DEPARTMENT OF CHEMISTRY
RESTRUCTURED SYLLABUS

effective from Session 2013-14

Semester I

Physical Chemistry

Thermodynamics I

Lectures

a. Basic concepts and definitions — Applicability of thermodynamics, thermodynamic systems and their classification, Universe, system, surroundings and different types of boundaries
b. Zeroth law and temperature
c. Thermometry
d. Processes, reversible and irreversible process, thermodynamic equilibrium and steady state.
e. Work and heat involved in a thermodynamic process.
f. First law and Concept of internal energy
g. Application to various kinds of processes
h. State and path functions, exact and inexact differentials
i. Change in Internal energy
j. Joule’s experiment and consequences
k. Enthalpy
l. Specific heat at constant volume and pressure, relationship between them and their differences
m. Standard states
n. Kirchoff’s equations

Chemical Kinetics and Catalysis

Lectures

a. Rate of a reaction
b. Rate laws and rate constants
c. Order and molecularity
d. Integrated rate laws
e. Half life and its significance
f. Determination of order of reaction

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Kinetic Molecular Theory of Gases

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Inorganic Chemistry

(A) Atomic Structure
H-Spectra; Wave mechanical model; de Broglie relation; Heisenberg Uncertainty Principle & its significance; Schrödinger Wave Equation (qualitative approach); Radial and Radial Probability Functions; Angular and angular probability functions (qualitative idea only); s, p and d – type atomic orbital envelope diagrams; nomenclature of atomic orbitals. Exchange energy, Hund’s rule, limitations of Aufbau Principle.

(B) Periodic Table
Modern form of Periodic Table (IUPAC version), Nomenclature of Super-heavy elements (Z >100), screening effect and Slater’s rules.
Inert Pair Effect, trends in atomic/ionic size, ionization energy, electronegativity and electron affinity of the s-, p-, d- and f- block elements, ionic potential and diagonal relationship in the Periodic Table. Scales of Electronegativity: Mulliken Scale, Pauling Scale and Alred–Rochow Scale. Variation of electronegativity with bond order and oxidation states.

(C) Radioactivity
Atomic nucleus – nuclear stability, n/p ratio and different modes of decay, nuclear binding energy, nuclear forces, Meson field theory, Nuclear Shell Model (elementary idea) and magic numbers.
Nuclear reactions – nuclear fission, nuclear fusion, spallation and transmutation of elements. Uses of isotopes in Chemistry.

Organic Chemistry

(A) General Introduction and Bonding Features in Organic Molecules (12 lectures)
DBE, steric effects, inductive effects, bond energy, bond polarity & bond polarizability, bond distance, Resonance, Steric inhibition of resonance, hyperconjugation, bond moment, dipole moment, orbital pictures of ethylene, acetylene, allene, formaldehyde and carbene. Orbital pictures of dienes, enynes, enones, vinylcyanide; π- MO diagrams of butadiene, 1,3,5-hexatriene, allyl systems, benzene: concepts of HOMO & LUMO; Aromaticity, Huckel’s (4n+2) rule, Frost diagram, anti-aromaticity, Homoaromaticity, application of Huckel’s rule to benzenoid and nonbenzenoid compounds. Relative strength of organic Acids-Bases.

(B) Stereochemistry of Acyclic Compounds (12 lectures)

Isomerism involving two like/unlike stereogenic centres (AA and ABA types), pseudoasymmetric centres, stereogenicity, chirotopicity, achirotopicity.

C) Reaction Mechanism (6 lectures)
Bond Cleavage & Bond Formation- heterolytic & homolytic bond cleavage at stereogenic (single) and non-stereogenic centres, racemization, formation of racemic products. Reactive intermediates: Electrophiles, nucleophiles, radicals. Carbocations (onium and enium ions), carbanions, carbenes; Structure and stability.
Semester II

Physical Chemistry

Thermodynamics II

Lectures

- a. Need for the Second Law
- b. Carnot's heat engine and refrigerator
- c. Statement of the second law and their equivalence
- d. Thermodynamic temperature scale
- e. Carnot's theorem
- f. Entropy as a state function
- g. Entropy change of various processes (reversible and irreversible)
- h. Clausius inequality
- i. Combined first and second law
- j. Thermodynamic equation of state
- k. Auxiliary state functions – Gibbs and Helmholtz energies
- l. Maxwell relations
- m. Joule-Thomson experiment
- n. Temperature dependence of Gibbs free energy (Gibbs-Helmholtz equations)
- o. Gibbs free energy of real gases and fugacity
- p. Spontaneity and equilibrium
- q. Gibbs-Helmholtz equation
- r. Concept of chemical potential of pure substances
- s. Partial molar quantities
- t. Gibbs-Duhem equation

Real gases

Lectures

- a. Deviation from ideal behaviour with reference to Andrew's and Amagat's experiment, Joule (qualitative idea) and Joule-Thomson experiment (qualitative idea).
- b. Compressibility factor
- c. Concept of attractive and repulsive forces among real gas molecules. Temperature dependence
- d. van der Waal's equation of state
- e. Critical state, critical pressure, volume and temperature, and their form for van der Waal's gas.
- f. Boyle temperature and their form for van der Waal's gas.
- g. Brief review of other equations of state (Dieterici).
- h. Virial equation of state, first and second virial coefficient, their relation to other constants and their significance.
- i. Reduced equation of state and the Law of corresponding states
- j. Continuity of states
- k. Nature of intermolecular forces

Quantum Mechanics I

- a. Blackbody radiation, Classical Theory of Rayleigh-Jean, Ultraviolet catastrophe and Planck's theory, Thermodynamic viewpoint
- b. Photoelectric effect, Einstein's Quanta,
- c. Compton effect,
- d. Dual nature of electromagnetic radiation
- e. de Broglie's hypothesis
- f. Wave particle duality
- g. Matter wave
- h. Concept of wave packets
- i. Uncertainty principle, its various mathematical forms and its justifications
**Inorganic Chemistry**

**(A) Ionic Bonding**
Packing of ions in crystals, radius ratio rules – applications & limitations; lattice energy – Born- Landé equation and its applications
Born-Haber Cycle and its applications; solvation energy, dissolution of ionic solutes in polar solvents; Polarizability & Faján’s Rules; Stoichiometric and non–stoichiometric defects in crystals (non – mathematical approach), Van der Waal’s forces, Hydrogen bonding and its applications.

**(B) Coordination Chemistry – I**
Double salts, Complex salts, Werner’s Coordination Theory, mono- poly- and ambidentate ligands, Chelate complexes, Inner metallic complexes, IUPAC nomenclature of complexes, application of chelates in qualitative and quantitative chemical analysis.

**(C) Covalent Bonding – I**
Formal Charge, VSEPR theory and structure of inorganic molecules, Berry pseudorotation, hybridization, Bent’s rule, dipole moment, resonance.

**Organic Chemistry**

**(A) Energetics of reaction (10L)**
Free energy profile for one-step & two-step reaction. Hammond postulate, Kinetically Controlled Vs Thermodynamically Controlled reactions, Investigation of reaction mechanism: Kinetic studies, study of intermediates, cross over experiments, stereochemical proof, isotope labelling- kinetic & non-kinetic, primary kinetic isotopic effect (kH/kD) only.

**(B) Tautomerism (3L)**
Application of thermodynamic principles in tautomericequilibria [keto-enoltautomerism, composition of theequilibrium in different systems (simple carbonyl, 1,3 and 1,2- dicarbonyl systems, phenols and related system), substituent and solvent effect].

**(C) Nucleophilic substitution and elimination reactions (8L)**
Nucleophilic substitution and elimination reactions of alkyl halides; S_N1, S_N2, S_Ni, NGP, E1, E2, E1cB mechanisms; Elimination vs Substitution; Saytzeff and Hoffmann rules; reactivity of aryl, vinyl, allyl and benzyl halides.

**(D) Stereochemistry of acyclic compounds (14L)**
Axial chirality, systems with odd and even number of cumulated double bonds, atropisomerism in biphenyl systems, R/S nomenclature of axially chiral systems. Resolution of recemic acids, bases and alcohols; Optical purity/enantiometricexcess. Topicity of ligands and faces (elementary idea). Homotopic, Enantiotopic & Diastereotopic ligands and faces; pro-chirality, pro-R, Pro-S, and re/si descriptors. Conformational Nomenclature- eclipsed, staggered, gauche, anti; dihedral angle, energy barrier of rotation, relative stability of conformers on the basis of steric effects; dipole-dipole interaction, H-bonding; conformational analysis of ethane, propane, n-butane, 1,2-dchloroethane, 2-methylbutane, 1,2-glycols, invertomerism of trialkylamines.
Physical Chemistry

Chemical Equilibrium  
Lectures  
a. Thermodynamicsofmixingofidealgases  
b. Conditionsofspontaneityandequilibriumintermsofinternalenergy,Enthalpy,Gibbsan  
d. Helmholtzfreenegy  
c. Gibbssenergychangeofamixtureofgases  
d. Gibbssenergychangeofareaction  
e. Definitionofmolar Gibbssenergychangeofareaction  
f. Equilibriumminidealgasmixtureandheterogeneousreaction  
g. ConceptofEquilibriumconstant, concept of activity and concentration  
h. Effectoftemperatureandpressureonequilibrium  
i. ThermodynamicderivationofvantHoffequation  
j. TemperaturedependenceofequilibriumconstantandvantHoffisotherm  
k. Variousequilibriumconstantsandtheirinterrelation  
l. Temperaturedependenceof$K_c$  
m. Conceptofstandardstatefreeenergychangeofareactioninpressureandconcentration  

Electrochemistry I  
12 Lectures  
a. Activity,ionicactivities,meanionicactivities  
b. Activitycoefficientandmeanionicactivitycoefficient  
c. Debye-HuckelLimitinglaw(withoutderivation)  
d. Flowofelectricalcharge through a solution and its consequences  
e. Specificandequivalentconductance  
f. Effectofdilution,dielectricconstantofsolvent,viscosityofsolventandtemperatureon  
conductanceofstrongandweakelectrolytes  
g. ElectrophoreticandAssymetriceffect  
h. Determinationofacidityconstantofaweakacid:Ostwalddilutionlaw,ionicproductof  
water,determinationofionicradii  
i. Kohlrausch’s law  
j. Ionicmobilities  
k. Transportnumberanditsdetermination(Hittorf’sandmovingboundarymethod)  
l. Effectofconcentrationandtemperatureontransportnumber  
m. Abnormaltransportnumber  
n. Transport number in a mixture of two nonreactive electrolytes  

Quantum Mechanics II  
12 Lectures  
a. Operators,Linearoperators  
b. Hermitianoperators  
c. PostulatesofQuantumMechanics  
d. Schrödingerequation  
e. SolutionofSchrödingerequationaswavefunctionandenergy(eigenvaluesandeigenfunctions)  
f. Commutatorsandtheirinterplaywithrespectto$p_x$  
g. Expectationvalues  
h. Propertiesofeigenfunctions  
i. Energyquantization
Inorganic Chemistry

(A) Redox Equilibrium
Balancing redox reactions by the ion–electron method; Standard redox potential, Nernst equation, influence of pH, precipitation and complexation on redox potential, formal potentials, feasibility of redox titrations, redox potential at equivalent point, redox indicators; redox diagrams – Latimer and Frost diagrams of concerned elements and their applications (typical examples).

(B) Group Chemistry – I: Group 1 and 2
Solutions of alkali metals in liquid ammonia; complexation with crown–ethers, cryptands and related ligands; basic beryllium acetate; detection of metal ions – Na+, K+, Mg2+, Ca2+, Sr2+, Ba2+ in qualitative analysis.

(C) Group Chemistry – II: Groups 13 & 14
General trends in the oxidation states, hydrides, oxides, halides of B, Al, Ga, In, Tl; special features in the chemistry of boron trihalides, diborane, boron nitride and borazine; General trends in the oxidation states, catenation property, hydrides, halides and oxides of C, Si, Ge, Sn, Pb; special features in the chemistry of graphite, fullerenes, silicates, silicones and chlorofluorocarbons; ultra–pure silicon.

(D) Covalent Bonding – I
Molecular orbital theory: Qualitative approach to molecular orbital theory; MO energy level diagrams of H2, Li2 to N2, O2, F2, CO, NO, CN–, HF, HF2–, BeH2, CO2. Metallic bonding : qualitative treatment of Band Theory; conductors, semiconductors and insulators.

Organic Chemistry

(A) Aromatic substitution reactions (6L)
Aromatic electrophilic substitution reactions: π-complex, σ-complex, activating and deactivating groups, orienting influence of groups. Aryl halides: activated aromatic nucleophilic substitution, cine substitution. Ipso substitution.

(B) Mechanism of free-radical substitution (2L)
Alkane H, allyl/benzyl H; reactivity and selectivity of substitution by chlorine and bromine;

(C) Addition to carbon-carbon multiple bonds (12L)
Reactivity, regioselectivity (Markownikoff’s rule), stereoselectivity, chemoselectivity; halogenation, hydrogenation, hydration, oxymercuration-demercuration, hydroboration-oxidation, epoxidation, hydroxylation, ozonolysis, carbene addition to alkynes, allenes.; free radical addition to C=C bond, peroxide effect; electrophilic and free radical addition to conjugated dienes; 1,2- vs 1,4-addition; Michael addition; Birch reduction of alkadienes and alkynes; reactions involving alkynic C-H cleavage; Diels-Alder reaction (simple treatment). Interconversion of constitutional isomers of alkene and alkynes, Interconversion of E and Z isomers of alkenes.

D) Spectral Methods in Organic Chemistry- UV & IR and NMR Spectra (15L)
UV-Spectra: Electronic Transitions ($\sigma \rightarrow \sigma^*$, $\pi \rightarrow \pi^*$, $n \rightarrow \sigma^*$, $n \rightarrow \pi^*$), Relative position of $\lambda_{\text{max}}$ considering conjugative effect, steric effect, solvent effect, effect of pH, relative intensity of absorption of allowed transitions, bathochromic shift, hypochromic shift, hyperchromic shift, hypsochromic shift with typical examples.


NMR Spectra
Nuclear spin, NMR-active nuclei, principle of PMR, equivalent & non-equivalent protons, anisotropy, chemical shifts, shielding/deshielding protons, upfield& downfield shifts. NMR peak area, relative peak positions of Toluene, nitro-benzene, o, m, p- dichloro- and dinitro-benzenes &chloronitobenzenes; spin-spin coupling in ethanol (ordinary grade), ethyl bromide; 1,1-dibromoethane; 1,2-dibromoethane; 1,1,2-tribromoethane.
Semester IV

Physical Chemistry

Electrochemistry II

Lectures

a. Electrochemical cells
b. Electrode, electrolyte
c. Electrodereaction and cell reaction
d. Nernst equation
e. Standard electrode potential and application
f. Formal potential and its application
g. Thermodynamic functions from cell potential measurement
h. Concentration cells (with and without transference)
i. Liquid junction potential, its determination and elimination
j. Application of e.m.f. measurement (related to practical experiments)

Statistical Mechanics and Reaction Rate Theories

Lectures

a. Energy states and levels
b. Micro and macro states
c. Thermodynamic probability
d. Entropy and probability
e. Maxwell-Boltzmann statistics
f. Distribution of molecular states: Boltzmann distribution
g. Application to Maxwell’s velocity distribution and barometric distribution
h. Partition function and its significance
i. Translational, rotational and vibrational partition function and their significance
j. Thermodynamic properties (internal energy, enthalpy, Helmholtz free energy, Gibb’s free energy, chemical potential, entropy and value of beta)
k. Reaction coordinate and PES
l. Transition state theory and activated complex
m. Expression of rate constant in terms of partition function, the Eyring equation

Liquid and Solid state

Lectures

a. General features of liquid state (short and long range order/disorder, hole theory)
b. Vapour pressure
c. Young and Laplace equation
d. Surface tension
e. Surface energy
f. Excess pressure
g. Capillarity phenomenon
h. Work of adhesion and cohesion
i. Contact angle
j. Spreading of liquids
k. Dupree equation
l. Temperature dependence of surface tension
m. Measurement of surface tension
n. Viscosity of liquids
o. Temperature dependence of viscosity of liquids
p. Poiseuille’s equation and Measurement of surface viscosity
Solid state Lectures
a. Types of solids: crystalline state and its properties
b. Types of crystals
c. Lattice points
d. Lattice planes
e. Unit lattice
f. Basis
g. Bravais lattice and its 14 lattice types
h. Miller indices
i. X-ray diffraction
j. Bragg’s law
k. Calculation of basis per unit crystal, volume, density per unit cell
l. Diffraction techniques (Qualitative treatment only): single crystal and powder
m. Structure elucidation of NaCl, KCl, CsCl, diamond, graphite and hcp
q. Specific heat of solids (Dulong & Petit law, Einstein theory, Debye correction qualitatively)

Quantum Mechanics III Lectures
a. Particle on a Ring
b. Concept of the effective potential
c. Particle on a sphere: coordinate system
d. Form of Schrödinger equation in polar coordinates
f. The diatomic rigid rotor: solution of theta and phi part (basic expressions only)
g. Expression of $L^2, L_z$ in polar coordinates, physical significance
h. Concept of effective potential
i. Central force problem and formulation of the Schrödinger equation for hydrogen atom

Colloids, Polymers and Surface Processes Lectures
a. Colloids: Definition, general properties
b. Optical properties of colloids
c. Rayleigh equation and its outcomes
d. Qualitative understanding of electrokinetic phenomenon: electrophoresis, electroosmosis, streaming potential and sedimentation potential
e. Electrical double layer, Zeta potential
f. Mechanism of coagulation
g. Schulze-Hardy rule
h. Gold number
i. Surface excess and Gibbs adsorption isotherm
j. Surfactant
k. Critical micellar concentration, its stensometric and conductometric determination
l. Micelles
m. Thermodynamic of micellization
n. Liquid crystals
o. Polymer and degree of polymerization
p. Molecular weight of polymer (number and weight average molecular weight)
q. Number distribution and weight distribution function
r. Expression of number average and weight average molecular weight and their interrelation
Inorganic Chemistry

(A) Definition of acids and bases; solvents
Recapitulation of Arrhenius concept, Bronsted–Lowry definition, solvent system definition, Lux–Flood definition; Relative strength of hydracids, strength of oxoacids, Pauling’s rules; HSAB principle, superacids; Solvent properties of water and liquid ammonia; reactions in liquid ammonia.

(B) Acid – Base equilibria
pH (of strong acid/base solution and weak acid/base solution), buffer solution, pH of a buffer solution, Henderson’s equation, buffer capacity; salt hydrolysis, pH of salt solutions (salt of strong acid/weak base; strong base/weak acid and weak acid / weak base); indicators, indicator constant, choice of indicators in acid – base titrations.

(C) Solubility equilibria
Solubility product & common ion effect; applications in group analysis – precipitation of sulphides and hydroxides.

(D) Group Chemistry – III : Group 15, 16, 17 and 18
Group 15 : Catenation, oxidation states, trends in the hydrides, halides, and oxides ; special features in the chemistry of hydrazine, hydroxylamine, hydrazoic acid/azides and phosphonitrilic compounds.
Group 16 : Catenation, atomicity, trends in the halides and hydrides; oxides and fluorides of S and Te; special features in the chemistry of the oxoacids of sulphur; Structure and bonding in O$_2$F$_2$, polythiazyl, tetrasulphurtetranitride.
Group 17 : Trends in the Chemistry of oxides, oxoacids and hydracids; special features in the chemistry of interhalogens, polyhalides, pseudohalogens, uses of potassium bromate and potassium hydrogen iodate in quantitative analysis.
Group 18 : Trends in the ionization energy and reactivities of He, Ne, Ar, Kr, Xe; reactivity, structure and bonding in fluorides and oxofluorides of Xe.

Organic Chemistry

A) Alcohols & Ethers (4 lectures)
Relative reactivity of 1°, 2°, and 3° alcohols in reactions via H-O and C-O cleavages; reactions of alcohols as nucleophiles, nucleophilic substitution reactions at carbinol C, S$_{N\text{i}}$, dehydration, dehydrogenation, oxidation of alcohols. Reactions of epoxides and ethers via C-O cleavage, reactions of $\alpha$-glycols: cyclic ketal/acetal formation, complex formation with H$_3$BO$_3$, oxidative cleavage of glycolic bond.

B) Aldehydes & Ketones (12 Lectures)
Nucleophilic addition to C=O bond: reactivity of carbonyl compounds, relative stability of adducts, formation of acetal, ketal, thiaoacetal, thiketals, and cyanohydrin, Grignard reaction, LiAlH$_4$ and NaBH$_4$ reductions, electrolytic reductions, reductive coupling, M.P.V reduction, Cannizzaro reaction, Internal Cannizzaro reaction, benzil-benzoilic acid rearrangement; nucleophilic addition to $\alpha$, $\beta$- unsaturated carbonyl compounds, reactions of benzoquinones, reactions with derivatives of NH$_3$, Wolff-Kishner reduction, Aldol condensation, Claisen
condensation, Directed Aldol condensation, Wittig reaction, Acyloin condensation (use of $\text{Me}_3\text{SiCl}$)
Mannich reaction, Enamine reaction, Reformatsky reaction, Darzen’s reaction, Perkin reaction, Benzoin condensation, Tischenko reaction. Electrophilic substitution at $\alpha$–position of carbonyl compounds, D-exchange, Nitrosation, halogenation, Haloform reaction, $\text{SeO}_2$ oxidation.

C) Carboxylic Acids & Derivatives (6 lectures)
Nucleophilic substitution reaction at the acyl carbon of acyl halide, anhydride, ester, amide; tetrahedral mechanism, esterification of carboxylic acid and hydrolysis of esters: $\text{A}_\text{Ac}2$, $\text{A}_\text{Ac}1$, $\text{A}_{\text{Al}}1$, $\text{B}_\text{Ac}2$, $\text{B}_{\text{Al}}1$, $\text{B}_{\text{Al}}2$ mechanisms. Reactions via cleavage of $\alpha$-C-H (use of trimethylsilyl chloride): HVZ reaction, Claisen ester condensation, Bouveault Blanc reduction, decarboxylation, Hunsdiecker reaction, action of heat on hydroxy acids.

Group-II

D) Organometallic compounds and Organonitogen Compounds (10 lectures)

i) Grignard reagents: Preparation and synthetic applications of Grignard reagents and organolithium compounds. Organocuppercompounds: Corey-House, Organocuprates.

ii) Organonitogen Compounds: Acidity of $\alpha$-H of nitroalkanes, reduction of aromatic nitro compounds, alkyl cyanides and isocyanides and their hydrolysis, Von Richter reaction. Distinction among $1^\circ$, $2^\circ$, and $3^\circ$ amines and their separation, Hofmann’s exhaustive methylation, carbylamine reaction, partial reduction of aromatic nitro compounds.
Amines: Ring substitution vs N-substitution in aromatic amines, diazotisation and coupling reactions, synthetic applications of aromatic diazonium compounds. Preparation and synthetic uses of diazomethane and diazoacetic ester.

E) Rearrangement Reactions (8 lectures)

F) Phenols (4 lectures)
Ambident nucleophile, ring substitution Vs O-Substitution. Reactions of phenols: Reimer-Tiemann reaction, Kolbe reaction, Houben-Hoesch reaction alkylation, acylation, Fries rearrangement, Claisen rearrangement, nitration, sulphonation, halogenation,
Semester V

Physical Chemistry

**Phaseequilibria**

**Lectures**

a. Definitionofphase
b. Phaseboundaries
c. Components
d. Thermodynamicconditionforphaseequilibrium
e. Phaseruleanditsderivation
f. Phaseequilibriumforonecomponentsystem (for example H2O, S, CO2)
g. Firstandsecondorderphasetransition
h. Clapeyronequation
i. Clausius-Clapeyronequation
j. Trouton’srule
k. Liquidvaporequilibriumfortwocomponentsystem
l. ReviewoftheGibbs-DuhemandtheDuhem-Margulesequation
m. Constantboilingmixture
n. Criticalsolutiontemperature
o. Completelyimmisciblesystems
p. Thermodynamicsofmixingofbinarysolutions
q. Simpleeutecticsystems

**SpectroscopyI**

**Lectures**

a. Spectroscopy-Natureofelectromagneticradiation,rangeofwavelength
b. Transitionmomentintegral(qualitativeidea)andallowedtransitions
c. Separationofelectronicandnuclearmotion – Born-Oppenheimerapproximation
d. Signaltonoiseratio
e. Widthandintensityoftransition,linebroadening

Rotationalspectroscopy

f. Rigidrotor(diatomiconly)
g. Selectionrule
h. Spectrum: position and intensity of spectral lines.
i. Non-rigidrotorandits’seffectionenergylevels
j. Selectionruleandspectrum
k. Application
l. Isotopeeffect

**AtomicStructureandAtomicSpectra**

**Lectures**

a. AppropriatetreatmentofSchrodingersequationforHydrogenicsystem
b. Solutionofradial,thet anda phipart(Generalexpression)
c. Shapesofs,p,dorbitals
d. Hydrogenicwavefunctionsupton=3
e. Atomicorbitalsandtheirenergies
f. Spectroscopictransitionsandselectionrules.
g. Conceptofelectronicspin
h. Spectraofcomplexatoms-singleandtripletstates
i. Spin-orbitcouplingandfinestructure
j. Term-Symbol and LS coupling
Inorganic Chemistry

(A) Isomerism, Reactivity and Stability of coordination complexes
Constitutional, Geometrical and optical isomerism with respect to C.N. = 4 and 6; Mills and Quibell complex, examples of purely inorganic optically active complexes; labile and inert complexes; substitution in square planar complexes and trans – effect (examples and applications); choice of ligands and stability of various oxidation states of the 3d metal ions; stability constant of complexes.

(B) Structure and Bonding in coordination complexes
VBT, CFT, splitting of d⁶ configurations in octahedral and tetrahedral fields, crystal field stabilization energy in weak and strong fields, pairing energy, Jahn – Teller distortion and its application; MOT (elementary idea), sigma and pi – bonding in octahedral complexes (a pictorial approach)

(C) Organometallic Chemistry
18 electron rule and its application to carbonyls (including carbonyl hydrides and carbonylates), nitrosyls, cyanides, metal–carbon sigma and pi – bonded organometallic complexes of transition metals; bonding and IR spectra of carbonyls and nitrosyls; Zeise’s salt – its preparation properties and structure; ferrocene – its preparation, properties and sturture; elementary idea of fluxional molecules; oxidative addition, reductive elimination and insertion reactions; homogenous catalysis of organometallic compounds – hydrogenation, hydroformylation, and polymerization of alkenes (Ziegler – Natta catalyst)

Organic Chemistry

A) Synthetic strategies and asymmetric synthesis (14 lectures)
Disconnection approach towards synthesis of bifunctional molecules (both cyclic and acyclic): concepts of synthons, synthetic equivalents (ethyl acetoacetate, ethyl cyano acetate and diethyl malonate as examples). Functional group interconversion (FGI).Protection and deprotection of common functional groups (-OH, carbonyl, -NH₂, -CO₂H) in synthetic route, activation of synthetic equivalents.Umpolung: Illogical electrophiles and nucleophiles. Disconnection and synthesis of 1,3; 1,4 and 1,5-dioxygenated compounds. Robinson ring annulation, applications of Claisen rearrangement, Favorskii rearrangement and Demjanov rearrangements involving electron deficient C, O, N. Large ring synthesis: High dilution techniques. Asymmetric synthesis:

B) Pericyclic reactions (8 lectures)

C) Stereochemistry of alicyclic compounds and Dynamic stereochemistry (12 lectures)
Analytical Chemistry

UNIT 1: CONVENTIONAL METHODS OF ANALYSIS

(a) Redox Titrimetric analysis of Fe, Cu, Zn, Cr, Mn. Formol titration, estimation of sugars and vitamin C (principles only).
(b) Complexometric Titrations – Metal ion indicators, masking, demask agents (examples). Principles for the estimation of (Ca + Mg), (Fe + Al), and (Cu + Zn) in a mixture of complexometry.
(c) Basic concepts and simple application of chromatography – Thin layer, paper and column chromatography, Rf-values. Ion exchange chromatography (IEC): Ion exchange resins and their ion exchange capacities, deionization of water. Solvent extraction: Definition, types, principle and efficiency; factors affecting extraction, extraction with a metal chelator, gas chromatography, HPLC, extraction with dithiozone.

UNIT 2: INSTRUMENTAL METHODS OF ANALYSIS

(a) Flame Spectrometry – Introduction, Principles, Elementary Theory and Instrumentation of atomic absorption and atomic emission spectrometry; Determination of Ca and Mg in tap water (application).
(b) Radiochemical methods and Environmental analysis. Basic instrumentation, Measurement of radioactivity, Neutron activation analysis, Isotope dilution analysis, radiometric titrations, hazards of radiation and safety measures.

UNIT 3: ERROR ANALYSIS AND ANALYSIS OF SAMPLES

(a) Error Analysis – Errors and their classifications, determinate and indeterminate errors, systematic and random errors, accuracy and precision, distribution of random errors; statistical analysis of data; methods of least squares and standard deviation, confidence interval, significance testing

Semester VI

Physical Chemistry
Thermodynamics III
Lectures
a. The Nernst heat theorem
b. Third law of thermodynamics
c. Residual entropy
d. Raoult’s law
e. Henry’s Law
f. Positive and negative deviation from ideal behaviour
g. Ideal solution and ideally diluted solution
h. Definition and thermodynamic origin of colligative properties
i. Thermodynamic derivation of colligative properties of solution using chemical potential and their interrelationships (lowering of vapour pressure, depression of freezing point, elevation of boiling point and osmotic pressure)

j. Abnormal colligative properties

**Spectroscopy II**

**Lectures**

- Vibration of diatomic molecule and simple harmonic oscillator
- Review of solution of quantum harmonic oscillator (general expression)
- Selection rule for harmonic oscillator
- Spectrum
- Anharmonicity and its effect on energy levels
- Selection rule for anharmonic oscillator
- Vibrational spectrum
- Rotational – vibrational coupling in the limit of Born-Oppenheimer approximation
  - Raman spectroscopy (Qualitative)
- Rayleigh and Raman scattering
- Polarizability ellipsoids
- Features and conditions for Raman activity (for linear and non-linear AB₂ molecule)
- Rotational and vibrational Raman spectra and its characteristics

**Photochemistry**

**Lectures**

- Potential energy curves for electronic states, Frank-Condon principle
- Decay of excited states by radiative and non-radiative paths
- Timescales
- Fluorescence and phosphorescence
- Jablonski diagram
  - Mechanism of relaxation through non-radiative paths (Unimolecular and bimolecular mechanism (collision, energy transfer))
- Photophysics of the excited state
- Law of photochemistry
- Quantum yield and its measurement for photochemical processes
- Photostationary state
- Photosensitized reactions
- Photochemistry of Photosynthesis

**Inorganic Chemistry**

(A) Magnetism and Spectra of Coordination Complexes

Orbital and spin magnetic moments, spin only magnetic moments of 3dⁿ ions and their correlation with effective magnetic moments, quenching of magnetic moments in presence of crystal field; ferromagnetic and anti-ferromagnetic coupling (elementary idea with examples only); d – d spectra, weak – field splitting schemes, qualitative Orgel diagrams for dⁿ systems and their spectroscopic ground states, selection rules for spectral transitions, charge transfer spectra (elementary idea with examples only).

(B) Bioinorganic Chemistry

Essential and trace elements of life; role of metal ions in biology – Na⁺, K⁺, Ca²⁺, Mg²⁺, Fe²⁺/³⁺, Cu²⁺/¹⁺, Zn²⁺; active site structures and bio-functions of myoglobin, haemoglobin, cytochromes, ferredoxins, carbonic anhydrase; photosynthesis – PS–I and PS–II, sodium ion pump and ionophores, metal ion induced toxicity and chelation therapy, metal ion as drugs (cisplatin and a few gold drugs)

(C) Chemistry of the Lanthanides
General characteristic with respect to electronic configuration, oxidation states and ionization enthalpies, lanthanide contraction, separation of lanthanides by ion – exchange method.

**Organic Chemistry**

**A) Heterocyclic compounds (12 lectures)**
Synthesis (including retrosynthetic approach), Knorpyrole synthesis, Hantz pyridine synthesis, Fischer indole synthesis, Skraup’squinoline synthesis, Bischler-Napieralski synthesis, reactivity, orientation and important reactions of furan, pyrrole, thiophene, pyridine, indole, quinoline, and isoquinoline.

**B) Carbohydrates (10 lectures)**

**C) Amino acids (10 lectures)**
Synthesis of α-amino acids (Gabriel, Strecker, azlactone, acetamido, malonic ester methodologies). Isoelectric point, ninhydrin reaction, resolution of amino acids. Peptides: geometry of peptide linkage, peptide synthesis including Merrifield synthesis, structure determination of peptides, C-terminal and N-terminal unit determination, determination of amino acid sequence.

**Biochemistry**

**A) Structural aspects of Biomolecules 9 lectures**


*(Globular proteins and structural aspects of carbohydrates are excluded as Chem (H) students study these in details in Bioinorganic Chemistry)*.


B) **Bioenergetics and Metabolism**: (2.5 marks)  
2 lectures  
Principles of Bioenergetics: Bioenergetics and Thermodynamics, Phosphoryl group transfers and ATP generation, Biological Oxidation and Reduction reaction.

C) **Carbohydrate metabolism**: (5 marks)  
5 lectures  
Intracellular metabolism of glucose - glycolysis, reaction and energetic of TCA cycle, (gluconeogenesis, glycogenesis, glycogenolysis, reactions and physiological significance of pentose phosphate pathway, regulation of glycolysis, TCA cycle, and glycogen metabolism).

D) **Oxidative phosphorylation and electron transport chain**: (2.5 marks)  
2 lectures  
Structure of mitochondria, sequence of electron carriers, ATP synthesis, inhibitors of ETC, basic concept of oxidative phosphorylation, inhibitors and uncouplers of oxidative phosphorylation.

E) **Lipid metabolism**: (2.5 marks)  
Metabolism (anabolism and catabolism) of triglyceride, Transport of fatty acid into mitochondria, Beta-oxidation of fatty acids, reactions and energetic of beta oxidation, biosynthesis of saturated and unsaturated fatty acids, metabolism of ketone bodies, biosynthesis of phospholipids and cholesterol.

F) **Amino acid metabolism**: (5 marks)  
General reactions of amino acid metabolism (oxidative deamination, transamination, decarboxylation etc), glucogenic and ketogenic amino acids, urea cycle, biosynthesis and catabolism of amino acids (glycine, phenylalanine, glutamic acid), inborn errors of amino acid metabolism.

G) **Nucleotide metabolism**: (2.5 marks)  
Biosynthesis and catabolism of purines and pyrimidines (Adenine and cytosine)

H) **Enzymes**: (20 marks)  
- **Cofactors** – Definition, examples of a) metal ions b) coenzymes c) prosthetic group  
  Definition, examples of holoenzymes, Apoenzyme.  
- **Classification of enzymes**, IUPAC system, Name & examples of each class  
- **Mechanism of enzyme activity**—standard free energy change in a reaction-transition state, activation energy both in non-enzymatic and enzymatic reaction, reaction rate, rate constant, rate limiting step, rate equation, binding energy, specificity of enzymes geometric and stereo specificity with example, lock & key hypothesis, induced fit hypothesis, proximity and orientation effect, strain and distortion theory, enzyme catalysis-i) acid-base catalysis, ii)metal ion catalysis iii) covalent catalysis – Examples .  
- **Regulatory enzyme**- allosteric enzyme, definition & example, allosteric modulators, feedback inhibition, kinetic properties of allosteric enzyme, K enzymes, M enzymes, sequential model & symmetry model, examples, regulation by covalent modification (likephosphorylation), example, regulation by proteolytic cleavage of protein, zymogens,example  
- **Isozymes**-Definition and basis of difference, example-lactate dehydrogenase.