

**Course No: CH14201CR**  
**Title: Inorganic Chemistry (04 Credits)**

*Max. Marks: 100*  
*External Exam: 80 Marks.*

*Duration: 64 Contact hours*  
*Internal Assessment: 20 Marks*

**Unit-I: Mechanisms of Ligand Substitution Reactions in Octahedral Metal Complexes: (16 Contact hours)**

Energy profile of a reaction; reactivity of metal complexes; inert and labile complexes.

Types of substitution reactions; mechanistic classification of substitution reactions:-Dissociative, Associative, Dissociative conjugate base and Interchange. Empirical criteria to differentiate the mechanism of substitution.

Substitution in octahedral complexes- Classification of metal ions based on water exchange rates. Metal-complex formation- the Eigen-Wilkins mechanism. Anation reactions.

Hydrolysis Reactions; Simple Acid hydrolysis, Acid catalysed and Base hydrolysis. Stereochemical changes in Octahedral Substitution Reactions.

Substitution reactions without metal-ligand bond breaking.

**Unit-II: Mechanism of Ligand Substitution Reactions in Square-Planar complexes: (16 Contact hours)**

Significance of the two-term rate<sup>law</sup>, Mechanism, and Steric course of the substitution reactions.

Factors affecting the rate of substitution:- Entering and leaving groups; nucleophilicity of entering group and the  $n_{pt}$  scale, central metal ion, solvent, and the non-leaving groups.

The Trans effect;- Theories, applications in synthesis.

cis-trans isomerization in square planar complexes.

**Unit-III: Electron Transfer Reactions in Coordination Complexes: (16 Contact hours)**

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 reactions as outer and inner sphere.

Factors affecting the rate of electron transfer- Chemical activation; sigma and pi nature of donor/acceptor orbitals; Electron configuration of oxidant/reductant. Bridging ligand effects in inner-sphere reactions.

Homogenous Catalysis using Organometallic Compounds: Catalysis, Terminology of Catalysis and Tolman Catalytic loop;

Oxidative addition, reductive elimination and migration (insertion) reactions.

Hydrogenation and Hydroformation reactions in alkenes.

#### **Unit-IV: Organo Metallic Compounds**

**(16 Contact hours)**

Introduction, History and Importance of organometallic compounds as reagents, additives and Catalysts.

Nomenclature and Classification of Organometallic compounds.

Effective atomic number (18-Valence electron) rule and its significance.

Stability of Organometallic Compounds towards heat, oxidation and hydrolysis.

Preparation, Properties, Structure, bonding and applications of Alkyls and aryls of Li, B and Al.

Synthesis, Structure and bonding in Zeise's Salt.

Metal Clusters: Introduction to metal clusters; Dinuclear species ; Metal –metal multiple bonds.

#### ***Books Recommended:***

1. Advanced Inorganic Chemistry, 6th ed. /5th ed. F.A. Cotton , G. Wilkinson (Wiley 1999/1988)
2. Inorganic Chemistry, 4th ed. J. E. Huheey, E. A. Keiter..... (Harper Collins, 1993)
3. Chemistry of the Elements 2nd ed. - N. N. Greenwood, A. Earnshaw (Butterworth, 1997)
4. Mechanisms of Inorganic Reactions - D. Katakis, G. Gordon (Wiley, 1987)
5. Reaction Mechanism of Inorganic and Organometallic systems, 2nd ed.- R. B. Jordan (Oxford, 1998)
6. Mechanisms of Inorganic Reactions, 2nd ed. - F. Basolo, R.G. Pearson (Wiley, 1967)
7. Inorganic Chemistry- K. F. Purcell, I.C. Kotz (Saunders, 1977).
8. Electronic Spectra of Transition Metal Complexes - D. Sutton (McGraw-Hill, 1968)
9. Elements of Magnetochemistry - R. L. Dutta, A. Syamal (Affiliated East -West, 1993).

**Course No. CH14202CR**  
**Title: Organic Chemistry (04 Credits)**

*Max. Marks: 100*  
*External Exam: 80 Marks.*

*Duration: 64 Contact hours*  
*Internal Assessment: 20 Marks*

**Unit-1: Aromatic Electrophilic Substitution (16 Contact hours)**

**Overview:** Arenium ion mechanism, Sigma and pi – complexes, Energy profile diagram, Effect of leaving group. Orientation and reactivity in mono substituted benzene ring, *Ortho / Para ratio*, Ipso attack.

The Third substitution : Orientation of substitution in benzene ring with more than one substituent. Orientation in other ring systems. Carboxylation of aromatic rings with  $\text{COCl}_2$  and amidation with  $\text{NH}_2\text{COCl}$ . Reversal of F.C. acylations. Synthetic application of F.C. acylation and nitration reactions (Toluene to nitro<sup>-</sup> benzoic acids, synthesis of *ortho & Para* nitro anilines)

**Aromatic Nucleophilic substitution:**

Discussion of different mechanism ( $\text{S}_{\text{N}}1$ ,  $\text{S}_{\text{N}}\text{Ar}$ , Benzyne and  $\text{S}_{\text{RN}}1$ ). Structure reactivity relationships. Effect of leaving group and attacking nucleophile. Mechanisms of Von- Richter, Sommelet-Hauser and Smiles rearrangements and Chichibabin reaction.

**Free Radical Substitution:**

Free radical substitution mechanisms. Mechanisms at an aromatic substrate. Neighbouring Group Assistance in free radical reaction, reactivity for aliphatic and aromatic substrates. Reactivity in the attacking radical. Effect of solvent on reactivity.

Allylic halogenation (NBS), oxidation of aldehydes to carboxylic acids, auto-oxidation, coupling of alkynes and arylation of aromatic compounds by diazonium salts, Sandmeyer reaction, free radical rearrangement and Hunsdiecker reaction.

**Unit-II: Addition to carbon-hetero multiple bonds. (16 Contact hours)**

**Overview of reactivity carbonyl compounds:** Mechanisms of addition of water, hydrogen cyanide, alcohols, amines, organometallic reagents and hydrides to aldehydes and ketones.

Mechanism of Wittig, Mannich, Aldol, Cross Aldol, Cannizzaro's, Knoevenagel, Robinson annulation, Claisen, Dickman, Benzoin, Perkin and Stobbes reactions.

**Addition to carbon-carbon multiple bonds:**

General mechanism, reactivity, orientation and stereochemical implications of additions reactions involving electrophiles, nucleophiles and free radicals. Addition to cyclopropane ring. Hydrogenation of

double/triple bonds and aromatic rings. Hydroboration, Ene-reaction, Michael reaction and Sharpless asymmetric epoxidation.

### **Unit-III: Molecular Rearrangements**

**(16 Contact hours)**

General mechanistic treatment of nucleophilic, electrophilic and free radical rearrangements. Nature of migration and migratory aptitude and memory effect. Detailed study of following rearrangements: Wagner-Meerwein, Pinacol- Pinacolone, Demjanov, Benzil-Benzilic acid, Favorskii, Arndt-Eistert, Neber, Hofmann, Curtius, Lossen, Schmidt, Beckmann, Baeyer-Villiger, Pyne and Dienone - phenol rearrangements.

### **Unit-IV: Pericyclic reactions.**

**(16 Contact hours)**

Molecular orbital symmetry, Frontier orbitals of ethene, 1,3- butadiene, 1,3,5-hexatriene and allylic systems. HOMO, LUMO concept, FMO approach. Classification of Pericyclic reactions. Woodward Hofmann rules for the following pericyclic reactions. Cycloadditions'. Thermal and Photochemical 2+2 and 4+2 cycloadditions. Suprafacial and antarafacial cyclo addition.

**Electrocyclic Reactions:** Thermal and Photo-induced Electrocyclic reactions of  $4n$  and  $4n + 2$  systems and their stereochemistry. Conrotatory and disrotatory motions.

**Sigmatropic rearrangements:** Classification, [1,3], [1,5] and [3,3] sigmatropic shifts. Cope and Claisen rearrangements. Suprafacial and antarafacial shifts of hydrogen atom.

#### ***Books Recommended***

1. Advanced Organic Chemistry Reactions, Mechanism and Structure, 4th Ed., Jerry March. (Wiley, 1999).
2. Advanced Organic Chemistry 4th Ed. - F. A. Carey and R. J. Sundberg. (Plenum, 2001).
3. A Guide Book to Mechanism in Organic Chemistry 6th Ed.- Peter Sykes. (Longman, 1996).
4. Structure and Mechanism in Organic Chemistry 2nd Ed. - C. K. Ingold. (CBS, 1994).
5. Modern Organic Reactions 2nd Ed. - H.O. House (Benjamin, 1972)
6. Principles of Organic Synthesis 2nd Ed. - R.O.C. Norman (Chapmann Hall, 1978)
7. Reaction Mechanism in Organic Chemistry 3rd Ed. - S.M. Mykherjee and S.P. Singh. Macmillan, 1998).
8. Organic Chemistry - J. Hornback, pk. (Brooks/Cole, 1998)
9. Fundamentals of Organic Chemistry, 5th ed.- Solomons. (Wiley, 1992)
10. Organic Chemistry, 5th Ed.- John McMurry. (Brooks/Cole, 2000)

## Course No: CH14203CR

### Title: Laboratory Course in Organic Chemistry-I (04 Credits)

*Max. Marks: 100*

*External Exam: 80 Marks.*

*Duration: 64 Contact hours*

*Internal Assessment: 20 Marks*

1. **Qualitative Analyses of Organic Compounds**
2. **Physical Properties:** Physical state, colour, odour, solubility behavior and melting / boiling points.
3. **Chemical Properties**
  - (a) **Flame test**
  - (b) **Detection of elements:** Nitrogen, Sulphur and Halogens
  - (c) **Detection of Functional Groups:** Detection of Carbohydrates, Unsaturation, Carboxylic acids, Carbonyl compounds, Phenols, Alcohols, Halides, Amines, Amides, Imides, Ureas, Thioureas, Nitrocompounds and Hydrocarbons.
  - (d) **Preparation and recrystallization of the derivatives of above mentioned group of compounds.**
4. **Detection of functional groups using IR spectroscopy ( spectra to be provided)**
5. **Separation, Purification and identification of Organic compounds from a three component mixture:**
  - (a) **Separation based on solubility in water and organic solvents.**
  - (b) **Separation based on chemical properties:** Solubility in Sodium bicarbonate, Sodium Hydroxide and Hydrochloric acid.

(C) *Identification of individual components using physic-chemical properties*

#### **Books Recommended:**

1. Experiments and Techniques in Organic Chemistry - D. Pasto, C. Johnson and M. Miller (Prentice-hall, 1992.)
2. Microscale and Macroscale Organic Experiments- K.L. Williamson (D.C. Heath and Co., 1989).
3. Advanced Practical Organic Chemistry, 2<sup>nd</sup> ed. - N.K. Vishnoi (Vikas, 1999).
4. Vogel's Textbook of Practical Organic Chemistry, 5<sup>th</sup> ed.- A.R. Tatchell (ELBS, • 1996)
5. Comprehensive Practical Organic Chemistry, V. K. Ahluwalia and Renu Aggarwal, (University Press-2000)

**Course No: CH14204EA**  
**Title: Solid State Chemistry (04 Credits)**

*Max. Marks: 100*  
*External Exam: 80 Marks.*

*Duration: 64 Contact hours*  
*Internal Assessment: 20 Marks*

**Unit-I: Structure of Solids** **(16 Contact hours)**

*Lattices and Unit cells:* Miller indices; Laue, Bragg, and Debye-Scherrer method of X-ray structural analysis of crystals.

*Indexing the reflections;* identification of cubic unit cells from systematic absences in diffraction pattern.

*Structure of simple lattices and X-ray intensities;* structure factor and its relation to intensity and electron density; phase problem.

Introduction to neutron and electron diffraction techniques. Their comparison with X-ray diffraction technique.

**Unit-II: Theories of Solids** **(16 Contact hours)**

**Free electron theory of metals:** The Drude Model, Lorentz modification, Sommerfield Model; Fermi-Dirac distribution function, Density of states, electron heat capacity, Hall effect.

**Electron Energy Bands:** Nearly free electron model, Bloch Theorem and periodicity of Bloch functions and their eigenvalues, energy bands in general periodic potential-Kronig-Penney model. Qualitative band schemes for insulators, semiconductors and metals.

**Semiconductors:** Intrinsic & extrinsic semiconductor (n-type & p-type), temperature dependence of charge carriers, p-n junction- devices based on p-n junction (Tunnel diode, injection laser).

**Unit-III: Electric and Magnetic Properties of Solids** **(16 Contact hours)**

**Dielectric Properties of Solids:** Dielectric constant, Polarization and Polarizability, Piezoelectricity, pyroelectricity and ferroelectricity, ferroelectric materials and their applications.

**Magnetic properties of solids:** origin of magnetism in solids, Diamagnetism, paramagnetism (Langevin's and quantum mechanical formulations), ferromagnetism (Weiss theory), antiferromagnetism and ferrimagnetism. Temperature dependence of magnetization.

**Super conductors:** Characteristic properties- Zero resistance, Meissner effect, Heat capacity, Thermal conductivity, absorption of em radiations and Josephson effect. BCS theory of superconductivity. Applications.

## **Unit-IV: Defects and Diffusion in Solids and Solid state Reactions (16 Contact hours)**

Crystal defects and their types, Point defects: Schottky and Frenkel defects, Thermodynamics of Schottky and Frenkel defect formation, Colour centres. Extended defects: Dislocations and their types, Large and small angle boundaries.

Diffusion in solids and diffusion coefficients

Solid state reactions - general principles. Experimental procedures. Kinetics of Solid-state reactions (Solid-Solid & Solid-Gas reactions), Methods for Improving the reactivity of solids.

### ***Books Recommended:***

1. Physical Chemistry - P. W. Atkins, ELBS , Oxford, 1997.
2. Physical Chemistry- A Molecular Approach - D. A. McQuarie & J. D. Simon, University Science Books, 1997.
3. Introduction to Solids, Azaroff, Tata McGraw,1993.
4. Solid State Chemistry and its Applications, West, Wiley,1989.
5. The Physical Chemistry of Solids, Borg, Biens, Academic press, 1992.
6. Solid State Reactions, Schmalzried, Academic press, 1995.
7. Solid State Physics, N.W.Ashcroft and N.D.Mermin, Saunders college, 2001.
8. Elements of Solid state Physics, J.P. Srivastava, Prentice Hall of India, 2003.

**Course No: CH14205EA**  
**Title: Analytical Techniques. (04 Credits)**

*Max. Marks: 100*

*External Exam: 80 Marks.*

*Duration: 64 Contact hours*

*Internal Assessment: 20 Marks*

**Unit-I: Chromatographic techniques (16 Contact hours)**

Introduction, Types and Classification; principles – differential migration, nature of partition forces, partition, Mobile phases, stationary phases, resolution, separation time, zone migration, column packing materials, development techniques, differential migration, partition coefficient, retention time, retention volume..

Plate theory, HETP, band broadening, efficiency and resolution. Basic principles and applications of Liquid-Solid and Liquid-Liquid column chromatography. Paper and thin layer chromatography, ion exchange (size exclusion),

Gas-Liquid chromatography. HPLC-theory, column efficiency, extra column and band broadening, temperature effects and diffusion. Chiral chromatography, chiral stationary phases, applications of HPLC, Electrophoresis.

**Unit- II: Electroanalytical and Thermal Methods (16 Contact hours)**

Electrophoresis: Factors affecting ion migration, electro-osmosis, theory and applications of capillary electrophoresis.

Polarography – diffusion current, half-wave potential, Ilkovic equation, DME. (Applications in organic/inorganic analysis).

Amperometric titrations-Basic principle and applications.

Coulometry and Electrogravimetry: Electrogravimetry, Controlled-Potential Coulometry, Constant-Current Coulometric Titrations.

Thermal Methods; Thermogravimetry (TG/TGA), Differential Thermal analysis (DTA), Differential scanning calorimetry (DSC), Thermometric titrations

**Unit-III: Magnetic Resonance Spectroscopy (16 Contact hours)**

Basic principles-Nuclear spin, spin angular momentum, quantization of angular momentum, nuclear magnetic moment, precessional (Larmor) frequency, energy levels in a magnetic field, resonance absorption of radio frequency radiation. Population of energy levels, Relaxation processes (T<sub>1</sub>, T<sub>2</sub>).

Shielding and deshielding of magnetic nuclei. Chemical shift, its measurement and factors influencing chemical shifts; local paramagnetic and diamagnetic shielding, neighboring group anisotropy.



Spin-Spin coupling, coupling constants. Low and high resolution  $^1\text{H}$  NMR spectrum of protons undergoing chemical exchange (ethanol). Chemical equivalence and magnetic equivalence. Double resonance techniques; spin decoupling, nuclear overhauser enhancement.

Instrumentation; FT-NMR and its advantages. NMR studies of nuclei other than proton –  $^{13}\text{C}$ ,  $^{19}\text{F}$  and  $^{31}\text{P}$ .

#### **Unit-IV: Electron Spin Resonance spectroscopy (16 Contact hours)**

Basic principles- electron spin, magnetic moment of an electron and its interaction with applied magnetic field. Splitting of spin energy states and absorption of microwave radiation.

Hyperfine coupling, Isotropic and anisotropic hyperfine coupling constants, Fermi contact, Spin polarization effects, Dipolar coupling, McConnell equation and calculation of spin densities in inorganic radicals such as  $\text{CO}_2\cdot$ ,  $\text{CH}_3\cdot$ ,  $\text{BH}_3\cdot$  and  $\text{F}_2\cdot$ .

Spin orbit coupling and significance of g tensors.

Zero field splitting and Kramer's degeneracy (fine structure), Applications

#### **Books Recommended:**

1. Chromatographic methods A. Braithwaite and F.J. Smith fifth edition-kluwer academic publishers 1999 ISBN 0751401587
2. Essence of Chromatography Colin.F. Poole-Elsevier. Inc
3. Principles and Practice of Analytical Chemistry, 5<sup>th</sup> Edition, F. W. Fifield, D. Kealey, Balckwell Sciences Ltd. 2000.
4. Modern Analytical Chemistry, David Harvey, McGraw-Hill Higher Education, 2000.

## Course No: CH14206EA

Title: Laboratory Course in Organic Chemistry-II (04 Credits)

*Max. Marks: 100*

*External Exam: 80 Marks.*

*Duration: 64 Contact hours*

*Internal Assessment: 20 Marks*

### 1. Quantitative Estimation of following compounds

- (a) Glucose.
- (b) Glycine
- (c) Acetone
- (d) Phenol.
- (e) Ascorbic acid.

### 2. Determination of Iodine and Saponification values of an oil sample.

### 3. Organic Preparations

- (a) Acetylation of Cholesterol or salicylic acid.
- (b) Oxidation of Cyclohexanol by chromic acid to get adipic acid.
- (c) Aldol condensation: Dibenzal acetone and benzaldehyde.
- (d) Cannizarro's reaction of 4-Chlorobenzaldehyde.
- (e) Aromatic electrophilic substitutions in benzene, benzoic acid or aniline.
- (f) Beckman rearrangement starting from acetophenone.
- (g) Haloform reaction: Preparation of Iodoform.

#### ***Books Recommended:***

1. Experiments and Techniques in Organic Chemistry - D. Pasto, C. Johnson and M. Miller (Prentice-hall, 1992.)
2. Microscale and Macroscale Organic Experiments- K.L. Williamson (D.C. Heath and Co., 1989).
3. Advanced Practical Organic Chemistry, 2nd ed. - N.K. Vishnoi (Vikas, 1999).
4. Vogel's Textbook of Practical Organic Chemistry, 5th ed.- A.R. Tatchell (ELBS, • 1996)
5. Comprehensive Practical Organic Chemistry- Quantitative Estimations and Preparations, V. K. Ahluwalia and Renu Aggarwal, (University Press-2000)

**Course No: CH14207EO**  
**Title: Chemistry in Everyday Life-II (04 Credits)**

*Max. Marks: 100*  
*External Exam: 80 Marks.*

*Duration: 64 Contact hours*  
*Internal Assessment: 20 Marks*

**Unit I** **(16 Contact hours)**

**Water- An Amazing Chemical Stuff.**

Molecular structure and its unique properties. Distribution of water on earth. Water content of various organisms and food material. Composition of natural water. The Hydrologic cycle: Recycling & purification.

Hard and Soft water. Standards for drinking water. Major causes of water pollution. Contamination of water: Chemical substances affecting potability, color, turbidity, odour, taste, pH and conductivity of water. Methods of treatment of water for domestic and industrial purposes: Sedimentation, Coagulation, Filtration, Sterilization, Break point Chlorination, Flocculation & Fluorination, demineralization and reverse osmosis. Determination of alkalinity of water. Water born diseases.

**Unit II** **(16 contact hours)**

**Fossil Fuels- Coal, Oil & Natural Gas.**

**Coal:** Formation of Coal deposits. Types & composition of coal. Fuel value of various coals. Analysis of coal: Proximate and ultimate analysis. Significance of fuel gas analysis. Carbonization of coal. Manufacture of metallurgical coke by Otto Hoffman's by product oven.

**Oil & Natural Gas:** Formation of oil fields, composition & chemical structures of petroleum products. Refining of petroleum, cracking & catalytic reforming. Octane & Cetane rating of fuels. Diesel engine fuel, Kerosene and Gasoline. Lead in petrol: its role, disadvantages & alternatives. LPG & CNG as fuel, addition of mercaptanes to natural gases for safety reasons.

**Alternative Fuels:** Ethanol, Bio-fuels, Bio-gas, Hydrogen & Fuel cells.

**Unit III: Nutrition** **(16 contact hours)**

**Digestive Processes:** Breaking down of larger molecules into smaller molecules undergoing metabolism like carbohydrates, Proteins, fats and Vitamins. Aerobic and Anaerobic Metabolism of Carbohydrates. Role of Fat in Animal Metabolism.

**Energy value of Nutrients:** Fats and oils, sweets, vegetables and fruits. Counting of energy calories. Per day energy requirements.

**Food Additives:** Flavoring agents, Preservatives (antimicrobial and antioxidant agents). Shelf life of food material. Artificial sweeteners.

**Food Adulterants:** Adulterants in Milk, Ghee, Oil, Coffee, Tea, Chilli & Turmeric Powders & Pulses

**Unit IV: Forensic Chemistry**

**(16 contact hours)**

Introduction. History of forensic science, Theory of forensic analysis. Fingerprint development, Ninhydrin, Silver Nitrate and Phenolphthalein reactions. Cyanoacrylate and Luminol Tests. Alcohol Detection. Drug Analysis. Hair , Urine and Blood Analysis. DNA fingerprinting. Superglue fuming.

Soil Analysis: pH, Microscopic and Chromatographic Analysis. Instrumentation.

**Books recommended**

1. Industrial Chemistry by B.K.Sharma. (Goel publishing House).
2. Applied Chemistry by K.Bagavathi. (Sundan MJP Publishers)
3. Text book of Engineering Chemistry by S.S. Dara. (S.Chand and Co)
4. Engineering Chemistry by M.M.Uppal. & S. Bhatia. (Khanna Publishers)
5. Engineering Chemistry by J.C.Kuricose & J.Rajaram (Tata McGraw Hill)
6. General Organic and Bio-chemistry by Bettelheim and Brown. (Campbell books/cole) - 2009
7. Forensic Chemistry by Suzana Bell (Pearson Prentice-Hall)- 2006
8. Forensic Chemistry Handbook by Lawrence Kobilisky ( John Wiley & Sons Inc.) - 2012
9. [http:// www.aafs.org](http://www.aafs.org)
10. <http://www.fbi.gov>.