

Lesson plan (2023-24)

Subject - chemistry

Babita Gupta

B.Sc. 1st semester

July 2023

Inorganic chemistry

Atomic Structure

Idea of de Broglie matter waves, Heisenberg uncertainty principle, atomic orbitals, quantum numbers, radial and angular wave functions and probability distribution curves, shapes of s, p, d orbitals

August 2023

Periodic Properties

General principles of periodic table: Aufbau and Pauli exclusion principles, Hund's multiplicity rule. Electronic configurations of the elements, effective nuclear charge, Slater's rules. Atomic and ionic radii, ionization energy, electron affinity and electronegativity –definition, methods of determination or evaluation, trends in periodic table (in s & p block elements).

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 (BeF₂, BF₃, CH₄, PF₅, SF₆, IF₇, SO₂, ClO₄⁻) Valence shell electron pair repulsion (VSEPR) theory to NH₃, H₃O⁺, SF₄, ClF₃, ICl₂⁻ and H₂O. MO theory of heteronuclear (CO and NO) diatomic molecules, bond strength and bond energy, percentage ionic character from dipole moment and electronegativity difference.

Ionic Solids

Ionic structures (NaCl, CsCl, ZnS (Zinc Blende), CaF₂) radius ratio effect and coordination number, limitation of radius ratio rule, lattice defects, semiconductors, lattice energy (mathematical derivation excluded) and Born-Haber cycle, solvation energy and its relation with solubility of ionic solids, polarizing power and polarisability of ions, Fajan's rule.

September 2023

Physical Chemistry

Gaseous States

Maxwell's distribution of velocities and energies (derivation excluded) Calculation of root mean square velocity, average velocity and most probable velocity. Collision diameter, collision number, collision frequency and mean free path. Deviation of Real gases from ideal behaviour. Derivation of Vander Waal's Equation of State, its application in the calculation of Boyle's temperature (compression factor) Explanation of behaviour of real gases using Vander Waal's equation.

Critical Phenomenon:

Critical temperature, Critical pressure, critical volume and their determination. PV isotherms of real gases, continuity of states, the isotherms of Vander Waal's equation, relationship between critical constants and Vander Waal's constants. Critical compressibility factor. The Law of corresponding states. Lequifaction of gases.

October 2023

Liquid States

Structure of liquids. Properties of liquids – surface tension, viscosity vapour pressure and optical rotations and their determination.

Solid State

Classification of solids, Laws of crystallography – (i) Law of constancy of interfacial angles (ii) Law of rationality of indices (iii) Law of symmetry. Symmetry elements of crystals. Definition of unit cell & space lattice. Bravais lattices, crystal system. Xray diffraction by crystals. Derivation of Bragg equation. Determination of crystal structure of NaCl, KCl. Liquid crystals: Difference between solids, liquids and liquid crystals, types of liquid crystals. Applications of liquid crystals.

November 2023

Organic chemistry

1. Structure and Bonding

Localized and delocalized chemical bond, van der Waals interactions, resonance: conditions, resonance effect and its applications, hyperconjugation, inductive effect, Electromeric effect & their comparison.

2. Stereochemistry of Organic Compounds-I Concept of isomerism. Types of isomerism. Optical isomerism, elements of symmetry, molecular chirality, enantiomers, stereogenic centre, optical activity, properties of enantiomers, chiral and achiral molecules with two stereogenic centers, diastereomers, threo and erythro diastereomers, meso compounds, resolution of enantiomers, inversion, retention and racemization.

3. Stereochemistry of Organic Compounds-II Relative and absolute configuration, sequence rules, R & S systems of nomenclature. Geometric isomerism determination of configuration of geometric isomers. E & Z system of nomenclature, Conformational isomerism conformational analysis of ethane and n-butane, conformations of cyclohexane, axial and equatorial bonds, Newman projection and Sawhorse formulae, Difference between configuration and confirmation.

December 2023

4. Mechanism of Organic Reactions

Curved arrow notation, drawing electron movements with arrows, half-headed and double-headed arrows, homolytic and heterolytic bond breaking. Types of reagents electrophiles and nucleophiles. Types of organic reactions. Energy considerations. Reactive intermediates carbocations, carbanions, free radicals, carbenes, arynes and nitrenes (formation, structure & stability).

5. Alkanes and Cycloalkanes

Methods of formation (with special reference to Wurtz reaction, Kolbe reaction, Corey-House reaction and decarboxylation of carboxylic acids), physical properties. Cycloalkanes nomenclature, synthesis of cycloalkanes and their derivatives – photochemical (2+2) cycloaddition reactions, dehalogenation of -dihalides, pyrolysis of calcium or barium salts of dicarboxylic acids, Baeyer's strain theory

B.Sc. 3rd semester

July 2023

Inorganic chemistry

1. Chemistry of Elements of First transition series: Definition of transition elements, position in the periodic table, General characteristics & properties of 1st transition elements, Structures & properties of some compounds of transition elements – TiO_2 , VOCl_2 , FeCl_3 , CuCl_2 and $\text{Ni}(\text{CO})_4$

August 2023

2. Chemistry of Elements of IInd & IIIrd transition series

General characteristics and properties of the IInd and IIIrd transition elements Comparison of properties of 3d elements with 4d & 5d elements with reference only to ionic radii, oxidation state, magnetic and Spectral properties and stereochemistry

3. Coordination Compounds

Werner's coordination theory, effective atomic number concept, chelates, nomenclature of coordination compounds, isomerism in coordination compounds, valence bond theory of transition metal complex

4. Non-aqueous Solvents

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

September 2023

Physical chemistry

1. Thermodynamics-I

Definition of thermodynamic terms: system, surrounding etc. Types of systems, intensive and extensive properties. State and path functions and their differentials. Thermodynamic process.

Concept of heat and work. Zeroth Law of thermodynamics, 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 for ideal gasses and real gas: and inversion temperature.

2. Thermodynamics-II

Calculation of w.q. dU & dH for the expansion of ideal gasses under isothermal and adiabatic conditions for reversible process, Temperature dependence of enthalpy, Kirchoff's equation. Bond energies and applications of bond energies.

October 2023

3. Chemical Equilibrium

Equilibrium constant and free energy, concept of chemical potential, Thermodynamic derivation of law of chemical equilibrium. Temperature dependence of equilibrium constant; Van't Hoff reaction isochore, Van't Hoff reaction isotherm. Le-Chatelier's principle and its applications Clapeyron equation and Clausius – Clapeyron equation its applications.

4. Distribution Law

Nernst distribution law – its thermodynamic derivation, Modification of distribution law when solute undergoes dissociation, association and chemical combination. Applications of distribution law: (i) Determination of degree of hydrolysis and hydrolysis constant of aniline hydrochloride. (ii) Determination of equilibrium

November 2023

Organic chemistry

1. Alcohols

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 [$\text{Pb}(\text{OAc})_4$ and HIO_4] and pinacol-pinacolone rearrangement.

2. Phenols

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, Mechanisms of Fries rearrangement, Claisen rearrangement, Reimer-Tiemann reaction, Kolbe's reaction and Schotten and Baumann reactions.

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

Fieser rules, calculation of max of simple conjugated dienes and , -unsaturated ketones.
Applications of UV Spectroscopy in structure elucidation of simple organic

December 2023

4. Carboxylic Acids & Acid Derivatives Nomenclature of Carboxylic acids, 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. Reduction of carboxylic acids. Mechanism of decarboxylation. Structure , nomenclature and preparation of acid chlorides, esters, amides and acid anhydrides. Relative stability of acyl derivatives. Physical properties, interconversion of acid derivatives .

Bsc 5th semester

July 2023

Inorganic chemistry

1. Metal-ligand Bonding in Transition Metal Complexes

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

August 2023

2. Thermodynamic and Kinetic Aspects of Metal Complexes

A brief outline of thermodynamic stability of metal complexes and factors affecting the stability, substitution reactions of square planar complexes of Pt(II).

3. Magnetic Properties of Transition Metal Complexes

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

4. Electron Spectra of Transition Metal Complexes

Types of electronic transitions, selection rules for d-d transitions, spectroscopic ground states, spectrochemical series. Orgel-energy level diagram for d1 and d9 states, discussion of the electronic spectrum of $[Ti(H_2O)_6]^{3+}$ complex ions.

September 2023

Physical chemistry

1. Quantum Mechanics-I

Black-body radiation, Planck's radiation law, photoelectric effect, heat capacity of solids, Compton effect, wave function and its significance of Postulates of quantum mechanics , quantum mechanical operator, commutation relations, Hamiltonian operator, Hermitian operator, average value of square of Hermitian as a positive quantity, Role of operators in quantum mechanics, To show quantum mechanically that position and momentum cannot be predicated

simultaneously, Determination of wave function & energy of a particle in one dimensional box, Pictorial representation and its significance.

2. Physical Properties and Molecular Structure

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 permeability, magnetic susceptibility and its determination. Application of magnetic susceptibility, magnetic properties – paramagnetism, diamagnetism and ferromagnetism.

October 2023

3. Spectroscopy-I

Introduction: Electromagnetic radiation, regions of spectrum, basic features of spectroscopy, statement of Born-Oppenheimer approximation, Degrees of freedom. Rotational Spectrum Diatomic molecules. Energy levels of rigid rotator (semi-classical principles), selection rules, spectral intensity distribution using population distribution (Maxwell-Boltzmann distribution), determination of bond length, qualitative

4. Spectroscopy-II

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, effects of anharmonic motion and isotopic effect on the spectra., 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, Quantum theory of Raman spectra.

November 2023

Organic chemistry

1. NMR Spectroscopy-I Principle of nuclear magnetic resonance, the PMR spectrum, number of signals, peak areas, equivalent and nonequivalent protons positions of signals and chemical shift, shielding and deshielding of protons, proton counting, splitting of signals and coupling constants, magnetic equivalence of protons.

2. NMR Spectroscopy-II

Discussion of PMR spectra of the molecules: ethyl bromide, n propyl bromide, isopropyl bromide, 1,1-dibromoethane, 1,1,2-tribromoethane, ethanol, acetaldehyde, ethyl acetate, toluene, benzaldehyde and acetophenone.. Simple problems on PMR spectroscopy for structure determination of organic compounds.

3. Carbohydrates-I

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 glucose and fructose. Open chain and cyclic structure of D(+)-glucose & D(-) fructose. Mechanism of mutarotation. Structures of ribose and deoxyribose.

December 2023

4. Carbohydrates-II

An introduction to disaccharides (maltose, sucrose and lactose) and polysaccharides (starch and cellulose) without involving structure determination. Organometallic Compounds Organomagnesium compounds: the Grignard reagents-formation, structure and chemical reactions. Organozinc compounds: formation and chemical reactions.

Even semester

B.sc 2nd semester

January 2024

Inorganic chemistry

1. Hydrogen Bonding & Vander Waals Forces

Hydrogen Bonding – Definition, Types, effects of hydrogen bonding on properties of substances, application Brief discussion of various types of Vander Waals Forces . Metallic Bond and Semiconductors Metallic Bond- Brief introduction to metallic bond, band theory of metallic bond Semiconductors- Introduction, types and applications.

2. s-Block Elements

Comparative study of the elements including , diagonal relationships, salient features of hydrides (methods of preparation excluded), solvation and complexation tendencies including their function in biosystems. Chemistry of Noble Gasses Chemical properties of the noble gasses with emphasis on their low chemical reactivity, chemistry of xenon, structure and bonding of fluorides, oxides & oxyfluorides of xenon.

3. p-Block Elements

Emphasis on comparative study of properties of p-block elements (including diagonal relationship and excluding methods of preparation). Boron family (13th gp): Diborane – properties and structure (as an example of electron – deficient compound and multicentre bonding), Borazene – chemical properties and structure Trihalides of boron Carbon family

February 2024

4. Nitrogen Family (15th group)

Oxides – structures of oxides of N,P. oxyacids – structure and relative acid strengths of oxyacids of Nitrogen and phosphorus. Structure of white, yellow and red phosphorus. Oxygen Family (16th group) Oxyacids of sulfur – structures and acidic strength H₂O₂–structure, properties and uses. Halogen Family

Physical chemistry

1. Kinetics-I

Rate of reaction, rate equation, factors influencing the rate of a reaction concentration, temperature, pressure, solvent, light, catalyst. Order of a reaction, integrated rate expression for zero order, first order, second and third order reaction. Half life period of a reaction. Methods of determination of order of reaction.

2. Kinetics-II

Effect of temperature on the rate of reaction – Arrhenius equation. Theories of reaction rate – Simple collision theory for unimolecular and bimolecular reaction.

3. Electrochemistry-I

Electrolytic conduction, factors affecting electrolytic conduction, specific, conductance, molar conductance, equivalent conductance and relation among them, their variation with concentration. Arrhenius theory of ionization, Ostwald's Dilution Law. Debye-Huckel – Onsager's equation for strong electrolytes. Transport number, definition and determination by Hittorf's methods

March 2024

4. Electrochemistry-II

Kohlrausch's Law, calculation of molar ionic conductance and effect of viscosity temperature & pressure on it. Application of Kohlrausch's Law in calculation of conductance of weak electrolytes at infinite dilution. Applications of conductivity measurements: determination of degree of dissociation, determination of K_a of acids determination of solubility product of sparingly soluble salts, conductometric

Organic chemistry

1. Alkenes

Nomenclature of alkenes, mechanisms of dehydration of alcohols and dehydrohalogenation of alkyl halides, The Saytzeff rule, Hofmann elimination, physical properties and relative stabilities of alkene

2. Arenes and Aromaticity

Nomenclature of benzene derivative: Aromatic nucleus and side chain. Aromaticity: the Huckel rule, aromatic ions, annulenes up to 10 carbon atoms, aromatic, anti-aromatic and non-aromatic compounds. Aromatic electrophilic substitution general pattern of the mechanism, mechanism of nitration, halogenation, sulphonation, and Friedel-Crafts reaction. Energy profile diagrams. Activating, deactivating substituents and orientation.

April 2024

3. Dienes and Alkynes

Structure of butadiene,. Chemical reactions 1,2 and 1,4 additions (Electrophilic & free radical mechanism), 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, hydroborationoxidation of alkynes

4. Alkyl and Aryl Halides

chemical reactions. Mechanisms and stereochemistry of nucleophilic substitution reactions of alkyl halides , SN2 and SN1 reactions with energy profile diagrams. Methods of formation and reactions of aryl halides.

Bsc 4th semester

January 2024

Inorganic chemistry

1. Chemistry of f – block elements Lanthanides Electronic structure, oxidation states and ionic radii and lanthanide contraction, complex formation, occurrence and isolation, lanthanide compounds.

2. Chemistry of f – block elements Actinides General features and chemistry of actinides, chemistry of separation of Np, Pu and Am from U, Comparison of properties of Lanthanides and Actinides and with transition elements .

3. Theory of Qualitative and Quantitative Inorganic Analysis-I

Chemistry of analysis of various acidic radicals, Chemistry of identification of acid radicals in typical combinations.

February 2024

4. Theory of Qualitative and Quantitative Inorganic Analysis-II

Chemistry of analysis of various groups of basic radicals.

Physical chemistry

1. Thermodynamics-III Second law of thermodynamics, need for the law, different statements of the law, Carnot's cycles and its efficiency, Carnot's theorem, Thermodynamics 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, entropy as a criteria of spontaneity and equilibrium. Entropy change in ideal gases and mixing of gasses.

2. Thermodynamics-IV

Third law of thermodynamics: Nernst heat theorem, statement of concept of residual entropy, evaluation of absolute entropy from heat capacity data. Gibbs and Helmholtz functions; Gibbs function (G) and Helmholtz 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.

3. Electrochemistry-III

Electrolytic and Galvanic cells – reversible & Irreversible cells , conventional representation of electrochemical cells. EMF of cell and its measurement, Weston standard cell, activity and activity coefficients. Calculation of thermodynamic quantities of cell reaction (G, H & K). Types of reversible electrodes – metalmetal ion gas electrode, metal –insoluble salt- anion and redox electrodes. Electrode reactions, Nernst equations, derivation of cell EMF and single electrode potential. Standard Hydrogen electrode, reference electrodes, standard electrodes potential, sign conventions, electrochemical series and its applications.

March 2024

4. Electrochemistry-IV

Concentration cells with and without transference, liquid junction potential, application of EMF measurement i.e. valency of ions, solubility product activity

Organic chemistry

1. 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. Applications of IR spectroscopy in structure elucidation of simple organic compounds.

2. Amines

Structure and nomenclature of amines, physical properties. Separation of a mixture of primary, secondary and tertiary amines. Structural features affecting basicity of amines. Preparation of alkyl and aryl amines (reduction of nitro compounds, nitriles, reductive amination of aldehyde and ketonic compounds. Gabriel Phthalimide reaction

April 2024

3. Diazonium Salts

Mechanism of diazotization, structure of benzene diazonium chloride, reduction of diazonium , coupling reaction and its synthetic application.

4. Aldehydes and Ketones

Nomenclature and structure of the carbonyl group. Synthesis of aldehydes and ketones with particular reference to the synthesis of aldehydes from acid chlorides, advantage of oxidation of alcohols with chromium trioxide (Sarett reagent) pyridinium chlorochromate (PCC) and pyridinium dichromate., Physical properties. Comparison of reactivities of aldehydes and ketones. Mechanism of benzoin, aldol, Perkin and Knoevenagel condensations. Condensation with ammonia and its derivatives. Wittig reaction. Mannich reaction. Oxidation of aldehydes, Baeyer–Villiger oxidation of ketones, Cannizzaro reaction. MPV, Clemmensen, Wolff-Kishner

Bsc 6th semester

January 2024

Inorganic chemistry

1. Organometallic Chemistry

Definition, nomenclature and classification of organometallic compounds. Preparation, properties, and bonding of alkyls of Li, Al, Hg, and Sn a brief account of metal-ethylenic complexes, mononuclear carbonyls and the nature of bonding in metal carbonyls.

2. Acids and Bases, HSAB Concept

Arrhenius, Bronsted – Lowry, the Lux – Flood, Solvent system and Lewis concepts of acids & bases, relative strength of acids & bases, Concept of Hard and Soft Acids & Bases. Symbiosis, electronegativity and hardness and softness

3. Bioinorganic Chemistry

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.

February 2024

4. Silicones and Phosphazenes

Silicones and phosphazenes, their preparation, properties, structure and uses

Physical chemistry

1. Spectroscopy-III

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 sigma and pi and n molecular orbital (MO) their energy level and respective transitions.

2. Photochemistry

Interaction of radiation with matter, difference between thermal and photochemical processes. Laws of photochemistry: Grotthus-Draper law, Stark- Einstein law (law of photochemical equivalence) 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).

3. Solutions:

Dilute Solutions and Colligative Properties 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 vapor pressure, molecular weight determination, Osmosis law of osmotic pressure and its measurement, determination of molecular weight from osmotic pressure. Elevation of boiling point.

March 2024

4. Phase Equilibrium

phase component and degree of freedom, thermodynamic derivation of Gibbs phase rule, phase equilibria of one component system –Example – water and Sulphur systems. Phase equilibria of two component systems solid-liquid equilibria, simple eutectic

Organic chemistry

1. Heterocyclic Compounds-I 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 reactions in pyridine derivatives. Comparison of basicity of pyridine, piperidine and pyrrole

2. Heterocyclic Compounds-II 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 electrophilic substitution reactions of, quinoline and isoquinoline.

April 2024

3. Synthetic Polymers

Addition or chain-growth polymerization. Free radical vinyl polymerization, ionic vinyl polymerization, Ziegler-Natta polymerization and vinyl polymers. Condensation or step growth polymerization. Polyesters, polyamides, phenol formaldehyde resins, urea formaldehyde resins, epoxy resins and polyurethanes. Natural and synthetic rubbers.

4. Amino Acids, Peptides & Proteins

Classification of amino acids. Acid-base behavior, isoelectric point and electrophoresis. Preparation 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, solidphase peptide synthesis