VIDYASAGAR UNIVERSITY

CHEMISTRY

(Honours & General)

Under Graduate Syllabus

(3 Tier Examination Pattern)

w.e.f. 2014-2015

REVISED

Vidyasagar University

Midnapore 721 102

West Bengal

Chemistry (Honours)
w.e.f. 2014-15

Distribution of Papers and Marks in B. Sc. (Hons) Chemistry Examination

Part -I: 1st Year

Theoretical Papers:			Marks
Paper -I	Group -A	: Organic Chemistry	50
	Group -B	: Inorganic Chemistry	50
Paper-II	Group-A	: Physical Chemistry	50
	Group-B	: Industrial Chemistry	50

Part -II: 2nd Year

Paper -III	Group -A	: Organic Chemistry	50
	Group -B	: Inorganic Chemistry	50
Paper-IV		: Physical Chemistry	50
Paper-V	Group-A	: Organic Practical	50
	Group-B	: Inorganic Practical	50
	Group-C	: Physical Practical	50

Part -III: 3rd Year

Paper -VI	Group -A	: Organic Chemistry	50
	Group -B	: Inorganic Chemistry	50
Paper-VII		: Physical Chemistry	50
Paper-VIII	Group-A	: Organic Practical	50
	Group-B	: Inorganic Practical	50
	Group-C	: Physical Practical	50

Part-I
Paper –I
Group A (Organic Chemistry)
Full Marks -50 (University Examination: 45, Internal assessment: 5)

Unit I:

Classification and nomenclature of organic compounds (trivial and IUPAC)

Molecular formula and the index of hydrogen deficiency (IHD)/Double bond equivalent (DBE) 2L

Bonding in organic compounds:

VB Theory: Hybridisation sp^3, sp^2, sp; orbital picture of bonding (C-C, C-N, C-O system), bond polarization and bond polarisability. Inductive effect, electromeric effect, conjugation, resonance, hyperconjugation, steric effect, steric inhibition of resonance. 2L

M.O. theory: sketch the π MOs (with HOMO and LUMO in ground state and excited state) of butadiene, hexatriene, allylic system, pentadienyl system, cyclobutadiene and benzene. Frost diagram, Huckel's rules for aromaticity and antiaromaticity and homoaromaticity. 2L

Physical properties: Bond length, bond strength (bond dissociation energy and bond energy) bond angle, inter and intra molecular forces-Vander Waals force and hydrogen bonding. Polar and nonpolar molecules, dipole moment of organic molecules. 2L

Organic acids and bases: Bronsted and Lewis concept. Acidity of hydrocarbons, alcohols, phenols and carboxylic acids. Basicity of amines. Effect of structure, subtituent and solvent on acidity and basicity. 4L

Unit II:

Stereochemistry of alicyclic compounds:

Representation of molecules in Fischer, Flying-Wedge, Sawhorse and Newman formulas and their interconversions. Chirality, elements of symmetry – simple axis of symmetry (C_n), plane of symmetry (σ_v, σ_d, σ_h), centre of symmetry (i), alternating axis of symmetry (S_n, $n \geq 2$). 4L

Configuration: Stereogenic centre; stereoisomerism (enantiomerism and diastereoisomerism). Stereoisomerism of the following; one stereogenic centre (chiral centre/asymmetric carbon, chiral nitrogen): two unlike and like stereocentres (AB, AA), meso form; ABA type, stereogenecity, chirotopicity, pseudoasymmetric atom. Configurational nomenclature /descriptor; D/L, R/S, threo/erythro. 6L

Stereogenic axis; stereoisomerism of C=C and C=N systems, cis/trans, syn/anti, E/Z system of nomenclature. Chiral axis in allene and biphenyls (atropisomerism), R/S descriptor. 2L

Unit III:

Optical activity of chiral compounds; specific rotation, optical purity (enantiomeric excess), recemic compounds, racemisation (through cationic, anionic and radical intermediates), resolution of acids, bases and alcohols via diastereomeric salt formation. 2L

Topicity of ligand and faces (elementary idea):

Homotopic, enatiotopic and diastereotopic ligands, Prochirality, Pro-R/Pro-S descriptors, homotopic ,enatiotopic and diastereotopic faces, Re/Si descriptors. 2L

Conformation: Staggered and eclipsed conformations, dihedral angle, torsion angle, energy barrier of rotation, relative stability of conformers on the basis of steric effect, dipole-dipole interaction, hydrogen bonding; conformational analysis of ethane, propane, n-butane, 1,2-dihaloethane, 1,2-glycols, 1,2-halohydrin, invertomerism of trialkyl amines. 4L

Stereochemistry of alicyclic compounds:

Static stereochemistry: Bayer strain theory; energy profile of ring inversion of cyclohexane, symmetry properties of chair, boat and twist-boat form. Conformational analysis of methyl cyclohexane 1,2-,1,3-,and 1,4 dimethyl cyclohexane. Conformational energy of substituents in cyclohexane. 5L

Preferred conformations of disubstituted derivatives of cyclohexane (1-methyl-1-phenyl cyclohexane, cis and trans-1,3- and -1,4- ditertiary butyl cyclohexane, cis and trans-1,2-dibromo cyclohexane, cis and trans cyclohexane-1,3-diol). Physical properties with respect to dipole moment and acid strength in cyclohexane system. 4L

Unit IV:

Reaction mechanism; General principles

Bond cleavage-Homolysis and heterolysis. Classification of regents-electrophiles and nucleophiles.

Reactive intermediates: Carbocations (cerbenium and carbonium ions). Carbanions, carbon radicals, carbenes-geometry, electrophilic/nucleophilic behaviour, stability, generation and fate (elementary idea). 2L

Reaction energetic: ΔG, ΔH and ΔS terms in relation to reaction equilibrium with particular reference to the following: halogenations of alkane and alkene, keto-enol tautomerism, intermolecular and intramolecular reactions. 4L

Reaction kinetics: Rate equation, TS theory-rate constant and free energy of activation, free energy profiles for one-step, two-step reactions. Hammond postulates, principle of microscopic reversibility, kinetic control vs thermodynamic control, catalysed reaction, isotope effect primary kinetic isotope effect (K_H/K_D). 2L

Nucleophilic substitution at saturated carbon

Mechanism ; SN^1, SN^2, SN^i,$SN^{2`}$ mechanisms, effect of solvent, substrate structure, leaving group, nucleophiles including ambident nucleophiles (cyanide & nitrite). Crown ether as phase transfer catalyst. Substitution involving NGP; relative rate and stereochemical features [systems, alkylhalides, allylhalides, benzyl halides, alcohols, ethers, epoxides]. 6L

Group B (Inorganic Chemistry)

Total Lectures : 50-60

Full Marks -50 (University Examination: 45, Internal assessment: 5)

Unit – I:

Atomic structure: (12 L)

Bohr's theory of atomic structure and its limitation, Sommerfild's modifications, application of Bohr's theory to Hydrogen and hydrogen like atoms and ions, Spectrum of hydrogen atom, quantum numbers and their significance.

Wave particle duality, Planks radiation law (without derivation), de Brogile equation, .Heisenberg's uncertainty principle and its significance, Schroendinger wave equation, radial and angular probability distribution. Quantum mechanical model of atom. Concept of atomic orbitals, Shapes of s, p, d and f orbitals. Many electron atoms, Pauli's exclusion principle and Hund's rule, exchange energy. Aufbau (building up) principle and its limitations.

Electronic energy level diagram and electronic configurations of Hydrogen like and polyelectronic atoms and ions, variation of orbital energy with atomic number, term symbols of free atoms and ions.

Unit– II:
Chemical bonding – I: (10 L)

Ionic bonding: Size effects, radius ratio rules and their limitations. Packing of ions in crystals, lattice energy, Born-Lande equation and its applications, Born-Haber cycle and its applications. Solvation energy, polarizing power and polarizability, ionic potential, Fajan's rules. Defects in solids (elememetary idea).

Covalent bonding: Lewis structures, Octet rule and expanded octet, dative bond, retro-dative bond, hypervalence, formal charge. Valence Bond Theory, directional character of covalent bonds, hybridizations, hybrid orbitals [sp, ds, sp^2, sp^3, d^3s, dsp^2, d^2sp^3, sp^3d (qualitative approach)], equivalent and non-equivalent hybrid orbitals, Bent's rule, VSEPR theory, shapes of molecules and ions containing lone pairs and bond pairs (examples from main groups chemistry), partial ionic character of covalent bonds, bond moment, dipole moment and electronegativity differences. Concept of resonance, resonance energy, resonance structures (examples from main group chemistry).

Weak interactions : Van der Waals and London forces, ion-dipole and dipole-dipole interaction, hydrogen bonding.

Overlap (symmetry and energy permitted) of orbitals and bond formation, σ-bond, π-bond, μ-bond, δ-bond, banana bond (3c-2e), bond multiplicity and bond strength.

Unit– III:

(a) **Periodic Classification: (08 L)**

Modern periodic table (current IUPAC Version). General Characteristic of s, p, d and f block elements. Effective nuclear charge. Screening effect. Slaters Rules. Atomic radii. Ionic radii (Brag-Slater, Pauling's Univalent radii). Covalent radii (tetrahedral and octrahedral). Ionisation potential. Electron affinity. Electronegetivity. Pauling's, Muliken's and Allred Rechow's electronegetivity Scales. General trends of variation of elemental forms, oxidation states, catenation property, aqueous and redox chemistry. Properties of important classes of' compounds, complex formation and stereo chemistry relative to s, p, d and f block elements. Inert pair effect.

(b) Acid & bases: (07 L)

Arrhenius concept. Theory of solvent system. Bronsted Lowry's concept, relative strength of acids and bases, effect of substituents and solvents. Hydracids and oxyacids. Pauling's rules. Amphoterism. Lux-flood concept. Lewis concept. Usanovich's concept. Super acid. HSAB principle (Hard-soft acids and bases). Acid base neutralisation curves, indicators. Solvent properties of water, liquid ammonia, liquid sulpher-di-oxide, liquid HF and liquid H_2SO_4.

(c) Solubility equilibria: (03 L)

Solubility product principle, common ion effect and their application in Chemical analysis. Precipitation reactions.

Unit – IV:
Study of elements and their compounds: (12 L)

General trends of variation of electronic configuration, elemental forms, metallic nature, magnetic properties (if any), catenation and catalytic properties (if any), oxidation states, inert pair effect (if any), aqueous and redox chemistry in common oxidation states, properties and reactions of important compounds such as hydrides, halides, oxides, oxyacids (if any), complex chemistry (if any) in respect of the following elements:
(i) s-block elements: Li-Na-K (Group 1), Be-Mg-Ca-Sr-Ba (Group 2).
(ii) p-block elements: B-Al-Ga-In-Tl (Group 13).

Paper-II
Group A (Physical Chemistry)
Full Marks -50 (University Examination: 45, Internal assessment: 5)

Unit - I

Gas: Distribution of components of molecular speed and kinetic energy ($v, v_x, \epsilon, \epsilon_x$ etc). Maxwell molecular speed distribution, K.E. distribution, calculation of average quantities, different types of speeds, velocities. Barometric distribution. Principle of equipartition of energy, degree of freedom, calculation of C_p and C_v, variation with temperature. 8L

Collision of gases: collision diameter, collision cross-section, collision frequency, collision density, mean free path, viscosity of gases, effect of pressure and temperature. Wall collision and rate of effusion. 2L

Real gases: Compressibility factor, Andrew's and Amagat's curves, continuity of state.van der Waals' equation of state,virial equation, critical state, critical parameters in terms of van der Waals constants, determination of critical constants, law of corresponding states. 5L

Unit - II

Thermodynamics–I

Scope, definition of systems (isolated, closed, open), surroundings, boundary, different types of processes, variables (intensive and extensive), functions (state and path). Partial and total derivative, Euler's reciprocity, cycle rule, exact and inexact differentials, slopes. 3L

Zeroth and first laws of thermodynamics.Heat and work (reversible, irreversible, isothermal, adiabatic), Internal energy, enthalpy, Joule's experiment (ideal and van der Waals gas), different types of heat capacities. Second law of thermodynamics, Carnot and refrigeration cycles, entropy change, Clausius inequality, Gibbs and Helmholtz free energies, Gibbs–Helmholtz equation, equilibrium and spontaneity criteria.

Maxwell's relations and the thermodynamic equations of state, Combination of first and second law of thermodynamics. Joule–Thomson experiment (ideal and van der Waals gas). 8L

Thermochemistry: Thermochemical equation, Kirchoff's equations, different type of heats of reactions (entropy, enthalpy and Gibbs energy) and their standard state. Hess's law, Lavoisier and Laplace's law. 5L

Unit – III

Surface tension: Properties of liquid, vapour pressure equation, surface tension, surface energy, interface, effect of temperature (Eötvös equation, critical temperature), determination of surface tension (capillary rise, capillary depression, stalagmometer), excess pressure inside bubbleand drops (basic idea of the Young-Laplace equation), cohesion, adhesion, work of cohesion and adhesion, spreading of liquid over other surface. 4L

Adsorption: Physical and chemisorption, adsorption isotherms: Freundlich, Langmuir andGibbs absorption isotherms, surface excess, BET equation (no derivation). 3L

Colloidal state: Definition, colloids classification, properties, ultracentrifuge, electrokinetic phenomena, zeta potential, iso-electric point, Schulze-Hardy rule, protective colloids, gold number, Perrin method for determination of Avogadro number, colloidal electrolytes, CMC values, emulsions, gels, thixotropy. 5L

Viscosity: Definition, viscosity of gas and liquid and effect of temperature, laminar and turbulent flow, Newtonian, non-Newtonian fluid, Newton's law of viscosity, Poiseuille's law, viscosity coefficient, effect of temperature on viscosity coefficient, measurement (Ostwald viscometer, falling sphere method). 5L

Unit – IV

Chemical Kinetics: Rate law, integrated rate law, advancement of reaction, order, molecularity. Zero, first, second, higher and pseudo-first order reactions. Determination of order of reaction, temperature dependence of reaction rates, Arrhenius equation, activation energy. Elementary reactions;multi-step reactions: consecutive, opposing, and parallel reactions(all first order). 6L

Collision theory**:**unimolecular (Lindemann) and bimolecular reactions; transition state theory (TST), entropy of activation, Eyring equation, primary kinetic salt effect, relation between TST and hard sphere collision theory. 4L

Catalysis: Definition, catalyst and inhibitor, criteria of catalysis, types of catalysis (homogeneous and heterogeneous), auto-catalytic reaction. Theory of acid-base catalysis with examples. 3L

Enzyme catalysis:Properties of enzymes, Michaelis–Menten equation, Lineweaver–Burk equation, turnover frequency, catalytic efficiency, effect of temperature and pH. 3L

Group B (Industrial Chemistry)
Full Marks -50 (University Examination: 45, Internal assessment: 5)

Unit-I

(a) Errors, Precision and Statistics:

Introduction, Accuracy and Precision, Significant figures, Classification of Errors- determinate & indeterminate errors, Normal error curve, Ways of expressing accuracy- absolute and relative, Minimization of Errors, Rules for computations, Statistical treatment of experimental data- Mean, median and standard deviation, Reliability of results, Rejection of results. 6L

(b) Basic principles of chromatographic separation: Gas Liquid Chromatography (GLC), Thin Layer Chromatography (TLC), GPC, HPLC, paper chromatography, ion-chromatography. The application of TLC in identification and separation of products of nitration of benzene. 6L

Unit-II

Fuels: Solid, Liquid and gaseous fuels

a) Origin of coal, analysis of coal, high and low temperature carbonization coal. 3L
b) Petroleum and petrochemicals: petroleum hydrocarbons-classification, chemicals structure, crude oil, naptha, kerosene, diesel, lube oil, separation of crude oil, (distillation- atmospheric and vacuum), cracking, octane number, cetane number, flush point. 6L
c) Natural gas, LPG, coal gas, water gas. 3L

Unit-III

Some important industrial products (manufacture and application): Polymer (PVC, polyethylene, Bakelite, nylon-66, terylene, natural rubber, buna and neoprene rubber), vulcanization of rubber, Detergents (dodecylbenzene sulphonates), Pesticides (DDT, BHC and few others commonly used in agriculture), Dyes and Pigments (methyl orange, phenolphthalein, mercurochrome, ultramarine, zinc-white, litho phone, carbon black), Fertilizers (superphosphate of lime, urea, ammonium sulphate), Ceramics (only glass and cement). 15L

Unit-IV

(a) Oils and fats: types of oil and fats, analysis of oils, saponification, recovery of glycerin, hydrogenation of oils. 6 L

(b) Water: deionization of water, analysis of hardness of water, determination of DO, BOD, COD, TOC in water. 6 L

2nd Year
Part II

Paper –III
Group A (Organic Chemistry)
Full Marks -50 (University Examination: 45, Internal assessment: 5)

Unit I:

Elimination reactions

Alkyl halides and alcohols, 1,2-(β) elimination: E1, E2 and E1cB mechanism. Orientation in E2 elimination (Saytzeff and Hofmann)- effect of substrate structure, base and leaving group, stereochemistry of E2 elimination-stereospecific and stereoselective reactions. Substitution Vs elimination : E1/SN^1 and E2/SN^2. Syn elimination (Ei). Mechanism and stereochemistry of pyrolysis of esters and xanthates, α-elimination. 4L

Addition reactions

Addition to Carbon- Carbon multiple bond: electrophilic and free radical mechanism, stability of alkenes-heat of hydrogenation and heat of combustion.

Mechanism of the following reactions: Halogenation, hydrohalogenation (regioselectivity, peroxide effect), hydration of alkene (including oxymercuration-demercuration, hydraboration-oxidation), epoxidation, hydroxylation, ozonolysis (involving 1, 3-dipolar mechanism), hydration of alkyne, stereochemistry of bromination, hydroxylation and carbene addition. Electrophilic addition to allene and butadiene. Dissolving metal reduction of alkynes and benzenoid aromatics (Birch). 8L

Dynamic stereochemistry: Conformations and reactivity in cyclohexane system: E2 elimination, nucleophilic substitution (SN^1, SN^2, NGP), rearrangement (pinacol-pinacolone and related rearrangements, Favorski

rearrangement). Oxidation of cyclohexanol, esterification, saponification and lactonization. 3l

Unit II:

Carbonyl Chemistry

Nucleophilic addition to carbonyl group- Aldehydes and ketones: Addition to HCN, $NaHSO_3$, water, alcohol, thioalcohol (Umpolung), derivatives of ammonia, ylides (Wittig reaction), nucleophilic addition to α,β - unsaturated carbonyl compounds (general principles). Quinones, reactions of p-benzoquinone. Hydride addition ($LiAlH_4$, $NaBH_4$ reduction), MPV reduction, Wolff-Kishner, dissolving metal (Clemenson reduction, Bouveaultr-Blanc reduction). Acidity of α-H: reaction via enols and enolate ion (carbanions), aldol condensation, Knovenagel reaction, Claisen ester condensation, Perkin reactions, Darzen's reaction, halogenations of ketones, α-halogenation of acids (HVZ reaction). 8L

Nucleophilic substitution at the acyl carbon- carboxylic acids and their derivatives: Esterification and hydrolysis (B_{AC}^2, A_{AC}^2 , A_{AC}^1, A_{Al}^1 mechanism, non kinetic use of isotope labels), amides (formation and hydrolysis). Carbonyl compounds without α-H; Cannizaro reaction, Tischenko reaction, benzoin condensation. 3L

Stereoselectivity and asymmetric synthesis- enentoselectivity/ diastereoselectivity; asymmetric synthesis involving achiral and chiral reagent; chiral substrate and achiral reagent (Cram's rule and Felkin-Anh model). 2L

Unit lll:

Aromatic Substitution

Electrophilic aromatic substitution:- Mechanism orientation and reactivity (including free energy profiles) of halogenations, nitration, sulfonation, Friedel-Craft reactions, chloromethylation, formylation (Gatterman-Koch, Gatterman, Reimer- Tiemann and Vilsmeyer-Haack). Kolbe-Schmidt

reaction, Houben-Hoesch reaction. IPSO substitution. Synthesis of naphthalene, anthracene and their derivatives; Pthenenthrene (Bardhan-Sengupta synthesis), orientation and reactivity in polynuclear hydrocarbons (naphthalene and anthracene). 10L

Nucleophilic aromatic substitution: Addition-elimination mechanism, reactivity and orientation in activated aromatic substitutions. Elimination-Addition, mechanism, benzyne intermediate. SN^1 mechanism. 2L

Chemoselectivity: different reactivity of $–NH_2$ and –OH in aromatic system. 1L

Chemistry of nitrogen containing compounds:

Aliphatic and aromatic amines (preparation, separation and identification of primary, secondary and tertiary amines), alkylation including Hoffmann's exhaustive methylation, reactions of aliphatic and aromatic amines with nitrous acid, carbyl amine reaction, Mannich reaction, Eschweiler Clarke reaction, enamines, diazomethane, diazoacetic ester, aromatic nitrocompounds, aromatic diazonium salts, nitriles and isonitriles, Ritter reaction.

3L

Unit lV:

Organometallics:

Preparation of Grignard reagent and organolithium. Reactions: addition of Grignard and organolithium to carbonyl compounds, substitution on –COX, conjugate addition by Gilman cuprates, Reformatsky reaction. 2L

Molecular rearrangements:

Intramolecular Vs intermolecular rearrangements. Crossover experiment.

1,2-shift: Migration to electron deficient carbon;

Wagner-Meerwein, pinacol-pinacolon, dienenone-phenone, Wolff rearrangement in Arndt- Eistert synthesis, Benzil-benzillic acid rearrangement.

Migration to electron deficient nitrogen:

Beckmann, Schmidt (carbonyl compound), Hofmann, Lossen, Curtious, Schmidt (carboxylic acid).

Migration to electron deficient oxygen:

Baeyer-Villeger, Dakin, Hydroperoxide rearrangement.

Aromatic rearrangements;

Migration from oxygen to ring carbon: Fries, Claisen rearrangement

Migration from nitrogen to ring carbon: Hofmann-Mertious, Fischer-Hepp, N-azo to C-azo, Bamberger, Orton, Benzidine-Semidine rearrangement. 8L

Group B (Inorganic Chemistry)

Total Lectures : 50-60

Full Marks -50 (University Examination: 45, Internal assessment: 5)

Unit – I:

Radioactivity & nuclear chemistry: (10 L)

Radioactive decay, half life and average life of radio elements, units of radioactivity, natural radioactive disintegration series, radioactive equilibrium, group displacement law, isotope, isotone, isobars and nuclear isomerism. Application of isotope in medicine, agriculture, reactor mechanism (isotope as tracer), age of minerals, age of earth, radio carbon dating, nuclear particles, nuclear forces, nuclear models (elementary idea), nuclear stability, nuclear binding energy, nuclear reactions, magic numbers, mass defect, proton-neutron ratio, packing fraction, transmutation of elements, fission, fusion and spallation reaction. Nuclear energy, hazards of nuclear radiations.

Unit – II:

Redox chemistry: (10 L)

Oxidation and reduction, oxidation numbers, balancing of redox reaction by oxidation number and ion electron method.

Standard redox potential, Sign conventions. Nernst equation, influence of complex formation, precipitation and change of pH on redox potential, formal potential, feasibility of a redox titration, redox potential at the equivalence point, redox indicators, redox potential diagram (Latimer, Frost and Pourbaix diagrams) of common elements and their applications. Dis-proportionation and com-proportionation reactions (Typical examples). Redox titration using $KMnO_4$ and $K_2Cr_2O_7$.

Unit– III:

(a) Chemical bonding - II: (10 L)

Types of bonding. Overlap of atomic orbitals. VB and MO concepts, LCAO method. Bonding of homo- and hetero-nuclear diatomic molecules (H_2, H_2^+, H_2^-, He_2^+, B_2, C_2, N_2, O_2, NO, CO, CN^-, HF), bond order, bond length.

Metallic bonding: Qualitative idea of band theory, conducting, semi-conducting and insulating properties with examples from main group elements.

Close-packing: hcp (ABAB…. type), ccp (ABCABC…..type); holes: cubic, tetrahedral and octahedral; radius ratio principle and different polyhedra; structures of MX (NaCl, CsCl and ZnS) , MX_2 (CaF_2, SiO_2, TiO_2) / M_2X (Na_2O), MX_3 (AlF_3). Structure of simple silicates, metallic structure, alloy structure.

(b) Chemistry of coordination compounds - I: (08 L)

Double salts and complex salts, detection of complexes in solution, ligands, ambidentate and polydentate ligands, coordination number, Werner's coordination theory. IUPAC nomenclature. Factors affecting the stability of complexes in solution. Overall and stepwise formation constants, determination of stability constants by Job's method, perfect and

imperfect complexes, chelate complexes, flexidentate behavior of ligand, inner-metalic complexes, their properties and applications in analytical chemistry. Complexones, masking and demasking interactions, metallochrome indicators, titration of metal ions and their mixtures with EDTA, hardness of water and its determination.

Unit – IV:

Study of elements and their compounds: (14 L)

Comparative study of p-block elements: Group trends in electronic configuration, modification of pure elements, common oxidation states, inert pair effect, catenation and catalytic properties (if any), and their important compounds in respect of the following groups of elements:

i) Group-14 (C, Si, Ge, Sn, Pb)
ii) Group-15 (N, P, As, Sb, Bi)
iii) Group-16 (O, S, Se, Te)
iv) Group-17 (F, Cl, Br, I)
v) Group- 18 (He, Ne, Ar, Kr, Xe)

Paper-IV
Physical Chemistry
Full Marks -50 (University Examination: 45, Internal assessment: 5)

Unit – I

Thermodynamics-II

Clapeyron equation, Clausius–Clapeyron equation, Trouton's rule. Open systems, activity, fugacity, activity coefficients,partial molar quantities, chemical potential, thermodynamics of mixing ($\Delta_{mix}G$, $\Delta_{mix}S$, $\Delta_{mix}H$), Gibbs–Duhem equation. 5L

Colligative properties: Ideal solutions, thermodynamic properties of binary solution, colligative properties. Raoult's laws. Colligative properties (relative lowering of vapour pressure, elevation of boiling point, depression of freezing point, vant Hoff's law for osmotic pressure) statement, derivation (using chemical potential), application, critical comment on limitation. Abnormal colligative properties, van't Hoff's factor, deviation from ideality (negative, positive). Duhem–Margules relation, Konowaloff's rule, non-ideal and ideally dilute solutions. 10L

Unit – II

Chemical equilibrium: Extent of reaction, law of mass action, thermodynamic equilibrium constant, K_p, K_c and K_x and relationship between them, effect of temperature, pressure and addition of inert gas on equilibrium and equilibrium constant, Le Chatelier principle,van't Hoff isotherm and equation. Examples of equilibria in homogenous and heterogeneous systems. 8L

Ionic Equilibrium: Debye-Huckel limiting law (no derivation), solubility and solubility product, ionic product of water, *pH*, Henderson equation, concept of buffer solution, buffer capacity, hydrolysis, indicators (acid-base, adsorption, redox, metal ion). 7L

Unit - III

Quantum mechanics–1: Drawback of classical mechanics, stability of atom, black body radiation, photoelectric effect; Compton effect, wave-particle duality, de Broglie hypothesis, Heisenberg's uncertainty principle. Concept of operators, different types of operators, properties and interpretation of wavefunctions (normalization, orthogonality, probability distribution) eigen function, eigen values. Commutation of operators, commutators, theorem, postulates of quantum mechanics, time-dependent, time-independent Schrodinger equation, stationary state, stationary state wavefunction, applications, free particle, boundary condition. 15L

Unit - IV

Electrolytic conduction: Conductance, conductivity, molar and equivalent conductivities, limiting molar conductivity, measurement, variation with dilution, Ostwald's dilution law, ionic mobility, Kohlrausch law, asymmetry effect, electrophoretic effect, temperature dependence of ion conductivity. Stoke's law, Hittorf's rule, conductivity of ions in aqueous and non-aqueous solvent, Debye-Huckell-Onsagar equation (no derivation), Debye-Falkenhagen effect and Wien effect, application of conductance measurement, conductometric titration, Transport number, abnormal transport number, solvation of ions, measurement of transport numbers (moving boundary method) 8L

Electromotive Force: Electrochemical cell, reversible and irreversible, EMF and electrical work, measurement of EMF, temperacture co-efficient of EMF, standard cell, different type of electrodes, electrodepotential, Nernst's equation, standard electrode potential, reference electrode, (hydrogen, quinhydrone, glass, calomel), chemical and concentration cells, liquid junction potential, salt bridge, applications of potentiometric measurement. 7L

Paper-V
Group A (Organic Chemistry Practical)
Full Marks -50 Time: 6 Hrs

(A) Identification of a solid unknown organic compound (40)

i) Physical characteristics

ii) Solubility test with preliminary conclusion

iii) Detection of elements (N,S and Cl) in a given solid sample

iv) Determination of melting point of the organic sample

v) Detection of the following functional groups in organic samples

Carbonyl- keto, aldehyde, carboxylic acid, phenolic hydroxyl, unsaturation, aromatic (nitro, amino), amido

vi) Preparation of a suitable derivative of the supplied organic sample and determine the Melting point of derivative

vii) Literature survey

viii) Naming of the compound with structure

(B) Laboratory note book (5)

(C) Viva-voce: (5)

Group B (Inorganic Chemistry Practical)
Full Marks -50 Time: 6 Hrs

Inorganic Qualitative Analysis:

(A) Qualitative analysis of inorganic sample containing not more than four radicals (Basic and acid) selected from the list given below: (40)

Basic radicals: Cu(II), Sb(III), Bi(III), Fe(II/III), Cr(III), Al(III), Zn(II), Mn(II), Co(II), Ni(II), Ca(II), Ba(II), Sr(II), Mg(II), Na(I), K(I), NH_4^+.

Acid radicals: Cl^-, F^-, Br^-, I^-, $[Fe(CN)_6]^{3-}$, $[Fe(CN)_6]^{4-}$, SO_3^{2-}, SO_4^{2-}, S^{2-}, PO_4^{3-}, CrO_4^{2-}, BO_3^{3-}, H_3BO_3, NO_3^-, NO_2^-, $Cr_2O_7^{2-}$, SCN^-.
(also oxides, hydroxides and carbonates may be given which should not be counted as radicals)

Less common ions not to be set in examinations. Tests should be recorded in laboratory note book.
Less common ion (Special test only): Ti(III/IV), Zr(IV), V(IV/V), Mo(VI).
Insoluble compound: Al_2O_3, Fe_2O_3, Cr_2O_3, SnO_2, $SrSO_4$, $BaSO_4$, CaF_2.

Reporting of the systematic analysis of the samples for qualitative analysis should be presented in the following scheme:

1. Physical characteristics and solubility of the sample.
2. Preliminary tests for basic and acid radicals: only the positive test should be mentioned.
3. Systematic analysis of the sample: (a) the group present should be clearly analyzed, (b) the confirmatory tests should be reported.
4. Tests for acid radicals: only the positive tests for acid radicals present, including spot tests, tests for acid radicals in presence of other interfering radicals.
5. Probable composition with proper justification.

(B) Laboratory note book (5)
(C) Viva-voce: (5)

Group C (Physical Chemistry Practical)

Full Marks -50 Time: 6 Hrs

Students have to carry out all the listed experiments in their practical classes and have to report those with properly singed in their laboratory note book during examination. One experiment will be assigned to a candidate through single draw lottery during examination.

(A) Students have to perform one experiment to be set among the followings (40)

1. Determination of pH of an unknown solution by colour matching method.
2. Determination of surface tension of a liquid by stalagmometer.
3. Determination of viscosity of a liquid by Ostwald's method.
4. Determination of distribution co-efficients: I_2 in water-organic solvent (CCl_4/$CHCl_3$)
5. Adsorption isotherm study of acetic acid on charcoal.
6. Study of the kinetics of acid catalyzed hydrolysis of methyl acetate.
7. Study of the decomposition kinetics of hydrogen peroxide ($FeCl_3$ catalysed).
8. Solubility product study (by titration) of (i) Silver acetate and (ii) strontium oxalate (iii) KHTa in the presence and absence of common ions (any one of the three).

(B) Laboratory note book (5)

(C) Viva-voce: (5)

3rd Year
Part III
Paper –VI
Group A (Organic Chemistry)
Full Marks -50 (University Examination: 45, Internal assessment: 5)

Unit I:

Spectroscopy

UV: Electronic transitions ($\sigma \longrightarrow \sigma^*$, $n \longrightarrow \sigma^*$, $\pi \longrightarrow \pi^*$, $n \longrightarrow \pi^*$), absorption maximum and absorption intensity considering conjugative effect, steric effect, solvent effect, red shift (bathocromic shift), blue shift (hypsochromic shift), hyperchromic effect, hypochromic effect (typical examples). Woodward rule with reference to conjugate dienes, trienens and α,β- unsaturated carbonyls including cyclic systems. 4L

IR: Stretching and bending vibrations, Hooke's law, characteristics stretching frequencies of O-H, N-H, C-H, C-D, C=C, C=N, C=O functions, factors affecting stretching frequencies (H-bonding, mass effect, electronic factors, bond multiplicity, ring size). 4L

^{1}HNMR: Nuclear spin, NMR-active nuclei, principle of proton magnetic resonance, chemically equivalent and non-equivalent protons, chemical shift, upfield and downfield shifts, shielding/deshielding of protons (systems involving C = C, C = O, $C \equiv C$, benzene) NMR peak area (integration). First order coupling, (spilliting of the signals; ordinary ethanol, bromoethane, dibromoethanes), coupling constants, relative peak positions of different kinds of protons of substituted benzenes (toluene, nitrobenzene, halobenzene, dinitrobenzenes, chloronitrobenzenes). 7L.

Unit II:

Synthesis

General synthetic strategy: Disconnection approach- Target molecule, retrosynthetic analysis, function group interconversion (FGI), disconnection, synthon, electrophilic and nuclephilic synthons, synthetic equivalent, latent polarity. 2L

Ring synthesis: Methidologies: i) C-C disconnection involving carbanion chemistry (Ethyl acetoacetate, diethyl malonate). ii) carbonyl condensation – two group disconnection: α,β- unsaturated carbonyl compounds, 1,3- dicarbonyl compounds, 1,5- dicarbonyl compounds, Robinson annelation. Iii) Large ring synthesis: high dilution technique, Acyloin condensation (use of trimethyl silyl chloride). 8L

Unit III

Carbohydrate Chemistry

Monosaccharides- classification, configuration of D-glucose and D-fructose and their ring structures, mutarotation, anomeric effect.

Reactions: Osazone formation, bromine-water oxidation, epimerization, stepping-up (Killani method) and stepping-down (Ruff & Wohl's degradation method) of aldose.

Disaccharides – glycosidic linkages, structure of sucrose, inversion of sucrose. 5L

Amino acids, peptides and nucleic acids

Amino acids: Synthesis of α-amino acids (Gabriel, Strecker, azolactone, acetamidomalonic ester methodologies), isoelectronic point, ninhydrin reaction.

Peptides: peptide linkage, peptide synthesis including Merrifield resin, C-terminal, N-terminal and their determination (Edmann, Sanger and dansyl chloride).

Nucleic acids: structure of nucleosides and nucleotides, pyrimidine and purine bases (structure and nomenclature only), elementary idea of RNA and DNA; Watson-Crick model, complimentary base-pairing in DNA. 8L

Unit IV

Heterocyclic Compounds

Reactivity, orientation and important reactions of furan, pyrrole, thiophene, pyridine, indole.

Synthesis (including retrosynthetic approach)

Furan: Paal-Knoor synthesis, Feist-Benary synthesis

Pyrrole: Knoor synthesis, Hantzsch synthesis

Thiophene: Hinsberg synthesis

Pyridine: Hantzsch synthesis

Indole: Fischer, Madelung, Reissert synthesis

Quinoline: Skaurp, Friedlander synthesis

Isoquinoline: Bischler-Napieralski synthesis 8L

Pericyclic reaction

Definition and classification of pericyclic reactions, thermal and photochemical electrocyclic reactions of neutral species involving 4 and 6 electrons- FMO approach. Cycloaddition reactions [2+2] and [4+2], Diels-Alder reaction-FMO approach. 5L

Group B (Inorganic Chemistry),

Total Lectures : 50-60

Full Marks -50 (University Examination: 45, Internal assessment: 5)

Unit – I:

Chemistry of coordination compounds - II: (13 L)

(a) **Stability of Coordination Complexes:** Thermodynamic and kinetic stability of complexes, substitution reactions in square planar complexes, trans effect, and labile and inert complexes.

(b) **Types of Isomerism in Coordination Compounds:** Types of isomerism in coordination compounds : Constitutional, geometrical and optical isomerism in respect of coordination numbers 4 and 6. Determination of configuration of cis-, trans-isomers by chemical methods. Resolution of optical isomers.

(c) **Nature of bonding in coordination compounds (including colour and spectra):** Nature of coordinate linkage, EAN rule, electro-neutrality principle, VB theory, its limitations. Crystal field and Ligand field theory, d-orbital splitting in octahedral, tetrahedral and square planar fields, crystal field stabilization energy in weak and strong field complexes, pairing energy, explanation of magnetic behavior and spectral features including charge transfer spectra of transition metal complexes, selection rules for electronic spectral transitions, qualitative Orgel diagram for $3d^1$ – $3d^9$ systems, spectrochemical series, Jahn-Teller distortion. Metal - Ligands bonding (MO concept - elementary idea) sigma & pi-bonding in octahedral complexes (qualitative approach) and stabilization of unusual oxidation states due to complex formation.

Unit – II:

(a) **Magneto chemistry:** (7L)

Diamagnetic and paramagnetic susceptibility, Curie equation (without derivation), magnetic moment and its determination by Guoy method, L-S coupling, term symbol, orbital and spin moment (qualitative treatment), quenching of magnetic moment, super-exchange, anti-ferromagnetic interaction (elementary idea with examples only), application of spin only values of magnetic moments to determine valency and stereochemistry of coordination compounds (based on VBT and CFT).

(b) Chemistry of d-block elements: (10 L)

Comparative study of the metals of first transition series with reference to electronic configuration, atomic and ionic radii, ionization potential oxidation states, aqueous and redox chemistry, complex chemistry, magnetic properties, metallic nature and catalytic properties. Trends in physical and chemical properties in passing from 3d through 4d to 5d block elements.

Extraction and purification scheme (omitting technical details) and technical uses of the following metals: Ti, V, Cr, Mn, Co, Ni, Pt, Ag, Au, Cd, Hg and U.

Unit– III:

(a) Organometallic compounds: (12 L)

Definition, acid ligands, hapticity (s) of ligands, 18-electron rule, application of 18-electron rule to carbonyl, nitrosyl, cyanide and hydrido complexes. Preparation, Properties and bonding of carbonyl, nitrosyl and cyanide complexes, metal carbonylates, carbonyl hydrides, metal olefin, alkynes and cyclopentadienyl complexes, Ziese's salt (preparation, structure and bonding), Ferrocene (preparation, Structure, bonding and reactions). Metal-metal bonded compounds and metal culsters (simple examples).

Simple examples of fluxtional molecules, coordinative unsaturation, oxidative addition and insertion reactions, homogeneous catalysis by organometallic compounds: hydrogenation, hydroformylation and polymerization of alkenes (Ziegler Natta Catalyst).

(b) Chemistry of f-block elements: (03 L)

f-block elements: electronic configuration, ionization energies, oxidation states, variation in atomic and ionic (3+) radii, magnetic and spectral properties of lanthanides, comparison between lanthanide and actinides, separation of lanthanides (by ion-exchange method).

Unit – IV:

(a) Bioinorganic chemistry: (08 L)

Essentials and trace elements of life, basic reactions in the biological systems and the role of metal ions specially Na^{+}, K^{+}, Mg^{2+}, $Fe^{3+/2+}$, Cu^{2+} & Zn^{2+}. Transport across biological membrane-Na^{+} ion pump, ionophores.

Bio-function of hemoglobin and myoglobin, cytochromes and ferridoxins, photosynthesis: photo system I and II, Carbonate-bicarbonate buffering system and carbonic anhydrase. Biological nitrogen fixation. Toxic metal ions and their effects, chelation Therapy, metal dependent diseases and Pt and Au complexes as drugs (examples only).

(b) Instrumental analysis: (05 L)

Basic Principles, Instrumentations and simple applications of conductometry, potentiometry, polarography, UV-Visible and IR spectrophotometry. Analysis of water (BOD, COD, DO, TDS), air & soil samples. Principles for determination of BOD, COD, DO, TDS in water samples. Detection and estimation of As, Hg, Cd, Pb in water sample.

Paper-VII

Physical Chemistry
Full Marks -50 (University Examination: 45, Internal assessment: 5)

Unit - I

Quantum mechanics–2: Particle in one dimensional box, wavefunction, normalized wavefuction, probability of finding of particle, expectation values ($\langle x \rangle$, $\langle x^2 \rangle$, $\langle p_x \rangle$, $\langle p_x^2 \rangle$ etc.), uncertainty, particle in one dimensional box, degeneracy, tunneling effect. 5L

Simple harmonic oscillator, Schrodinger equation, energy (no derivation) wavefunction (no derivation), probability density, expectation values, uncertaninty.Rigid rotator, Schrodinger equation, energy (no derivation) wavefunction (no derivation). 5L

Hydrogen atom: Hydrogen-like system, Schrodinger equation in polar coordinates, radial solution, radial wavefunction, real hydrogen-like wavefunction, probability density, probability of finding of electron, radial distribution function, quantum numbers, energy expression (no derivation), degeneracy, concept of orbitals (s,p,d) and shapes. 5L

Unit - II

Photochemistry:Thermal versus photochemical reactions, Grotthüs-Draper law, Lambert-Beer's law, Einstein's law of photochemical equivalence, quantum yield, actinometer, effect of adsorption of light, phosphorescence, fluorescence, photochemical reactions(decomposition of HI and combination of H_2 and Br_2), photo-stationary state, Jabolonsky diagram. 5L

Molecular geometry: Polarization, dipole moment, permittivity, relative permittivity, Debye-Langevin equation (No derivation), Clausius-Massoti equation (No derivation), application towards explanation of structure. Spectroscopy, microwave and I.R spectra energy expressions (no derivation) selection rule applications, potential energy diagram, Franck-Condon principle, Raman spectra, comparison with fluorescence. 10L

Unit - III

Crystalline state: Laws of Crystallography, unit cell, lattice, different crystalline systems with characteristics, Bragg's equation, application towards structure of NaCl and KCl. Specific heats of solid elements, Dulong-Petit'slaw,limitations, Einstein's equation, success and limitations, Debye's T^3 law (no derivation 5L

Thermodynamics–III

Third law of thermodynamics, Nernst heat theorem, Lewis-Randall statement Plank statement.

Macrostates and microstates, Ensemble, mathematical probability versus thermodynamic probability,thermodynamic probability and the concept of entropy, Partition function and representation of the thermodynamic functions; Boltzmann distribution, non-degenerate and degenerate cases. 10L

Unit - IV

Phase Equilibrium: Phase, phase stability, first-order phase transition, transition temperature, phase boundary, slope of phase boundary, vapour pressure, critical point, boiling point and melting point (normal and standard). Henry's law, Nernst's distribution law, solvent extraction, phase, component, degree of freedom, phase rule, derivation from

thermodynamics. One component system, (water, CO_2 and sulphur), triple point. Two component system liquid-liquid and solid-liquid systems (phenol-water, triethylamine-water, nicotine-water) isopleths, tie-line, lever rule, critical solution temperature, simple eutectic compound with congruent and incongruent melting points, peritectic line. 12L

Paper-VIII

Group A
(Organic Chemistry Practical)
Full Marks -50 Time: 6 Hrs

(A) Organic preparation: (25 marks)

m-dinitrobenzene, Aspirin, Methyl orange, p-bromo acetanilide, p-bromo aniline from p-bromo acetanilide, phthalimide from phthalic anhydride, benzanilide, anthranillic acid from phthalimide, benzilic acid from benzil, benzil from benzoin, benzoic acid by oxidation of benzene derivative(ph-CHO/ph-CH_2OH/ph-CH_3).

(B) Spectroscopic analysis of organic compounds: (15 marks)

Assignment of labelled peaks in the ^1H NMR spectrum of the known organic compounds explaining the relative δ values and splitting pattern and also assignment of labelled peaks in the IR spectrum of the same compound.

p-nitro aniline, p-nitro benzaldehyde, p-bromo acetanilide, p-amino benzoic acid, p-methyl α-bromo acetophenone, o-hydroxy acetophenone, o-hydroxy benzaldehyde, salicylamide, vanillin, cinamic acid, benzal acetone, diethyl maleiate, diethyl fumarate, glucose, fructose.

Laboratory note book:(5 marks)

Viva-voce: (5 marks)

Group B (Inorganic Chemistry Practical)

Full Marks -50 Time: 6 Hrs

A. Quantitative analysis:(30 marks)

(i) Acidimetry and alkalimetry.

a. Titration of Na_2CO_3 + $NaHCO_3$ mixture vs HCl using phenolphthalein and methyl orange indicators.

b. Titration of HCl + CH_3COOH mixture vs NaOH using two different indicators to find the composition.

(ii) Volumetric analysis with potassium permanganate and potassium dichromate solutions.

(iii) Iodometry and complexometry

(iv) Estimation of mixtures of Fe(III)-Ca(II), Fe(III)-Cu(II), Fe(III)-Cr (VI), Fe(III)-Mn(II), Ca(II)-Mg(II), Cu(II)-Zn(II).

(vi) Gravimetric estimation of chloride, sulphate and nickel as dimethyl glyoxime complex.

(vii) Determination of total hardness of water by EDTA titration.

(viii) Estimation of available (a) chlorine in bleaching powder (b) oxygen in pyrolusite.

B. Preparation of inorganic compounds: (10 marks)

i) Ammonium manganous sulphate, $(NH_4)_2SO_4$, $MnSO_4 .6H_2O$

ii) Ammonium ferrous sulphate hexa hydrate (Mohr's salt), $(NH_4)_2SO_4$, $FeSO_4 .6\ H_2O$

iii) Ammonium ferric sulphate (Ferric alum), $(NH_4)_2SO_4$, $Fe_2(SO_4)_3.24H_2O$ or $(NH_4)_2Fe(SO_4)_2.12H_2O$

iv) Potash alum, K_2SO_4, $Al_2(SO_4)_3.24H_2O$

v) Tetra ammine carbonato cobalt(II) nitrate hemi hydrates, $[Co(NH_3)_4(CO_3)](NO_3)$. $½H_2O$.

vi) Bis-acetylacetonato copper(II), $[Cu(acac)_2]$

C. Laboratory note book:(5 marks)*

D. Viva-voce: (5 marks)

* All type of quantitative analysis (acidimetry, alkalimetry, permanganometry, dichromatometry, idometry, complexometry, gravimetry) and preparation should be recorded in laboratory note book. Each carries marks.

Group C (Physical Chemistry Practical)
Full Marks -50 Time: 6 Hrs

Students have to carry out all the listed experiments in their practical classes and have to report those with properly singed in their laboratory note book during examination. One experiment will be assigned to a candidate through single draw lottery during examination.

(A) Students have to perform one experiment to be set among the followings (40 marks)

1. Conductometric titration of HCl vs NaOH; acetic acid & oxalic acid vs NaOH; mixed acid (HCl +CH_3COOH) vs NaOH.
2. Determination of ionization constant of weak electrolyte and its conductance at infinite dilution using conductometer (verification of Ostwald dilution law).
3. Determination of solubility and solubility product of AgCl by EMF measurement.
4. Potentiometric estimation of Mohr salt solution with standard $K_2Cr_2O_7$ and the determination of formal potential of Fe^{3+}/Fe^{2+} system.
5. Determination of pK_a values of weak monobasic acid and pK_2 of dibasic acid using *pH*-meter.

6. Verification of the Lambet-Beer's law and determination of the concentration of a solution.
7. Determination of pK_{in} of Bromochresol green using colorimeter.
8. Determination of optical rotation of cane sugar by polarimeter.
9. Determination of critical solution temperature of phenol-water system and effect of impurities on CST.

(B) Laboratory note book:(5 marks)
(C) Viva-voce: (5 marks)

Recommended list of books

Organic Chemistry:

1. D. Nasipuri: Stereochemistry of organic compounds: Principles and Applications
2. P. Sykes: A Guide to Mechanism in Organic Chemistry
3. J. March: Advanced Organic Chemistry
4. I. L. Finar: Organic Chemistry (Vol. I)
5. R. T. Morrison and R. N. Boyd: Organic Chemistry
6. W. Kemp: Organic spectroscopy
7. R. O. C. Norman and J. M. Coxon: Principle of organic synthesis
8. S. Warren: Organic synthesis: The disconnection approach
9. J. Clayden, N. Greeves, S. Warren and P. Wothers: Organic chemistry
10. J. A. Joule and K. Mills: Heterocyclic Chemistry (4 th Edition)
11. W. Carruthers: Modern methods of organic synthesis

Inorganic Chemistry:

1. Inorganic Chemistry: Principles of Structure and Reactivity by Huheey/Medhi, Pearson.
2. Inorganic Chemistry by Meissler/Tarr, Pearson.

3. 10. Advanced Inorganic Chemistry – F. A. Cotton & G. Wilkinson
4. Inorganic Chemistry – J. E. Huheey, E. A. Keiter & R. L. Keiter
5. Chemistry of The Elements – N. N. Greenwood & A. Earnshaw
6. Concept and Model in Inorganic Chemistry – Douglass, McDanniel & Alexander
7. Coordination Chemistry – S. F. A. Kettle
8. Theoretical Inorganic Chemistry M. C. Dey and I. Selbin
9. Inorganic Electronic Spectroscopy – A. B. P. Lever
10. Principles and Application of Organo-transition Metal Chemistry – J. P. Collman, L. S. Hegedus, Borton & R. G. Finke
11. Organometallic Chemistry – An Introduction – R. C. Mahrotra & A. Singh
12. Principles of Organometallic Chemistry _ G. E. Coats, H. L. H. Green, P.Powell & K. Wade
13. Basic Organomtallic Chemistry – J. J. Zuckerman and I. Haiduc
14. The Organometallic Chemistry of Transition Metals – R. H. Carbtree
15. Bioinorganic Chemistry – R. W. Hay
16. Introduction to Bioinorganic Chemistry - D.R. Williams
17. Elements of Bioinorganic Chemistry – G. N. Mukherjee & A. Das
18. Instrumental Methods Analysis – Williiard, merit, Dean & Sett
19. Inorganic Chemistry – A. G. Sharpe
20. General and Inorganic Chemistry- R. Sarkar
21. Elementary Inorganic Chemistry- R. L. Dutta
22. Inorganic Chemistry – J. D. Lee
23. Nuclear and Radiochemistry – G. Friedlander, J. W. Kennedy, E. S. Macias, J. M. Miller.
24. Essentials of nuclear chemistry – H. J. Arnikar.
25. Inorganic chemistry – W. W. Porterfield
26. Inorganic chemistry – Gary Wulfsberg
27. Inorganic chemistry – Seriver, Atkins

28. Essential trends in Inorganic chemistry – D. M. P. Mingos.
29. Fundamental concepts of Inorganic chemistry – A. K. Das.

Physical Chemistry

1. D. A. Mcquarrie and J. D. Simon: Physical Chemistry – A Molecular Approach
2. I. N. Levine: Physical Chemistry
3. G. W. Castellan: Physical Chemistry
4. P. W. Atkins: Physical Chemistry
5. K. Denbigh: The Principles of Chemical Equilibrium
6. C. N. Banwell and E.M. McCash: Fundamentals of Molecular Spectroscopy
7. R. S. Berry, S. A. Rice and J. Ross: Physical Chemistry
8. T. Engel and P. Reid: Physical Chemistry
9. W. J. Moore: Physical Chemistry
10. K. J. Laidler: Chemical Kinetics

Practical Chemistry books

1. G. Svehla: Vogel's Qualitative Inorganic Analysis.
2. J. Mendham, R. C. Denny, J. D. Barnes, M. J. K. Thomas: Vogel's Text Book of
Quantitative Chemical Analysis.
3. G. N. Mukherjee: Semi-Micro Qualitative Inorganic Analysis (CU Publications)
4. Vogel's Text Book of Practical Organic Chemistry (5th Edition)
5. N. G. Mukherjee: Selected Experiments in Physical Chemistry
6. Subhas C. Das: Advanced Practical Chemistry
7. Nad, Mahaparta, Ghoshal: Advanced Course in Practical Chemistry.
8. Quantitative analysis – Vladimir Alexeyev.

CHEMISTRY
(GENERAL)

Distribution of Papers and Marks in B. Sc. (General) Chemistry Examination

Category A: For students with honours in subjects other than chemistry
Total Marks: 200 (theoretical) + 100 (Practical) = 300
Category B: For pass course students only
Total Marks: 250 (theoretical) + 150 (Practical) = 400

Part -I: 1st Year

Theoretical Papers:			Marks
Paper -I	Group -A	: Organic Chemistry	50
	Group -B	: Inorganic Chemistry	50

Part -II: 2nd Year

Paper -II	Group -A	: General Chemistry	50
	Group -B	: Physical Chemistry	50

Practical:

Paper -III

(a) Inorganic Qualitative analysis	30
(b) Inorganic .Quantitative Estimation	20
(c) Organic Chemistry Experiments:	
(i) Qualitative analysis	20
(ii) Preparation	10
(d) Laboratory Note Book	10
(e) Viva Voce	10

Part -III: 3rd Year
For pass course (Category B) students only

Group-A	: Applied Chemistry	50
Group -B	: Practical	50

Note: (i) Each theoretical paper shall be of three hours duration.
(ii) The Practical Examination shall have duration of six hours in one day only.

B. Sc. (General), Part -I, 1st year
Paper-I

Group -A: Organic Chemistry **50 Marks**
(University Examination: 45, Internal assessment: 5)

1. Inductive effect, electromeric effect, conjugation, resonance and resonance energy, hyperconjugation, homolytic and heterolytic bond breaking, electrophiles and nucleophiles; carbocations, carbanions and radicals (stability and reactivity of).

2. Aliphatic compound: a) General as well as IUPAC nomenclature is to be known (aliphatic compounds up to eight carbon atoms are included).

b) Stereochemistry of carbon compounds: Different types of isomerism, geometrical and optical isomerism, optical activity, asymmetric carbon atom, elements of symmetry (plane and centre), chirality, enantiomers and diastereomers, R and S nomenclature, E and Z nomenclature, D and L nomenclature, Fischer projection formula of simple molecules containing one and two asymmetric carbon atoms.

c) Alkanes, alkyl halides.

e) Unsaturated hydrocarbons (alkenes, alkynes): general methods of synthesis of alkenes, electrophilic addition reaction, mechanism of

bromination and hydrohalogenation, Markownikoff's addition, peroxide effect, hydroboration, ozonide formation, polymerization reaction of alkenes (definition and examples only), general methods of synthesis, acidity, hydration and substitution reactions of alkynes.

f) Monohydric alcohols: Primary, secondary & tertiary, polyhydric alcohols; pinacol-pinacolone rearrangement reaction; glycols, glycerine.

g) Ethers: Williamson synthesis, dimethyl ether, diethyl ether.

h) Aldehydes and ketones: formaldehyde, acetaldehyde, acetone, chloral, haloform reactions. Cannizzaro's reaction, Reformatsky's reaction, Relative reactivities and distinction of aldehydes and ketones, formation and reactions of enolates-aldol condensation (with mechanism), Perkin reaction, Knoevenagel reaction, Benzoin Condensation, Claisen Condensation, Oxidation and

Reducation reactions.

i) Fatty acids, acid chlorides, amides, anhydrides, esters, mechanism of esterification of carboxylic acids and hydrolysis of ester (BAc2 and AAc2 only).

j) Nitrogen containing compound: Amines: primary, secondary, tertiary and their comparative studies, quaternary ammonium compounds. Cyanides and isocyanides. Hoffman degradation reaction.

k) Oxalic, malonic, succinic, lactic, malic, tartaric, citric, maleic and fumaric acids.

3. Carbohydrates: Classification, Elementary idea of monosaccharaides, disaccharides and polysaccharides highlighting glucose, fructose, sucrose, starch & cellulose.

4. Preparation and synthetic uses of

i) Grignard reagents

ii) Ethyl malonate

iii) Ethyl aceto acetate

5. Aromatic Chemistry:

i) Aromaticity, Huckel's rule, Benzene and its structure, M.O. treatment, resonance. Reactions and synthesis of benzene, toluene, xylenes including Friedel. Craft's alkylation and acylation reactions, orientation.

ii) Study of the preparation, properties and reactions of the following aromatic compounds.

a) Halogen derivatives: chlorobenzene, benzylchloride and benzotrichloride.

b) Nitrobenzene, m-dinitrobenzene, s-trinitrobenzene, trinitrotoluene (TNT)

c) Aniline, toluidine, methyl and dimethylaniline, benzylamine, phenylhydrazine, sulphanilic acid.

d) Benzene diazonium salts and its reactions. Sandmeyer reaction.

e) Benzyl alcohol, benzaldehyde, acetophenone, benzophenone.

f) Phenols: synthesis, acidic character and chemical reactions of phenols, Kolbe reactions, Reimer-Tiemann reaction, Fries rearrangement, Claisen rearrangement. salicylaldehyde, salicylic acid, picric acid.

Group -B: General Chemistry **50 Marks**

(University Examination: 45, Internal assessment: 5)

Section-I: *Extra-nuclear Structure of atoms*

Bohr's theory for hydrogen atom (simple mathematical treatment), atomic spectra of hydrogen and Bohr's model, quantum numbers and their significance, Pauli's exclusion principle, Hund's rule, electronic configuration of many electron atoms, *Aufbau* principle and its limitations. Qualitative introduction to orbitals : shapes of s, p and d orbitals. Electronic configuration of atoms of elements. 6L

Section-II: *Radioactivity*

Natural radioactivity, units, radioactive disintegration series, group displacement law, law of radioactive decay, half-life and average life of radio elements. Stability of atomic nucleus: n/p ratio, nuclear binding energy, mass defect. Nuclear reactions: fission, fusion, transmutation of elements, artificial radioactivity, measurement of radioactivity (simple idea). Isobars, Isotopes, Isotones and their uses. 6L

Section-III: *Chemical Periodicity:*

Classification of elements on the basis of electronic configuration: general characteristics of s-, p-, d- and f-block elements. Positions of hydrogen and noble gases. Atomic and ionic radii, ionization potential, electron affinity, and electronegativity; periodic and group-wise variation of above properties in respect of s- and p- block elements, Diagonal relationship. Periodicity in ionic radii, atomic radii, electronegativity, and ionisation potential. 6L

Section-IV: Chemical bonding

Ionic bonding

General characteristics of ionic compounds, sizes of ions, radius ratio rule and its limitation. Lattice energy, Born Haber cycle, Fajan's Rule.

Covalent bonding

General characteristics of covalent compounds, valence-bond approach, hybridization involving s-, p-, d-orbitals, Valence Shell Electron Pair Repulsion (VSEPR) concept, shapes of simple molecules and ions of main group elements, bond moment and dipole moment, partial ionic character of covalent bonds, hydrogen bonding and its effect on physical and chemical properties.

Coordinate bonds and Coordination compounds

Complex salts and double salts, Warner's theory of coordination, IUPAC nomenclature of coordination complexes (mononuclear complexes only), chelate complexes, stereochemistry of coordination numbers 4 and 6. 18L

Part II, 2nd year

Paper-II

Group -A: Inorganic Chemistry 50 Marks

(University Examination: 45, Internal assessment: 5)

1. Comparative study of p-block elements

Group trends in electronic configuration, common oxidation states, inert pair effect, and their important compounds in respect of the following groups of elements: (i) B-Al-Ga-In-Tl (ii) C-Si-Ge-Sn-Pb (iii) N-P-As (iv) O-S (v) F-Cl-Br-I. 24L

2. Acid-Base concept

Arrhenius and Bronsted-Lowry's concept, relative strength of acids bases, amphoterism, Lux-Flood concept, Lewis concept. pH, Buffer and its application, acid base-indicator. HSAB principle (qualitative idea). 6L

3. Redox chemistry

Balancing of equations by ion-electron methods, elementary idea on standard redox potentials with sign convention, Nernst equation (without derivation). Influence of complex formation and change of pH on redox potentials, formal potential, feasibility of a redox titration, redox indicators, disproportionation and comproportionation reactions (typical examples). 6L

4. Chemical Equilibrium: Reversible and irreversible reactions, Law of mass action, equilibrium constants (Kp, Kc), Equilibrium in homogenous gaseous and liquid system. Dependence of equilibrium constants on pressure & temperature and on addition of foreign substances. Le chatelier principle.Common ion effect and solubility product: their application in analytical chemistry. 8L

Group -B: Physical Chemistry **50 Marks**

(University Examination: 45, Internal assessment: 5)

1. Gaseous State of Matters: Gas Laws, Kinetic theory of gas, derivation of gas laws from kinetic theory, average kinetic energy of translation, Boltzman constant and absolute scale of temperature, Maxwell's distribution law of molecular speeds (without derivation), most probable, average and root mean square speeds of gas molecules, principle of equipartition of energy (without derivation), Mean free path and collision frequencies, Real gases, compressibility factor, deviation from ideality, van der Waals' equation of state.

2. Liquid State: Physical properties of liquids and their measurements, Vapour pressure, surface tension, viscosity.

3. Thermodynamics: The First Law, reversible and irreversible work. Concepts of internal energy and enthalpy, Isothermal and adiabatic expansion of gases and work involved. Thermochemical laws and heats of different types of reactions. Criteria of a perfect gas. The second law and its mathematical form, the Carnot's cycle. Qualitative ideas of entropy and of free energy (G). The condition for spontaneity of a chemical process. Joule-Thomson effect (derivation excluded).

4. Dilute Solutions: The colligative properties. Lowering of vapour pressure, elevation of boiling point, depression of freezing point and osmotic pressure. Experimental methods of their determination. Molecular weight determination. Abnormal behavior of electrolyte solutions and the Van't Hoff factor.

5. Chemical Kinetics: order and molecularity of reactions. First and second order reactions and their rate constants. Half life periods.

6. Catalysis: (i) The phenomenon of catalysis and the characteristics of catalyzed reactions. The mechanism of homogeneously catalyzed reactions. (ii) Elementary idea of absorption of heterogeneous catalysis. (iii) Meaning and examples of autocatalysis, catalytic poisons, promoters, enzyme catalysis, acid-base catalysis.

7. Electrochemistry (Conductance): Anhenius· theory of electrolytic dissociation. Specific, equivalent and molecular conductivities and their measurement. Transport number & its measurement Velocity of ions, ionic mobility, kohlrausch's Law, conductometric titration.

8. Colloidal state: Different types of colloids. Methods of preparation of lyophobic colloids. Characteristic properties of colloids. Ideas of coagulation, peptisation. Gold number, electrophoresis and endosmosis, isoelectric point, Tyndall effect Brovvnian motion.

Paper -III

Practical Syllabus in Chemistry for General Course 100 Marks

1) Inorganic qualitative analysis

Qualitative analysis of inorganic mixture containing not more three radicals (Basic and acid) selected from the list given below:

Basic Radicals: Cu(II), Bi(III), Sb(III), Fe(II/III), Cr(III), Al(III), Zn(II), Mn(II), Co(II), Ni(II), Ca(II), Ba(II), Sr(II), Mg(II), Na(I), K(I), NH_4^+.

Acid radicals: Cl^-, F^-, Br^-, I^-, SO_3^{2-}, SO_4^{2-}, S^{2-}, PO_4^{3-}, CrO_4^{2-}, BO_3^{3-}, H_3BO_3, NO_3^-, NO_2^-.

Reporting of the systematic analysis of the samples for qualitative analysis should be presented in the following scheme:

1. Physical characteristics and solubility of the sample.
2. Preliminary tests for basic and acid radicals: only positive test should be mentioned.
3. Wet tests for acid and basic radicals.
4. Confirmatory tests of radicals.
5. Name and symbol of detected radicals.

2) Inorganic Quantitative analysis: Volumetric analysis by acidimetry-alkalimetry and oxidation-reduction methods (using Potassium permanganate and potassium dichromate).

(i) Titration of Na_2CO_3 + $NaHCO_3$ mixture vs HCl using phenolphthalein and methyl orange indicators.

(ii) Standardization of $KMnO_4$ solution by standard oxalic acid solution (supplied) and estimation of Fe^{2+} in Mohr's salt solution by $KMnO_4$ solution.

(iii) Standardization of $KMnO_4$ solution by standard oxalic acid solution (supplied) and estimation of Fe^{2+} and Fe^{3+} in a mixture by $KMnO_4$ solution.

(iv) Estimation of (i) Fe^{2+} in Mohr's salt solution, (ii) Fe^{3+} in a solution by standard $K_2Cr_2O_7$ solution (supplied).

(v) Estimation of Fe^{2+} and Fe^{3+} in a mixture by standard $K_2Cr_2O_7$ solution (supplied).

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3) Qualitative Analysis of Single Organic Compound(s)

Experiment A: Detection of special elements (N, Cl, and S) in organic compounds.

Experiment B: Solubility and Classification (solvents: H_2O, dil. HCl, dil. NaOH)

Experiment C: Detection of functional groups -NO_2, -NH_2, -COOH, carbonyl
(-CHO, >C=O), -OH (phenolic) in solid organic compounds.
Experiments A - C with unknown (at least 6) solid samples containing not more than two of the above types of functional groups should be done.

4) Organic Preparations:

a) Benzil from benzoin
b) Phthalimide from urea
c) m-dinitrobenzene from nitrobenzene

Part III: 3rd year
Paper: IV

Group -A: Applied Chemistry **50 Marks**

(University Examination: 45, Internal assessment: 5)

1. Chemical separation process: chromatographic separation TLC, GLC column, HPLC.

2. Manufacturing of some important Industrial Products: Polymers (PVC, Polyethylene, Nylon-66, Rubber). Detergents (Dodecyl benzene sulphonate), Pigments (Zinc white, Carbon black), Fertilisers (Superphosphate of lime, Urea, Ammonium Sulphate), glass, Cement.

3. Petroleum distillation process, LPG, Octane number, Cetane number, Flash point.

4. Amino acids, peptide and proteins: definition, classification and uses.

5. Nucleic acids: Structures of nucleosides, nucleotides, elementary ideas of RNA and DNA.

6. Drug: Synthesis and use of paracetamol (antipyretic), aspirin (analgesic) sulphanilamide (sulpha drug) and Chloroquinone (antimalarial).

7. Synthesis of dye and use: methyl orange, methylene blue, congo red, malachite green.

8. Pesticides: Common pesticides: Production, applications and residual toxicity of gammaxane, aldrin, parathion, malathion, DDT.

9. Food Additives: Food flavour, food colour, food preservatives, artificial sweeteners, acidulants, alkalies, edible emulsifiers and edible foaming agents, sequesterants-uses and abuses of these substances in food beverages.

10. Hydrogenation of oil.

11. Error analysis: Accuracy and precision of quantitative analysis, determinate-, indeterminate-, systematic- and random-errors. Methods of least squares and standard deviations.

Group -B: Practical Chemistry **50 Marks**

1. Estimation of total hardness of water.
2. Estimation of available oxygen in pyrolusite.
3. Cement analysis.
4. Separation of Chemicals by TLC
5. Determination of the strength of the H_2O_2 sample.
6. To find the P^H of an unknown solution by comparing colour of a series of HCl solutions
+ 1 drop of methyl orange, and a similar series of NaOH solutions + 1 drop of phenolphthalein.
7. Analysis of Brass.
8. Determination of intrinsic viscosity of a polymer.
9. Titration of HCl + CH_3COOH mixture vs. NaOH using two different indicators to find the composition.

Recommended list of Books:

Textbooks

1. General and Inorganic Chemistry (Vol-I + Vol-II) : P. K. Dutt
2. Organic Chemistry : S. Sengupta
3. Elementary Physical Chemistry : S. R. Palit
4. General and Inorganic chemistry – Poddar, Ghosh.
5. Advance Inorganic Chemistry – S. P. Banerjee.
6. Inorganic Chemistry- Malik, Tuli, Madan.

Practical Chemistry book

1. A. K. Nad, B. Mahapatra and A. Ghoshal: An Advanced Course in Practical Chemistry