DEPARTMENT OF CHEMISTRY

ISLAMIC UNIVERSITY OF SCIENCE AND TECHNOLOGY, AWANTIPORA-192122, J&K, India

Semester-I

Department of Chemistry
Islamic University of Science and Technology Awantipora

Overview of the Course Scheme
First Semester

Semester	Course Code	Course Title	Course Type	Maximum Marks			Credit Distribution			Credits	Total Credits
				Internal*	Final	Total	L	T	P		
I	CHM501C	Metal-Complexes and Reaction Mechanism	Core	50	50	100	3	1	0	4	22
	CHM502C	Stereochemistry and Reaction Intermediates	Core	50	50	100	3	1	0	4	
	CHM503C	Quantum Chemistry and Thermodynamics	Core	50	50	100	3	1	0	4	
	CHM504C	Introduction to Spectroscopic Methods	Core	50	50	100	3	1	0	4	
	CHM505C	Laboratory Course in Physical Chemistry	Core	50	50	100	0	0	2	2	
	CHM506C	Laboratory Course in Inorganic Chemistry	Core	50	50	100	0	0	2	2	
	CHM507E	Mathematics for Chemists	Discipline Centric	25**	25	50	2	0	0	2	
	CHM508E	Green Chemistry	Discipline Centric	25**	25	50	2	0	0	2	

*(Midterm 30 marks + Assignment 10 marks + Attendance 10 marks)
**(Midterm 15 marks + Assignment 5 marks + Attendance 5 marks)

A total of 22 credits to be taken by students with following breakup:
Core =20 Credits
Discipline Centric =2 Credits

First Semester
Core Course
Course Title: Metal-Complexes and Reaction Mechanism
Course Code: CHM501C

Credits = 4
M.M. = 100

Unit I: Metal-Ligand Bonding

Brief review of Valence bond theory, Bent rule and energetics of hybridization, VSEPR Theory- shapes of trigonal bypyramidal, Octahedral and pentagonal bipyramidal molecules/ions (PCl_5, VO_3^-, SF_6, $[SiF_6]^{2-}$, $[PbCl_6]^{2-}$ and IF_7), Limitations of VSEPR theory.
Crystal field theory (CFT), Salient features, Spectrochemical series, Splitting of d-orbitals in octahedral, square planar and tetrahedral geometry, Applications of CFT: Colors of transition metal complexes, Magnetic properties of octahedral complexes, Jahn-Tellar distortion, Factors affecting crystal field stabilization energy (CFSE), Limitations of CFT, Experimental evidence for metal-ligand covalent bonding in complexes, Nephelauxetic effect, Ligand field theory.

Unit II: Molecular Orbital Theory and Stability of Transition Metal 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.
Step-wise and overall formation constant and their relationship, Trends in step-wise constant (kinetic and thermodynamic stability) of metal complexes, Factors affecting the stability of metal complexes with reference to the nature of the metal ion and ligand, Chelate effect, Macrocyclic effect, their thermodynamic origin, Determination of binary formation constant by pH metry and spectrophotometry.

Unit III: Reaction Mechanism in Octahedral Transition Metal Complexes

Reactivity of metal complexes, Inert and labile complexes, Kinetic application of valence bond and crystal field theories, Kinetics of octahedral substitution, Acid hydrolysis, Factors affecting acid hydrolysis, Base hydrolysis, Conjugate base mechanism, Direct and indirect evidences in favour of conjugate mechanism, Anation reactions, reactions without metal ligand bond cleavage.

Unit IV: Reaction Mechanism in Square Planar Complexes and Redox Reactions

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.
Factors affecting the rate of electron transfer-Chemical activation, Sigma and pi nature of donar/ acceptor orbitals, electron configuration of oxidant/reductant, Bridging ligand effect in inner sphere reactions.

Books Recommended:

1. Inorganic Chemistry, J. E. Huhey, Harpes & Row. 4th Edn. 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. Coordination Chemistry; Ajay Kumar; 2nd Edn ; Aaryush Education; 2014.
5. Inorganic Chemistry; Shriver & Atkins; 5th Edn; Oxford University Press; 2010.
6. Reaction Mechanism of Inorganic and Organometallic Systems; R. B. Jordan; Oxford; 3rd Edn.; 2007.
7. Comprehensive Coordination Chemistry eds., G. Wilkinson, R. D. Gillars and J. A. Mc Clevert, Pergamon. 2nd Edn. 2003.
8. Advanced Inorganic Chemistry, F. A. Cotton and G. Wilkinson, John Wiley 6th Edn, 1999.
9. Chemistry of the Elements, N. N. Greenwood and A. Earnshaw, Pergamon. 2nd Edn, 1997.
10. Inorganic Electronic Spectroscopy, A. B. P. Lever, Elsevier. 2nd Edn, 1997.
11. Inorganic and Organometallic Reaction Mechanisms; 2nd edn.; Jim D. Atwood; Wiley; 1997
12. Mechanisms of Inorganic Reactions; D. Katakis, G. Gordon; Wiley; 1987.
13. Magnetochemsitry, R. L. Carlin, Springer Verlag, 1986.
14. Inorganic Chemistry; K. F. Purcell, L. C. Kotz; Saunders; 1977.
15. Electronic Spectra of Transition Metal Complexes; D. Sutton; McGraw Hill; 1968.
16. Mechanisms of Inorganic Reactions; F. Basolo, R.G. Pearson; Wiley; 2nd Edn.; 1967.

First Semester
Core Course
Course Title: Stereochemistry and Reaction Intermediates
Course Code: CHM502C

Credits = 4
M.M = 100

Unit I: Nature of Bonding in Organic Molecules

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, Antiaromaticity, Homoaromaticity, molecular orbital approach (Frost diagrams). NMR interpretation of aromaticity. Inclusion compounds-cyclodextrins, Catenanes and rotaxanes, Fullerenes.

Unit II: Reaction Intermediates and Mechanism

Carbocations: Structure and stability, Classical and non-classical, Stability and reactivity of bridge-head carbocations.
Carbanions: Generation, structure and stability.
Radical: Generation, structure, stability and reactions, Cage-effects, Radical–cations and radical-anions.
Carbenes: Formation and structure, Reactions involving carbenes and carbenoids.
Nitrenes: Generation, Structure and reactions of nitrenes.
Arynes: General methods of generation and reactivity.
Reaction Mechanism and its determination: Types of reactions, general methods of determining reaction mechanism (kinetic and thermodynamic requirements, structure of products, isotopic labeling, stereochemical evidence, kinetic isotope effects), transition states and intermediates, Hammond postulate.

Unit III: Stereochemistry

Optical activity and chirality, Molecules with more than one chiral center, Erythro- and threo isomers. Methods of resolution, Optical purity. Fischer's projection formula. 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 synthesis, Crams rule. Enantiotopic and diastereotopic atoms, Groups and faces, Stereochemistry of the compounds containing nitrogen and sulfur.

Unit IV: Conformational Analysis

Conformational analysis of mono, di and tri-substituted cyclohexanes and their stereochemical features (geometrical and optical isomerism), Conformation and reactivity of substituted cyclohexanes, cyclohexanol (Oxidation and Acylation) and cyclohexanone (Reduction). Conformation and stereochemistry of cis and trans-decalin and 9-methyldecalin, Interconversion of sawhorse, Newman and Fischer projections.

Books Recommended:

1. Advanced Organic Chemistry, Reactions, Mechanism and Structure, Jerry March, John Wiley. 7th Edn.; 2013
2. Organic Chemistry, Paula Yurkanis Bruce, Pearson; 7 edition (29 December 2012).
3. Stereochemistry of Organic Compounds, D. Nasipuri. 3rd Edn. 2011
4. Advanced Organic Chemistry, J. Singh and L. D. S. Yadav, Pragati Prakashan. Meerut India, Ed., 2011.
5. Advanced Organic Chemistry; F. A. Carey and R. J. Sundberg; Springer Plenum; 5th Edn.; 2007.
6. Organic Chemistry by I. L. Finar Vol-I and II,. ELBS Publications. 6th Edn.; 2002.
7. A Guide Book to Mechanism in Organic Chemistry; Peter Sykes; Longman; 6th Edn.; 1996
8. Organic Chemistry, R. T. Morison & R. N Boyd, Prentice Hall, 6th Edn.; 1992.
9. Carbenes, Nitrenes and Arynes, T. L. Gilchrist and C. W. Rees, Thomas Nelson and Sons Ltd., London. 1971.
10. Fundamentals of Aromaticity, Manzoor Ahmad Rather, Aadil Khursheed, Scimedtech Publishing, 1st Ed, 2018.
11. Organic Chemistry, J. Clayden, N. Greeves and S. Warren. Oxford University Press, 2nd Edition 2016.
12. Organic Chemistry, Joseph M. Hornback, Cengage Learning; 2 edition (January 31, 2005).

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

Credits = 4
M.M=100

Unit I: Quantum Chemistry-I

Operator concept, Quantum mechanical operators (cartesian and spherical polar co-ordinate systems), Schrodinger equation (Time dependent and independent), Properties of quantum mechanical operators, Postulates of quantum mechanics.
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: Quantum Chemistry-II

Born-Oppenheimer approximation, Solution of the Hydrogen-like atom problem- radial and angular wave functions. Angular momentum and electronic structure of atom, General theory of angular momentum, Eigen functions and eigenvalues of angular momentum operators, Ladder operators, Spin angular momentum, Anti-symmetry and Pauli's principle. Atomic term symbols, Term separation of p^n and d^n configurations, Spin-Orbit coupling, Zeeman splitting.

Unit III: Classical Thermodynamics

Brief review of concepts of laws of thermodynamics. Entropy and entropy change, Helmoltz and Gibbs free energy, Change in free energy, Gibbs-Helmholtz equation. Partial molar properties, Partial molar free energy and chemical potential, partial molar volume and partial molar heat content and their significances, Determination of these quantities, Concept of fugacity and determination of fugacity. Application of phase rule to two component systems, eutectics.

Unit IV: Interface Thermodynamics

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- Ira. N. Levine, Prentice Hall, 7th Edn.; 2013.
3. Quantum Chemistry, Prasad, New Age Publishers, 4th Edn.; 2010.
4. Introduction to Quantum chemistry; A. K. Chandra; Tata McGraw Hill; 1998.
5. Physical Chemistry- P. W. Atkins, Oxford University Press, 8th Edn.; 2006.
6. Physical Chemistry- A Molecular Approach- D. A. McQuarie & J. D. Simons, 1997.
7. Physics and Chemistry of Interfaces, H-J, Butt, K. Graf and M. Kappl, 2nd Edn, Wiley- VCH, 2006.
8. Physical Chemistry of surfaces, A. W. Adamson,A. P. Gast, John Wiley, 6th Edn., 1987

First Semester
Core Course
Course Title: Introduction to Spectroscopic Methods
Course Code: CHM504C

Credits = 4
M.M = 100

Unit I: Statistical Methods

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).

Unit II: Microwave and IR Spectroscopy

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, 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.

Unit III: Raman and UV-Visible Spectroscopy

Classical and quantum theories of Raman effect, Pure rotational, Vibrational and vibrational-rotational Raman spectra, Selection rules,
Principle of UV-Vis spectroscopy, Beer-Lambert's Law and derivation, Additivity of absorbance, Factors causing deviations from Beer's law, 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 IV: NMR spectroscopy

Principle and theory, Nuclear spin, Saturation, Shielding of magnetic nuclei, Chemical shift and its measurement, 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).

Books Recommended:

1. Quantitative Chemical Analysis; Daniel Harris, Freeman 9th Edn.; 2016
2. Introduction to Spectroscopy, Pavia, Cengage Learning India Pvt Ltd, New Delhi, 5th Edn.; 2015
3. Fundamentals of Analytical Chemistry, D. A. Skoog and D. M. West, Holt Rinehart and Winston Publications, 4th Edn.; 2014.
4. Analytical Chemistry by G. D. Christian, John Wiley & Sons Inc, Singapore., 7th Edn.; 2013.
5. Principles of Instrumental Analysis, Skoog, Holler, Nieman, 6th Edn.; 2006
6. Spectrometric Identification of Organic Compounds Robert M. Silverstein, John Wiley, 7th Edn; 2005.
7. Introduction to Instrumental analysis: R. D Braun (Tata McGraw-Hill), 1987
8. NMR in Chemistry, MacMillan Ltd, W. Kemp, 1986.
9. Instrumental Methods of Chemical Analysis, G. W. Ewing, McGraw Hill Pub, 5th Edn.; 1985.
10. Fundamentals of Molecular Spectroscopy, C.N. Banwell, E. M.Mccash, Tata McGraw Hill Pub, 4th Edn. 1994.

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

Credits = 2
M.M. = 100

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 be HCl.

Calorimetry

5. Determination of heat of neutralization of a strong acid with a strong base.
6. Determination of heat of neutralization of a weak acid with a strong base.

Spectrophotometry

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

Chemical Kinetics

10. Study of the sonication of an ester and to find the order of the reaction and the rate constant.
11. Determination of order of reaction between $K_2S_2O_8$ and KI by Initial rates method.

Viscometery

12. To find the viscosity of a given liquids at different concertation's and hence to find the unknown concentration.
13. 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.

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

Credits = 2
M.M. = 100

Qualitative Analysis

1. Analysis of two cations and anions (macro analysis of elements).
2. Identification of cations including those of less common elements using semi-micro technique.

Separation and estimation of following binary metal ion system using Gravimetry and Tritimetry

3. Cu-Ni: Estimation of both by gravimetric method
4. Ag-Cu, Estimation of Ag gravimetrically and Cu volumetrically
5. Cu-Zn: Estimation of both by gravimetric method
6. Cu-Fe: Estimation of both by gravimetric method
7. Ca-Mg: Estimation of both by titrating against EDTA solution
8. Zn-Mg: Estimation of both by titrating against EDTA solution

Preparations of Coordination compounds of transition metals

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

9. $[Cu(NH_3)_4]\ SO_4.H_2O$
10. cis-$K[Cr(C_2O_4)_2(H_2O)_2].2H_2O$
11. $K_3[Cr(C_2O_4)_3].\ 3H_2O$
12. $[Co(en)_2(C_2O_4)]Cl.\ H_2O$
13. $[Co(NH_3)_5(NO_2)](NO_2)_2$
14. trans- $[Co(en)_2Cl_2]Cl$
15. $Ni(en)_3]Cl_2$
16. $Ni(acac)_2$
17. $[Ni(NH_3)_6]Cl_2$
18. $Ni(dmg)_2$

Separation and Identification of following given mixtures by paper/thin layer chromatography

19. Ni (II) and Co (II).
20. Co (II) and Ni (II).
21. Cu (II), Ni (II) and Co (II).

Books Recommended:

1. Quantitative Chemical Analysis; Daniel Harris, Freeman 9th Edn.; 2016.
2. Inorganic syntheses, Thomas B. Rauchfuss, Vol. 35. Wiley, 2010
3. Advanced Experimental Inorganic Chemistry; Ayodha Singh; Campus Books, 2002.
4. Vogel's Quantitative Analysis Mendham, Denny; Pearson Education, 6th Edn.; 2000
5. Synthesis and Technique in Inorganic chemistry, G. S. Girlomi; R. J. Angleci; University Science Books. 3rd Edn.; 1999.
6. Experimental Inorganic / Physical Chemistry; Mounir A. Malati Horwood/1999.
7. The Synthesis and Characterization of Inorganic compounds W. A Jolly, 3rd Edn.; 1990
8. Advanced Practical Inorganic Chemistry; Adams; Raynor, Wiley; 1965.
9. Thin Layer Chromatography, A laboratory handbook, E. Stahl, Springer Verlag, 2nd Edn.; 1965.

First Semester
Discipline Centric Course
Course Title: Mathematics for Chemists
Course Code: CHM507E

Credits = 2
M.M = 50

Unit I: Probability and Vectors

Probability: Variables, Discrete and continuous, Sample space, Event probability, Fundamental counting principles: Permutations and combinations, Binomial probabilities, Probability distribution functions, Probability involving discrete and continuous variables**,** Average values, Distribution moments and variance.
Vectors: Vectors, Dot, Cross and triple products with applications.

Unit II: Determinants and Matrix Algebra

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 III: Calculus (Differentiation and Integration)

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 IV: Elementary Differential Equations

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).

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. Mathematical Method in Physical Science; M. L. Boas, John Wiley and Sons; 3rd Edn.; 2005.
5. Mathematical Methods for Scientists and Engineers; D. A. McQuarie; Viva Books Pvt Ltd.; 2009.
7. Basic Mathematics for Chemists; Tebbutt; Wiley; 2nd Edn.; 1998
9. Mathematical Techniques in Chemistry; J. B. Dence; Wiley; 1975.
10. Mathematics for Chemists; C. L. Perrin; Wiley; 1971.

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

Credits = 2
M.M. = 50

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Unit I: Principles and Concept of Green Chemistry

Concept and principles, Development of green chemistry- atom economy reactions, Rearrangement reactions, Addition reactions, Atom uneconomic-sublimation elimination-wittig reactions, Toxicity measures, Need of green chemistry in our day to day life.

Unit II: Environmental Performance

Importance of measurement, Lactic acid production, Safer gasoline, Introduction to life cycle assessment, Four stages of life cycle assessment (LCA), Carbon foot printing-green process, Matrics, Eco labels- integrated, Pollution, Prevention and control (IPPC)-REACH (Registration, Evaluation, Authorization of Chemicals).

Unit III: **Green Energy Process**

Design for energy efficiency, Photochemical reactions, Advantages, Challenge faced by photochemical process, Microwave technology on chemistry, Microwave heating, Microwave assisted reactions, Sono chemistry and Green chemistry, Electrochemical synthesis-examples of electrochemical synthesis.

Unit IV: Renewable Resources

Biomass, Renewable energy, Fossil fuels, Energy from biomass, Solar power, Other forms of renewable energy-Fuel-Cells, Alternative economics, Syngas economy, Hydrogen economy, Bio-refinery chemicals from fatty acids, Polymer from renewable resources, Some other natural chemical resources.

Books Recommended:

1. Green Chemistry in Pharmaceutical Industry, P. J. Dunn. A. Wells, M. T. Williams, Wiley VCH, 2010.
2. Green Chemistry- An Introductory Text; M. Lancester, RSC Publishing, 2nd Edn.; 2010
3. Green Chemistry; Samuel Delvin; IVY Publishing House; Ist Edn.; 2008.
4. Methods and Reagents of Green Chemistry: An Introduction, P. Tundo (Editor), A. Perosa, F. Zecchini, 2007.
5. Green Chemistry- Environment Friendly Alternatives; Rashmi Sangh & M. M Srivastava; Narosa, 2007.
6. Green Chemistry– Environment Benign Reactions, V. K. Ahluwalia, CRC Press, 2007
7. Green Chemistry theory and Practice, P. T. Anastas and J. C. Warner, Oxford University Press, 2000
8. Stream Lined Life-Cycle assessment, T. E. Graedel, Prentice Hall, New Jersey, 1998.