JYOTI NIVAS COLLEGE AUTONOMOUS, BANGALORE – 560 095
SYLLABUS FOR 2024 BATCH AND THEREAFTER
Programme: B.Sc.
II Semester
SEP
Chemistry II: Foundation of Chemistry II

Semester: II **Course Code: 24IICH2T**

Chemistry - II **56 Hours**

CREDITS:3

Course Objectives

This course aims to impart to the student, knowledge of:

I. Understanding Core Concepts:

1. Sinusoidal wave equations, time-dependent Schrödinger wave equations, and the postulates of quantum mechanics.
2. Operators (Laplacian, Hamiltonian) and their significance, as well as radial and angular probability distributions.
3. Lattice energy, Born-Haber cycle, valence bond theory, hybridization, VSEPR theory, and molecular orbital theory.
4. Weak interactions and their effects on physical properties.
5. Properties of liquids (viscosity, surface tension), Raoult's law, azeotropic mixtures, distribution law, and colligative properties.
6. The structure, aromaticity, substitution reactions of benzene and its derivatives, nucleophilic substitution, and elimination reactions in alkyl and aryl halides.

II. Analytical Skills:

7. Analyzing Schrödinger's equation for particles in one-dimensional boxes and interpret radial and angular probability distribution curves.
8. Calculating lattice energies, bond lengths, bond angles, and bond energies.
9. Solve numerical problems related to viscosity, surface tension, and molecular mass determination.
10. Interpreting energy profile diagrams for substitution and elimination reactions, and analyze the effects of substituents on reactivity and orientation.

III. Practical Applications:

11. Using quantum mechanics and chemical bonding theories to solve real-world problems, predict molecular shapes, and understand physical properties.
12. Applying concepts like Raoult's law, distribution law, and colligative properties to practical scenarios such as distillation and solvent extraction.

IV. **Critical Thinking:**

13. Evaluating the significance of ψ and ψ^2, compare photophysical and photochemical processes, and analyze the behavior of ideal and non-ideal solutions.
14. Critically analyzing the mechanisms of aromatic electrophilic and nucleophilic substitutions, and the influence of different factors on substitution and elimination reactions.

Course Specific Outcomes:

After the completion of this course, the student would be able to:

1. Grasp sinusoidal wave equations, time-dependent Schrödinger wave equations, and the postulates of quantum mechanics.
2. Understand operators (Laplacian, Hamiltonian) and their significance, as well as radial and angular probability distributions.
3. Learn about lattice energy, Born-Haber cycle, valence bond theory, hybridization, VSEPR theory, and molecular orbital theory.
4. Comprehend weak interactions and their effects on physical properties.
5. Understand properties of liquids (viscosity, surface tension), Raoult’s law, azeotropic mixtures, distribution law, and colligative properties.
6. Understand the structure, aromaticity, substitution reactions of benzene and its derivatives, nucleophilic substitution, and elimination reactions in alkyl and aryl halides.
7. Analyze Schrödinger's equation for particles in one-dimensional boxes and interpret radial and angular probability distribution curves.
8. Calculate lattice energies, bond lengths, bond angles, and bond energies.
9. Solve numerical problems related to viscosity, surface tension, and molecular mass determination.
10. Interpret energy profile diagrams for substitution and elimination reactions, and analyze the effects of substituents on reactivity and orientation.
11. Use quantum mechanics and chemical bonding theories to solve real-world problems, predict molecular shapes, and understand physical properties.
12. Apply concepts like Raoult’s law, distribution law, and colligative properties to practical scenarios such as distillation and solvent extraction.
13. Evaluate the significance of ψ and ψ^2, compare photophysical and photochemical processes, and analyze the behavior of ideal and non-ideal solutions.
14. Critically analyze the mechanisms of aromatic electrophilic and nucleophilic substitutions, and the influence of different factors on substitution and elimination reactions.

CO No.	Course outcomes statement	Knowledge level
1.	Grasp sinusoidal wave equations, time-dependent Schrödinger wave equations, and the postulates of quantum mechanics.	K1, K2
2.	Understand operators (Laplacian, Hamiltonian) and their significance, as well as radial and angular probability distributions.	K1, K2

3.	Learn about lattice energy, Born-Haber cycle, valence bond theory, hybridization, VSEPR theory, and molecular orbital theory.	K1, K2
4.	Comprehend weak interactions and their effects on physical properties.	K1, K2
5.	Understand properties of liquids (viscosity, surface tension), Raoult's law, azeotropic mixtures, distribution law, and colligative properties.	K1, K2
6.	Understand the structure, aromaticity, substitution reactions of benzene and its derivatives, nucleophilic substitution, and elimination reactions in alkyl and aryl halides.	K1, K2
7.	Analyze Schrödinger's equation for particles in one-dimensional boxes and interpret radial and angular probability distribution curves.	K3, K4
8.	Calculate lattice energies, bond lengths, bond angles, and bond energies.	K3, K4
9.	Solve numerical problems related to viscosity, surface tension, and molecular mass determination.	K1, K2,K3, K4
10.	Interpret energy profile diagrams for substitution and elimination reactions, and analyze the effects of substituents on reactivity and orientation.	K3,K4
11.	Use quantum mechanics and chemical bonding theories to solve real-world problems, predict molecular shapes, and understand physical properties.	K3, K4
12.	Apply concepts like Raoult's law, distribution law, and colligative properties to practical scenarios such as distillation and solvent extraction.	K3
13.	Evaluate the significance of ψ and ψ^2, compare photophysical and photochemical processes, and analyze the behavior of ideal and non-ideal solutions.	K3,K4,K5
14.	Critically analyze the mechanisms of aromatic electrophilic and nucleophilic substitutions, and the influence of different factors on substitution and elimination reactions.	K3, K4, K5, K6

K1 – Remember, K2 – Understand, K3 – Apply, K4 – Analyze, K5 – Evaluate, K6 – Create

Mapping of COs with POs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	✓	✓								✓
CO 2	✓	✓								✓
CO 3	✓	✓								✓
CO 4	✓	✓								✓

CO 5	✓	✓								✓
CO 6	✓	✓								✓
CO 7	✓	✓		✓			✓		✓	✓
CO 8	✓	✓		✓			✓		✓	✓
CO 9	✓	✓		✓			✓		✓	✓
CO10	✓	✓		✓			✓		✓	✓
CO11	✓	✓		✓			✓		✓	✓
CO12	✓	✓		✓			✓		✓	✓
CO13	✓	✓		✓			✓		✓	✓
CO14	✓	✓	✓	✓			✓		✓	✓

Programme Objectives aligned with Graduate attributes

PO1- Knowledge

PO2- Scientific thinking

PO3- Entrepreneurial skills

PO4- Analytical skills

PO5- Communication skills

PO6- Social commitment

PO7- Research and Inquiry

PO8- Conservation of Environment

PO9- Employability

PO10- Academic orientation

Syllabus

Chemistry II: Foundation of Chemistry II

Semester: II **Course Code: 24IICH2T**
Chemistry - II **56 Hours**
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Unit I **14 Hours**

Chapter 1.1 Quantum Mechanics **9 Hours**

Sinusoidal wave equation; Derivation of time-dependent Schrodinger wave equation. Postulates of quantum mechanics.

Concept of operators – definition, basic operations and properties of operators, Hermitian condition and its significance. Significance of: (i) Laplacian operator, (ii) Hamiltonian operator, and (iii) Eigen values and Eigen functions. Significance of ψ and ψ^2. Application of Schrodinger equation to the (i) particle in a one-dimensional box.

Qualitative description of radial probability distribution and angular probability distribution curves. Definition and difference between an orbit and an orbital. Nodes or nodal planes. Shapes of s, p and d orbitals.

Chapter 1.2 Photochemistry **5 Hours**

Laws of photochemistry. Grotthus-Draper law, Stark-Einstein law – Statements, differences between photophysical and photochemical processes- any four differences with examples.

Comparison of photochemical and thermal reactions with an example of each. Quantum yield- definition, Magnitude of Quantum yield of the photochemical combination of (i) H_2 and Cl_2 (ii) H_2 and Br_2 (iii) dissociation of HI (iv) dimerisation of anthracene: the reason for low, high and medium quantum yields.

Photosensitisation-definition with example, photostationary equilibrium – definition and example.

Singlet and triplet states – definitions. Fluorescence, phosphorescence, luminescence, bioluminescence and chemical sensors – definitions of all these with suitable examples. Jablonski diagram.

Beer-Lambert's law-statement and its application in colorimetric estimations. Numerical problems on absorption coefficient and molar extinction coefficient.

Unit II **14 Hours**

Chapter 2.1 Chemical Bonding **14 Hours**

Ionic bond: Lattice energy: definition and significance. Born-Haber cycle for NaCl and MgO. Born - Lande equation (derivation not required, problems on Born-Lande expression to be worked out). Calculation of lattice energies of NaCl and MgO, effect of lattice energy on solubility of ionic compounds.

Covalent bond: Valence bond approach- postulates of valence bond theory. Hybridisation-definition and directional characteristics of sp, sp2, sp3, sp2d, sp3d2. Formation and Shapes of $BeCl_2$, BF_3, $SiCl_4$, PCl_5 and SF_6.

VSEPR theory: statement. Examples with reference to shapes of CH_4, NH_3, NH_4^+, H_2O, BrF_3 and ICl_2^- .

Molecular orbital theory: (bond order, stability and magnetic properties to be discussed). Polarisation concept: Fajan's rules -statement, explanation with examples, bond length, bond angle and bond energy - definitions. Polar and non-polar molecules- examples. Dipole moment-definition, unit, examples with zero and definite dipole moment values.

Weak interactions: (i) Hydrogen bond: Intra-molecular and Inter-molecular types, examples. Anomalous properties of HF, H_2O, NH_3 and alcohols, carboxylic acids, nitrophenols and biomolecules (ii) van-der Waal's forces: Noble gases and molecular crystals (dry ice, iodine and solid SO_2).

Metallic bond: Band theory, electrical properties of metals, semiconductors and insulators.

Unit III 14 Hours

Chapter 3.1 Liquids and Solutions 9 Hours

Properties of liquids: Viscosity–definition, co-efficient of viscosity, mathematical expression, factors affecting viscosity-effect of temperature, size, weight, shape of molecules and intermolecular forces on it. Surface tension-Definition, mathematical expression, effect of temperature and solute on surface tension. Numerical problems on viscosity and surface tension by drop number method.

Liquid Mixture: Review of Raoult's law of dilute solutions, ideal and non-ideal solutions. Completely miscible liquids - theory of fractional distillation of binary liquids with diagram. T-C curves for all the three types, azeotropic mixtures -examples.

Partially miscible liquids: Critical solution temperature-definitions with any one example for each type - explanations with curves (three types). Effect of addition of salt on CST of phenol-water system. Immiscible liquids, examples. Theory of Steam distillation with derivation for the expression of ratio proportion of liquid mixtures and its applications.

Distribution law: Statement, partition coefficient and condition for validity of distribution of distribution law. Application-solvent extraction (no derivation)

Dilute solutions: Review of colligative properties. Determination of molecular mass of a solute by (i) Berkeley-Hartley's method (ΔTb) (ii) Beckmann's method (ΔT_f) and (iii) Landsberger's method. Numerical problems on determination of molar mass. Abnormal molar mass, van't Hoff factor i and its significance.

Chapter 3.2 Surface Chemistry 5 Hours

Theories of adsorption: Adsorption isotherms- Freundlich adsorption isotherm – equation and limitations. Langmuir adsorption isotherm and BET equation (derivation not included).

Adsorption indicators: definition and examples. Surface film on liquids-different types.

Catalysis: Types and theories with examples (intermediate compound theory and adsorption theory). Heterogeneous catalysis: surface reactions, unimolecular, bimolecular surface reactions. pH dependence of rate constant of catalysed reactions. Autocatalysis with examples.

Unit IV 14 Hours

Chapter 4.1 Aromatic hydrocarbons 8 Hours

Review: Nomenclature, structure of benzene - using molecular orbital theory.

Criteria for aromaticity- Huckel's rule. (examples: cyclopentadienyl anion, cycloheptatrienyl cation, benzene, naphthalene, anthracene and phenanthrene). Anti-aromaticity: definition. General mechanism of aromatic electrophilic substitution.

Review: Mechanism of nitration of benzene

Aromatic electrophilic substitution: Evidence for the formation of nitronium ion, energy profile diagram and isotopic effect. Effect of substituent on reactivity and orientation in second substitution - Orienting influence of substituents in toluene, chlorobenzene, nitrobenzene and phenol towards electrophilic substitution reactions.

Aromatic nucleophilic substitution: Ipso substitution - Ex: conversion of 2,4-dinitrochlorobenzne to 2,4-dinitrophenylhydrazine. Birch reduction - statement with an example.

Oxidation of naphthalene to phthalic acid, phthalic anhydride and 1,4-napthaquinone. Anthracene to anthraquinone and phenanthrene to phenanthraquinone.

Alkenyl benzenes: Styrene, cis- and trans-stilbenes - structures and their preparations. Biphenyl: Preparation by Ullmann reaction.

Chapter 4.2 Organic halogen compounds 6 Hours

Alkyl halides: Nomenclature. Nucleophilic substitution reactions - S_N1 and S_N2 mechanisms with energy profile diagrams. Effect of (i) nature of alkyl groups (ii) nature of leaving groups, (iii) nucleophiles and (iv) solvents on S_N1 and S_N2 mechanisms. Elimination reactions - E1 and E2 mechanisms; substitution vs elimination. Hofmann and Saytzeff eliminations-explanation with mechanism.

Aryl halides: Preparation by halogenation. Relative reactivity of alkyl, allyl, vinyl, aryl and aralkyl halides towards nucleophilic substitution.

References: Recommended Books

1. Puri B R, Shama L R and Kalia L, Principles of Inorganic Chemistry, 33rd Edition, 2020, Vishal Publishing Co..
2. Lee J D, Concise Inorganic Chemistry, 5th Edition, 2008, Blackwell – Wiley India Edition, Wiley Publishing.
3. Weller M, Overton T, Rourke J, Armstrong F, Shriver and Atkin's Inorganic Chemistry, International Edition, 2018, Oxford.
4. Puri B R, Sharma L R, Pathania M S, Principles of Physical Chemistry, 44th Edition, 2018, Vishal Publishing Co.
5. dePaula J, Keller J, Atkin's Physical Chemistry, International Edition, 2018, Oxford.
6. Bahl A, Bahl B S, Tuli G D, Essentials of Physical Chemistry, 28th Edition, 2020, S Chand Publications.
7. Barrow G M, Physical Chemistry, 5th Edition, 2019, SIE Publications.
8. Morrisson R T, Boyd R N, Bhattacharjee S K, Organic Chemistry, Morrisson, 7th Edition, 2010, Pearson Publications.
9. Solomon T W G, Fryhle C B, Snyder S A, Solomon's Organic Chemistry, Global Edition, 2017, Wiley Publishing.
10. Clayden J, Greeves N, Organic Chemistry, 2nd Edition, 2014, Oxford.
11. Holler F J, Crouch S R, Skoog and West's Fundamentals of Analytical Chemistry, 9th Edition, 2014, Cenage Learning.
12. Harris D C, Quantitative Chemical Analysis, 9th Edition, 2015, W H Freeman and Co.