student should be able to apply the knowledge of

1. Chemistry of dyes and pigments
2. Applications of dyes and pigments in various field
3. Synthetic methods and physical properties of pigments and dyes

Unit 1 **7 Hrs**

Introduction of pigments, colour index,generic names of pigments, colour constitution number, polymorphism, properties required in a pigment and extender, dyes, pigment dyestuffs,and hue of the pigment (Bathochromic and hyper chromic shift),practices and requirement of pigments

Unit 2 **8 Hrs**

Classification of dyes: Various unit operations in the manufacture of intermediates and dyes, Introduction of various functionalgroups,synthesis of dyes, basics of azo dyes,diazotisation and coupling reactions, azoic colours;vat dyes,reactive dyes, acid dyes, mono azo dye; diasazo, nitro, diphenylamine and

anthraquinone dyes; acid mordant dyes, azo metal complex dyes, synthesis of different dyes.

Unit 3 **7 Hrs**

General methods of processing and synthesis of inorganic pigments: Crushing and grinding, vaporization, co-precipitation, filtration, drying, flushing, calcinations/roasting, vapour phase oxidation etc.

Unit 4 **8 Hrs**

Raw materials for organic pigments: A brief study of coal tar distillation and the role of distillation products in the manufacture of synthetic dyes: bases and precipitants used in the colour striking.

Suggested Readings

1. Zollinger, H. (2003). *Color Chemistry: Syntheses, Properties, and Applications of Organic Dyes and Pigments*. John Wiley and Sons.
2. Venkataraman, K. (Ed.). (2012). *The Chemistry of Synthetic Dyes*(Vol. 4). Elsevier.
3. Buxbaum, G. (Ed.). (2008). *Industrial Inorganic Pigments*. John Wiley and Sons.
4. Herbst, W., and Hunger, K. (2006). *Industrial Organic Pigments: Production, Properties, Applications*. John Wiley and Sons.

Course Title: Petroleum Chemistry
Paper Code: CAC.576
Total Lectures: 30

L	T	P	Cr
2	0	0	2

Course Outcomes: At the end of this course student will be able to

(i) Understand the role of petroleum as a source of energy and various processes for economic isolations of petroleum products.

(ii) Apply the concepts for conversion of primary petrochemicals into value added compounds

(iii) Understand various techniques and scope in petroleum chemistry.

Unit 1 **7 Hrs**

Petroleum Refining: Fossil fuel and origin of petroleum, Petroleum resources: detection and exploration of petroleum. Nature of extracted crude oil, classification of crude oil, Physicochemical characteristics of crude oil. General processing of crude oil – Fractionation (atmospheric and vacuum) and stripping, solvent method, de-asphalting, Refining.

Unit 2 **8 Hrs**

Cracking process: thermal and catalytic. Blending of gasoline, knocking and Octane rating,gasoline additives for Aviation fuel. Diesel oil, Cetane rating, Kerosene. LPG-Composition and uses. Synthetic petrol (Fischer-Tropsch method).Desuplhurization and denitrogenation of gasoline.

Unit 3 **8 Hrs**

Petroleum Speciality Products: Raw materials for aliphatic, and inorganic petrochemicals. hydrocarbon solvents, petroleum derived pesticides, refrigeration gases, lubricants and waxes, carbon black, petroleum coke. Methyl tert-butyl ether, polyvinyl acetate, polyvinyl chloride, Teflon, polythene, polypropylene, ethylenepropylene elastomers; Oxo-process.

Unit 4 **7 Hrs**

Petroleum as a raw material for aromatic petrochemicals: Caprolactam, polysterene, terephthalates.Cumene process (Hock process): phenol-acetone production.
Chemicals and products from natural gas: Syn-gas, methanol, ammonia; Ammonia-Urea plant; Fertilizer.

Suggested Readings:

1. Prakash, S., (2010).*Petroleum Fuels Manufacturing Handbook*. McGraw-Hill.
2. Tissot, B. P.,Welte, D. H., (1984).*Petroleum Formation and Occurrence*.Springer-Verlag.
3. Speight, J. G., (2014).*The Chemistry and Technology of Petroleum*. CRC Press.
4. Jones, D. S. J.,andPujado, P. R., (2008). *Handbook of Petroleum Processing*. Springer-Verlag.

Course Title: Advanced Instrumental Methods
Paper Code: CAC.577
Total Lectures: 30

L	T	P	Cr
2	0	0	2

Course Outcomes: The student will have knowledge of

1. The current trends in the analysis of regulatory

Unit 1 **7 Hrs**

Regulatory requirements of Food and Drug Administration (FDA) for food and drug analysis, Environmental Protection Agencies for air water and soil analysis and NABL.Uncertainity calculations and quality assurance.

Unit 2 **7 Hrs**

Advanced Spectroscopic Analysis.:UV-Vis-NIR and its applications, Confocal Raman Spectroscopy, Time Resolved Fluorescence and Fluorescence Correlation Spectroscopic Techniques and their application,

Unit 3 **8 Hrs**

Advanced Mass Spectroscopy: Ion cyclotron mass spectrometer, Ion Trap Mass Spectrometer, C-Trap and Orbitrap Mass spectrometry.
Electron Microscopy including TEM, STEM, FESEM with dark field and bright field imaging.

Unit 4 **8 Hrs**

Chromatographic Techniques: HRMS and MS/MS techniques for analysis of Pesticide residue, Proteomic and Metabolomic analysis. Capillary Electrophoresis,

Suggested Readings:

1. Skoog, D. A., West, D. M., Holler, F. J., and Crouch, S. (2013). *Fundamentals of Analytical Chemistry*. Nelson Education.
2. Rouessac, F., andRouessac, A. (2013). *Chemical Analysis: Modern Instrumentation Methods and Techniques*. John Wiley and Sons.
3. Gross, J. H. (2006). *Mass Spectrometry: A Textbook*. Springer Science and Business Media.
4. Pavia, D. L., Lampman, G. M., Kriz, G. S., and Vyvyan, J. A. (2008). *Introduction to Spectroscopy*. Cengage Learning.
5. Hollas, J. M. (2004). *Modern Spectroscopy*. John Wiley and Sons.
6. Lakowicz, J. R. (2006). *Principles of Fluorescence Spectroscopy*. Springer.

Course Title: Project
Paper Code: CAC.599
Total Contact Hrs:

L	T	P	Cr
0	0	32	16

Course Outcome: The student would be able to

1. Investigate various aspects related to the chemistry problem.
2. Appreciate the literature and its relevance to his topic of interest
3. Write research proposal independently
4. Would generate interest in current topics of research.

Project supervisor would be allocated at the start of the semester and research project would be undertaken in discussion with the project supervisor. At the end of the semester the student has to prepare a project report as per the university guidelines. Upon submission of the project report, the projects would be evaluated based on a project presentation.