Semester-I

First Semester

Core Course

Course Title: Metal-Complexes and Reaction Mechanism

Course Code: CHM501C

Credits = 4
M.M. = 100
L T P=3 1 0

Course Learning Outcomes: After completion of this course, the students will be able to:

CLO 1:	Learn about theories, bonding and structure of coordination compounds
CLO 2:	Understand thermodynamic and kinetic stability of coordination compounds
CLO 3:	Learn about the reactivity and types of reactions in octahedral transition metal complexes.
CLO 4:	Understand and analyze inorganic reactions in square planar complexes and redox reactions of transition metal complexes.

Unit I: Metal-Ligand Bonding **(Contact hours: 16)**

Brief review of Crystal field theory (CFT), Jahn-Tellar distortion, Limitations of CFT, Application of CFSE (Atomic radii, ionic radii, lattice energy and spinels). Experimental evidence for metal-ligand covalent bonding in complexes.

Molecular orbital theory of bonding in octahedral complexes: Composition of ligand group orbitals, Molecular orbitals and energy level diagram for sigma bonded ML_6, Effect of pi-bonding. Molecular orbital and energy level diagram for tetrahedral and square planar complexes

Unit II: Stability of Transition Metal Complexes **(Contact hours: 16)**

Stepwise and overall formation constants. Factors affecting stability of complexes with respect to the nature of metal ion and ligands. Stability of uncommon oxidation states.

Determination of formation constants by pH-metry and spectrophotometry.

Metal Chelates: Characteristics; Chelate effect and the factors affecting stability of metal chelates.

Applications of metal chelates in chemical analysis and medicine.

Complexes of macrocyclic ligands: Crown ethers and cryptands.

Unit III: Reaction Mechanism in Octahedral Transition Metal Complexes **(Contact hours: 16)**

Reactivity of metal complexes, Inert and labile complexes, Kinetic application of valence bond and crystal field theories, Types of substitution reactions; mechanistic classification of substitution reactions: Dissociative, Associative, Dissociative conjugate base and Interchange.

Kinetics of octahedral substitution, Acid hydrolysis, Factors affecting acid hydrolysis, Base hydrolysis, Conjugate base mechanism, Direct and indirect evidence in favor of conjugate mechanism, Anation reactions, reactions without metal ligand bond cleavage.

Unit IV: Reaction Mechanism in Square Planar Complexes and Redox Reactions **(Contact hours: 16)**

Substitution reactions in square planar complexes, Trans-effect, Mechanism of substitution reaction, Factors affecting the rate of substitution- entering and leaving group, Nucleophilicity of entering group.

Redox reactions: Complementary and non-complementary reactions, Classification as outer sphere and inner sphere redox reactions, Mechanism of outer sphere and inner sphere electron transfer reactions- the elementary steps involved, Formation of precursor and successor complexes, Rate laws, Characterization of redox processes as outer and inner sphere. Rate of outer sphere Electron transfer as a function of Structural Reorganization and exergonicity; Marcus Model (an elementary idea)

Books Recommended:

1. Inorganic Chemistry, J. E. Huhey, Harpes & Row. 4thEdn. 2008.
2. Principles of inorganic chemistry; B. R. Sharma, L. R. Sharma, K. C. Kalia; thomos press (India) limited 2010.
3. Inorganic Chemistry; G.L. Miessler & D. A. Tarr; 3rd Edn; Pearson Edn Inc; 2004.
4. Inorganic Chemistry; Shriver & Atkins; 5thEdn; Oxford University Press; 2010.

Reference Books

5. Mechanisms of Inorganic Reactions; F. Basolo, R.G. Pearson; Wiley; 2ndEdn.; 1967.
6. *d*– and *f*–block chemistry; Chris J Jones; RSC; Tutorial chemistry text, 2002.
7. Coordination Chemistry; Ajay Kumar 2nd Edn;Aaryush Education; 2014.
8. Inorganic and Organometallic Reaction Mechanisms; Jim D. Atwood 2nd edn.; Wiley; 1997
9. Advanced Inorganic Chemistry, F. A. Cotton and G. Wilkinson, John Wiley 6thEdn, 1999.
10. Chemistry of the Elements, N. N. Greenwood and A. Earnshaw, Pergamon. 2nd Edn, 1997

Course Title: Stereochemistry and Reaction Mechanism
Course Code: CHM502C

Credits = 4
M.M = 100
L T P=3 1 0

Course Learning Outcomes: After completion of this course, the students will be able to:

CLO 1:	To learn various types of electron displacements in organic compounds along with the concepts of aromaticity and antiaromaticity.
CLO 2:	To gain the knowledge of aliphatic nucleophilic substitution reactions and importance of these reactions in organic synthesis
CLO 3:	To explore the knowledge of aromatic electrophilic substitution reactions and apply them in synthesizing organic molecules.
CLO 4:	To learn about the concepts of chirality and optical activity in stereocenters with one and multiple stereocenters. will also learn about biphenyls, allenes and spiro-compounds.

Unit I: Nature of Bonding in Organic Molecules **(Contact hours: 14)**

Bonding in organic compounds. Review and recapitulation of some basic concepts (Inductive effect, Resonance effect, Hyperconjugation, Cross-conjugation, Electromeric effect.

Aromaticity in benzenoid and non-benzenoid compounds, Huckel's rule of aromaticity, Annulenes; Systems with π-electron numbers other than six (2, 4,8,10 and more than ten π-electron systems), Aromaticity of hetero annulenes. Aromaticity in fused ring systems. Anti-aromaticity, Homoaromaticity, molecular orbital approach (Frost diagrams). NMR interpretation of aromaticity.

Unit II: Aliphatic Nucleophilic Substitution **(Contact hours: 16)**

The SN2, SN1, mixed SN1 and SN2 and SET reactions: Mechanism, Reactivity and Stereochemical aspects (problem solving approach).

The Neighboring group participation by π & σ bonds, anchimeric assistance, classical and non-classical carbocations, phenonium ions, norbornyl system, carbocation rearrangements in neighboring group participation. Intramolecular displacement by hydrogen, Oxygen, nitrogen, sulfur and halogen. Alkyl, cycloalkyl, Aryl participation, participation in bicyclic system, migratory aptitude, intimate and solvent separated ion-pair, trans annular, pinacol and carbocation rearrangements and related rearrangements in neighboring group participation, NGP in elimination and addition reactions.

Unit III: Aromatic Electrophilic and Nucleophilic Substitution **(Contact hours: 14)**

The arenium ion mechanism, orientation and reactivity, energy profile diagram, the ortho/ para ratio, ipso attack, orientation in other ring systems, Naphthalene, Anthracene, Six and five membered heterocycles, Diazonium coupling Vilsmeier reaction, Gattermann – Koch reaction, etc. (problem solving approach)

Aromatic Nucleophilic Substitution: the SNAr, SN1 Benzyne & SNR1, Mechanisms, Reactivity effect of substrate structure, leaving group and attacking nucleophile (problem solving approach)

Unit IV: Stereochemistry **(Contact hours: 16)**

Elements of symmetry. Optical activity and chirality, Molecules with more than one chiral center, Erythro- and threo isomers. Methods of resolution, Optical purity.

Different representations: Sawhorse, Newman and Fischer projections. Convention for assigning D, L and R, S notation of chiral molecules with one, two and multiple chiral centers, biphenyls and allenes.

Study of dissymmetry of allenes, Biphenyls, Spiro compounds. Chirality due to helical shape (Trans-cyclooctene and cyclononene).

Asymmetric induction, Cram's rule. enantiotopic and diastereotopic atoms, Groups and faces.

Stereochemistry of the compounds containing nitrogen, phosphorus and sulfur.

Books/References

1. Advanced Orgnaic Chemistry-Reactions, Mechanism and Structure, Jerry March, 6th Edition John Wiley.
2. Advanced Organic Chemistry, F.A. Carey and R.J. Sundberg, Plenum.
3. A Guide Book to Mechanism in Organic Chemistry, Peter Sykes, Longman.
4. Structure and Mechanism in Organic Chemistry, C.K. Ingold, Cornell University Press.
5. Organic Chemistry, J.clayden, N.Greevs, S. Wawen, P. Wothers, Oxford Press.
6. Modern Organic Reactions, H.O. House, Benjamin.
7. Stereochemistry of Organic Compounds, D. Nasipuri, New Age International.
8. Stereochemistry of Organic Compounds, Stereochemistry of Organic Compounds, Samuel H. Wilen, Ernst L. Eliel

First Semester
Core Course
Course Title: Quantum Chemistry and Thermodynamics
Course Code: CHM503C

Credits = 4
M.M=100
L T P=3 1 0

Course Learning Outcomes: After completion of this course, the students will be able to:

CLO 1:	Understand basic ideas and concepts of quantum mechanics with examples of some basic problems
CLO 2:	Understand and do measurements of various thermodynamic properties, but also the application of mathematical methods to the study of chemical questions and the spontaneity of processes
CLO 3:	Understand the Entropy production and various types of energy and mass flows in non-equilibrium systems
CLO 4:	Understand various types of interfaces, capillary phenomenon and adsorption models

Unit I: Quantum Chemistry-I **(Contact hours: 16)**

Need for quantum mechanics, Operator concept, Quantum mechanical operators (cartesian and spherical polar co-ordinate systems), Eigen value equations and their significance. Schrodinger equation (Time dependent and independent), Properties of quantum mechanical operators, Postulates and theorems of quantum mechanics.
Review of particle in a box problem, extension to two and three dimensions, applications. Solution of harmonic oscillator and the rigid rotator problems. Quantum mechanical tunneling

Unit II: Solution Thermodynamics **(Contact hours: 16)**
Gibbs-Duhem Equation, Gibbs-Duhem Margules Equation and its applications.
Ion-solvent Interactions: Ion-Ion interactions: Activity and activity coefficients, Debye-Huckel theory of activity coefficients of electrolyte solutions; Derivation of Debye-Huckel limiting law, Validity and extension to high concentrations, Ion-pair formation- Bjerrum model, Debye-Huckel-Onsager conductance equation and brief idea of its extension

Unit III: Irreversible Thermodynamics **(Contact hours: 16)**
Basic principles of non-equilibrium thermodynamics: Second law of thermodynamics for open systems, law of conservation of mass, charge and energy. Irreversible processes and uncompensated heat, degree of advancement, reaction rate & affinity of a reaction. Relation of uncompensated heat to other thermodynamic functions. Entropy production, entropy production due to matter flow, heat flow, charge flow and chemical reactions; entropy production and efficiency of galvanic cells.
Concept of forces and fluxes, Onsager‘s theory of irreversible processes, phenomenological laws, their domain of validity. Principle of microscopic reversibility and Onsager relations, Chemical reactions near equilibrium. Curie–Prigogine principle. Transformation properties of forces and fluxes.

Unit IV: Surface Chemistry **(Contact hours: 16)**
Liquid Surface: Surface tension, pressure difference across curved surfaces (Laplace equation), vapor pressure of droplets (Kelvin equation), Capillary condensation, Solid liquid interface: Contact angle, Young’s equation. Wetting, wetting as contact angle phenomena, Thermodynamics of Interfaces: Surface excess, surface tension and thermodynamic parameters, Gibbs adsorption isotherm. Solid surfaces: Adsorption at solid surfaces, adsorption models, Langmuir adsorption isotherm, BET adsorption isotherm and its use in estimation of surface area, Adsorption on porous solids.

Books Recommended:

1. Quantum Chemistry, D. A. McQuarie, Viva Books Pvt Ltd,Student Edn. 2018
2. Quantum Chemistry, R. K. Prasad, New Age Publishers, 4^{th} Edn.; 2010.
3. Physics and Chemistry of Interfaces, H-J, Butt, K. Graf and M. Kappl, 2nd Edn, Wiley- VCH, 2006.
4. Physical Chemistry of Surfaces, A. W. Adamson, A. P. Gast, John Wiley, 6^{th} Edn., 1987

Reference Books:

5. Quantum Chemistry; Ira. N. Levine, Prentice Hall, 7^{th} Edn.; 2013.
6. Thermodynamics of Irreversible Processes; DeGroot, Mazur; Dover;1986.
7. Introduction to Thermodynamics of Irreversible Processes; I. Prigogine; Wiley Interscience; 1967.
8. Modern Thermodynamics, D Kondipodi & I Prigogine, John Wiley. & Sons, 2002
9. Physical Chemistry- P. W. Atkins, Oxford University Press, 8^{th} Edn.; 2006.
10. Physical Chemistry- A Molecular Approach- D. A. McQuarie & J. D. Simons, 1997.

First Semester
Core Course
Course Title: Spectroscopy
Course Code: CHM504C

Credits = 4
M.M = 100
L T P=3 1 0

Course Learning Outcomes: After completion of this course, the students will be able to:

CLO 1:	Study vibrational and rotational spectroscopy of polyatomic molecules, Raman effect and Raman Spectroscopy
CLO 2:	Understand basic principle, taking spectra, interpretation, and application
CLO 3:	Learn about the different pulse sequences and application of NMR spectroscopy to the structural characterization of molecules
CLO 4:	Gain knowledge and information to the most general EM- techniques and the relevant areas where they are presently used

Unit I: Rotational and vibrational Spectroscopy (Contact hours: 20)
Introduction to spectroscopy, Interaction of light with mater, Peak position, Peak intensity and peak width.
Principle of microwave spectroscopy, Classification of molecules, Rigid-rotor model, Effect of isotopic substitution on the transition frequencies, Intensities, non-rigid rotor, Stark effect and applications, Principle of IR, Modes of vibration in molecules, Zero point energy, Force constant and bond strength, Morse Potential energy diagram, Anharmonicity, Derivation of selection rules for diatomic molecules based on harmonic oscillator approximation, Vibrational-Rotational Spectroscopy, PQR Branches. Characteristic vibrational frequencies of various functional groups (group frequencies and fingerprint region), Effects of hydrogen bonding and solvent effect on vibrational frequencies, Overtones, Combination bands and Fermi resonance.
Classical and quantum theories of Raman effect, Pure rotational, Vibrational and vibrational-rotational Raman spectra, Selection rules,

Unit II: Electronic Spectroscopy (Contact hours: 15)
Principle of **Electronic Spectroscopy** UV-Vis spectroscopy, Beer-Lambert's Law and derivation, Additivity of absorbance, Factors causing deviations from Beer's law, Electronic spectroscopy of molecules: Energy levels, Vibrational course structure: progressions Intensity of Vibrational-Electronic spectra; Franck-Condon principle. Electronic excitations, involving π, σ and n-electrons, Chromophores and auxochromes, shifts in UV spectroscopy (Electron donating, Electron withdrawing, Conjugation and extended conjugation), Instrumentation: Single and double-beam spectrophotometers.

Unit III: NMR spectroscopy (Contact hours: 18)
Principle and theory, nuclear spin, Magnetic properties of nuclei. Resonance phenomena and resonance condition, population of energy states (saturation), Relaxation process, sensitivity of NMR instrument, Chemical Shift (Shielding of magnetic nuclei) its measurement, Magnetic Anisotropy, Factors influencing chemical shift, Spin-spin splitting, Coupling constant (Factors effecting Coupling constant "J"), Effect of solvent, Proton and Deuterium exchange, Applications to simple molecules (substituted aliphatic and aromatic compounds).

Unit IV: Electron Microscopy (Contact hours: 12)
Electron Microscopy: Scanning electron microscopy (SEM): basics, instrumentation, applications. Transmission electron microscopy (TEM): Introduction, Basic theory, Electron gun, Electromagnetic lenses, Imaging, Operating parameters-magnification, resolution, depth of field; Sample preparation, Specimen orientation and manipulation; Applications; Selected Area Electron Diffraction.

Books Recommended:

1. Introduction to Spectroscopy, Pavia, Cengage Learning India Pvt Ltd, New Delhi, 5thEdn.; 2015
2. Modern Spectroscopy, J. Michael, 4th Edn; Wiley 2013
3. NMR Spectroscopy: Basic Principles, Concepts and Applications in Chemistry 3rd Edition, Kindle Edition.
4. Nature and Science, Transmission & Scanning Electron Microscopy, Ma, et al, 4(3), 2006

References Books

5. Fundamentals of Molecular Spectroscopy, C.N. Banwell, E. M. Mccash, Tata McGraw Hill Pub, 4thEdn. 1994.
6. Principles of Instrumental Analysis, Skoog, Holler, Nieman,6thEdn.;2006
7. Spectrometric Identification of Organic Compounds Robert M. Silverstein, JohnWiley,7thEdn;2005.
8. Introduction to Instrumental analysis: R. D Braun (Tata McGraw-Hill),1987
9. Instrumental Methods of Chemical Analysis, G.W. Ewing, McGraw Hill Pub, 5thEdn.;1985.

First Semester

Core Course
Course Title: Laboratory Course in Physical Chemistry
Course Code: CHM505C

Credits = 2
M.M. = 100
L T P 0 0 2

Course Learning Outcomes: After completion of this course, the students will be able to:

CLO 1:	Handle and do experiments on potentiometry
CLO 2:	Understand the basics of instrument and how to do experiments on polrimetry and spectrophotometry
CLO 3:	Do experiments using the kinetics approach for different reactions
CLO 4:	Do experiment and use various types of viscometers

Potentiometry

1. Determination of strength of an acid by titration with an alkali
2. Determination of *p*Ka value of a weak acid

Polarimetry

3. Determination of the specific rotation of an optically active compound and determination of unknown concentration from the calibration curve.
4. Determination of the rate constant of inversion of cane sugar catalysed by $HCl/HNO_3/H_2SO_4$

Spectrophotometry

5. Establishing the validity of Beer-Lambert law.
6. Determination of composition of a binary mixture through spectrophotometry.
7. Spectrophotometric titration of Fe(II) vs $KMnO_4$.

Chemical Kinetics

8. Study of the saponification of an ester and to find the order of the reaction and the rate constant.
9. Determination of order of reaction between $K_2S_2O_8$ and KI by initial rate method. And determination of ionic strength.

Viscometery

10. To find the viscosity of a given liquids at different concertation's and hence to find the unknown concentration.
11. To find the radius of the molecule of a liquid.

Books Recommended:

1. Experiments in Physical Chemistry, Schoemaker et al., MGH, 8th Edn.; 2011
2. Experimental Physical Chemistry, Arthur M. Halpern, George C. McBane, Freeman, 3rd Edn.; 2006.
3. Advanced Practical Physical Chemistry, Yadav, Goel Pub, 1994.
4. Chemistry Experiments for Instrumental Methods, Sawyer, Heineman, Beebe, Wiley, 1984.
5. Findley's Practical Physical Chemistry, B.P. Levitt, 1973.

Reference Books

5. Quantitative Chemical Analysis; Daniel Harris, Freeman 9th Edn.; 2016.
6. Experimental Inorganic/Physical Chemistry; Mounir A. Malati Horwood, 1999.

First Semester
Core Course
Course Title: Laboratory Course in Inorganic Chemistry
Course Code: CHM506C

Credits = 2
M.M. = 100
L T P 0 0 2

Course Learning Outcomes: After completion of this course, the students will be able to:

CLO 1:	Acquire hands-on experience/practical knowledge in performing experiments.
CLO 2:	Learn about the preparation and characterization of various coordination complexes.
CLO 3:	Separate metal ions on the basis of their reactivity by using chromatography.

Separation and estimation of following binary metal ion system using Gravimetry and Tritimetry (any 1)

1. Estimation of Ag as AgCl by gravimetric method
2. Ni-Cu; Estimation of Ni gravimetrically and Cu volumetrically

Preparations of Coordination compounds of transition metals

Theoretical appraise of first row transition metal coordination chemistry. Synthesis as a Laboratory technique (Concepts, Calculations, Design of Synthetic procedures and Characterizations)

3. Preparation of at least three to four inorganic compounds from the below mentioned List.

   $[Cu(NH_3)_4]\ SO_4.H_2O$; cis-$K[Cr(C_2O_4)_2(H_2O)_2].2H_2O$; $K_3[Cr(C_2O_4)_3].\ 3H_2O$; $[Co(en)_2(C_2O_4)]Cl.H_2O$; $[Co(NH_3)_5(NO_2)](NO_2)_2$; $[Ni(en)_3]Cl_2$; $[Ni(acac)_2]$; $[Ni(NH_3)_6]Cl_2$; $[Ni(dmg)_2]$

4. Preparation of trans dichlorobis (ethylenediamine)cobalt(III) chloride and its conversion to cis-isomer. Analyse via *UV/Vis.* spectroscopy
5. Preparation and applications of metal organic frameworks (MOFs): MOF−5/ZIF−8/MIL−101

Separation and Identification of following given mixtures by paper/thin layer chromatography (Any 1)

6. Fe (III), Al (III) and Cr (III).
7. Co (II) and Ni (II).
8. Li (I), Na (I) and K (I).

Experiments based on Spectrophotometry

9. To study the complexation reaction between Fe(III) & salicylic acid and determination of composition of the corresponding complex by jobs method of continuous variation.
10. Spectrophotometric determination of Iron using 1,10-Phenanthroline.

Books Recommended

1. Advanced Practical Inorganic Chemistry, Gurdeep Raj, Goel Publishing House, 25th Edition, 2014.
2. Synthesis and Technique in Inorganic chemistry, G. S. Girlomi; R. J. Angleci; University Science Books. 3rd Edn.; 1999.
3. Vogel's Quantitative Analysis Mendham, Denny; Pearson Education, 6thEdn.; 2000

Reference Books

4. Quantitative Chemical Analysis; Daniel Harris, Freeman 9th Edn.; 2016.
5. Inorganic syntheses, Thomas B. Rauchfuss,Vol. 35. Wiley, 2010
6. Advanced Experimental Inorganic Chemistry; Ayodha Singh; Campus Books, 2002.
7. Experimental Inorganic/Physical Chemistry; Mounir A. Malati Horwood, 1999.
8. The Synthesis and Characterization of Inorganic compounds W. A Jolly, 3rd Edn.; 1990
9. Advanced Practical Inorganic Chemistry; Adams; Raynor, Wiley; 1965.
10. Thin Layer Chromatography, A laboratory handbook, E. Stahl, Springer Verlag, 2nd Edn.; 1965.

First Semester
Discipline Centric Course
Course Title: Mathematical and Statistical Methods for Chemists
Course Code: CHM509E

Credits = 3
M.M=100
L T P=3 0 0

Course Learning Outcomes: After completion of this course, the students will be able to:

CLO 1:	Inculcate in them a mathematical aptitude, thinking, and skills to solve problems
CLO 2:	Apply the knowledge of determinants and matrix algebra to understand and solve the quantum and thermodynamic problems
CLO 3:	Apply the basic calculus to kinetics, quantum chemistry, thermodynamics and to real world problems
CLO 4:	Use different statistical methods for refining and analyzing the data

Unit I: Determinants and Matrix Algebra **(Contact hours: 10)**
Determinants, Basic concepts, Types and properties
Matrices: Rectangular, Square, Diagonal & triangular matrices, Trace of a matrix, Addition and multiplication of matrices, Zero & identity matrix, Transpose, Adjoint & inverse of matrices, Special matrices (Symmetric, Skew-symmetric, Hermitian, Skew-Hermitian, Unitary matrices.)
Matrix equations: Homogeneous and non-homogeneous linear equations and conditions for their solutions, Eigen-value problem

Unit II: Calculus (Differentiation and Integration) **(Contact hours: 10)**
Functions and their continuity and differentiability, Rules for differentiation, Applications of differential calculus including maxima and minima finding (Examples: Maximally populated rotational levels, Bohr's radius, Most probable velocity from Maxwell distribution), Integration, Basic rules for integration, Integration by substitution, Integration by parts, Applications of integral calculus (Kinetics: zero, first, second order reactions)

Unit III: Elementary Differential Equations **(Contact hours:12)**
Partial differentiation, Co-ordinate transformations (Cartesian to spherical polar co-ordinates). Order and degree of differential equations, Homogeneous and non-homogeneous equations. Variable-separable equations: Linear first order differential equations and its solutions. Second order differential equations, Solution by auxiliary equation method. (Applications to quantum chemistry).

Unit IV: Statistical Methods **(Contact hours: 10)**
General introduction: Instrumental and non-instrumental methods of analysis in analytical chemistry. Errors in chemical analysis, Classification of errors, Determinate and indeterminate errors, Accuracy and precision, Mean, Median, Average deviation and standard deviation, Confidence limit, Correlation coefficient and regression analysis, Comparison of methods: F-test and T-test, Rejection of data based on Q-test, Grubs test, Least squares method for deriving calibration graph, Concepts and difference between sensitivity, (LOD) and (LOQ).

Books Recommended:

1. Physical Chemistry; Thomas Engel & Philip Reid; Pearson Education 3rd Edn.; 2013
2. Mathematics for Physical Chemistry; R. G. Mortimer; Esevier; 4th Edn.; 2013.
3. The Chemistry Mathematics Book; E. Steiner; Oxford; 2nd Edn.; 2008.
4. Quantitative Chemical Analysis; Daniel Harris, Freeman 9thEdn.; 2016
5. Mathematical Method in Physical Science; M. L. Boas, John Wiley and Sons; 3rd Edn.; 2005.

References Books

6. Mathematical Methods for Scientists and Engineers; D. A. McQuarie; Viva Books Pvt Ltd.; 2009.
7. Basic Mathematics for Chemists; Tebbutt; Wiley; 2nd Edn.; 1998
8. Mathematical Techniques in Chemistry; J. B. Dence; Wiley; 1975.
9. Mathematics for Chemists; C. L. Perrin; Wiley; 1971.

First Semester
Discipline Centric Course
Course Title: Green Chemistry
Course Code: CHM508E

Credits = 3
M.M=100
L T P=3 0 0

Course Learning Outcomes: After completion of this course, the students will be able to….

CLO 1 :	Understand the fundamental principles of twelve of green chemistry
CLO 2 :	Understand the principles of green chemistry
CLO 3:	Understand how to design and develop the new green synthetic approach for synthesis of natural and unnatural compounds
CLO 4:	Design, develop and practice the green methods and processes in chemical sciences

Unit I: Introduction. (Contact hours: 4)
Need for Green Chemistry, Goals of Green Chemistry, Limitations/ Obstacles in the pursuit of the goals of Green Chemistry.

Unit II: Principles of Green Chemistry. (Contact hours: 18
Designing a Chemical synthesis using these principles-Prevention/ minimization of hazardous/ toxic products reducing toxicity-Green Solvents-Energy requirements for reactions-Selection of starting materials-Use of catalytic reagents in relations-Prevention of chemical accidents-Strengthening/Developments of analytical techniques.

Unit III: Green synthesis/reactions. (Contact hours: 16)
Green Synthesis of the following compounds: adipic acid, catechol, disodium iminodiacetate (alternative to Strecker synthesis). Microwave assisted reactions in water. Microwave assisted reactions in organic solvents. Diels-Alder reaction and Decarboxylation reaction. Ultrasound assisted reactions. Surfactants for carbon dioxide. Designing of Environmentally safe marine antifoulant. Green synthetic approach for synthesis non-toxic Rightfit pigment (organic and inorganic pigments). An efficient, green synthesis of a compostable and widely applicable plastic (poly lactic acid) made from corn. Production of Healthier fats and oil by Green Chemistry. Development of Fully Recyclable Carpet.

Unit IV Future Trends in Green Chemistry (Contact hours: 8)

Oxidation reagents and catalysts; Biomimetic, multifunctional reagents; Combinatorial green chemistry; Proliferation of solventless reactions; co crystal controlled solid state synthesis (C2S3); Green chemistry in sustainable development.

Books Recommended:

1. Green Chemistry theory and Practice, P. T. Anastas and J. C. Warner, Oxford University Press, 2000.
2. Green Chemistry- Environment Friendly Alternatives; Rashmi Sangh & M. M Srivastava; Narosa, 2007.
3. Green Chemistry– Environment Benign Reactions, V. K. Ahluwalia, CRC Press, 2007
4. Methods and Reagents of Green Chemistry: An Introduction, P. Tundo (Editor), A. Perosa, F. Zecchini, 2007.
5. Real-World cases in Green Chemistry, M.C. Cann & M.E. Connely American Chemical Society, Washington, 2000.

References Books

6. Green Chemistry in Pharmaceutical Industry, P. J. Dunn. A. Wells, M. T. Williams, Wiley VCH, 2010.
7. Green Chemistry- An Introductory Text; M. Lancester, RSC Publishing, 2ndEdn.; 2010
8. Green Chemistry; Samuel Delvin; IVY Publishing House; IstEdn.; 2008.
9. Introduction to Green Chemistry, A.S. Matlack, Marcel Dekker, 2001