JYOTI NIVAS COLLEGE AUTONOMOUS, BANGALORE – 560 095
Programme: B.Sc.
I Semester
SEP
CHEMISTRY - I
Foundation of Chemistry I

CREDITS: 3 **NO. OF HOURS: 56**
Course Code: 24ICH1T

Course Objectives

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

I. Understanding Core Concepts:

1. Foundational theories in atomic structure, quantum mechanics, periodic trends, and organic chemistry nomenclature.
2. Key Principles in stoichiometry, gaseous states, and analytical methods.

II. Analytical Skills:

3. Derivation and solving problems related to atomic and molecular structures, stoichiometry, and gas laws.
4. Calculations for significant figures, oxidation numbers, and volumetric analysis.

III. Practical Applications:

5. Periodic properties to predict and explain chemical behavior.
6. Chromatographic techniques and volumetric analysis in laboratory settings.
7. Laboratory safety protocols and proper handling of hazardous materials.

IV. Critical Thinking:

8. The limitations of classical mechanics and the implications of modern quantum theory.
9. Stability and reactivity of various chemical species, including hydrocarbons and elements in the periodic table.

Course Specific Outcomes:

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

I. Understand Core Concepts:

- CO1. Master foundational theories in atomic structure, quantum mechanics, periodic trends, and organic chemistry nomenclature.
- CO2. Grasp key principles in stoichiometry, gaseous states, and analytical methods.

II. Showcase Analytical Skills:

- CO3. Develop skills to derive and solve problems related to atomic and molecular structures, stoichiometry, and gas laws.
- CO4. Perform calculations for significant figures, oxidation numbers, and volumetric analysis.

III. Possess Practical Applications:

- CO5. Apply periodic properties to predict and explain chemical behavior.
- CO6. Utilize chromatographic techniques and volumetric analysis in laboratory settings.
- CO7. Implement laboratory safety protocols and proper handling of hazardous materials.

IV. Develop Critical Thinking:

- CO8. Analyze and evaluate the limitations of classical mechanics and the implications of modern quantum theory.
- CO9. Compare the stability and reactivity of various chemical species, including hydrocarbons and elements in the periodic table.

CO No.	Course outcomes statement	Knowledge level
1.	Master foundational theories in atomic structure, quantum mechanics, periodic trends, and organic chemistry nomenclature.	K1, K2, K3
2.	Grasp key principles in stoichiometry, gaseous states, and analytical methods.	K1, K2, K3
3.	Develop skills to derive and solve problems related to atomic and molecular structures, stoichiometry, and gas laws.	K1, K2, K3
4.	Perform calculations for significant figures, oxidation numbers, and volumetric analysis.	K1, K2, K3
5.	Apply periodic properties to predict and explain chemical behavior.	K2, K3
6.	Utilize chromatographic techniques and volumetric analysis in laboratory settings.	K3, K4, K5
7.	Implement laboratory safety protocols and proper handling of hazardous materials.	K2, K3, K4
8.	Analyze and evaluate the limitations of classical mechanics and the implications of modern quantum theory.	K3, K4, K5
9.	Compare the stability and reactivity of various chemical species, including hydrocarbons and elements in the periodic table.	K1, K2,K3, K4

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	✓	✓		✓			✓			✓

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

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Unit I **14 Hours**
Chapter 1.1 Atomic Structure **5 Hours**
Review: Bohr's atomic model, Wave-particle duality - de Broglie equation, Heisenberg uncertainty principle, Hund's rule of maximum multiplicity, Pauli exclusion principle and Aufbau principle. Qualitative description of quantum numbers (n, l, m and s) and their relationship
Derivation of energy, radius and ionisation energy for hydrogen and hydrogen like species based on Bohr's model. Numerical problems. Limitations of classical mechanics – blackbody radiation and photoelectric effect. Electronic configuration (Elements up to Z = 30), stability of half-filled and completely filled orbitals. Relative energies of atomic orbitals, the concept of exchange energy, anomalous electronic configurations (Cr and Cu).
Chapter 1.2 Periodic Table and Periodic Properties **9 Hours**
Review: Modern periodic table (concerning the classification of elements based on outer electronic configuration)
Periodic properties: Periodic trends in <u>*atomic and ionic radii (Self Study Component)*</u>, ionisation energy - Factors affecting the values of ionisation energy, electron affinity and electro negativity - determination of electronegativity by Pauling's method, factors determining electronegativity. Applications of electronegativity in predicting and explaining chemical behaviour - reactivity and reducing power.
<u>*Diagonal relationship and its influence on the properties of beryllium and aluminium (Self Study Component)*</u>
Chemistry of Elements: Comparative study of elements of alkali (Group I) and alkaline earth metals (Group II), Halides, oxides and carbonates of alkali and alkaline earth metals. Chalcogens (Group XVI) and halogens (Group XVII) with respect to electronic configuration, atomic and ionic radii, ionisation energy and electronegativity. Hydrides of chalcogens and halogens - comparative study of all these with respect to their reactivity.
Unit II **14 Hours**
Chapter 2.1 Introduction to Analytical Methods **2 Hours**
Review: Significant figures- definition, rules for computing significant figures and their computations with an example.
Errors - Classification- determinate and indeterminate – Gaussian distribution, minimisation of determinate errors, accuracy and precision.
Basic Laboratory Safety: PPE, GHS symbols and hazard types, SDS – importance and examples (HCl and NH_3)
Chapter 2.2 Stoichiometry **2 Hours**
Equivalent weights of acids-definition, examples for a monobasic and a dibasic acid, Equivalent weights of bases-definition, sodium hydroxide and barium hydroxide as examples, Equivalent weights of salts-definition with sodium carbonate as an example, Methods of expressing concentration of solutions in terms of normality and molarity and their definitions. Numerical problems.
Chapter 2.3 Oxidation numbers **2 Hours**
Definition, rules, and calculation of oxidation numbers of elements in molecules and ions. Balancing of redox reactions by ion-electron method. Equivalent weights of oxidising and reducing agents definitions - potassium dichromate, potassium permanganate, and ferrous ammonium sulphate.

Chapter 2.4 Gaseous State **8 Hours**

Maxwell-Boltzmann distribution law, the mathematical expression for both mole and molecule – explanation of the terms only. Explanation of velocity distribution curves based on this law (no derivation). Mean free path, collision frequency and collision number. Definition and expressions using SI units (no derivations). Derivation of expression for most probable speed from Maxwell-Boltzmann equation. Definitions and expressions for rms velocity and average velocity (no derivations) and their relationships. Problems with most probable velocity, rms velocity and average velocity. Andrew's isotherm on carbon dioxide and explanation of the curves (no experimental details). Derivation of critical constants T_c, P_c and V_c from van der Waal's equation and their experimental determination by Cagniard de La Tour method for T_c and P_c. Amagat's mean density method for V_c. Problems on calculating T_c, P_c and V_c, a and b. Law of corresponding states, statements, reduced equation of state and explanation. Joule-Thomson effect: Statement with explanation. Joule-Thomson coefficient, inversion temperature definition (no derivation). Application of Joule-Thomson effect to the liquefaction of air and hydrogen by Linde's process.

Unit III **14 Hours**

Chapter 3.1 Volumetric Analysis **4 Hours**

Introduction – quantitative analysis. Principle of volumetric analysis, primary standards. Types of titration – neutralisation, redox, complexometric and precipitation, with an example of each. A brief account of indicators in neutralisation titrations, types of complexometric titrations and different types of argentometric titrations.

Chapter 3.2 Chromatography **10 Hours**

General description, definition, terms and parameters used in chromatography, classification of chromatographic methods, criteria for selection of stationary and mobile phases and nature of adsorbents.

Column chromatography: Principle - Column efficiency, factors affecting the column efficiency, van Deemter's equation and its modern version. Paper chromatography: Principle and applications.

Thin layer chromatography: Principle, Mechanism, Rf value, efficiency of TLC plates, methodology–selection of stationary and mobile phases, plate development, spray reagents, identification of analytes, qualitative applications.

Ion exchange chromatography: Principle resins, types with examples- cation exchange and anion exchange resins, mechanism of cation and anion exchange process and applications of ion-exchange chromatography (softening of hard water, separation of lanthanides, industrial applications).

Unit IV **14 Hours**

Chapter 4.1 Basic Concepts in Organic Chemistry **5 Hours**

Review: Nomenclature of monofunctional organic compounds.

Bond cleavage - Homolytic and heterolytic - Explanation with examples for each type. Types of reagents: Electrophilic and nucleophilic reagents-meaning, examples for each type. Reactive intermediates - generation and relative stabilities of carbocation, carbanion, carbon free radicals and carbenes - explanation for relative stability and reactivity based on inductive, resonance and hyperconjugation effects. Introduction to benzyne – stability based on Huckel's rule of aromaticity and generation of benzyne with mechanism.

Types of reactions: addition, substitution and elimination-explanation examples for each type of reaction.

Chapter 4.2 Hydrocarbons **9 Hours**

Alkanes: Sources, Nomenclature of branched chain alkanes, preparation of symmetrical and unsymmetrical alkanes: Corey- House reaction and Wurtz reaction - their merits and demerits. Conformational analysis of ethane and n-butane, Sawhorse and Newman projection formulae to be used -Energy profile diagram.

Cycloalkanes: Nomenclature. Methods of preparation from (1) dichloropropane, (2) cyclopentanone, (3) benzene. Explanation for stability based on heat of hydrogenation data.

Baeyer's strain theory and its limitations, Sachse - Mohr theory of strainless rings; cyclopropane ring - banana bonds.
Alkenes: Preparation of alkenes by Wittig reaction. Addition of HX to unsymmetrical alkene - Markownikov's rule and anti-Markownikov's addition with mechanisms. Reactions: Hydroboration - oxidation, reduction, oxymercuration - demercuration, epoxidation- general reactions, with an example of ethene (or propene). Oxidation with $KMnO_4$ and OsO_4 without mechanism. Ozonolysis- mechanism and its importance.
Dienes: Classification- isolated, conjugated, cumulated-one example for each type. Structure of allene and butadiene.1,2-addition and 1,4 addition reactions. Diels Alder reaction: 1,3-butadiene with maleic anhydride as an example.
Alkynes: Methods of preparation: dehydrohalogenation of vicinal and germinal dihalides and higher alkynes from terminal alkynes. Reactions-Birch reduction and its significance. Oxidation with $KMnO_4$, acidic nature of terminal alkynes with example of reaction with ammoniacal solutions of silver nitrate and cuprous chloride.

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. Norman R O C, Coxon J M, Principles of Organic Synthesis, 3rd Edition, 2017, C R C Press.
12. Mendham J, Denny R C, Barnes J D, Thomas M, Sivasankar B, Vogel's Textbook of Quantitative Chemical Analysis, 6th Edition, 2009, Pearson.