DEPARTMENT OF CHEMISTRY / PHARMACEUTICAL CHEMISTRY

UNIT – I:

Bonding Theories of Metal Complexes: Crystal field theory: salient features, splitting of metal orbitals in regular and distorted octahedral, square planar, tetrahedral, square pyramidal and trigonalbipyramidal geometries. Measurement of crystal field splitting energy, High spin and low spin octahedral complexes. Crystal field stabilization energies. Factors affecting the magnitude of crystal field splitting. Jahn-Teller distortion. Applications and limitations of crystal field theory. Molecular orbital theory: Nephelauxetic effect. Molecular orbital diagrams of octahedral, tetrahedral and square planar complexes. Molecular orbital treatment of π-bonding in complexes.Magneto Chemistry of Metal Complexes: Types of magnetism: para, dia, ferro and antiferro magnetism. Temperature independent paramagnetism.Behavior of para, dia, ferro and antiferro magnetic substances with temperature.Magnetic susceptibility measurement; Gouy method and Faraday method. Magnetic properties of metal ions – spin moment and orbital moment. Orbital contribution to magnetic moment. Spin orbit coupling, Quenching of orbital angular momentum by ligand fields.

Reaction Mechanisms of Metal Complexes: Reactivity of metal complexes; inert and labile complexes. Concept of liability and inertness of complexes in terms of Valance bond and crystal field theories.Nucleophilic substitution reaction of octahedral complexes: Dissociative (SN1) and associative (SN2) mechanism. Acid hydrolysis, factors affecting acid hydrolysis, Base hydrolysis. Conjugate base (CB) mechanism: Evidences in favour of conjugate base mechanism.Reaction without the breakage of metal-ligand bond.Nucleophilic substitution reactions of square planar complexes. Mechanisms of substitution in square planar metal complexes, Trans effect, theories of trans effect, polarization theory and π-bonding theory, Application of trans-effect, Electron transfer reactions: inner sphere and outer sphere mechanisms, Cross reactions and Marcus-Hush theory.

UNIT –II:

Organometallic Compounds: Classification and nomenclature of organometallic compounds; principles of synthesis of organometallic compounds, synthesis, structure and properties of organometallic compounds of Al &Sn. 18-electron rule and stability of organo transition metal compounds.Synthesis, structure and bonding of olefin, allyl and cyclopentadienyl organometallic compounds of Fe, Pd and Pt. Application of organomtallic compounds of B and Si in organic synthesis. Organometallic compounds in homogeneous catalysis – Hydrogenation, Hydroformylation and isomerization processes.

Bioinorganic Chemistry: Metal ions in biological systems; Brief survey of metal ions in biological systems. Basic principles underlying biological selection of elements.Effect of metal ions concentration and physiological effects. Oxygen transport and storage: hemoglobin and myoglobin. Geometric, electronic and magnetic aspects of dioxygen binding, oxygen adsorption isotherms and cooperativity, physiological significance of hemoglobin, Role of globin chain in hemoglobin. Metals in medicine: Metals used for diagnosis, Radio diagnosis, Magnetic resonance imaging. Metals used for therapy – lithium, gold and platinum. Chelate therapy.

UNIT –III:

Reaction Mechanism: Investigation of reaction mechanisms: kinetics, isotopes, study of intermediates and product analyses–study of reaction intermediates; formation and stability of carbonium ions, carbanions, carbenes, nitrenes, free radicals and arynes; mechanism in aromatic necleophilic substitutions: SNAr, benzyne mechanisms. Elimination reactions: various types of eliminations and their mechanistic pathways, orientation in eliminations, elimination *vs* substitution. Study of nucleophilic substitutions with specific reference to the neighboring group participation (through pi and sigma bonds).Factors effecting the reactivity and mechanism of necleophilic substitutions (substrate structure, nature of the leaving group and attacking nucelophile*etc*).Selective organic name reactions: Mannich reaction, Michael addition, Tschitcibabin reaction, Shapiro reaction, Barton reaction. Rearrangement reactions: Hoffmann, Curtius, Favarski, Bayer-Villiger, Beckmann, Fries, Banzidine, Benzil-Benzilic acid and Dienone-phenol rearrangements, Von Ritcher rearrangement- Hoffman, Lffler, Freytag reaction–Robinson's annulations–Knoevenagel condensation, The Darzens condensation.

Synthetic Organic Chemistry: Formation of C-C and C=C bonds: C-C single bonds: alkylation–importance of enolates–Alkylation of relatively acidic methylene group, alkylation of ketones–The enamine reaction lithium dialykylcuprates(Gilman's reagent)–Synthetic application of carbenes and carbenoids. C=C (double) bonds: Beta elimination reactions–pyrolyticsyn eliminations–Wittig and related reactions–Peterson olefination–Stereoselective synthesis of tri and tetra substituted ethylenes–Oxidative decarboxylation of carboxylic acids.

Heterocyclic Chemistry: Classification of the heterocycles based on the nature of the hetero atom and size of the ring π-excessive and π-deficient heterocycles – synthesis, properties and comparative study and reactivities of furan, pyrrole and thophene: Synthesis and reactivity of indole, pyridine, quinoline, isoquinoline, coumarin, pyrazoles, imidazoles, isozxazoles, pyrimidines.

UNIT –IV:

Oxidations and Reductions: Oxidations: Oxidation of C=C with transition metal oxidants–$KmnO_4$ and OsO_4, stereochemistry of perhydroxylation. Epoxidation and subsequent transformation of epoxides–Reactions of alkenes with singlet oxygen–Cleavage of glycols [HIO_4 and $Pb(OAc)_4$]–Allylic oxidation with transition metal oxidants. Reductions: Group III – hydride transfer reagents to reduce carbonyl groups and other functional groups ($NaBH_4$ and $LiAlH_4$)–stereochemistry of hydride reduction (cyclohexanone)–Group IV hydride donors–dissolving metal reductions–addition of hydrogen – reductive removal of functional groups–Reductive C-C (single) bond and C=C (double) bond formation.

Reagents in Organic Synthesis: Use of the following reagents in organic synthesis and functional group transformations: phase transfer catalysts: tetra alkyl ammonium halides and crown ethers, Woodward-Prevost hydroxylation, 1,3-dithianes (Reactivity and umpolung effect), lithium diisopropyl amide (LDA), dicyclohexylcarbodiimide (DCC), trimethylsilysliodide, tri-*n*-butylitin hydride, dichlorodicyanobenzoquinone (DDQ), selenium dioxide, Wilkinson's catalyst and Baker's yeast, Merrifield resins.

Stereochemistry: Molecular symmetry in organic molecules: symmetry elements and symmetry operations–Configuration–R, S nomenclature, E,Z nomenclature for unsaturated systems, Re and Si faces, prochirality–recemization and recemic modifications – Resolution of recemic modifications. Principles of chemical reactivity; kinetic control and thermo dynamic control – partial and absolute asymmetric synthesis – Introduction to stereo selective synthesis–stereochemistry of nitrogen compounds with a tetra co-ordinate chiral center–stereochemistry of the compounds containing–C=N and N=N, concept of dynamic enantiomerism and Atrop-isomerism–Conformational analyses of mono and di substituted cyclohexanes.

UNIT –V:

Thermodynamics: Concept of standard states–standard entropy–entropy changes in chemical reactions–entropy of mixing, standard entropies of ions. Third law of thermodynamics–calculation of absolute entropies of solids, liquids and gases–tests and exceptions–Gibb's and Helmholtz free energy, standard free energy of formation–Variation of free energy with temperature and pressure–free energy change in phase transformations Clapeyron and Clausius-Clapeyron equation–Maxwell's relationships and thermodynamic equation of state–Non-ideal systems: Fugacity of gas, determination (general and graphical methods). Activity and activity coefficients of electrolyte solutions–Determination using Debye-Huckel equation and EMF method–vant Hoff's reaction isotherm. Non-ideal mixtures: Concept of partial molar properties–partial molar free energy–chemical potential, Gibb's-Duhem equation–variation of chemical potential with temperature and pressure.

Electrochemistry and Electrochemical Cells: Conductance of strong electrolytes–interionic attraction theory–thickness of ionic atmosphere, Debye Huckel Onsager treatment and derivation of conductance equation–tests and deviations–ion association–ion pair formation association constant. Electrochemical cells: Reversible and irreversible cells–Nernst equation of cell emf (thermodynamic formulation)–relation to equilibrium constant of cell reaction and other thermodynamic parameters. Chemical cell and concentration cells with and without transference; Liquid junction potential and its determination; Application of emfmeasurements.Determination of pH, pKa and Ksp–potentiometric titrations (acid-base, redox and precipitation).

Kinetics: Simultaneous reactions: Derivation of first order rate expression for parallel, opposing and consecutive reactions. Theory of absolute reaction rates–application to reactions between atoms and molecules–Thermodynamic formulation of reaction rates–Calculation of activation parameters. Lindemann's theory of unimolecular reactions and Hinshelwood modification–Effect of solvent and ionic strength on rates of ion-ion and ion dipole reactions–Isotopic effect on reaction rates–substrate and solvent isotopic effect, Termolecular reactions: Reactions of nitric oxide with hydrogen, oxygen and halogens. Kinetics of fast reactions: Flow methods–stopped flow and continuous flow methods–Relaxation methods - Flash photolysis.

UNIT –VI:

Quantum Chemistry: Planck's equation theory and derivation of Plank's temperature radiation law – Derivation of time independent Schrodinger wave equation–wave function and significance of ψ and ψ^2-normalization and orthogonality of wave function–well behaved functions–Operators like momentum (ρ), angular momentum (L), Energy (E), Hamiltonian (H) and Hermitian–Properties of Hermitian operator–Operator algebra–Postulates of quantum mechanics. Applications: Application of Schrodinger wave equation to particle in a one dimensional box and three dimensional box–degenerate states–quantum mechanical tunneling (qualitative treatment). Rigid rotator; Application of Schrodinger equation to rigid rotator–derivation of energy expression and wave function of a rigid.

Photochemistry: Photo physical processes–Radiationless processes (vibrational relaxation, internal conversion, intersystem crossing) and their rate constants – Radiative process–Fluorescence emission, phosphorescence emission. Kinetics of phtophysicalunimolecular processes. Delayed fluorescence.Quantum yield and its determination, fluorimetry, phosphorimetry. Bimolecular processes–quenching–Stern-Volmer relationship derivation and deviations. Photochemical processes–Unimolecular processes. Isomerisations and rearrangements (photochemistry).Photoreduction (hydrogen abstraction by carbonyl group) Norrish Type I and II process.

UNIT-VII:

Microwave Spectroscopy: Classification of molecules based on moment of intertia.Ddiatomic molecule as rigid rotator and its rotational energy levels.Selectionrules.Calculation of bond lengths from rotational spectra of diatomic molecules.Isotoic effect on rotational spectra.Calculation of atomic mass from rotational spectra.

Vibrational Spectroscopy: Vibrational energy levels of diatomic molecules, selection rules, calculation of force constant from vibrational frequency. Anharmonic nature of vibrations.Fundamental bands, overtones and hot bands, Fermi resonance, Vibration-rotation spectra of diatomic molecules.Vibrations of poly atomic molecules.Normal modes of vibrations, concept of group frequencies.Characteristics of vibrational frequencies of functional groups; stereo chemical effect on the absorption pattern in carbonyl group, cis-trans isomerism and hydrogen bonding.

Electronic Spectroscopy: Elementary energy levels of molecules – selection rules for electronic spectra; types of electronic transitions in molecules. Chromophone: conjugated dienes, trienes and polyenes, unsaturated carbonyl compounds, benzene and its derivatives. Woodward-Fieserrules.Polynuclear aromatic hydrocarbons and diketones.Solvent and structural indluence on absorption maxima, steriochemicalfactors.Cis-trans isomers, and cross conjugation, Application of electronic spectra.

UNIT-VIII:

NMR Spectroscopy: Theory of NMR, Nuclear energy levels – Instrumentation–Relaxation phenomenon–spin-spin and spin-lattice relaxations. Shielding and de-shielding mechanism–chemical shift. Factors affecting the chemical shift.Isotropic and anisotropic effects– alkanes, olefins, acetylenes and aromatic systems. Low and High spin resolution NMR spectra of ethyl alcohol. Spin-Spin coupling, strong and weak coupled systems–coupling mechanism-types of coupling constants.Factors affecting coupling constants (hybridization, dihedral angle and steric effects).Applications of spin-spin coupling to structure and stereochemistry of organic molecules–NOE effect and its applications, Lanthanide shift reagents.

ESR Spectroscopy: Introduction, principle, Instrumentation of ESR spectrometer; Presentation of ESR spectra–Hyperfine coupling constant; ESR spectrum of hydrogen atom, Landay's splitting factor and its significance. ESR spectra of organic radicals like methyl, ethyl, isopropyl, benzene (anions &cation radicals), *p*-benzosemiquinone and naphthalene anion and Cu(II)salicylaldimine complex.

Mass Spectroscopy: Principle, Ionization of molecules–Instrumentation–Determination of molecular formula–General patterns of fragmentation–preliminary account of chemical ionization–Fragmentation patters in different functional group systems–Application of mass spectroscopy in the structural determinations.

Combined Applications of UV, IR, ^{1}H NMR and MS spectroscopy.

UNIT – IX:

Principles of Drug Discovery: Drug Discovery without lead: Penicillin and Librium. Lead Discovery: Random Screening, Nonrandom Screening, Drug metabolism Studies, Clinical Observations.

SAR Studies: Introduction i) Binding role of Hydroxyl group, Amino group, Aromatic ring, Double bond, Ketones and Amides. ii) Variation of substituents: Alkyl substituents, Aromatic substituents, Extension of structure, Chain extension/contraction, ring expansion/contraction, ring variation, ring fusion. iii) Simplification of the structure, rigidification, conformational blockers. X-ray crystallographic studies. Drug development based on SAR–Morphine modification.Development of Cimetidine and Captopril from the lead molecules. Clinical Trials: Phase–I, Phase–II, Phase–III, Phase–IV trials (Introductory treatment only).

Synthetic Pharmaceuticals: Synthesis and Pharmacological activity of the following drugs: Benzocaine (Local anesthetic), Phenobarbitone, Nitrazepam (Hypnotic), Diclofenac, Celecoxib (Anti-inflammatory), Pheneramine (Anti-histamine), Enalapril (Anti-hypertensive), Isoprenalin (Sympathomimetic), Procainamide (Cardio-vascular) and Omeprazole (anti-ulcer), Cis-platin, 5-Flouoro Uracil (Anti-Cancer), Tinidazole (Anti-amoebic), Miconozole (Anti-fungal), Ciprofloxacin, Norfloxacin (Antibacterial), Ethembutal (Anti-tubercular), Clofazimine (Anti-leprosy and anti T.B), Cloxacillin, Cephalexin (Antibiotics) and Zidoviudine (Anti-AIDS).

UNIT - X:

Introduction to green chemistry and green synthesis: Introduction, principle, atom economy and scope. Introduction to alternative approaches. Solvent free reactions–principles, scope utility of solvent free reactions condition, controlling solvent free reactions. Phase changes, optimum reaction temperature, miscibility of reactants and catalysts, basic principles of green synthesis, different approaches to green synthesis–a) use of green reagents in green synthesis–dimethylcarbonate, polymer supported reagents–per acids, chromic acid, PNBS. b) Green catalysts–acid catalysts, oxidation catalyst, basic catalyst. c) phase transfer catalysts in green synthesis–aliquat 336, benzyltrimethylammonium chloride or bromide (TMBA), TEBA, tetra-n-butyl ammonium chloride, bromyl, chlorate or hydroxide, benzyltriphenylphosphonium iodide.

Chromatography Methods: General discussion, Adsorption and Partition chromatography, principles and applications of paper chromatography, thin layer chromatography. Gas chromatography–Applications and instrumentation: detectors used in GC–thermal conductivity detectors, flame ionization detectors, N-P, photo ionization detectors; HPLC-applications and instrumentation: Refractometric, Fluorescence, Diode array detectors; GC-MS and LC-MS; techniques and applications.