RAMAKRISHNA MISSION RESIDENTIAL COLLEGE
(AUTONOMOUS)
NARENDRAPUR, KOLKATA- 700103

DEPARTMENT OF CHEMISTRY

B. Sc. Chemistry (Honours & General) Syllabus 2015

Effective from July 01, 2015

COURSE STRUCTURE

HONOURS COURSE

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Semester	Duration	Marks		
		Theoretical(T)	Practical(P)	Total
Semester I	July-Dec.	75	25	100
Semester II	Jan.-June	75	25	100
Semester III	July-Dec.	75	25	100
Semester IV	Jan.-June	75	25	100
Semester V	July-Dec.	150	50	200
Semester VI	Jan.-June	100	100	200
Total		550	250	800

GENERAL COURSE

Semester	Duration	Marks		
		Theoretical (T)	Practical (P)	Total
Semester I	July-Dec.	50	25	75
Semester II	Jan.-June	50	25	75
Semester III	July-Dec.	50	25	75
Semester IV	Jan.-June	50	25	75
Total		200	100	300

SEMESTER-WISE DISTRIBUTION OF SUBJECTS
CHEMISTRY HONOURS

SEMESTER – I**: 100 Marks**

TWO PAPERS OF 50 (M) EACH

Paper	Group	Subjects	Marks
I	A	Inorganic Chemistry Theoretical	25
	B	Organic Chemistry Theoretical	25
II	A	Physical Chemistry Theoretical	25
	B	Practical	25

SEMESTER –II**: 100 Marks**

TWO PAPERS OF 50 (M) EACH

Paper	Group	Subjects	Marks
III	A	Inorganic Chemistry Theoretical	25
	B	Organic Chemistry Theoretical	25
IV	A	Physical Chemistry Theoretical	25
	B	Practical	25

SEMESTER – III**: 100 Marks**

TWO PAPERS OF 50 (M) EACH

Paper	Group	Subjects	Marks
V	A	Inorganic Chemistry Theoretical	25
	B	Organic Chemistry Theoretical	25
VI	A	Physical Chemistry Theoretical	25
	B	Practical	25

SEMESTER – IV**: 100 Marks**
TWO PAPERS OF 50 (M) EACH

Paper	Group	Subjects	Marks
VII	A	Inorganic Chemistry Theoretical	25
	B	Organic Chemistry Theoretical	25
VIII	A	Physical Chemistry Theoretical	25
	B	Practical	25

SEMESTER – V**: 200 Marks**

FOUR PAPERS OF 50 (M) EACH

Paper	Subjects	Marks
IX	Inorganic Chemistry Theoretical	50
X	Organic Chemistry Theoretical	50
XI	Physical Chemistry Theoretical	50
XII	Practical	50

SEMESTER – VI**: 200 Marks**

FOUR PAPERS OF 50 (M) EACH

Paper	Group	Subjects	Marks
XIII	A	Inorganic Chemistry Theoretical	25
	B	Organic Chemistry Theoretical	25
XIV	A	Physical Chemistry Theoretical	25
	B	Biomolecules & Materials' Chemistry Theoretical	25
XV		Practical	50
XVI		Practical	50

Modalities of Paper Setting in B. Sc. Chemistry Course

One set of questions to be set from each unit as follows:

For a unit carrying eight (8) marks:

A set of questions carrying a total of 12 to 14 marks to be set. Students will be required to answer questions of 8 marks only.

For a unit carrying nine (9) marks:

A set of questions carrying a total of 14 to 16 marks to be set. Students will be required to answer questions of 9 marks only.

For a unit carrying ten (10) marks:

A set of questions carrying a total of 15 to 17 marks to be set. Students will be required to answer questions of 10 marks only.

For a unit carrying fifteen (15) marks:

A set of questions carrying a total of 23 to 26 marks to be set. Students will be required to answer questions of 15 marks only.

RAMAKRISHNA MISSION RESIDENTIAL COLLEGE (AUTONOMOUS)

NARENDRAPUR, KOLKATA- 700103

DEPARTMENT OF CHEMISTRY

Syllabus

For

3 year 6 semester B. Sc. Honours Course in Chemistry

Semester - I

Paper-I Group - A Full Marks-25

Inorganic Chemistry (Theoretical)

Unit -1: Extra nuclear Structure of atom 9M

Bohr's theory to hydrogen like atoms and ions: spectrum of hydrogen atom Quantum numbers. Introduction to the concept of atomic orbital; shapes, radial and angular probability diagrams of s, p and d orbitals (qualitative idea). Many electron atoms and ions: Pauli's exclusion principle. Hund's rule, exchange energy. Aufbau principle and its limitation. Electronic energy level diagrams and electronic configurations of hydrogen-like and polyelectronic atoms and ions. Term symbols of atoms and ions for atomic numbers <30.

Unit – 2: Chemical Bonding and Structure - 1 8M

Covalent bonding: Valance Bond theory, H2 molecule and related species, elementary idea of Resonance, Hybridizations, equivalent and non-equivalent hybrid orbitals. Bent's rule, pseudo rotation, and VSEPR theory. Different types of electron pairs in a molecule: stereochemically inert pair, lone pair, shapes of molecules and ions containing lone pairs and bond pairs (examples from main groups' chemistry). Bond moment, dipole moment.
Ionic bonding: 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 (elementary idea), Size effects, radius ratio rules and their limitations, packing of ions in crystals.

Unit – 3: Chemical periodicity 8M

Periodic table, Modern IUPAC Periodic table, General characteristic of s, p, d and f block elements, Position of hydrogen and noble gases in the periodic table. Effective nuclear charges, screening effects. Slater's rules.
Group and Periodic trends of atomic radii, ionic radii (Pauling's univalent), covalent radii, Ionization potential, electron affinity and electronegativity (Pauling's; Electronegativity difference, Ionic resonance energy, concept of resonance, absolute scales: Mulliken's and Allred-Rochow's scales) and factors influencing these properties. Inert pair effect and Relativistic Effect.

Paper-I Group - B Full Marks 25

Organic Chemistry (Theoretical)

Unit -1: Acyclic stereochemistry 15M

Representation of molecules in saw horse, Fischer, flying-wedge and Newman formulae and their inter translations, symmetry elements, and molecular chirality. Configuration: stereogenic units i) stereocentres: systems involving 1, 2, 3 centres, stereogenicity, chirotopicity. Pseudoasymmetric (D/L and R/S descriptor, threo/erythro and syn/anti nomenclatures (for aldols)
ii) stereo axis: chiral axis in allenes & biphenyls, R/S descriptor; cis/trans, syn/anti, E/Z descriptors (for C=C, C=N). Optical activity of chiral compounds: specific rotation, optical purity (enantiomeric excess), racemic compounds, racemisation (through cationic and anionic and radical intermediates), resolution of acids, bases and alcohols via diastereomeric salt formation. Topicity of ligands and faces (elementary idea): Pro-R, Pro-S and Re /Si descriptors. Conformation: Conformational nomenclature, eclipsed, staggered, gauche and anti; dihedral angle, torsion angle, energy barrier of rotation, relative stability of conformers on the basis of steric effect, dipole-dipole interaction, H-bonding; conformational analysis of ethane, propane, n-butane, haloethane, 1, 2-haloethane, 1, 2- glycol, 1, 2-halohydrin; invertomerism of trialkylamines.

Unit -2: Bonding and physical properties of organic molecules 10M

Concept of hybridization, resonance (including hyperconjugation), orbital pictures of bonding (sp3, sp2, sp: C-C, C-N & C-O system). Inductive effect, bond polarization and bond polarizability, steric effect, steric inhibition of resonance. MO theory: sketch and energy levels of π MOs of i) acyclic p orbital system: C=C, butadiene, 1, 3, 5-hexatriene and allyl systems ii) cyclic p orbital system: benzene; Frost diagram, Huckel's rules for aromaticity & antiaromaticity; homoaromaticity. Physical properties: bond distance, bond angles, mp/bp & dipole moment in terms of structure and bonding (covalent & non covalent).

Paper-II Group – A Full Marks 25

Physical Chemistry (Theoretical)

Unit-1: The Gaseous State and the Liquid State 8M

The gaseous state: Deviation from ideal behaviour. Real gas isotherm. Significance of the van der Waals' equation and the explanation of the real gas behaviour using it. Continuity of state. Boyle temperature and the critical constants in terms of van der Waals'constants. Law of corresponding state. Virial equation of state and the significance of the second virial coefficient.
Intermolecular forces (Debye, Keesom and London interactions, Lennard-Jones potential - elementary idea).

The liquid state: Short range order and long range disorder in liquids. Vapour pressure. Surface tension, surface energy, excess pressure, capillary rise and measurement of surface tension. Work of cohesion and adhesion, spreading of liquid over other surface. Vapour pressure over curved surface. Temperature dependence of surface tension.

Unit-2: Transport Phenomena in Liquid State: Viscosity and Conductance 8M

Flux, force, phenomenological coefficients & their inter-relationship (general form), different examples of transport properties.

Viscosity: General features of fluid flow (streamline flow and turbulent flow). Newton's equation, viscosity coefficient. Poiseuille's equation, temperature dependence of viscosity, principle of determination of viscosity coefficient of liquids by falling sphere method,

Electrolytic Conductance: Types of conductors, types of Electrolytes. Ionogens and ionophores. Ions in Solution, solvodynamic radius. Conductance of electrolyte solutions: specific conductance, equivalent conductance of electrolytes and its splitting into ionic conductance. Variation of Conductance for weak and strong electrolytes. Kohlrausch empirical equation, Kohlrausch's law of independent migration of ions. Conductance at infinite dilution. Debye –Huckel theory of Ion atmosphere (qualitative)-asymmetric effect, relaxation effect and electrophoretic effect. Migration of ions: ionic mobility, transference number. Principles of Hittorf's method and moving boundary method. Principle of conductance measurement. Determination of Λ_o, .Conductometric titrations.

Unit-3: Thermodynamics-I: The Laws: Energy (U) and Entropy(S) 9M

Introduction: Importance and scope, definition of system and surroundings, types of systems. Extensive and intensive properties and state of a system. Steady state and equilibrium state.

The zeroth law: Concept of thermal equilibrium, the zeroth law of thermodynamics and temperature.

Preliminaries: Thermodynamic coordinates, equation of state, change of state, thermodynamic processes. Partial derivatives. State functions and path functions. Exact and inexact differentials and their properties. Concept of heat and work (IUPAC convention).Reversible and irreversible processes. Calculation of work done and P-V diagrams for different processes.

First law of thermodynamics: Statement. Law of existence and conservation of the state function 'energy'. Applications of the first law to ideal gas. Joule's experiment and its consequence. Adiabatic and isothermal changes of an ideal gas.

Second law of thermodynamics: The need of a second law. Concept of heat reservoir and heat engines. Carnot cycle and refrigerator. Kelvin – Planck (KP) and Clausius (CL) statements and their equivalence. Efficiency of heat engines; Carnot's theorems.

Entropy –definition and concept. Clausius inequality. Criteria for spontaneity and equilibrium. Entropy and unavailable work.

Second Law in terms of Entropy. Validity of KP and CL statements and W_{rev}vsW_{irrev} from entropic point of view. Entropy change of an ideal gas. Diagrammatic representation of various thermodynamic processes using T, P,V, U and S as coordinates. Non-crossing of two adiabats.

Paper-II **Group - B** **Full Marks 25**

Chemistry Practical

Unit -1:	Qualitative analysis of organic compounds	-	20 M
Unit -2:	Lab. Quiz / viva	-	5 M

Examination: 4 hours

Semester - II

Paper-III Group - A Full Marks-25

Inorganic Chemistry (Theoretical)

Unit – 1: Chemical Bonding and Structures - 2 **9M**

Molecular orbital concept of bonding (elementary pictorial approach): sigma and pi-bonds and delta interaction, multiple bonding. MO diagrams of Li_2, Be_2, B_2, C_2, N_2, O_2, F_2, X_2, and their ions wherever possible CO, NO, NO^+, CN^-, HF, BeH_2, and H_2O: bond orders, bond lengths. Metallic bonding: qualitative idea of band theory, conducting, semi conducting and insulating properties with examples from main group elements. Hydrogen bonding and its effects on the physical and chemical properties of compounds of the main group elements.

Unit – 2: Nucleus, Nuclear Reactions and Isotopes **8M**

Nuclear stability and nuclear binding energy Justification / Explanation of various forms of decay. Nuclear forces: meson exchange theory. Nuclear models (elementary idea): Concept of nuclear quantum number, magic numbers. Nuclear Reactions: Artificial radioactivity, transmutation of elements, fission, fusion and spallation. Nuclear energy and power generation. Separation and uses of isotopes. Radiochemical methods; principles of determination of age of rocks and minerals, radio-carbon dating, hazards of radiation and safety measures. Isotope Labeling and tracer study.

Unit - 3: Acid-Base reactions and Solvent Systems in Inorganic Chemistry **8M**

Acid-Base concepts: Arrhenius concept, theory of solvent system (in H_2O, NH_3 SO_2 and HF), Bronsted-Lowry's concept, relative strength of acids: Oxoacids and Hydracids, Pauling's rules. Amphoterism, Lux-Flood concept, Lewis concept, Superacids, HSAB principle, Acid-base equilibria in aqueous solution and pH, Buffer solution, Henderson equation, Buffer action, Buffer capacity, pH of salts. Acid-base neutralization curves, indicator, choice of indicators. Gas phase acidity and proton affinity; B-strain, F-strain.

Paper-III Group - B Full Marks-25

Organic Chemistry (Theoretical)

Unit – 1: General treatment of reaction mechanism **15M**

Mechanistic classification- ionic, radical and pericyclic; heterolytic bond cleavage and heterogenic bond formation, homolytic bond cleavage and homogenic bond formation; representation of mechanistic steps using arrow formalism. Reactive intermediates: carbocations (cabenium and carbonium ions), carbanions, carbon radicals, carbenes – structure using orbital picture, electrophilic/nucleophilic behaviour, stability, generation and fate (elementary idea) Reaction thermodynamics: free energy and equilibrium, enthalpy and entropy factor, intermolecular & intramolecular reactions. Heat of hydrogenation and heat of combustion. Application of thermodynamic principles in tautomeric equilibria [keto-enol tautomerism, composition of the equilibrium in different systems (simple carbonyl, 1, 3 and 1, 2- dicarbonyl systems, phenols and related system), substituent and solvent effect]. Concept of acids and bases: effect of structure, substituent and solvent on acidity and basicity. Reaction kinetics: transition state theory, rate const and free energy of activation, free energy profiles for one step and two step reactions, catalyzed reactions, kinetic control and thermodynamic control of reactions, isotope effect, primary kinetic isotopic effect (k_H/k_D), principle of microscopic reversibility, Hammond postulate and its application in halogenation of alkanes.

Unit – 2: Nucleophilic substitution reactions **10M**

Substitution at sp^3 centre - Mechanism: S_N1, S_N2, S_N2(prime), S_{Ni} mechanisms, effect of solvent, substrate structure, leaving group, nucleophiles including ambident nucleophiles (cyanide & nitrite) substitution involving NGP; relative rate & stereochemical features [systems: alkyl halides, allyl halides, alcohols, ethers, epoxides]. Halogenation of alkanes and carbonyls.
Substitution at sp^2 carbon (carbonyl system) - Mechanism: $B_{AC}2$, $A_{AC}2$, $A_{AC}1$, $A_{AL}1$
(in connection to acid and ester). Systems: amides, anhydrides & acyl halides
[formation and hydrolysis]

Paper-IV Group - A Full Marks-25

Physical Chemistry (Theoretical)

Unit-1: Kinetic Theory of gases **8M**

Kinetic Theoretical interpretation of pressure, temperature and energy.

Nature of distribution of molecular velocity and speed in one, two and three dimensions. The Maxwell-Boltzmann distribution of molecular speeds. Different measures of speed and velocity of gas molecules. Kinetic energy distribution in one, two and three dimensions. Calculation of number of molecules having energy $\geq \varepsilon$.

Principle of equipartition of energy and computation of heat capacity of gases. Temperature variation of heat capacity.

Collision of gas molecules: collision diameter and collision frequency. Mean free path.

Wall collision frequency. Effusion and Graham's law.

Viscosity of gases.

Unit -2: Chemical Kinetics **8M**

Introduction of reaction rate in terms of extent of reaction: rate constants, order and molecularity of reactions. Principles of determination of order of a reaction by half-life and differential methods. Order with respect to concentration vs. order with respect to time. Principles of determination of rate constant by physical property measurement. Rate-determining step and steady-state approximations - explanation with suitable examples. Opposing reactions, consecutive reactions and parallel reactions (all steps first order). Kinetic and thermodynamic control of products. Chain reactions.

Temperature dependence of rate constant: Arrhenius equation, energy of activation.

Collision theory (detailed treatment), transition state theory (thermodynamic treatment), Lindeman theory of so called unimolecular reactions.

Unit-3: Thermodynamics II: The Auxiliary functions and applications to systems of fixed composition **9M**

The fundamental equation of thermodynamics: The combined First and Second Law.

The Auxiliary state functions: Enthalpy (H), Helmholtz Energy (A) and Gibbs Energy (G).

The fundamental equations for H, A and G. The concept of available work. Criteria for spontaneity and equilibrium in terms of S, U, H, A and G.

Thermodynamic Relationships: Response of U, S, H, A and G towards the change of P, V, T and relations to measurable properties. Maxwell Relations. Thermodynamic Equations of state. Gibbs-Helmholtz equations. Changes of U, S, H, A and G in different processes.

Heat changes in constant pressure and in constant volume processes. C_P, C_V and $C_P - C_V$ relation. Joule-Thomson Experiment and its consequences. Joule-Thomson coefficient for real gases. Inversion temperature.

Paper-IV **Group - B** **Full Marks-25**

Chemistry Practical

Unit -1:	Separation / purification of mixtures of solid organic compounds	-	10 M
Unit -2:	Simple Chemical estimations	-	10 M
Unit -3 :	Lab. Quiz / viva	-	5 M

Examination: 4 hours

Semester-III

Paper-V Group-A Full Marks-25

Inorganic Chemistry (Theoretical)

Unit – 1: Coordinate Bond and coordination compounds: 9M

Coordinate bonding: double and complex salts. Werner's theory of coordination complexes, Classification of ligands, Ambidentate ligands, chelates, Coordination numbers, Trend of coordination number along periods and groups, Isomerism in coordination compounds, constitutional and stereo isomerism, Geometrical and optical isomerism in square planar and octahedral complexes. Optically active complexes, IUPAC nomenclature of coordination complexes (up to two metal centers). Coordination complexes with unusual oxidation states of d- block elements. Complex stability.

Unit – 2: General Chemistry of Group 1, Group 2, Group 13, Group 14 and Group 18 Elements:

8M

Trends in Elemental states, atomic properties, geometries and reactivities of oxides, oxy acids, hydrides, halides, Boron-nitrogen, Silicon and Xenon compounds.

Unit – 3: General Chemistry of Group 15, Group 16, and Group 17 Elements: 8M

Trends in Elemental states, atomic properties, geometries and reactivities of oxides, oxy acids, hydrides, halides, Phosphorus-nitrogen and Sulphur-nitrogen compounds, polyhalides, interhalogens and basic properties of halogens.

Paper-V Group-A Full Marks-25

Organic Chemistry (Theoretical)

Unit – 1: Addition reactions including organometallics 15M

Electrophilic addition to C=C: Mechanism, reactivity, regioselectivity and stereoselectivity. Reactions: halogenations, hydrohalogenation, hydration, hydrogenation, epoxidation, hydroxylation, ozonolysis, electrophilic addition to diene (conjugated dienes and allenes).
Radical addition: HBr addition. Dissolving metal reduction of alkynes and benzenoid aromatics (Birch).
Nucleophilic addition to C=O: Mechanism, reactivity, equilibrium and kinetic control. Reactions with alcohols, amines, thiols, HCN, bisulfate, Wittig reaction. Carbonyl Reduction: hydride addition, Wolff-Kishner reduction, dissolving metal (Bouveault-Blanc reduction, Clemmensen Reduction), Cannizzaro reaction, Tischenko reaction, aldol condensation, benzoin condensation. Hydrolysis of nitriles and isonitriles.
Organometallics: preparation of Grignard reagent, organo lithium and Gilman cuprates and their reaction.

Unit - 2: Elimination and aromatic substitution Elimination 10M

Mechanisms: E1, E2 and E1cB; reactivity, orientation (Saytzeff/ Hofmann) and stereoselectivity; substitution vs. elimination, Electrophilic aromatic substitution: Mechanisms, orientation and reactivity. Reactions: nitration, nitrosation, sulfonation, halogenation, Friedel-Crafts reactions, one carbon electrophilic (reactions: chloromethylation, Gatterman-Koch, Gatterman, Hoesch, Vilsmeier-Haack reaction, Reimer-Tiemann, Kolbe-Schmidt). Nucleophilic aromatic substitution: Addition-elimination mechanism, SN1 mechanism, benzyne mechanism.

Paper-VI Group-A Full Marks-25

Physical Chemistry (Theoretical)

Unit-1 Thermodynamics III: Absolute Entropy Values, Third Law of Thermodynamics and Chemical Energetics: 8M

Nernst's heat theorem. The third law of thermodynamics. Limiting values of thermal properties at absolute zero. Estimation of absolute entropies of pure substances. Production of low temperatures by adiabatic demagnetisation. Inaccessibility of absolute zero.

Chemical Energetics: Thermodynamic functions of Chemical Reactions and their standard values. Standard thermodynamic functions of formation and combustion. Standard enthalpy values. Hess' law. Heats of reaction at constant pressure and constant volume. Effect of temperature and pressure on reaction heats – Kirchoff's equation. Effect of T and P on entropy and Gibbs energy of reaction. Chemical energy and work.

Unit -2: Thermodynamics IV: Chemical Potential and Systems of variable composition-I 8M

Composition as a variable. Chemical potential (μ) and other partial molar properties. Chemical potential in terms of G, H, U, A. Chemical potential and material equilibrium. Other partial molar properties and interrelation among various partial molar properties, T, P dependence of μ. Maxwell relations involving chemical potential. Gibbs –Duhem Equation.
Homogeneous functions and Euler's Identity. Explicit expressions for various extensive variables.

Chemical potential and other properties of ideal substances- pure and mixtures:

Gaseous Phase: i) Pure ideal gas-its Chemical potential and other thermodynamic functions and their changes during a change of state. ii) Ideal mixture of Ideal gases: Thermodynamic parameters of mixing. Chemical potential of an ideal gas in an ideal gas mixture.
Concept of standard states and choice of standard states of ideal gases.

Condensed Phase: i) Chemical potential of pure solid and pure liquids. ii) Solutions: Ideal solution: Definition, Raoult's law. Mixing properties of ideal solutions, chemical potential of a component in an ideal solution. Choice of standard states of solids and liquids.

Unit-3: Thermodynamics V: Chemical Potential and Systems of variable composition-II 9M

Chemical potentialand other properties of non-ideal substances- pure and mixtures:

Real Gas: i) Pure real gas-its chemical potential, fugacity, fugacity coefficient. Effect of T and P on fugacity. Estimation of fugacity. i) Mixture of real gases: Chemical potential and fugacity of a real gas in a mixture. Variables of mixing, and excess variables of mixing. Ideal mixtures of real gases- the Lewis-Randal Rule. Choice of standard states of real gases.

Non-ideal, Non- electrolytic solutions: Extension of fugacity concept to condensed phase [elementary idea]. Chemical potentials of the components of a real solution, their activity and activity coefficients. Effect of temperature and pressure on activity. Variables of mixing and excess variables of mixing. Conventions regarding the standard states and activity coefficients. Relation between activity coefficients of binary solutions. The molality and molarity scales and standard states.

Electrolytic solutions: Chemical potential of an ion in solution. Activity and activity coefficients of ions in solution. Debye-Huckel limiting law-brief qualitative description of the postulates involved, qualitative idea of the model, the equation (without derivation) for ion-ion atmosphere interaction potential. Estimation of activity coefficient for electrolytes using Debye-Huckel limiting law. Derivation of mean ionic activity coefficient from the expression of ion-atmosphere interaction potential. Applications of the equation and its limitations.

Condensed Phase: Activity of pure solids and pure liquids. Extension of the activity concept to gases.

Paper-VI **Group-B** **Full Marks-25**

Chemistry Practical

Unit -1: Qualitative inorganic analysis - 20 M

Qualitative inorganic analysis of mixtures containing one insoluble component and two soluble radicals from the following, and hence determination of the composition of the given mixture.

Cation Radicals: Na^{+}, K^{+}, $Ca^{+2}Sr^{+2}$, Ba^{+2}, Al^{+3}, Cr^{+3}, Mn^{+2}/Mn^{+4}, Fe^{+3}, Co^{+2}/Co^{+3}, Ni^{+2}, Cu^{+2}, Zn^{+2}, Pb^{+2}, NH_4^{+}, Mg^{+2} – Salts.

Anion Radicals: F^{-}, Cl^{-}, Br^{-}, BrO_3^{-}, I^{-}, IO_3^{-}, SCN^{-}, S^{2-}, SO_4^{2-}, $S_2O_3^{2-}$, NO_3^{-}, NO_2^{-}, PO_4^{3-}, BO_3^{3-}, CrO_4^{2-} / $Cr_2O_7^{2-}$, $Fe(CN)_6^{4-}$, $Fe(CN)_6^{3-}$.

Insoluble Materials: Al_2O_3(ig), Fe_2O_3(ig), Cr_2O_3(ig), SnO_2, $SrSO_4$, $BaSO_4$, CaF_2, SiO_2, $PbSO_4$, $PbCrO_4$.

Unit -2: Lab. Quiz / viva - 5 M

Examination: 4 hours

Semester - IV

Paper-VII Group - A Full Marks-25

Inorganic Chemistry (Theoretical)

Unit – 1: Inorganic Chains, Rings & Cages and Reagents 9M

Compounds with multicentre bonds (B_2H_6 and boranes); Poly acids of main group elements; Inorganic chains, rings and cages; Zintle ions; Crown ethers, cryptates and cryptands. Peracids and persalts, carbides.

Reagents: Hydrazoic acid and azide, hydrazine, hydroxylamine, arsenious oxide, phosphorous pentachloride, phosphorous pentoxide, SbF_5 Hypophosphorous acid, phosphorous acid, phosphoric acid and $SnCl_2$, $SnCl_4$, lead tetraacetate, PbO_2, Na_2SO_3, $Na_2S_2O_5$, $Na_2S_2O_3$, $Na_2S_2O_4$, $Na_2S_2O_6$, $Na_2S_4O_6$, telluric acid, $KBrO_3$, KIO_3, periodic acids and periodates, KHF_2, SF_6, $NaBiO_3$, Freons, perchloric acid.

Unit -2: Redox and Precipitation Reactions 8M

Ion-electron method of balancing equation of redox reaction. Elementary idea on standard redox potentials with sign conventions, Nernst equation (without derivation). Influence of complex formation, precipitation and change of pH on redox potentials; 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. Disproportionation and comproportionation reactions (typical examples).

Solubility product principle, common ion effect and their applications to the precipitation and separation of common metallic ions as hydroxides, sulfides, phosphates, carbonates, sulfates and halides.

Unit -3: Organometallic Compounds and Catalysis 8M

18-electron rule and its applications to carbonyls, nitrosyls, cyanides and nature of bonding involved therein. DCD Model of bonding and its applications in various compounds. Simple Polynuclear metal carbonyls. Metal alkene complexes: Zeise's salt. Alkyne complexes. Hapticity (η) of organometallic ligands, examples of mono and penta-hapto cyclopentadienyl complexes - Metallocenes. Simple examples of fluxional molecules, oxidative addition Reduction elimination (elementary idea) and insertion reactions.

Homogeneous catalysis by organometallic compounds: Hydrogenation, hydroformylation and polymerization of alkenes (Ziegler-Natta catalysis).

Paper-VII Group-B Full Marks-25

Organic Chemistry (Theoretical)

Unit - 1: Nitrogen compounds and Rearrangements 15M

Nitrogen compounds- amines (aliphatic & aromatic) [preparation, separation and identification of primary, secondary and tertiary amines], E. Clarke reaction, enamines, Mannich reaction, diazomethane, diazoacetic ester, aromatic nitro compounds, aromatic diazonium salts, nitrile and isonitrile. Rearrangements: 1, 2-shift-Rearrangement to electron-deficient carbon (Wagner-Meerwein rearrangement, pinacol rearrangement, dienone-phenol; Wolff rearrangement in Arndt Eistert synthesis, benzil-benzilic acid rearrangement). Electron-deficient nitrogen (Beckmann rearrangement, Schmidt rearrangement, Hofmann rearrangement, Lossen rearrangement, Curtius rearrangement). Electron-deficient oxygen (Baeyer-Villiger oxidation, hydroperoxide rearrangement (cumene hydroperoxide-phenol rearrangement), Dakin reaction. Aromatic rearrangements [migration from oxygen to ring carbon (Fries rearrangement, Claisen rearrangement); migration from nitrogen to ring carbon (Hofmann-Martius rearrangement, Fischer-Hepp rearrangement, N-azo to C-azo rearrangement, Bamberger rearrangement, Orton rearrangement, benzidine rearrangement.

Unit – 2: Carbanion chemistry and Cyclic stereochemistry 10M

Carbanions- formation of enols and enolates (metal), halogenations of enols and enolates, alkylation of enolates, reactions of enolates with carbonyls (aldehydes, ketones and esters), conjugate addition of enolates. Cyclic Stereochemistry: Baeyer strain theory. Conformational analysis: cyclohexane, mono and disubstituted cyclohexane, symmetry properties and optical activity. Conformation & reactivity in cyclohexane system: elimination (E2), rearrangement, nucleophilic substitution (S_N^1, S_N^2, NGP), oxidation of cyclohexanol, esterification, saponification, lactonisation.

Paper-VIII Group - A Full Marks-25

Physical Chemistry (Theoretical)

Unit-1: Quantum Mechanics I **8M**

Wave-particle duality and the de Broglie hypothesis.

Schrodinger equation and its time-independent form; nature of the equations, acceptability conditions imposed on the wave functions and probabilistic interpretation of wave function. Elementary concepts of operators and their properties. Eigen functions and eigen values. Linear operators. Commutation of operators, fundamental commutator and uncertainty relation (without derivation). Expectation values of observables.

Quantum Free-Particle (normalisation of wave function excluded).

Particle in a box: Schrodinger equation for one-dimensional box and its solution. Properties of the wave functions and eigen spectrum. Comparison with free particle eigenfunctions and eigen values. Calculation of the uncertainty product $\Delta x.\Delta p_x$. Classical Limit and correspondence principle. Extension of the problem to two and three dimensions and the concept of degeneracy.

Unit-2 Chemical andIonicEquilibria **8M**

Spontaneous reactions and equilibrium condition. Variation of reaction free energy as a function of advancement of reaction - role of $\Delta_r H$ and $\Delta_r S$. The law of mass action and the equilibrium constant.

Equilibrium involving ideal gases: K_p and and other forms of equilibrium constants.

Equilibrium involving real gases: K_f

Equilibrium involving gases together with immiscible liquids and/or solids.

Reaction equilibrium in solution: K_a. Equilibrium constants expressed in molality and molarity scales.

Coupled reactions.

Effects, if any, of the following on the equilibrium constant and equilibrium composition: temperature, pressure, volume, an inert substance, catalyst, excess of a reacting species over others.

Thermodynamic treatment of Le Chattelier principle.

Ionic equilibrium: Equilibrium constant for ionic reactions. Free energy and enthalpy of formation of ions in solution. Solubility product, pH, buffer, salt hydrolysis.

Unit-3 Electrochemical cells **9M**

Types of electrochemical cells with examples. Cell reactions. Concept and definition of half-cell potential. Standard electrode potential (IUPAC convention). Thermodynamic derivation of Nernst equation (emf). Hydrogen electrode and standard hydrogen electrode. Calomel electrodes (normal, decinormal and saturated calomel), quinhydrone electrode, glass electrode and their uses. Half-cells of various kinds for different redox couples. Principles of determination of emf (Pogendroff cells. compensation principle).Representation of half cells and cells from cell/ half-cell equilibria, Types of concentration cells. Liquid junction potential and its minimization. Potentiometric titrations (acid- base and redox). Determination of (i) standard electrode potential, (ii) activity solubility product, (iii) ionic product, (iv) mean activity coefficient, (v) transport number and (vi) ΔG, ΔH and ΔS of cell reactions from emf measurements.

Special Topics: Storage cells and Fuel cells.

Paper-VIII **Group-B** **Full Marks-25**

Chemistry Practical

Unit - 1: Experiments based upon physico-chemical principles	-	20 M
Unit – 2: Lab. Quiz / viva	-	5 M

Examination: 4 hours

Semester - V

Paper-IX Full Marks-50

Inorganic Chemistry (Theoretical)

Unit – 1: Bonding in Coordination Compounds 10M

VB description and its limitations, Elementary Crystal Field Theory; splitting of d^n configurations in octahedral, square planar, tetrahedral and square pyramid complexes, crystal field stabilization energy in weak and strong fields: pairing energy, Jahn-Teller distortion. Metal-ligand bonding (MO concept, elementary idea), sigma- and pi- bonding in octahedral complexes (qualitative pictorial approach) and their effects on the oxidation states of transitional metals (examples).

Unit – 2: Magnetic and Spectroscopic Properties 10M

d-d transitions : L-S coupling : qualitative Orgel diagrams for $3d^1$-$3d^9$ ions and their spectroscopic ground states; selection rules for electronic spectral transitions; Racah Parameter. Spectrochemical series of ligands ; Charge transfer spectra.
Orbital and spin magnetic moments, spin only moments of d^n ions and their correlation with effective magnetic moments including orbital contribution; quenching of magnetic moment; antiferromagnetic interactions (elementary idea with examples only) ; Spectral and magnetic properties of lanthanides

Unit – 3: Bio-inorganic Chemistry - I 10M

Elements of life, dioxygen molecule in life, dioxygen molecule carrier: Metalloprotein, Prosthetic groups and biological functions of hemoglobin, myoglobin, Hemocyanin, Hemerythrin. Electron transfer proteins: cytochromes and ferredoxins. Hydrolytic Enzymes: Carbonate, bicarbonate buffering system and carbonic anhydrase, carboxypeptidase A. Toxic metal ions and their effects, metal dependent diseases, chelation therapy (examples only). Pt and Au complexes as drugs (examples only),

Unit – 4: Chemistry of d- and f- block elements **10M**

Comparative chemistry with respect to following series: (a) V-Cr-Mn-Fe-Co-Ni-Cu (b) Fe-Ru-Os (c) Co-Rh-Ir (d) Ni-Pd-Pt and (e) Cu-Ag-Au
f-block elements: electronic configuration, ionization energies, oxidation states, variation in atomic and ionic (3+) radii, Lanthanide contraction, magnetic and spectral properties of lanthanides, comparison between lanthanide and actinides, separation of lanthanides (by ion-exchange method).

Unit – 5: Methods of Instrumental Analysis and Separation Techniques **10M**

Error analysis, Coulometry, Spectrophotometry : Principle of spectrophotometric estimation of iron, manganese and phosphorous, atomic absorption and atomic emission spectrometry; estimation of sodium and potassium in water samples.

Ion exchange resins and their exchange capacities, principle and simple applications of ion exchange separation. Chromatographic separations ; thin layer, paper and column chromatographic techniques and their simple applications, R_f-values and their significance, , migration rates of solutes, band broadening and column efficiency, column resolution.

Paper-X Full Marks-50

Organic Chemistry (Theoretical)

Unit – 1: Carbocycles and Heterocycles Polynuclear hydrocarbons 15M

syntheses and reactions of naphthalene, anthracene and phenanthrene.
Heterocyclic compounds: reactivity, orientation and important reactions of furan, pyrrole, pyridine, indole, synthesis (including retrosynthetic approach) pyrrole: Knorr pyrrole synthesis and Hantzsch synthesis. Hantzsch pyridine synthesis. Indole: Fischer, Madelung and Reissert synthesis, Skaurp quinoline and Bischler-Napieralski Synthesis of isoquinoline.

Unit – 2: Spectroscopy UV, IR, NMR (elementary) 15M

UV Spectra: Electronic transition (σ-σ^*, n-σ^*, π-π^* and n-π^*), relative positions of λ_{max} considering conjugative effect, steric effect, solvent effect, red shift (bathochromic shift), blue shift (hypsochromic shift), hyperchromic effect, hypochromic effect (typical examples).
IR Spectra: Modes of molecular vibrations, application of Hooke's law, characteristic stretching frequencies of O-H, N-H, C-H, C-D, C=C, C=N, C=O functions; factors effecting stretching frequencies (H-bonding, mass effect, electronic factors, bond multiplicity, ring size).
PMR Spectra: Nuclear spin, NMR active nuclei, principle of proton magnetic resonance, equivalent and non-equivalent protons, chemical shift δ), shielding / deshielding of protons, up-field and down-field shifts. NMR peak area (integration), diamagnetic anisotropy, relative peak positions of different kinds of protons (alkyl halides, olefins, alkynes, aldehyde H), substituted benzenes (toluene, anisole, 15 nitrobenzene, halobenzene, dinitrobenzenes, chloronitrobenzene), first order coupling (splitting of the signals: ordinary ethanol, bromoehane, dibromoehanes), coupling constants.

Unit – 3: Pericyclic reactions 10M

Definition and classification. Electrocyclic reactions: FMO approach, examples of electrocyclic reactions (thermal and photochemical) involving four and six pi electrons and corresponding cycloreversion reactions. Cycloaddition reactions: FMO approach, Diels-Alder reaction, photochemical [2+2] reactions Sigmatropic shifts and their order, [1,3] and [1,5] shifts, [3,3] shifts with reference to Claisen and Cope rearrangements.

Unit – 4: Carbohydrate chemistry 10M

Monosaccharides: Aldoses up to 6 carbons, structure of D-glucose & D-fructose (configuration & conformation), anomeric effect, mutarotation. Reactions: osazone formation, bromine – water oxidation, stepping–up (Kiliani method) and stepping–down (Ruff's & Wohl's method) of aldoses. Disaccharides: glycosidic linkages, structure of sucrose.

Paper-XI **Full Marks-50**

Physical Chemistry (Theoretical)

Unit-I: Colligative Properties and Phase Equilibria 10M

Colligative properties:
Colligative properties. Thermodynamic treatment of colligative properties of solution and their interrelationships. Abnormal colligative properties, Deviation from ideal behaviour of binary liquid mixture.
Phase equilibrium:
Definitions of phase, number of components and degrees of freedom. Phase rule and its derivations. Definition of phase diagram. First order phase transition and Clapeyron equation: Clausius- Clapeyron equation – derivation and uses.

Phase Equilibria for one component system – Water, CO_2 and sulphur. (Phase –rule treatment and the phase diagrams only).
Liquid- vapour equilibrium for two component systems. Ideal solutions at fixed temperature and pressure.
Deviations from Raoult's law and boiling point composition diagrams. Principle of fractional distillation. Duhem-Margules equation, Konowaloff's rule.

Phase rule treatment and the phase diagrams for the following:

Azeotropic solution. Liquid- liquid phase diagram for miscible liquid pairs. Solid- liquid phase diagram, Eutectic mixture. Systems having congruent and incongruent melting points. Partially miscible liquid pairs, Steam distillation.

Nernst distribution law. Solvent extraction.

Unit-2: Solid State and Electrical Properties of Molecules 10M

Solid state:
Types of solid, Bragg's law of diffraction. Laws of crystallography (Haüy's law and Steno's law). Permissible symmetry axes in crystals. Indexing of planes, Miller indices. Lattice, space lattice, unit cell, crystal planes, Bravais lattice. Distance between consecutive planes [cubic, tetragonal and orthorhombic lattices]. Relation between molar mass and unit cell dimension for cubic system. Application of Bragg's law, powder method.
Packing of uniform hard sphere, close packed arrangements (fcc and hcp). Tetrahedral and octahedral voids. Void space in p-type, F-type and I-type cubic systems.

Electrical properties of molecules:
Polarizability of atoms and molecules, dielectric constant and polarization, molar polarization for polar and nonpolar molecules. Clausius-Mosotti equation and Debye equation (both without derivation) and their application in determination of dipole moments.

Unit-3: Surface Chemistry, Colloids and Catalysis 10M

Adsorption and surfactants: Physical and chemical adsorption. Freundlich and Langmuir adsorption isotherms, Surface films on liquid Langmuir film balance, force-area plot, two-dimensional equation of surface film, Langmuir-Blodgett film,
Determination of surface area of adsorbent, Gibbs adsorption isotherm and surface excess, Surface active and surface inactive agents. Surfactants including Bio-surfactants, Micellisation of surfactants, Kraft Point & cloud point, Micellar catalysis, Liquid crystals.

Colloids: Lyophobic and lyophilic sols, Origin of charge and stability of lyophobic colloids, Coagulation and Schultz-Hardy rule, Zeta potential and Stern double layer (qualitative idea), Tyndall effect. Electrokinetic phenomena (qualitative idea only). Determination of Avogadro number by Perrin's method. Stability of colloids and zeta potential.

Catalysis: Homogeneous catalysis, mechanism of catalytic actions, acid- base catalysis. Primary kinetic salt effect.
Enzyme Catalysis: Michaelis – Menten equation, Lineweaver – Burk plot, turnover number, significance of K_m. Elementary idea of enzyme inhibition.
Heterogeneous catalysis (single reactant case only).

Unit-4: Quantum Mechanics II 10M

Simple Harmonic Oscillator (1D): Setting up of the Schrodinger stationary equation, energy expression (without derivation), expression of wave function for n=0 and n=1 (without derivation), characteristic features of the eigen spectrum.
Two body systems: Reduced mass. Stationary Schrodinger equation for the two body systems in spherical polar coordinates, separation of radial and angular (θ, φ) parts. Solution of φ- part and emergence of quantum number 'm'.
Rigid rotor: Schrodinger equation and the separated Θ and Φ parts. Spherical harmonics, energy expression (without derivation), degeneracy of the states and the characteristic features of the system. Expressions (without derivation) for the angular momentum operators L^2, L_z and their eigen spectrum.
Hydrogen atom: Schrodinger equation and its separation into the R, Θ and Φ parts. Idea about the emergence of the quantum numbers. Energy spectrum and the hydrogenic wave functions up to n= 2 (expression only); real wave functions. Concept of orbitals, radial, angular and probability plots of s, p and d orbitals. Radial distribution function. Shape of orbitals. Zeeman effect (normal) and the idea of space quantisation. Stern-Gerlach experiment and the idea of spin. Calculations of the averages of important quantities and discussion of the classical limits for all the three systems.

Unit-5: Magnetic Resonance Spectroscopy 10M

Introduction, basis of magnetic resonance spectroscopy, nmr active nuclei, the nmr spectrometer (Principle and schematic representation); chemical shift and δ scale, Shielding constant and its dependence on different contributions (elementary physical idea only). Qualitative discussion of spin-spin coupling and line structure splitting. Equivalent nuclei (in respect of two protons) and its simple consequences.
Elementary qualitative idea of electron spin resonance spectroscopy.
Applications of magnetic resonance spectroscopy.

Paper-XII **Full Marks-50**

Chemistry Practical

Unit -1: Experiments based upon physico-chemical principles	-	40 M
Unit -2: Lab. Quiz / viva	-	10 M

Examination: 6 hours

Semester-VI

Paper-XIII Group-A Full Marks-25

Inorganic Chemistry (Theoretical)

Unit – 1: Distribution, Extraction and Purification of Elements/ compounds 9M

Distribution and General methods of extraction of elements. Pyrometallurgy, Electrometallurgy Ellingham Diagram, Hydrometallurgy, Zone Refining referring Ti, Cr, Ni, Pt, Ag, U, Li, Si and Ge as representative examples. Separation of geometrical and optical isomers (with some specific examples).

Unit – 2: Environmental Chemistry 8M

Atmosphere, Lithosphere, Hydrosphere: Composition, Structure.
Chemical and photochemical reactions in atmosphere: Ozone-oxygen, SO_2, NO_x, CFC, Greenhouse gases and Green house effect: Acid rains.
Soil: Inorganic and organic components, acid-base and ion-exchange reactions and NPK of soil. Monitoring of pollution: Sampling and preservation; Analysis of air for CO, NO_x and particulates Monitoring of water quality: Analysis of NH_3, NO_3^-, NO_2^- , F^-, As, Cd, Hg, Cr, BOD, DO and COD.

Unit – 3: Reactions of coordination compounds 8M

Stability, lability and inertness of coordination complexes; Factors influencing lability / inertness in main group and transition metal complexes.
Reactions of coordination complexes: Substitution, Electron transfer and Racemisation reactions in coordination complexes and coordination polymers.
Substitution in square planar complexes: Trans Effect – Definition, theories (elementary idea) and applications.

Paper-XIII Group-B Full Marks-25

Organic Chemistry (Theoretical)

Unit – 1: Synthetic strategies and Asymmetric synthesis 15M

Retrosynthetic analysis: disconnections, synthons, donor and acceptor synthons, functional group interconversion, C-C disconnections and synthesis [one group and two group (1, 2 to 1, 6-dioxygenated], reconnection (1, 6-di carbonyl), natural reactivity and umpolung, protection-deprotection strategy [alcohol, amine, and carbonyl, acid]. Strategy of ring synthesis: thermodynamic factor, synthesis through enolate anion chemistry and carbonyl condensation reactions (including acetoacetic ester & malonic ester synthesis), synthesis through rearrangement (including pinacol, Favorski), synthesis of large rings, high dilution technique and acyloin reaction, Stobbe condensation. Asymmetric synthesis: stereoselective and stereospecific reactions, diastereoselectivity and enantioselectivity (only definition), diastereoselectivity: addition of nucleophiles to C=O, adjacent to a stereogenic centre (Felkin-Anh model).

Unit – 2: Amino acids, peptides and nucleic acids 10M

Amino acids: Synthesis: (Strecker, Gabriel, acetamido malonic ester, azlactone); isoelectric point, ninhydrin reaction. Peptides: peptide linkage, syntheses of peptides using N-protection & C-protection, solid phase synthesis; peptide sequence: C–terminal and N–terminal unit determination (Edmann, Sanger & dansyl chloride). Nucleic acids: pyrimidine & purine bases (only structure & nomenclature), nucleosides and nucleotides, DNA: Watson-Crick model, complimentary base –pairing in DNA

Paper-XIV Group-A Full Marks-25

Physical Chemistry (Theoretical)

Unit-1: Molecular Spectroscopy I **8M**

B.O.approximation (mention only), Characteristic features of spectral lines (spacing and intensity), selection rules, Lambert- Beer's Law & population effect. Rotational spectroscopy of diatomic molecules: rigid rotor model, determination of bond length, effect of isotopic substitution, effect of nuclear spin (mention only).
Vibrational spectroscopy of diatomic molecules: SHO model, selection rules, spectra, anharmonicity and its consequences on energy levels, overtones, hot bands.
Raman Effect, Characteristic features and conditions of Raman activity with suitable illustrations. Rotational and vibrational Raman spectra. Rule of mutual exclusion with examples.

Unit-2: Molecular Spectroscopy II **8M**

Potential energy curves (diatomic molecules). Frank-Condon principle and vibrational structure of electronic spectra. Bond dissociation and principle of determination of dissociation energy. Decay of excited states by radiative and non-radiative paths. Fluorescence and phosphorescence. Jablonsky diagram.

Elementary idea of polarization of light and optical rotation; circularly polarized light and circular dichroism, application of CD spectra to distinguish between enantiomeric pairs.

Photochemistry: Stark- Einstein law of photochemical equivalence. Photochemical reactions vs. thermal reactions. Quantum yield. Photostationary state. Photosensitized reactions. Actinometry. Kinetics of HI decomposition, dimerisation of anthracene.
Elementary idea of the following: excimer and exciplex, delayed fluorescence, charge transfer spectra.

Unit-3: Statistical thermodynamics: **9M**

Macrostates and microstates. Thermodynamic probability and the equilibrium state. Entropy and probability. Boltzmann distribution formula (with derivation). Applications to barometric distribution, molecular partition function and thermodynamic properties, Maxwell's speed distribution. Gibbs' paradox.

Heat capacity of solids: Equipartition principle and Dulong- Petit Law, Einstein's theory of heat capacity of solids and its limitations, Debye's T^3- Law.

Paper-XIV Group-B Full Marks-25

CHEMISTRY OF MATERIALS & BIOMOLECULES

Unit 1: Chemistry of Materials **9M**

Nanomaterials *:* Elementary introduction about nano- science and technology and their importance, self-assembly and structure, classification of nanomaterials and their preparation by various techniques, properties, applications & toxicity of nanomaterials, biomaterials (elementary idea).

Polymers*:* Classification, methods of polymerization, kinetics of addition polymerization, number average and mass average molar masses & their determination by different methods, Donan equilibrium

Unit 2: Bio-organic molecules **8M**

Proteins: Classification, structure (secondary, tertiary and quaternary structures), classification of enzymes, coenzymes (simple examples).
Nucleic Acids: Structure of nucleosides and nucleotides (structure elucidation excluded nomenclature of nucleosides), DNA and RNA, complementary base pairing, elementary idea of double helical structure of DNA (Watson – Crick model). Properties of DNA and RNA in solution.
Bio- energetics: Electron transport chain, oxidative phosphorylation & ATP cycle.

Unit 3: Bio-inorganic Chemistry (II): **8M**

Biological O_2 reduction, Cytochrome c oxidase, Biological O_2 production: Photosynthesis: Photosystem-1 and Photosystem-II, N_2 complexes, Biological nitrogen fixation, DNA binding and intercalation. Intercalating agent: Ethidium bromide. Organic radical: Tyrosyl radical in biology.
Metal ion transport across the biological membrane: Na^+/K^+-ion pump.

Paper-XV **Chemistry Practical** **Full Marks-50**

Unit 1: Quantitative Inorganic Analysis – 40M

Unit 2: Lab Quiz / Viva – 10M

Examination: 6 hours (one day)

Paper-XV Chemistry Practical Full Marks-50

Unit 1: Preparation, purification and characterization (spectroscopic/chromatographic) of organic compounds – 40M

Unit 2: Lab Quiz / Viva – 10M

Examination: 6 hours (one day)

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RAMAKRISHNA MISSION RESIDENTIAL COLLEGE
(AUTONOMOUS)
NARENDRAPUR, KOLKATA- 700103

DEPARTMENT OF CHEMISTRY

Syllabus
for
2 year 4 semester B. Sc. General Course in Chemistry

SYLLABI
B.Sc. GENERAL (THEORETICAL)
Semester – I

PAPER – I, GROUP – A (50 M)

Unit 1:	Structure of Atoms (Nuclear & Extra- nuclear).	-	10
Unit 2:	Chemical periodicity & Redox reactions.	-	10
Unit 3:	Thermodynamics (I).	-	10
Unit 4:	Reaction mechanism & Stereochemistry.	-	10
Unit 5:	(a) Organo-metallic compounds.		
	(b) Compounds with active methylene group	-	10

Semester – II

PAPER – II, GROUP – A (50 M)

Unit 1:	Acids - Bases & Ionic equilibrium.	-	10
Unit 2:	Thermodynamics (II).	-	10
Unit 3:	Chemical kinetics & Catalysis.	-	10
Unit 4:	s and p block of elements & their compounds – comparative study.	-	10
Unit 5:	(a) s and d block of elements & their compounds – comparative study.		
	(b) Some analytical reactions	-	10

Semester – III

PAPER – III, GROUP – A (50 M)

Unit 1:	Bonding (Ionic, Covalent & Metallic bonds) and structure.	-	10
Unit 2:	Coordinate bonds & Coordination compounds.	-	10
Unit 3:	Aliphatic compounds.	-	10
Unit 4:	Gaseous state of matter.	-	10
Unit 5:	Liquid & Solid states of matter and Conductance in solution.	-	10

Semester – IV

PAPER – IV, GROUP – A (50 M)

Unit 1:	Colligative properties and Phase rule.	-	10
Unit 2:	Electromotive force.	-	10
Unit 3:	(a) Extraction, purification & uses of Li, Cr, Ni, Ag, Au.		
	(b) Preparation, properties and uses of some important compounds.	-	10
Unit 4:	Aromatic compounds.	-	10
Unit 5:	Carbohydrates, Lipids, Nucleic acids & Proteins.	-	10

Semester-I

Paper-I Group-A Full Marks-50

CHEMISTRY GENERAL THEORETICAL

Unit – 1: **(10M)**

Structure of Atoms and Chemical Periodicity:

(a) ***Extra Nuclear Structure of Atoms*** : 8 – 10 (L)
Qualitative idea on black body radiation. Planck's Quantum Equation, Atomic spectra of Hydrogen, Bohr's atomic model, Bohr's theory for Hydrogen atom (simple mathematical treatment), Sommerfeld's model, Quantum numbers and their significance, Pauli's Exclusion Principle, Hund's Rule ; wave nature of electron, idea of atomic orbitals and their shapes, electronic configuration of many electron atoms, Aufbau principle and its limitations.

(b) ***Radioactivity and Nuclear Structure of Atoms*** :
Natural Radioactivity : Radioactive disintegration series, group displacement law, law of radioactive decay, half-life and average life of radioelements, radioactive equilibrium, measurement of radioactivity.
Atomic Nucleus : Stability of atomic nucleus, n/p ratio, nuclear binding energy, mass defect, Einsten's mass-energy relation, nuclear forces, Nuclear reactions : fission, fusion and spallation; transmutation of elements, artificial radioactivity; radioisotopes and their applications ; radiocarbon dating, medicinal and agricultural uses of isotopes, Hazards of radiation and safety measures.

Unit – 2:

(10M)

(a) ***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 these properties in respect of s- and p- block of elements.

(b) ***Redox Reactions***: Balancing of equations by oxidation number and ion- electron methods Oxidimetry- reductimetry.

Unit – 3: **(10M)**

Chemical Thermodynamics - I:

(a) Definition of Thermodynamic terms; Intensive and extensive variables isolated, closed, open and cyclic systems, reversible and irreversible processes. Thermodynamic functions and their differentials, Zeroth Law of Thermodynamics, concept of heat (q) and work (w).
(b) First Law of Thermodynamics, internal energy (U) and enthalpy (H); relation between Cp and Cv, calculation of w, q, dU and dH for expansion of ideal gas under isothermal and adiabatic conditions for reversible and irreversible processes including free expansion. Joule-Thomson Coefficient and inversion temperature.
(c) Application of First Law of Thermodynamics: Standard state, standard enthalpy of formation, standard enthalpy changes of physical and chemical transformations: fusion, sublimation, vaporization, solution, dilution, neutralization, ionization. Hess's Law of constant heat summation. Bond-dissociation energy, Kirchoff's equation, relation between ΔH and ΔU of a reaction.

Unit – 4: **(10M)**

Reaction mechanism & Stereochemistry:

(a) 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).
(b) Constitution and nomenclature of carbon compounds (IUPAC and trivial systems). Stereochemistry of carbon compounds: Different types of isomerism, geometrical and optical isomerism, optical activity, asymmetric carbon atom, elements of symmetry, chirality, enantiomers and diastereoisomers: E and Z nomenclature, D and L nomenclature (for carbohydrates and aminoacids only). R and S nomenclature, Fischer and Newman Projection formulae of simple molecules containing one and two asymmetric carbon atom (s).

Unit – 5: **(10M)**

(a) ***Organometallic Compounds*** :
Grignard Reagents – Preparation and reactions, Application of Grignard reagents in organic synthesis.
(b) **Compounds with active methylene group:** Synthetic uses of D.E.M. and E.A.A.\

(c) **Alcohols and Ethers:**
Methods of synthesis, physical properties, distinction of primary, secondary and tertiary alcohols and their chemical reactions. Ethers Williamson's ether synthesis, physical properties chemical reactions and uses of ethers.

(d) Phenols :
Synthesis, acidic character and chemical reactions of phenols. Kolbe reactions, Reimer-Tiemann reaction, Fries rearrangement. Claisen rearrangement, Houben-Hoesch reaction, Manasse reaction, Cresols, nitrophenols.

Paper-I Group-B Full Marks-25

CHEMISTRY GENERAL PRACTICAL

1. **Qualitative analysis of a single solid organic compound:**

   (a) Solubility classification (in water, dil. HCl, dil. NaOH, $NaHCO_3$ solution). 4M

   (b) Tests to detect presence/absence of the following functional groups: 10M
   $Ar\text{-}NH_2$, $Ar\text{-}NO_2$, Ar-OH, -COOH, >CO
   (distinction of aldehyde and ketone excluded),

   (c) Reporting of functional groups 1M

2. **Viva voce / Lab quiz** 5M

3. **Laboratory Note Book** 5M

   Examination: 3 hours

Semester-II

Paper-II Group-A Full Marks-50

CHEMISTRY GENERAL THEORETICAL

Unit – 1: **(10M)**

Acids-Bases and Ionic Equilibria:

Modern concepts of acids and bases: Arrhenius theory, theory of solvent system, Bronsted and Lowry's concept, Lewis concept with typical examples, applications and limitations. Strenghts of acids and bases (elementary idea). Ionisation of weak acids and bases in aqueous solution, application of Ostwald's dilution law, ionization constants, ionic product of water, pH-scale, buffer solutions and their pH values, buffer actions; hydrolysis of salts, solubility product principle and it's applications.

Unit – 2: **(10M)**

Thermodynamics (II):

Spontaneous processes, heat engine, Carnot cycle and its efficiency, Second Law of Thermodynamics, Entropy (S) as a state function, molecular interpretation of entropy, entropy changes on simple transformations. Free energy: Gibbs function (G) and Helmholtz function (A), Gibbs-Helmholtz equation, criteria for thermodynamic equilibrium and spontaneity of processes.
Chemical Equilibria of homogeneous and heterogeneous systems, derivation of expression of equilibrium constants; temperature, pressure and concentration dependence of equilibrium constants (K_p, K_c, K_x); Le Chatellier's Principle of dynamic equilibrium.

Unit – 3: **(10M)**

Chemical Kinetics and Catalysis:

Order and molecularity of reactions, rate laws and rate equations for first order and second order reactions (differential and integrated forms); Pseudo first order reactions. Zero order reactions. Determination of order of reactions. Temperature dependence of reaction rate, energy of activation.
Different types of Catalytic Reactions.

Unit – 4: **(10M)**

p-Block Elements and Their Compounds:

Comparative Study : Group trends in electronic configuration, modification of pure elements, common oxidation states, inert pair effect, chemical properties and reactions of common hydrides, halides, oxides and oxyacids (if any) in respect of following groups of elements : (i) B-AI, (ii) C-Si-Ge-Sn-Pb, (iii) N-P-As-Sb-Bi, (iv) O-S-Se-Te and (v) F-Cl-Br-I.

Unit – 5: **(10M)**

(a) ***s- and d-block elements and their compounds* :** Comparative Study : Group trends in electronic configurations, oxidation states, chemical properties and reactions in respect of following groups
elements: (i) Li-Na-K, (ii) Be-Mg-Ca-Sr-Ba (iii) Cr-Mn-Fe-Co-Ni, (iv) Cu-Ag-Au, (v) Zn-Cd-Hg.

(b) ***Analytical reactions leading in detection of***: carbonate, bicarbonate, lead, ammonia, nitrate, nitrite, phosphate, sulphide, sulphite, thiosulphate, sulphate, halides, borate, boric acid, borax bead test.

Paper-II Group-B Full Marks-25

CHEMISTRY GENERAL PRACTICAL

1. **Qualitative analysis of a mixture of two inorganic acid radicals / two basic radicals:** 15M

   Acid radicals:

   Cl^-, Br^-, I^-, NO_3^-, NO_2^-, $SO_4^{=}$, BO_3^{3-}, PO_4^{3-}, F^-, $S^{=}$, $SO_3^{=}$, $S_2O_3^{=}$, $CrO_4^{=}$

   (insoluble samples, $CO_3^{=}$, HCO_3^- are excluded)

   Basic radicals:

   Cu^{++}, Fe^{++}/Fe^{3+}, Al^{3+}, Cr^{3+}, Mn^{++}, Ni^{++}, Co^{++}, Zn^{++}, Ba^{++}, Sr^{++}, Ca^{++}, Na^+, K^+, NH_4^+ (insoluble samples are excluded)

2. **Viva voce / Lab quiz** 5M

3. **Laboratory Note Book** 5M

   Examination: 3 hours

Semester-III

Paper-III Group-A Full Marks-50

CHEMISTRY GENERAL THEORETICAL

Unit – 1: **(10M)**

Chemical Bonding and Structure:

(a) ***Ionic Bonding*** : General characteristics of ionic compounds, Sizes of ions, radius ratio rule and its limitation, packing of ions in crystals, Lattice energy, Born Haber Cycle.

(b) ***Covalent Bonding*** : General Characteristics of covalent compounds, valence-bond approach, directional character of covalent bond, hybridization involving s-, p- and d- orbitals, multiple bonding. Valence shell Electron Pair Repulsion (VSEPR) concept, shapes of simple molecules and ions (examples from main groups chemistry). Molecular orbital (elementary idea), sigma and pi bonds, bond length, bond order, bond energy. Bond moment and dipole moment, partial ionic character of covalent bonds. Fajan's Rules. Hydrogen bonding and its effect on physical and chemical properties.

(c) ***Metallic bonding***: Elementary idea of metallic bond.

Unit – 2: **(10M)**

Coordinate bonds and Coordination compounds:

Formation of coordinate bonds, difference between covalent & coordinate bonds, Complex salts and double salts, Werner's theory of coordination, chelae complexes, Isomerism, stereochemistry of coordination numbers 4 and 6. IUPAC nomenclature of coordination complexes (mononuclear complexes only).

Unit – 3: **(10M)**

Chemistry of Organic Compounds (I):

(a) ***Alkenes, alkenes and alkynes*** :

Isomerism, synthesis and chemical reactivity of alkanes, mechanism of free-redical halogenation of alkanes, Sulphonation of alkanes, detergents. General methods of synthesis of alkenes, heat of hydrogenation and stability of alkenes, Electrophilic addition reactions, mechanism of bromination and hydrohalogenation; Markownikoff's addition, peroxide effect. Hydration, hydroboration, ozonololysis, epoxidation, hydroxylation polymerization reactions of alkenes (definition and examples only). General methods of synthesis, acidity, hydration and substitution reactions of alkynes.

(b) ***Aldehydes and Ketones*** :

The nature of carbonyl group, methods of synthesis, physical properties, derivatives of carbonyl compounds, nucleophilic addition, 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 Reduction reactions, Aliphatic and aromatic aldehydes.

(c) Carboxylic Acids and Their Derivatives:

Acidity of carboxylic acids and effects of substituents on acidity, chemical reactivity, mechanism of esterification of carboxylic acids and hydrolysis of ester (BAc2 and AAc2 only); methods of synthesis and reactions of acyl halides, amides, esters and acid anhydrides.

Unit – 4: **(10M)**

Gaseous State of Matters :

Gas Laws, Kinetic theory of gas, collision and gas pressure, 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, Heat capacity of gases (molecular basis of); Viscosity of gases,
Real gases, compressibility factor, deviation from ideality, van der Waals' equation of state, critical phenomena, continuity of states critical constants, intermolecular forces, liquefaction of gases.

Unit – 5: **(10M)**

Liquid & solid states of matter; conductance in solution.

(a) ***Liquid State***:
Physical properties of liquids and their measurements, Vapour pressure, surface tension, viscosity, refractive index and dipole moment

(b) ***Crystalline State***:
Type of bonding in solids, law of constancy of angles, concept of unit cell, law of rational indices, Miller indices, symmetry elements in crystals, seven crystal systems, density of cubic crystal.

(c) ***Solutions of Electrolyte* (*conductance in solutions)***:
Electrolytic conductance, specific conductance, equivalent conductance and molar conductance of electrolytic solutions. Influence of temperature and dilution on conductance of weak electrolytes. Measurement of conductance, conductometric titration: acid-base and precipitation titrations as examples.

Paper-III Group-B Full Marks-25

CHEMISTRY GENERAL PRACTICAL

1. **Qualitative analysis of a soluble mixture containing three radicals from the following radicals:** 15M

   Acid radicals:

   Cl^-, Br^-, I^-, NO_3^-, NO_2^-, $SO_4^{=}$, BO_3^{3-}, PO_4^{3-}, F^-, $S^{=}$, $SO_3^{=}$, $S_2O_3^{=}$, $CrO_4^{=}$

   (insoluble samples, $CO_3^{=}$, HCO_3^- are excluded)

   Basic radicals:

   Cu^{++}, Fe^{++}/Fe^{3+}, Al^{3+}, Cr^{3+}, Mn^{++}, Ni^{++}, Co^{++}, Zn^{++}, Ba^{++}, Sr^{++}, Ca^{++}, Na^+,

   K^+, NH_4^+ (insoluble samples are excluded)

   In the examination a sample will contain either two soluble acid radicals or two soluble basic radicals.

2. **Viva voce / Lab quiz** 5M

3. **Laboratory Note Book** 5M

Examination: 3 hours

Semester-VI

Paper-IV Group-A Full Marks-50

CHEMISTRY GENERAL THEORETICAL

Unit – 1: **(10M)**

(a) **Solution of Non-Electrolytes (Colligative properties):**

Colligative properties of solution, Henry's Law and Roult's Law, relative lowering of vapour pressure, osmosis and osmotic pressure; elevation of boiling point and depression of freezing point of solvents ; Determination of molecular mass of solutes from measurement of Colligative properties of solutions.

(b) **Phase rule:**

Phase, component, system, degrees of freedom. The phase rule. Phase diagram of one component systems: water, carbondioxide and sulphur.
Heterogeneous systems: Nernst Distribution Law, miscibility and distillation of binary liquid mixtures, azeotroic mixtures, critical solution temperature, steam distillation. eutectic mixtures, congruent and incongruent melting points, solid solutions.

Unit – 2: **(10M)**

Electromotive force:

(a) Electrode potentials, Nernst Equation, Reference electrodes: Normal Hydrogen Electrode and calomel electrodes, emf of electrochemical cells and its measurement, Electrode potential series and its applications, Potentiometric titrations: (Fe (II)-permanganate, Fe (II)-dichromate titrations as examples): measurement of hydrogen ion concentration (pH) using glass-calomel electrode-pH meter, concentration cells.

Unit – 3: **(10M)**

(a) Extraction and purification of elements from natural sources: Li, Cr, Ni, Ag, Au.

(b) Preparation, properties and uses of some important compounds: $KMnO_4$, $K_2Cr_2O_7$, and Mohr's salt, Hydrazine, Hydroxylamine, Perchloric acid, Sodium Thiosulphate, Hypo phosphorous acid, $LiAlH_4$ & $NaBH_4$.

Unit – 4: **(10M)**

(a) **Chemistry of organic compounds - II :**

Resonance structure of benzene, General mechanism of electrophilic substitution reactions of benzene, Synthesis of aromatic compounds using nitration sulphonation, halogenation, Friedel-Craft alkylations and acylation reactions, Nuclear and side-chain halogenation of toluene.

(b) **Alkyl and Aryl halides :**

Methods of synthesis, SN_1, SN_2, E1, E2 reactions (elementary mechanistic aspects), Saytzeff and Hofmann elimination reactions, reactivity of aromatic halides, nucleophilic aromatic substitution reactions. Synthesis of DDT.

(c) **Organic Compounds Containing Nitrogen :**

Aromatic nitro-compounds – their synthesis and reduction under different conditions, Methods of synthesis of aliphatic amines, Heinsberg's method of amine separation, Hofmann degradation, Gabriel's phthalimide synthesis, distinction of primary, secondary and tertiary amines. Methods of synthesis of aromatic amines, basicity of aliphatic and aromatic amines, Diazotisation and coupling reactions and their mechanisms, synthetic applications of diazonium salts.

Unit – 5: **(10M)**

(a) Carbohydrates:

Introduction, occurrence and classification of carbohydrates; constitution of glucose, Osazone formation, Reactions of glucose and fructose, mutarotation. Cyclic structures – pyranose and furanose forms determination of ring size excluded, epimerization, chain-lengthening and chain-shortening in aldoses.

(b) Amino Acids, Proteins and Nucleic Acids :

Methods of synthesis of α-amino acids (glycine and alanine using Gabriel's phthalamide synthesis and Strecker synthesis, Physical properties: Zwitterion structures, isoelectric point; peptide synthesis (elementary idea), Nucleic acids: compounds, nucleosides and nucleotide, structures and functions (basic idea).

Paper-IV Group-B Full Marks-25

CHEMISTRY GENERAL PRACTICAL

1. **Quantitative chemical analysis**. 15M

2. **Viva voce / Lab quiz** 5M
3. **Laboratory Note Book** 5M

Examination: 4 hours