Chemistry

Syllabus for Various Courses Offered:

First Semester (Major) Syllabus: Paper – H1, Marks: 100 (80+20)

Unit-I General Chemistry (Marks: 20) 30 Lectures

A. **Atomic Structure: (10 Lectures):**Limitations of Bohr's atomic model; idea of the de Broglie matter waves, Heisenberg's uncertainty principle; Schrodinger's wave equation and its importance; quantum numbers; concept of wave function; physical concepts of Ψ and Ψ^2; radial and angular wave functions; shapes of s, p and d-orbitals, Aufbau principle, Pauli's Exclusion Principle, Hund's rule, Variation of orbital energies with atomic number and energy level diagram, electronic configurations of atoms, screening effect and effective nuclear charge, extra stability of half-filled and completely filled orbitals.

B. **Periodic properties: (10 Lectures):**Modern periodic table, classification of elements on the basis of electronic configuration; periodic variation in properties – atomic and ionic radii, oxidation states, ionization potential, electron affinity, electronegativity (Mulliken scale, Pauling's scale and Allred & Rochow scale); diagonal relationship.

C. **Statistical treatment of data analysis: (10 Lectures):** Accuracy and precision, classification of errors, detection and correction of determinant and indeterminant errors; the normal law of distribution of indetermination errors; the F and T tests, rejection of data, methods of least squares, propagation of errors in computation, significant figures.

Unit-II: Inorganic Chemistry (Marks: 20) 30 Lectures

A. **Redox Reactions**: **(10 Lectures):** Ion electron method of balancing equations, calculation of equivalent weights of oxidants and reductants, standard electrode potential, formal potential, electrochemical series; redox potentials and its applications, choice of indicators in redox titrations.

B. **Chemical Bonding**: **(20 Lectures):** (i) **Ionic Bonding**: Types of ionic solids; radius ratio effect; limitation of radius ratio rule; concept of lattice energy, Bond-Lande equation; Born-Haber cycle; solvation energy and solubility of ionic solids; ionic potential, polarizing power; polarizability of ions and Fajan's rule.

(ii) **Covalent Bonding**: Basic idea of valence bond theory and its limitations; Concept of hybridization of orbitals; Bent's rule; valence shell electron pair repulsion (VSEPR)

theory and its application to shapes of molecules and ions: BeF_2, BF_3, H_3O^+, NH_3, NH_4^+, ICl_2^+, H_2O, PCl_3, PCl_5, SF_4, SF_6, XeF_2, XeF_4, XeF_6, $XeOF_4$, ClF_3; formal charge, polarity of covalent bonds and dipole moment, percentage of ionic character of covalent bond, LCAO-MO theory and its application to homonuclear (H_2, N_2, O_2, O_2^{2-}, O_2^-, O^{2+}); heteronuclear diatomic molecules (CO, NO, HF) and polyatomic molecules (BeH_2, H_2O, NH_3).

(iii) **Bonding in Metals, Semiconductors and Hydrogen Bond:** Qualitative idea of free electron theory and band theory in solids; elementary ideas on semiconductors (n and p types); hydrogen bonding – concept and types of H-bonding – application to inorganic molecules, van der Waal's forces, π-π and C(H)-π interactions.

Unit-III: Organic Chemistry (Marks: 20) **30 Lectures**

A. Structure, Reactivity in Organic Molecules (10 lectures): Hybridization (sp^n ,n= 1,2,3) of organic compounds, bond lengths, bond angles, bond energy, bond polarity, bond polarizability, formation of σ and π bonds, localized and delocalized chemical bonds, van der Waals interaction, resonance, tautomerism, steric inhibition of resonance, hyperconjugation, inductive and field effects, H-bonding, dipole moment- bond moment and group moment, physical properties (m.p., b.p., solubility) related to molecular structures. Activation energy and Transition state. Energy profile diagrams for reactions with single or multiple steps. Concepts of kinetic and thermodynamic control.

B. Basic concept of organic reaction mechanism in aliphatic compounds: (10 lectures): Synthesis of alkanes, alkenes, alkynes and alkadienes. Synthesis (preparation)of alcohols and ethers, aldehydes and ketones, carboxylic acids and their derivatives, nitro alkanes, nitriles, amines. Study of a) Electrophilic and free radical addition at C=C, b) Nucleophilic addition at the C=O group of aldehydes and ketones; c) Nucleophilic substitution reactions - S_N^1, S_N^2, S_N^i; d) Elimination reactions - α and β –eliminations, *syn* – and *anti*-elimination; E_1 and E_2- mechanism.

C. Important reactions of aliphatic compounds with mechanism: (10 lectures): Corey-House synthesis, dihydroxylation of alkenes, woodward-prevost hydroxylation, addition of hydrogen halides, ozonolysis, hydroboration-oxidation, oxymercuration-demercuration reaction, catalytic hydrogenation of alkenes. Alkadienes: conjugated addition; 1,2 vs 1,4-additions. **Alkynes**: acidity, use of Lindlar's catalyst, Birch reduction of alkynes;

Alcohols: dehydration, oxidation, pinacol-pinacolone rearrangement; **Carbonyls:** Oppenauer oxidation, MPV reduction, Rosenmund reduction, Stephen's reaction, Sommelet reaction, Baeyer-Villiger oxidation, Wolff-Kishner reduction; Aldol, Claisen and Darzen-glycidic ester condensation; Cannizzaro and Tischenko reactions.

Unit-IV: Physical Chemistry (Marks: 20) 30 Lectures

A. The Gaseous state: (12 Lectures): Gas laws; postulates of kinetic theory of gases; derivation of the kinetic theory of gas equation- $PV= (1/3) mnc^2$; mean free path ; collision diameter; collision number; collision frequency; heat capacity of gases; viscosity of gases & effect of temperature. Real gases: Deviation from ideal behaviour – Regnault , Andrews and Amagat's experiments on gases; causes of deviation- van der Waals equation; critical phenomenon- critical constants, inter-relationships between critical constants and van der Waal's constants; law of corresponding states. Maxwell distribution of molecular velocities (no derivation) – most probable, average and root mean square velocities- their inter-relationship; Boltzmann equation (without derivation).

B. Crystalline state: (10 Lectures): Three laws of crystallography: Weiss and Miller indices; unit cell, seven crystal systems; 14 Bravais lattices; crystal packing; radius ratio - co-ordination number, X-ray diffraction (XRD) of crystals- derivation of Bragg's equation ; determination of crystal parameters of cubic systems- crystal structure of KCl, NaCl, CsCl, diamond, graphite, boron nitride and ice, defects in crystals- point defects- Schottky and Frenkel defects, colour center, semi- conductors.

C. Fundamentals of computer: (8 Lectures): History of development of computers, computer systems (mainframe, minis, micros and super computers); general awareness of computer hardware i.e. CPU and other peripheral devices (Input/Output and auxiliary storage devices); block diagram of computer; representation of characters, integers in computers (Bit, Byte, Word) and conversions – decimal to binary, decimal to hexadecimal; introduction to computer software (system & application); introduction to computer languages; introduction to computer programming; basic knowledge of computer programming in BASIC.

Second Semester (Major) Syllabus: Paper – H2, (A), Marks: 60 (48+12)

Unit-I: Inorganic Chemistry (Marks: 24) 36 Lectures

A. **Acid-Base Concept (8 lectures):** Arrehenius and Bronsted-Lowry concept, the solvent system concept (Franklin) and its limitations; Lewis concept; SHAB principle; pH and pH scale; effect of solvent on relative strengths of acids and bases – leveling effect; Relative strengths of acids and bases (pK_a and pK_b concept).

B. **s-Block Elements (8 lectures):** Group discussion of the elements with respect to position in the periodic table: electronic configuration, atomic and ionic radii, ionization enthalpy, electron affinity (electron gain enthalpy), electronegativity, oxidation states, variation in properties of oxides and hydroxide, solvation and complexation tendencies of alkali and alkaline earth metals. Chemistry of lithium and beryllium their anomalous behavior and diagonal relationship

C. **Noble Gas (6 lectures):** Preparation, properties and structure of xenon oxides, fluorides, oxy-fluorides

D. **p-Block Elements (8 lectures):** Group discussion of the elements with respect to position in the periodic table: electronic configuration, atomic and ionic radii, ionization enthalpy, electron affinity (electron gain enthalpy), electronegativity, oxidation states, variation of acidic and basic properties of their oxides and oxy-acids, inert pair effect and catenation.

E. **Preparation, properties and structure in the following compounds: (6lectures):** Diborane (with emphasis on bonding), Carbides, Hydrazine, hydroxylamine, hydrazoic acid, oxy acids of nitrogen, sulphur and halogens; per acids and salts of carbon and sulphur; interhalogen compounds, Pseudo-halogens, polyhalides, basic properties of Iodine. Sodium thiosulphate, Sodium dithionite, potassium iodide, boric acid, lithium aluminium hydride, lead tetraacetate.

Unit-II: Organic Chemistry; (Marks: 24) 36 Lectures

A. **Stereochemistry of organic compounds (6 lectures):** Types of stereoisomers– configurational and conformational, enantiomers and diastereomers, geometrical and pi-diastereomers and their nomenclatures, difference in chemical and physical properties of pi-diastereomers, optical isomers, chirality, asymmetry, dissymmetry, R/S and D/L notations of optical isomers, raceimic mixture and resolution.

B. **Conformation (9 lectures)**: Conformational nomenclature; eclipsed, staggered, gauche and anti; dihedral angle, energy barrier of rotation, relative stability of conformers on the basis of steric effects, conformational analysis of ethane, n-butane, cyclohexane and monosubstituted cyclohexanes; stability of cycloalkanes-strains in rings, angle strain and torsional strain, Baeyer strain theory and its limitations. Asymmetric synthesis: stereospecific and stereoselective synthesis, regioselectivie synthesis, application of cram's rule, prelog's rule and Ahn-Felkin rule.

C. **Aromatic compounds (7 lectures):** Aromaticity, Huckel's rule, non-aromatic, anti-aromatic, homo-aromatic (benzenoid and nonbenzenoid). Preparation and properties of benzene, naphthalene, anthracene and phenanthrene.

D. **Organic reaction mechanism in aromatic compounds (8 lectures):** Electrophilic substitution in benzene (general mechanism): alkylation, acylation, halogenations, nitration, sulphonation. Synthesis and reactions of arenes, aromatic alcohols, aromatic halides, phenols, carbonyls, quinones, amines, nitro compounds, carboxylic acids and name reactions of these compounds.

Paper – H2, (B) (Practical), Marks: 40 (32+08), Time: 6 hours
Inorganic Qualitative analysis

(Qualitative analysis of mixtures of inorganic salts containing not more than four radicals from the following list):

Basic Radicals: Silver, lead, bismuth, copper, cadmium, arsenic, antimony, tin, iron, aluminium, chromium, manganese, cobalt, zinc, nickel, calcium, barium, strontium, magnesium, potassium, ammonium.

Acid Radicals: fluoride, chloride, bromide, iodide, sulphate, sulphide, sulphite, phosphate, arsenite, arsenate, borate, nitrate, nitrite, ferrocyanide, ferricyanide, chromate, bromate, iodate, thiocyanate, silicate.

(Probable composition of the analyzed mixture be stressed upon)

RECOMMENDED BOOKS
Organic Chemistry(Honours):

1. Organic Chemistry - I.L. Finar, Vol. I, 6th Edn. ELBS
2. Advanced Organic Chemistry - J. March
3. A guide to Organic Reaction Mechanism - P. Sykes, Orient Longman.
4. Organic Chemistry - R.T. Morrison & R.N. Boyd, Prentice – Hall.
5. Fundamentals of Organic Chemistry - Solomon

6. Organic Chemistry - Wade (Jr)
7. Stereochemistry of Carbon Compounds - E. Eliel.
8. Stereochemistry of Carbon Compounds - D. Nasipuri, John Wiley
9. Organic Spectroscopy - Y.R. Sharma
10. Organic Spectroscopy - W. Kemp
11. Organic Spectroscopy - P.S. Kalshi
12. Organic Reaction Mechanism - P.S. Kalsi
13. Organic Reaction mechanism - R.K. Bansal
14. Advanced Organic Organic hemistry - N.K. Visnoi
15. Advanced Practical Chemistry - R. Mukhopadhaya & P. Chatterjee.
16. Advanced Organic Chemistry – Miller
17. Organic Chemistry - Loudon

Inorganic Chemistry(Honours):

1. Basic Inorganic Chemistry - F.A. Cotton & G. Wilkinson & Gous
2. New concise Inorganic Chemistry - J.D. Lee
3. Inorganic Chemistry – Principles of Structure and Reactivity-Huhey,Keiter & Medhi
4. Selected topics in inorganic chemistry – Mallick, Tuli, Madan
5. Modern Inorganic Chemistry –W.L.Jolly
6. Inorganic Chemistry VolI&II - R.L.Dutta.
7. General and Inorganic Chemistry VoilI&II – R.P.Sarkar
8. Inorganic Chemistry - D.K.Chakrabarty
9. Essentials of Nuclear Chemistry -- H.J.Arnikar
10. Elements of Bioinorganic Chemistry - G.N. Nukherjee & A. Das
11. Fundamental Concepts of Inorganic Chemistry- Vol 1 &2 -A.K. Das
12. Bio inorganic Chemistry -Ashim. Kr.Das

Physical Chemistry(Honours):

1. Physical Chemistry - P.C. Rakshit
2. Physical Chemistry - P.W. Atkins
3. Physical Chemistry - G. W. Castellan
4. Physical Chemistry - S. Glastone
5. Physical Chemistry - Marron & Pruton/ Marron & Lando
6. Molecular Spectroscopy - Barrow
7. Molecular Spectroscopy - Banwell
8. Introductory Quantum Chemistry – A.K. Chandra, TATA McGraw Hill.
9. Quantum Chemistry – D.A. Mcquarrie, Viva Books, Pvt. Ltd.
10. Atomic Structure and Chemical Bonds – Manas Chandtra
12. Programming in Basic –S. Gottfired
13. Programming in Basic –Balaguruswamy.
14. Statistical Methods – N.G. Das

Practical Chemistry(Honours):

1. Qualitative Inorganic Analysis – A.I.Vogel's Ed. G. Svehla
2. Quantitative Inorganic Analysis –A.I.Vogel
3. Advanced Experiments in Inorganic Chemistry -- G.N. Mukherjee
4. Hand Book of Organic Analysis-qualitative & quantitative-H.T. Clarke

5. Qualitative Analysis - V. Alexeyev
6. University Hand Book of Undergraduate Chemistry Experiments, University of Calcutta- G.N. Mukherjee (ed)
7. College Practical Chemistry-V.K. Ahluwalia, S. Dhingra & A. Gulati
8. Text Book of Practical Organic Chemistry-A.I. Vogel
9. Vogels Text Book of Practical Organic Chemistry