BACHELOR OF SCIENCE (B.Sc.)

(THREE YEAR DEGREE COURSE)

SUBJECT

CHEMISTRY

B.Sc. (CHEMISTRY)

COURSE STRUCTURE

FIRST YEAR

PAPER 101: Inorganic Chemistry	50 MARKS
PAPER 102: Organic Chemistry	50 MARKS
PAPER 103: Physical Chemistry	50 MARKS
PAPER 104: PRACTICAL (Based on Paper 101, 102, 103)	50 MARKS

SECOND YEAR

PAPER 201: Inorganic Chemistry	50 MARKS
PAPER 202: Organic Chemistry	50 MARKS
PAPER 203: Physical Chemistry	50 MARKS
PAPER 204: PRACTICAL (Based on Paper 201, 202, 203)	50 MARKS

THIRD YEAR

PAPER 301: Inorganic Chemistry	50 MARKS
PAPER 302: Organic Chemistry	50 MARKS
PAPER 303: Physical Chemistry	50 MARKS
PAPER 304 : PRACTICAL (Based on Paper 301, 302, 303)	50 MARKS

B.Sc. (CHEMISTRY)

FIRST YEAR DETAILED SYALLBUS

PAPER 101

Inorganic Chemistry

60 hrs (2 hrs/week)

Unit I

I. Atomic Structure **6 hrs**

Idea of de-Broglie matter waves, Heisenberg uncertainty principle, atomic orbitals, Schrödinger wave equation, significance of Ψ and Ψ^2, quantum numbers, radial and angular wave functions and probability distribution curves, shapes of s,p,d, orbitals. Aufbau and Pauli exclusion principles, Hund's multiplicity rule. Electronic configurations of the elements, effective nuclear charge.

II. Periodic Properties **5 hrs**

Atomic and ionic radii, ionization energy, electron affinity and electronegativity-definition, methods of determination or evaluation, trends in periodic table and applications in predicting and explaining the chemical behaviour.

Unit II

III. Chemical Bonding **20 hrs**

(A) Covalent Bond – Valence bond theory and its limitations, directional characteristics of covalent bond, various types of hybridization and shapes of simple inorganic molecules and ions. Valence shall electron pair repulsion (VSEPR) theory to NH_3, H_3O^+, SF_4, ClF_3, ICl_2^- and H_2O. MO theory, homonuclear and heteronuclear (CO and NO) diatomic molecules, multicenter bonding in electron deficient molecules, bond strength and bond energy, percentage ionic character from dipole moment and electronegativity difference.

(B) Ionic Solids – Ionic structures, radius-ratio effect and coordination number, limitation of radius-ratio rule, lattice defects,

semiconductors, lattice energy and Born-Haber cycle, solvation energy and solubility of ionic solids, polarizing power and polarisability of ions, Fajan's rule. Metallic bond-free electron, valence bond and band theories.

(C) Weak Interactions – Hydrogen bonding, vander Waals forces.

Unit III

IV. s-Block Elements 6 hrs

Comparative study, diagonal relationship, salient features of hydrides, solvation and complexation tendencies including their function in biosystems, an introduction to alkyls and aryls.

V. Environmental Chemistry 5 hrs

Pollution, long distance movement of pollutants, air pollution (CO, CO_2, NO_x, SO_2, H_2S, pesticides, ozone layer depletion, smog, acid rain, monitoring and control), water pollution (BOD, COD, sewage treatment, industrial wastewater treatment, reverse osmosis), soil pollution (causes, effects and remedies)

Unit IV

VI. p-Block Elements 15 hrs

Comparative study (including diagonal relationship) of groups 13-17 elements, compounds like hydrides, oxides, oxyacids and halides of group 13-16, hydrides of boron – diborane and higher boranes, borazine, borohydrides, fullerenes, carbides, fluorocarbons, silicates (structural principle), tetrasulphur tetranitride, basic properties of halogens, interhalogens and polyhalides.

Chemistry of Noble Gases 3 hrs

Chemical properties of the noble gases, chemistry of xenon, structure and bonding in xenon compounds.

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FIRST YEAR DETAILED SYALLBUS

PAPER 102

Organic Chemistry

60 hrs (2 hrs/week)

Unit I

I. Structure and Bonding **5 hrs**

Hybridization, bond lengths and bond angles, bond energy, localized and delocalized chemical bonding, van der Waals interactions, inclusion compounds, clathrates, charge transfer complexes, resonance, hyperconjugation, aromaticity, inductive and field effects, hydrogen bonding.

II. Mechanism of Organic Reactions **8 hrs**

Curved arrow notation, drawing electron movements with arrows, half-headed and double-headed arrows, homolytic and heterolytic bond fissions. Types of organic reagents – electrophiles and nucleophiles. Types of organic reactions. Energy considerations.

Reactive intermediates – Carbocations, carbanions, free radicals, carbenes, arynes and nitrenes (with examples). Assigning formal charges on intermediates and other ionic species.

Methods of determination of reaction mechanism (product analysis, intermediates, isotope effects, kinetic and stereochemical studies).

III. Alkanes and Cycloalkanes **7 hrs**

IUPAC nomenclature of branched and unbranched alkanes, the alkyl group, classification of carbon atoms in alkanes. Isomerism in alkanes, sources methods of formation (with special reference to Wurtz reaction, Kolbe reaction, Corey-House reaction and decarboxylation of carboxylic acids), Physical properties and chemical reactions of alkanes. Mechanism of free radical halogenation of alkanes: orientation, reactivity and selectivity.

Cycloalkanes – Nomenclature, methods of formation, chemical reactions, Baeyer's strain theory and its limitations. Ring strain in small rings

(cyclopropane and cyclobutane), theory of strainless rings. The case of cyclopropane ring: banana bonds.

Unit II

IV. Stereochemistry of Organic Compounds 15 hrs

Concept of isomerism. Types of isomerism.

Optical isomerism – Elements of symmetry, molecular chirality, enantiomers, stereogenic center, optical activity, properties of enantiomers, chiral and achiral molecules with two stereogenic centers, disasteromers, threo and erythro diastereomers, meso compounds, resolution of enantionmers, inversion, retention and recemization. Relative and absolute configuration, sequence rules, D & L and R & S systems of nomenclature.

Geometric isomerism – Determination of configuration of geometric isomers. E & Z system of nomenclature, geometric isomerism in oximes and alicyclic compounds.

Conformational isomerism – Conformational analysis of ethane and n-butane; conformations of cyclohexane, axial and equatorial bonds, conformation of mono-substituted cyclohexane derivatives. Newman projection and Sawhorse formulae, Fischer and flying wedge formulae. Difference between configuration and conformation.

Unit III

V. Alkenes, Cycloalkenes, Dienes and Alkynes 7 hrs

Nomenclature of alkenes, methods of formation, mechanisms of dehydration of alcohols and dehydrohalogenation of alkyl halides, regioselectivity in alcohol dehydration, The Saytzeff rule, Hofmann elimination, physical properties and relative stabilities of alkenes.

Chemical reactions of alkenes – Mechanisms involved in hydrogenation, electrophilic and free radical additions, Markownikoff's rule, hydroboration-oxidation, oxymercuration-reduction. Epoxidation, ozonolysis, hydration, hydroxylation and oxidation with $KMnO_4$. Polymerization of alkenes. Substitution at the allylic and vinylic positions of alkenes. Industrial applications of ethylene and propene.

Methods of formation, conformation and chemical reactions of cycloalkenes.

Nomenclature and classification of dienes: Isolated, conjugated and cumulated dienes. Structure of allenes and butadiene, methods of formation, polymerization. Chemical reactions – 1,2- and 1,4- additions, Diels Alder reaction.

Nomenclature, structure and bonding in alkynes. Methods of formation. Chemical reactions of alkynes, acidity of alkynes. Mechanism of electrophilic and nucleophilic addition reactions, hydroboration-oxidation, metal-ammonia reductions, oxidation and polymerization.

Unit IV

VI. Arenes and Aromaticity 8 hrs

Nomenclature of benzene derivatives. Aryl group. Aromatic nucleus and side chain.

Structure of benzene: Molecular formula and Kekule structure.

Stability and carbon-carbon bond lengths of benzene, resonance structure, MO picture.

Aromaticity: The Huckle rule, aromatic ions.

Aromatic electrophilic substitution – General pattern of the mechanism, role of σ and π complexes, Mechanism of nitration, halogenation, sulphonation, mercuration and Friedel-Craft's reaction. Energy profile diagrams. Activating and deactivating substituents, orientation and ortho/para ratio. Side chain reactions of benzene derivatives. Birch reduction.

Methods of formation and chemical reactions of alkylbenzenes, alkynylbenzenes, biphenyl, naphthalene and anthracene.

VII. Alkyl and Aryl Halides 10 hrs

Nomenclature and classes of alkyl halides, methods of formation, chemical reactions. Mechanisms of nucleophilic substitution reactions of alkyl halides, S_{N2} and S_{N1} reactions with energy profile diagrams.

Polyhalogen compounds: Chloroform, carbon tetrachloride.

Methods of formation of aryl halides, nuclear and side chain reactions.

The addition-elimination and the elimination-addition mechanisms of nucleophilc aromatic substitution reactions.

Relative reactivities of alkyl halides vs allyl, vinyl and aryl halides. Synthesis and uses of DDT and BHC.

B.Sc. (CHEMISTRY)

FIRST YEAR DETAILED SYALLBUS

PAPER 103

Physical Chemistry

60 hrs (2 hrs/week)

Unit I

I. Mathematical Concepts and Computers **16 hrs**

(A) Mathematical Concepts

Logarithmic relations, curve sketching, linear graphs and calculation of slopes, differentiation of functions like k_x, e^x, x^n, sin x, log x; maxima and minima, partial differentiation and reciprocity relations. Integration of some useful/relevant functions; permutations and combinations. Factorials. Probability.

(B) Computers

General introduction to computers, different components of a computer, hardware and software, input-output devices, binary numbers and arithmetics, introduction to computer languages. Programming. Operating systems.

Unit II

II. Gaseous States **8 hrs**

Postulates of kinetic theory of gases, deviation from ideal behavior, van der Waals equation of state.

Critical phenomena: PV isotherms of real gases, continuity of states, the isotherms of van der Waals equation, relationship between critical constants and van der Waals constants, the law of corresponding states, reduced equation of state.

Molecular velocities: Root mean square, average and most probable velocities. Qualitative discussion of the Maxwell's distribution of molecular velocities, collision number, mean free path and collision diameter. Liquification of gases (based on Joule-Thomson effect).

III. Liquid State **6 hrs**

Intermolecular forces, structure of liquids (a qualitative description).

Structural differences between solids, liquids and gases.

Liquid crystals: Difference between liquid crystal, solid and liquid. Classification, structure of nematic and cholestric phases. Thermography and seven segment cell.

Unit III

IV. Solid State **11 hrs**

Definition of space lattice, unit cell.

Laws of crystallography – (i) Law of constancy of interfacial angles, (ii) Law of rationality of indices and (iii) Law of symmetry. Symmetry elements in crystals.

X-ray diffraction by crystals. Derivation of Bragg equation. Determination of crystal structure of NaCl, KCl and CsCl (Laue's method and powder method).

V. Colloidal State **6 hrs**

Definition of colloids, classification of colloids.

Solids in liquids (sols): Properties – kinetic, optical and electrical; stability of colloids, protective action, Hardy-Schulze law, gold number.

Liquids in liquids (emulsions): Types of emulsions, preparation. Emulsifier.

Liquids in solids (gels): Classification, preparation and properties, inhibition, general application of colloids, colloidal electrolytes.

Unit IV

VI. Chemical Kinetics and Catalysis **13 hrs**

Chemical kinetics and its scope, rate of a reaction, factors influencing the rate of a reaction – concentration, temperature, pressure, solvent, light,

catalyst. Concentration dependence of rates, mathematical characteristics of simple chemical reactions – zero order, first order, second order, pseudo order, half life and mean life. Determination of the order of reaction – differential method, method of integration, method of half life period and isolation method.

Radioactive decay as a first order phenomenon. Experimental methods of chemical kinetics: Conductometric, potentiometric, optical methods, polarimetry and spectrophotometer.

Theories of chemical kinetics: Effect of temperature on rate of reaction, Arrhenius equation, concept of activation energy.

Simple collision theory based on hard sphere model, transition state theory (equilibrium hypothesis). Expression for the rate constant based on equilibrium constant and thermodynamic aspects.

Catalysis - Characteristics of catalysed reactions, classification of catalysis, homogeneous and heterogeneous catalysis, enzyme catalysis, miscellanceous examples.

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FIRST YEAR DETAILED SYALLBUS

PAPER – 104

PRACTICAL

180 hrs (6 hrs/week)

The duration of practical examination will be of six hours. M M = 50

Distribution of Marks

Inorganic experiments (mixture +titration) 12+8 = 20
Organic experiments 10 marks
Physical experiments 10 marks
Record 5 marks
Viva 5 marks

Inorganic Chemistry

Inorganic mixture analysis (preferably by semimicro method) – The mixture will have six ions, preferably three cations and three anions. It may contain ions of the same group and an interfering anion such as phosphate, oxalate, borate and fluoride. Not more than one interfering anion is to be given. The formal group analysis will be done for the separation and identification of cations of Group I to VI. Two marks will be awarded for each correct ion with proper tests. One mark will be deducted for each incorrect ion reported. Not more than 50 % marks will be awarded if proper tests are not given.

Volumetric analysis: Any four double titrations from acid-base, redox and complexometric types.

Organic Chemistry

Qualitative Organic Analysis

Detection of extra elements (N, S and halogens) and functional groups (alcoholic, phenolic, aldehydic, ketonic, carbonyl, carboxylic, esters, carbohydrates, amines, amides, nitro and anilide) in simple organic compounds.

Laboratory Techniques

***Calibration of thermometer*:** 80-82^{0}C(Naphthalene), 113.5-114^{0}C (Acetanilide), 132.5-133^{0}C (Urea), 100^{0}C (Distilled Water).

***Determination of melting point*:** Naphthalene 80-82^{0}C, Benzoic acid 121.5-122^{0}C, Urea 132.5-133^{0}C, Succinic acid 184.5-185^{0}C, Cinnamic acid 132.5-133^{0}C, Sallicylic acid 157.5-158^{0}C, Acetanilide 113.5-114^{0}C, m-initrobenzene 90^{0}C, p-ichlorobenzene 52^{0}C, Aspirin 135^{0}C.

***Determination of boiling point*:** Ethanol 78^{0}C, Cyclohexane 81.4^{0}C, Toluene 110.6^{0}C, Benzene 80^{0}C.

***Mixed melting point determination*:** Urea-Cinnamic acid mixture of various compositions (1:4, 1:1, 4:1).

***Distillation*:** Simple distillation of ethanol-water mixture using water condenser. Distillation of nitrobenzene and aniline using air condenser.

***Crystallization*:** Concept of induction of crystallization. Phthalic acid from hot water (using fluted filter paper and steamless funnel). Acetanilide from boiling water. Naphthalene from ethanol. Benzoic acid from water.

***Decolorisation and crystallization using charcoal*:** Decoloration of brown sugar (sucrose) with animal charcoal using gravity filtration. Crystallization and decolorisation of impure naphthalene (100 g of naphthalene mixes with 0.3 g of Congo Red using 1 g decolorizing carbon) from ethanol.

***Sublimation (simple and vacuum)*:** Camphor, Naphtalene, Phthalic acid and Succinic acid.

Physical Chemistry

Chemical Kinetics

1. To determine the specific reaction rate of the hydrolysis of methyl acetate/ethyl acetate catalyzed by hydrogen ions at rooms temperature
2. To study the effect of acid strength on the hydrolysis of an ester
3. To compare the strengths of HCl and H_2SO_4 by studying the kinetics of hydrolysis of ethyl acetate
4. To study kinetically the reaction rate of decomposition of iodide by H_2O_2

Distribution Law

1. To study the distribution of iodine between water and CCl_4
2. To study the distribution of benzoic acid between benzene and water

Colloids

1. To prepare arsenious sulphide sol and compare the precipitating power of mono-, bi- and trivalent anions

Viscosity, Surface Tension

1. To determine the percentage composition of a given mixture (non-interacting systems) by viscosity method
2. To determine the viscosity of amyl alcohol in water at different concentrations and calculate the excess viscosity of these solutions
3. To determine the percentage composition of a given binary mixture by surface tension method (acetone & ethyl-methyl ketone)

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SECOND YEAR DETAILED SYALLBUS

PAPER 201

Inorganic Chemistry

60 hrs (2 hrs/week)

Unit I

I. Chemistry of Elements of First Transition Series **10 hrs**

Characteristic properties of block elements.

Properties of the elements of the first transition series, their binary compounds (hydrides, carbides and oxides) and complexes with respect to relative stability of their oxidation states, coordination number and geometry.

II. Chemistry of Elements of Second and Third Transition Series **10 hrs**

General characteristics, comparative treatment with their 3d-analogues with respect to ionic radii, oxidation states, magnetic behaviour, spectral properties and stereochemistry. Comparison of Zr/Hf, Nb/Ta and Mo/W.

Unit II

III. Coordination Compounds **10 hrs**

Werner's coordination theory and its experimental verification, effective atomic number concept, chelates, nomenclature of coordination compounds, isomerism in coordination compounds, valence bond theory of transition metal complexes.

Unit III

IV. Chemistry of Lanthanide Elements **6 hrs**

Electronic structure, oxidation states and ionic radii and lanthanide contraction, complex formation, occurrence and isolation. Ceric ammonium sulphate and its analytical uses.

V. Chemistry of Actinides **4 hrs**

Electronic configuration, oxidation states and magnetic properties, chemistry of separation of Np, Pu and Am from U. Similarities between the later actinides and the later lanthanides.

Unit IV

VI. Oxidation and Reduction **8 hrs**

Electrode potential, electrochemical series and its applications. Principles involved in the extraction of the elements.

VII. Acids and Bases **6 hrs**

Arrhenius, Bronsted-Lowry, the Lux-Flood, solvent system and Lewis concept of acids and bases.

VIII. Non-aqueous Solvents **6 hrs**

Physical properties of a solvent, types of solvents and their general characteristics. Reactions in non-aqueous solvents with reference to liquid NH_3 and Liquid SO_2.

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SECOND YEAR DETAILED SYALLBUS

PAPER 202

Organic Chemistry

60 hrs (2 hrs/week)

Unit I

I. Electromagnetic Spectrum: Absorption Spectra **10 hrs**

Ultraviolet (UV) absorption spectroscopy – Absorption laws (Beer-Lambert law), molar absroptivity, presentation and analysis of UV spectra, types of electronic transitions, effect of conjugation. Concept of chromophore and auxochrome. Bathochromic, hypsochromic, hyperchromic and hypochromic shifts. UV spectra of conjugated enes and enones.

Infrared (IR) absorption spectroscopy – Molecular vibrations, Hooke's law, selection rules, intensity and position of IR bands, measurement of IR spectrum, fingerprint region, characteristic absorptions of various functional groups and interpretation of IR spectra of simple organic compounds.

Unit II

II. Alcohols **6 hrs**

Classification and nomenclature.

Monohydric alcohols – Nomenclature, methods of formation by reduction of aldehydes, ketones, carboxylic acids and esters. Hydrogen bonding. Acidic nature. Reactions of alcohols.

Dihydric alcohols – Nomenclature, methods of formation, chemical reactions of vicinal glycols, oxidative cleavage [$Pb(OAc)_4$ and HIO_4] and pinacol- pinacolone rearrangement.

Trihydric alcohols – nomenclature, methods of formation, chemical reactions of glycerol, synthesis of glycerol.

III. Phenols **6 hrs**

Nomenclature, structure and bonding, preparation of phenols, physical properties and acidic character. Comparative acidic strengths of alcohols and phenols, resonance stabilization of phenoxide ion. Reactions of phenols – electrophilic aromatic substitution, acylation and carboxylation. Mechanisms of Frie's rearrangement, Claisen rearrangement, Gatterman syntheis, Hauben-Hoesch reaction, Lederer-Manasse reaction and Reimer-Tiemann reaction.

Unit III

IV. Ethers and Epoxides **3 hrs**

Nomenclature of ethers and methods of their formation, physical properties. Chemical reactions – cleavage and autoxidation, Ziesel's method.

Synthesis of epoxides. Acid and base-catalyzed ring opening of epoxides, orientation of epoxide ring opening, reactions of Grignard and organolithium reagents with epoxides.

V. Aldehydes and Ketones **14 hrs**

Nomenclature and structure of the carbonyl groups. Synthesis of aldehydes and ketones with particular reference to the synthesis of aldehydes from acid chlorides, synthesis of aldehydes and ketones using 1,3-dithianes, synthesis of ketones from nitriles and from carboxylic acids. Physical properties.

Mechanism of nucleophillic additions to carbonyl group with particular emphasis on benzoin, aldol, Perkin and Knoevenagel condensations. Condensation with ammonia and its derivatives. Wittig reaction. Mannich reaction.

Use of acetals as protecting group. Oxidation of aldehydes, Baeyer-Villiger oxidation of ketones, Cannizzaro reaction. MPV, Clemmensen, Wolf-Kishner, $LiAlH_4$ and $NaBH_4$ reductions. Halogenation of enolizable ketones. An introduction to α, β unsaturated aldehydes and ketones.

Unit IV

VI. Carboxylic Acids 6 hrs

Nomenclature, structure and bonding, physical properties, acidity of carboxylic acids, effects of substituents on acid strength. Preparation of carboxylic acids. Reactions of carboxylic acids. Hell-Volhard-Zelinsky reaction. Synthesis of acid chlorides, esters and amides. Reduction of carboxylic acids. Mechanism of decarboxylation.

Methods of formation and chemical reactions of halo acids. Hydroxy acids: Malic, tartaric and citric acids.

Methods of formation and chemical reactions of unsaturated monocarboxylic acids.

Dicarboxylic acids: Methods of formation and effect of heat and dehydrating agents.

VII. Carboxylic Acid Derivatives 3 hrs

Structure and nomenclature of acid chlorides, esters, amides (urea) and acid anyhydrides.

Relative stability of acyl derivatives. Physical properties, interconversion of acid derivatives by nucleophilic acyl substitution.

Preparation of carboxylic acid derivatives, chemical reaction. Mechanisms of esterificaton and hydrolysis (acidic and basic).

VIII. Organic Compounds of Nitrogen 12 hrs

Preparation of nitroalkanes and nitroarenes. Chemical reactions of nitroalkanes. Mechanisms of nuclephilc substitution in nitroarenes and their reductions in acidic, neutral and alkaline media. Picric acid.

Halonitroarenes: Reactivity.

Amines: Structure and nomenclature of amines, physical properties. Stereochemistry of amines. Separation of a mixture of primary, secondary and tertiary amines. Structural features effecting basicity of amines. Amine salts as phase-transfer catalysts. Preparation of alkyl and aryl amines (reduction of nitro compounds, nitriles), reductive amination of aldehydic and ketonic compounds. Gabriel-phthalimide reaction, Hofmann bromamide reaction. Reactions of amines, electrophilic aromatic substituton in aryl amines, reactions of amines with nitrous acid. Synthetic transformations of aryl diazonium salts, azo coupling.

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SECOND YEAR DETAILED SYALLBUS

PAPER 203

Physical Chemistry

60 hrs (2 hrs/week)

Unit I

I. Thermodynamics – I **12 hrs**

Definitions of Thermodynamic Terms

System, surroundings etc. Types of systems, intensive and extensive properties. State and path functions and their differentials. Thermodynamic process. Concept of heat and work.

First Law of Thermodynamics

Statement, definition of internal energy and enthalpy. Heat capacity, heat capacities at constant volume and pressure and their relationship. Joule's law – Joule-Thomson coefficient and inversion temperature. Calculation of w, q, dU & dH for the expansion of ideal gases under isothermal and adiabatic conditions for reversible process.

Thermochemistry

Standard state, standard enthalpy of formation – Hess's law of heat summation and its applications. Heat of reaction at constant pressure and at constant volume. Enthalpy of neutralization. Bond dissociation energy and its calculation from thermo-chemical data, temperature dependence of enthalpy. Kirchhoff's equation.

II. Thermodynamics – II **13 hrs**

Second Law of Thermodynamics

Need for the law, different statements of the law, Carnot cycle and its efficiency. Carnot theorem. Thermodynamic scale of temperature.

Concept of Entropy

Entropy as a state function, entropy as a function of V & T, entropy as a function of P & T, entropy change in physical change, Clausius inequality, entropy as a criteria of spontaneity and equilibrium. Entropy change in ideal gases and mixing of gases.

Gibbs and Helmholtz Functions

Gibbs function (G) and Helmhotz function (A) as thermodynamic quantities. A & G as criteria for thermodynamic equilibrium and spontaneity, their advantage over entropy change, Variation of G and A with P, V and T.

Third Law of Thermodynamics

Nernst heat theorem, statement and concept of residual entropy.

Nernst distribution law – Thermodynamic derivation, applications.

Unit II

III. Chemical Equilibrium 5 hrs

Equilibrium constant and free energy. Thermodynamic derivation of law of mass action. Le-Chatelier's principle.

Reaction isotherm and reaction isochore – Clapeyron-Clausius equation and its applications.

IV. Solutions 5 hrs

Liquid-liquid mixtures: Ideal liquid mixtures, Raoult's and Henry's law. Non-ideal system: Azeotropes, HCl-H_2O and ethanol-water systems.

Partially miscible liquids: Phenol-water, trimethylamine-water, nicotine-water systems, immiscible liquids, steam distillation.

Unit III

V. Electrochemistry – I 10 hrs

Electrical transport:- Conduction in metals and in electrolyte solutions, specific conductance molar and equivalent conductance, measurement of equivalent conductance, variation of molar, equivalent and specific conductances with dilution.

Migration of ions and Kohlrausch law, Arrhenius theory of electrolyte dissociation and its limitations. Weak and strong electrolytes. Ostwald's dilution law, its uses and limitations. Debye-Huckel-Onsager equation for strong electrolytes (elementary treatment only). Transport number, definition and determination by Hittorf method and moving boundary method.

Applications of conductivity measurements: Determination of degree of dissociation, determination of K_a of acids, determination of solubility product of a sparingly soluble salt, conductometric titrations.

Unit IV

VI. Electrochemistry – II 10 hrs

Types of reversible electrodes – Gas-metal ion, metal-metal ion, metal-insoluble salt-anion and redox electrodes. Electrode reactions, Nernst equation, derivation of cell EMF and single electrode potential, strandard hydrogen electrode-reference electrodes and their applications, standard electrode potential, sign conventions, electrochemical series and its significance.

Electrolytic and Galvanic cells–Reversible and irreversible cells, conventional representation of electrochemical cells.

EMF of a cell and its measurements. Computation of cell EMF. Calculation of thermodynamic quantities of cell reactions (ΔG, ΔH and K).

Concentration cell with and without transport, liquid junction potential, application of concentration cells, valency of ions, solubility product and activity coefficient, potentiometric titrations.

Definition of pH and pK_a, determination of pH using hydrogen, quinhydrone and glass electrodes by potentiometric methods.

Buffers – Mechanism of buffer action, Henderson-Hazel equation, application of buffer solution. Hydrolysis of salts

VII. Phase Equilibrium 5 hrs

Statement and meaning of the terms-phase, component and degree of freedom, derivation of Gibbs phase rule, phase equilibria of one component system– water, CO_2 and S systems.

Phase equilibria of two component systems – Solid - liquid equilibria, simple eutectic – Bi-Cd, Pb-Ag systems, desilverisation of lead.

Solid solutions – Compound formation with congruent melting point (Mg-Zn) and incongruent melting point ($FeCl_3$-H_2O) and ($CuSO_4$-H_2O) system.

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SECOND YEAR DETAILED SYALLBUS

PAPER 204

PRACTICAL

180 hrs (6 hrs/week)

The duration of practical examination will be of six hours.

Distribution of marks: Total marks 50 will have inorganic gravimetric of 12 marks, volumetric 8 marks, organic expt 10 marks, physical expt 10 marks, record 5 marks and viva of 5 marks.

Inorganic Chemistry

Calibration of fractional weights, pipettes and burettes. Preparation of standards solutions. Dilution – 0.1 M to 0.001 M solutions.

Quantitative Analysis

Volumetric Analysis

(a) Determination of acetic acid in commercial vinegar using NaOH

(b) Determination of alkali content of antacid tablet using HCl

(c) Estimation of calcium content in chalk as calcium oxalate by permanganometry

(d) Estimation of hardness of water by EDTA

(e) Estimation of ferrous and ferric by dichromate method

(f) Estimation of copper using thiosulphate

Gravimetric Analysis

Analysis of Cu as CuSCN, Ni as Ni (dimethylgloxime) and Ba as $BaSO_4$

Organic Chemistry

Systematic Qualitative Organic Analysis

Identification of an organic compound through the functional group analysis, determination of melting point and preparation of suitable derivatives

Laboratory Techniques

A. Thin Layer Chromatography

Determination of Rf values and identification of organic compounds:

(a) Separation of green leaf pigments (spinach leaves may be used)

(b) Preparation of separation of 2,4-dinitrophenylhydrazones of acetone, 2-butanone, hexan-2, and 3-one using toluene and light petroleum (40:60)

(c) Separation of a mixture of dyes using cyclohexane and ethyl acetate (8.5:1.5)

B. Paper Chromatography: Ascending and Circular

Determination of R_f values and identification of organic compounds:

(a) Separation of a mixture of phenylalanine and glycine. Alanine and aspartic acid. Leucine and glutamic acid. Spray reagent – ninhydrin.

(b) Separation of a mixture of D, L – alanine, glycine, and L-leucine using n-butanol:acetic acid:water (4:1:5). Spray reagent – ninhydrin.

(c) Separation of monosaccharides – a mixture of D-galactose and D-fructose using n-butanol:acetone:water (4:5:1). Spray reagent – aniline hydrogen phthalate.

Physical Chemistry

Transition Temperature

1. Determination of the transition temperature of the given substance by thermometric /dialometric method (e.g. $MnCl_2.4H_2O/SrBr_2.2H_2O$)

Phase Equilibrium

2. To study the effect of a solute (e.g. NaCl, succinic acid) on the critical solution temperature of two partially miscible liquids (e.g. phenol-water system) and to determine the concentration of that solute in the given phenol-water system
3. To construct the phase diagram of two component (e.g. diphenylamine – benzophenone) system by cooling curve method

Thermochemistry

1. To determine the solubility of benzoic acid at different temperatures and to determine ΔH of the dissolution process
2. To determine the enthalpy of neutralization of a weak acid/weak base versus strong base/strong acid and determine the enthalpy of ionization of the weak acid/weak base
3. To determine the enthalpy of solution of solid calcium chloride and calculate the lattice energy of calcium chloride from its enthalpy data using Born-Haber cycle

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THIRD YEAR DETAILED SYALLBUS

PAPER 301

Inorganic Chemistry

60 hrs (2 hrs/week)

Unit I

I. Metal-ligand bonding in Transition Metal Complexes 10 hrs

Limitations of valance bond theory, an elementary idea of crystal field theory, crystal field splitting in octahedral, tetrahedral and square planner complexes, factors affecting the crystal-field parameters.

II. Thermodynamic and Kinetic Aspects of Metal Complexes 5 hrs

A brief outline of thermodynamic stability of metal complexes and factors affecting the stability, stability constants of complexes and their determination, substitution reactions of square planar complexes.

Unit II

III. Magnetic Properties of Transition Metal Complexes 7 hrs

Types of magnetic behavior, methods of determining magnetic susceptibility, spin-only formula, L-S coupling, correlation of μ_s and μ_{eff} values, orbital contribution to magnetic moments, application of magnetic moment data for 3d-metal complexes.

IV. Electronic spectra of Transition Metal Complexes 7 hrs

Types of electronic transitions, selection rules for d-d transitions, spectroscopic ground states, spectrochemical series, Orgel-energy level diagram for d^1 and d^9 states, discussion of the electronic spectrum of $[Ti(H_2O)_6]^{3+}$ complex ion.

Unit III

V. Organometallic Chemistry 10 hrs

Definition, nomenclature and classification of organometallic compounds,

Preparation, properties, bonding and applications of alkyls and aryls of Li, Al, Hg, Sn and Ti.

Metal carbonyls: 18-electron rule, preparation, structure and nature of bonding in the mononuclear carbonyls.

VI. Silicones and Phosphazenes 4 hrs

Silicones and phosphazenes as examples of inorganic polymers, nature of bonding in triphosphazenes.

Unit IV

VII. Hard and Soft Acids and Bases (HSAB) 7 hrs

Classification of acids and bases as hard and soft. Pearson's HSAB concept, acid-base strength and hardness and softness. Symbiosis, theoretical basis of hardness and softness, electronegativity and hardness and softness.

VIII. Bioinorganic Chemistry 10 hrs

Essential and trace elements in biological processes, metalloporphyrins with special reference to hemoglobin and myoglobin. Biological role of alkali and alkaline earth metal ions with special reference to Ca^{2+}. Nitrogen fixation.

B.Sc. (CHEMISTRY)

THIRD YEAR DETAILED SYALLBUS

PAPER 302

Organic Chemistry

60 hrs (2 hrs/week)

Unit I

I. Spectroscopy **10 hrs**

Nuclear magnetic resonance (NMR) spectroscopy: Proton magnetic resonance (^{1}H NMR) spectroscopy, nuclear shielding and deshielding, chemical shift and molecular structure, spin-spin splitting and coupling constants, areas of signals, interpretation of ^{1}H NMR spectra of simple organic molecules such as ethyl bromide, ethanol, acetaldehyde, 1,1,2-tribromoethane, ethyl acetate, toluene and acetophenone.

Problems pertaining to the structures elucidation of simple organic compounds using UV, IR and ^{1}H NMR spectroscopic techniques.

Unit II

II. Organometallic Compounds **4 hrs**

Organomagnesium compounds: The Grignard reagents– Formation, structure and chemical reactions.

Organozinc compounds: Formation and chemical reactions.

Organolithium compounds: Formation and chemical reactions.

III. Organosulphur Compounds **4 hrs**

Nomenclature, structural features, methods of formation and chemical reactions of thiols, thioethers, sulphonic acids, sulphonamides and sulphaguanidine.

IV. Hetrocyclic Compounds **8 hrs**

Introduction: Molecular orbital picture and aromatic characteristics of pyrrole, furan, thiophene and pyridine. Methods of synthesis and chemical reactions with particular emphasis on the mechanism of electrophilic substitution. Mechanism of nucleophilic substitution reaction in pyridine derivatives. Comparison of basicity of pyridine, piperidine and pyrrole.

Introduction to condensed five and six-membered heterocycles. Preparation and reactions of indole, quinoline and isoquinoline with special reference to Fisher indole synthesis, Skraup synthesis and Bischler-Napieralski synthesis. Mechanism of electrophilc substitution reactions of indole, quinoline and isoquinoline.

Unit III

V. Carbohydrates 8 hrs

Classification and nomenclature. Monosaccharides, mechanism of osazone formation, interconversion of glucose and fructose, chain lengthening and chain shortening of aldoses. Configuration of monosaccharides. Erythro and threo diastereomers. Conversion of glucose into mannose. Formation of glycosides, ethers and esters. Determination of ring size of monosaccharides. Cyclic structure of D(+)-glucose. Mechanism of mutarotation.

Structures of ribose and deoxyribose.

An introduction to disaccharides (maltose, sucrose and lactose) and polysaccharides (starch and cellulose) without involving structure determination.

VI. Amino Acids, Peptides, Proteins and Nucleic Acids 6 hrs

Classification, structure and stereochemistry of amino acids. Acid-base behavior, isoelectric point and electrophoresis. Preparation and reactions of α-amino acids. Structure and nomenclature of peptides and proteins. Classification of proteins. Peptide structure determination, end group analysis, selective hydrolysis of peptides. Classical peptide synthesis, solid-phase peptide synthesis. Structures of peptides and proteins. Levels of protein structure. Protein denaturation/ renaturation.

Nucleic acids: Introduction. Constituents of nucleic acids. Ribonucleosides and ribonucleotides. The double helical structure of DNA.

Unit IV

VII. Fats, Oils and Detergents 2 hrs

Natural fats, edible and industrial oils of vegetable origin, common fatty acids, glycerides, hydrogenation of unsaturated oils. Saponification value, iodine value, acid value. Soaps, synthetic detergents, alkyl and aryl sulphonates.

VIII. Synthetic Polymers 4 hrs

Addition or chain-growth polymerization. Free radical vinyl polymerization, ionic vinyl polymerization, Ziegler-Natta polymerization and vinyl polymers.

Condensation or step growth polymerization. Polyesters, plyamides, phenol formaldehyde resins, urea formaldehyde resins, epoxy resins and polyurethanes. Natural and synthetic rubbers. Elementary idea of organic conducting polymers.

IX. Synthetic Dyes 8 hrs

Colour and constitution (electronic concept). Classification of dyes. Chemistry and synthesis of Methyl orange, Congo red, Malachite green, Crystal violet, Phenolphthalein, Fluorescein, Alizarin and Indigo.

X. Organic Synthesis via Enolates 6 hrs

Acidity of α-hydrogens, alkylation of diethyl malonate and ethyl acetoacetate. Synthesis of ethyl acetoacetate: the Claisen condensation. Keto-enol tautomerism of ethyl acetoacetate.

Alkylation of 1, 3-dithianes. Alkylation and acylation of enamines.

B.Sc. (CHEMISTRY)

THIRD YEAR DETAILED SYALLBUS

PAPER 303

Physical Chemistry

60 hrs (2 hrs/week)

Unit I

I. Elementary Quantum Mechanics 15 hrs

Black-body radiation, Planck's radiation law, photoelectric effect, heat capacity of solids, Bohr's model of hydrogen atom (no derivation) and its defects, Compton effect. de-Broglie hypothesis. Heisenberg uncertainty principle. Hamiltonian Operator.

Schrödinger wave equation (time dependent and time independent) and its importance, physical interpretation of the wave function, postulates of quantum mechanics, particle in a one dimensional box.

Schrödinger wave equation for H-atom, separation into three equations (without derivation), quantum numbers and their importance, hydrogen like wave functions, radial wave functions, angular wave functions.

Molecular orbital theory, basic ideas – Criteria for forming MO from AO, construction of MO by LCAO – H_2^+ ion, calculation of energy levels from wave functions, physical picture of bonding and anti-bonding wave functions, concept of σ, σ^*, π, π^* orbitals and their characteristics. Hybrid orbitals – sp, sp^2, sp^3; calculation of coefficients of atomic orbitals used in sp and sp^2 hybrid orbitals and interpretation of geometry.

Introduction to valence bond model of H_2, comparison of MO and VB models.

Unit II

II. Spectroscopy 15 hrs

Introduction: Electromagnetic radiation, regions of the spectrum, basic features of different spectrometers, statement of the Born-Oppenheimer approximation, degrees of freedom.

Rotational Spectrum

Diatomic molecules. Energy levels of a rigid rotor (semi-classical principles), selection rules, spectral intensity, distribution using population distribution (Maxwell-Boltzmann distribution) determination of bond length, qualitative description of non-rigid rotor, isotope effect.

Vibrational Spectrum

Infrared Spectrum: Energy levels of simple harmonic oscillator, selection rules, pure vibrational spectrum, intensity, determination of force constant and qualitative relation of force constant and bond energies, effect of anharmonic motion and isotope on the spectrum, idea of vibrational frequencies of different functional groups.

Raman spectrum: Concept of polarizability, pure rotational and pure vibrational Raman spectra of diatomic molecules, selection rules.

Electronic Spectrum

Concept of potential energy curves for bonding and antibonding molecular orbitals, qualitative description of selection rules and Franck-Condon principle.

Qualitative description of σ, π and η MO, their energy levels and the respective transition.

Unit III

III. Physical Properties and Molecular Structure 7.5 hrs

Optical activity, polarization – (Clausius-Mossotti equation), orientation of dipoles in an electric field, dipole moment, induced dipole moment, measurement of dipole moment-temperature method and refractivity method, dipole moment and structure of molecules, magnetic properties-paramagnetism, diamagnetism and ferromagnetism, Magnetic susceptibility, its measurements and its importance.

IV. Photochemistry 7.5 hrs

Interaction of radiation with matter, difference between thermal and photochemical processes. Laws of photochemistry: Grothus-Drapper law, Stark-Einstein law, Jablonski diagram depicting various processes occurring in the excited state, qualitative description of fluorescence, phosphorescence, non-radiative processes (internal conversion, intersystem crossing), quantum yield, photosensitized reactions – energy transfer processes (simple examples), kinetics of photochemical reaction.

Unit IV

V. Solutions, Dilute Solutions and Colligative Properties 15 hrs

Ideal and non-ideal solutions, methods of expressing concentrations of solutions, activity and activity coefficient.

Dilute solution, colligative properties, Raoult's law, relative lowering of vapour pressure, molecular weight determination. Osmosis, law of osmotic pressure and its measurement, determination of molecular weight from osmotic pressure. Elevation of boiling point and depression of freezing point. Thermodynamic derivation of relation between molecular weight and elevation in boiling point and depression in freezing point. Experimental methods for determining various colligative properties.

Abnormal molar mass, van't Hoff factor, colligative properties, degree of dissociation and association of solutes.

B.Sc. (CHEMISTRY)

THIRD YEAR DETAILED SYALLBUS

PAPER 304

PRACTICAL

180 hrs (6 hrs/week)

The duration of practical examination will be of six hours. MM = 50

Distribution of marks: One inorganic experiment of 10 marks, one instrumentation experiment of 10 marks, one organic experiment of 10 marks and one physical experiment of 10 marks will be given in the annual practical examination. 5 marks are for record and 5 marks are for viva.

Inorganic Chemistry

Synthesis and Analysis

(a) Preparation of sodium trioxalatoferrate(III), $Na_3[Fe(C_2O_4)_3]$ and determination of its composition by permanganometry
(b) Preparation of Ni-dmg complex, $[Ni(dmg)_2]$
(c) Preparation of copper tetraammine complex. $[(Cu(NH_3)_4]SO_4$
(d) Preparation of *cis*-and *trans*-bisoxalatodiaquochromate(III) ion.

Instrumentation

Colorimetry

(a) Job's method (b) Mole-ratio method
(c) Adulteration of food stuffs (d) Effluent analysis, water analysis

Solvent Extraction

Separation and estimation of Mg(II) and Fe(II)

Ion Exchange Method

Separation and estimation of Mg(II) and Zn(II)

Organic Chemistry

Qualitative Analysis

Analysis of an organic mixture containing two solid components using water, $NaHCO_3$, NaOH for separation and preparation of suitable derivatives

Synthesis of Organic Compounds

(a) Acetylation of salicylic acid, aniline, glucose and hydroquinone. Benzoylation of aniline and phenol

(b) Aliphatic electrophlic substitution
Preparation of iodoform from ethanol and acetone

(c) Aromatic electrophilic substitution
Nitration
Preparation of m-dinitrobenzene
Preparation of p-nitroacetanilide
Halogenation
Preparation of p-bromoacetanilide
Preparation of 2,4,6-tribromophenol

(d) Diazotization/coupling
Preparation of methyl orange and methyl red

(e) Oxidation
Preparation of benzoic acid from toluene

(f) Reduction
Preparation of aniline from nitrobenzene
Preparation of m-nitroaniline from m-dinitrobenzene

Laboratory Techniques

Steam Distillation

Naphtalene from its suspension in water
Clove oil from cloves
Separation of *o*- and *p*-nitrophenols

Column Chromatography

Separation of fluorescein and methylene blue
Separation of leaf pigments from spinach leaves
Resolution of racemic mixture of (±) mandelic acid

Stereo-chemical Study of Organic Compounds via Models

R and S configuration of optical isomers
E, Z configuration of geometrical isomers
Coformational analysis of cyclohexanes and substituted cyclohexanes

Physical Chemistry

Electrochemistry

1. To determine the strength of the given acid conductometrically using standard alkali solution
2. To determine the solubility and solubility product of a sparingly soluble electrolyte conducometrically

3. To study the saponification of ethyl acetate condutometrically.
4. To determine the ionization constant of a weak acid condutometrically.
5. To titrate potentiometrically the given ferrous ammonium sulphate solution using $KMnO_4/K_2Cr_2O_7$ as titrant and calculate the redox potential of Fe^{2+}/Fe^{3+} system on the hydrogen scale

Refractrometry, Polarimetry

1. To verify law of refraction of mixtures (e.g. of glycerol and water) using Abbe's refractometer
2. To determine the specific rotation of a given optically active compound
3. To determine stoichiometry and stability constant of complexes

Molecular Weight Determination

1. Determination of molecular weight of a non-volatile solute by Rast method/ Beckmann freezing point method
2. Determination of the apparent degree of dissociation of an electrolyte (e.g. NaCl) in aqueous solution at different concentrations by ebullioscopy

Colorimetry

To verify Beer-Lambert law for $KMnO_4/K_2Cr_2O_7$ and determine the concentration of the given solution of the substance from absorbance measurement

Books Suggested for Theory Courses

1. Basic Inorganic Chemistry, F A Cotton, G Wilkinson and P L Gaus, Wiley
2. Concise Inorganic Chemistry, J D Lee, ELBS
3. Concepts of Models of Inorganic Chemistry, B Douglas, D McDaniel and J Alexander, John Wiley
4. Inorganic Chemistry, D E Shriver, P W Atkins and C H Langford, Oxford
5. Inorganic Chemistry, W W Porterfield Addition, Wesley
6. Inorganic Chemistry, A G Sharpe, ELBS
7. Inorganic Chemistry, G L Miessler and D A Tarr, Prentice Hall
8. Organic Chemistry, Morrison and Boyd, Prentice Hall
9. Organic Chemistry, L G Wade Jr, Prentice Hall
10. Fundamentals of Organic Chemistry, Solomons, John Wiley
11. Organic Chemistry, Vol. I, II & III, S M Mukherji, S P Singh and R P Kapoor, Wiley Eastern Ltd (New Age International)
12. Organic Chemistry, F A Carey, McGraw-Hill, Inc
13. Introduction to Organic Chemistry, Streitwieser, Heathcock and Kosover, Macmilan
14. Physical Chemistry, G M Barrow, International Student Edition, McGraw Hill
15. Basic Programming with Application, V K Jain, Tata McGraw Hill
16. Computers and Common Sense, R Hunt and Shelly, Prentice Hall
17. University General Chemistry, C N R Rao, Macmillan

18. Physical Chemistry, R A Alberty, Wiley Eastern Ltd

19. The Elements of Physical Chemistry, P W Atkins, Oxford

20. Physical Chemistry Through Problems, S K Dogra and S Dogra, Wiley Eastern Ltd

Books Suggested for Practical/Laboratory Courses

1. Vogel's Qualitative Inorganic Analysis, revised, Svehla, Orient Longman

2. Vogel's Textbook of Quantitative Inorganic Analysis, revised, J Bassett, R C Denney, G H Jeffery and J Mendham, ELBS

3. Standard Methods of Chemical Analysis, W W Scott, The Technical Press

4. Experimental Inorganic Chemistry, W G Palmer, Cambridge

5. Handbook of Preparative Inorganic Chemistry, Vol I & II, Brauer, Academic Press

6. Inorganic Synthesis, McGraw Hill

7. Experimental Organic Chemistry, Vol I & II, P R Singh, D S Gupta and K S Bajpai, Tata McGraw Hill

8. Laboratoy Manual in Organic Chemistry, R K Bansal, Wiley Eastern

9. Vogel's Textbook of Practical Organic Analysis, B S Furniss, A J Hannaford, V Rogers, P W G Smith and A R Tatchell, ELBS

10. Experiments in General Chemistry, C N R Rao and U C Agarwal, East-West Press

11. Experiments in Physical Chemistry, R C Das and B Behra, Tata McGraw Hill

12. Advanced Practical Physical Chemistry, J B Yadav, Goel Publishing House

13. Advanced Experimental Chemistry, Vol I – Physical, J N Gurtu and R Kapoor, S Chand & Co.

14. Selected Experiments in Physical Chemistry, N G Mukherjee, J N Ghosh & Sons

15. Experiments in Physical Chemistry, J C Ghosh, Bharati Bhawan