ST JOSEPH'S UNIVERSITY
Bengaluru-27

Syllabus for

B.Sc.Chemistry

I- II Semesters

2024-25

Department of Chemistry
School of Chemical Sciences
St Joseph's University
Bengaluru-560 027

Structure of the chemistry course for I-VI semesters of BSc degree

The B.Sc. degree course is a three-year program divided into six semesters. Each semester will consist of 14 weeks of instruction for theory and 11 weeks of instruction for practicals. In Chemistry there will be 10 discipline core papers and 10 practical papers from I to VI semesters. For theory papers, internal assessment (CIA) is given 40% weightage and end semester examination (SE) is given 60% weightage. The practical internal assessment (PIA) is given 60% weightage, and the end semester practical examination is given 40% weightage. The CIA is based on written tests, seminars, assignments, quiz etc. End semester theory examination is for 2 hours duration (60 marks) and practical examination is for 3 hours duration (20 marks).

Semester	Code number	Title of the paper	No. of hours of instruction	No. of hours of teaching per week	Continuous internal assessment (CIA)	End semester marks	Total marks
I	CH124	Chemistry I	45	**3**	**40**	**60**	**100**
	CH1P1	Practical I	44	**3**	**30**	**20**	**50**
II	CH224	Chemistry II	45	**3**	**40**	**60**	**100**
	CH2P1	Practical II	44	**3**	**30**	**20**	**50**
III	CH325	Chemistry III	45	**3**	**40**	**60**	**100**
	CH3P1	Practical III	44	**3**	**30**	**20**	**50**
IV	CH425	Chemistry IV	45	**3**	**40**	**60**	**100**
	CH4P1	Practical IV	44	**3**	**30**	**20**	**50**
V	CH5126	Chemistry V-1	45	**3**	**40**	**60**	**100**
	CH5P1	Practical V-1	44	**3**	**30**	**20**	**50**
	CH5226	Chemistry V-2	45	**3**	**40**	**60**	**100**
	CH5P2	Practical V-2	44	**3**	**30**	**20**	**50**
	CH5326	Chemistry V-3	45	**3**	**40**	**60**	**100**
	CH5P3	Practical V-3	44	**3**	**30**	**20**	**50**
VI	CH6126	Chemistry VI-1	45	**3**	**40**	**40**	**100**
	CH6P1	Practical VI-1	44	**3**	**30**	**30**	**50**
	CH6226	Chemistry VI-2	45	**3**	**40**	**40**	**100**
	CH6P2	Practical VI-2	44	**3**	**30**	**30**	**50**
	CH6326	Chemistry VI-3	45	**3**	**40**	**40**	**100**
	CH6P3	Practical VI-3	44	**3**	**30**	**30**	**50**

Summary of credits for I-VI semesters

Semester	Code number	Title of the paper	No. of hours of teaching per week	Credit
I	CH124 CH1P1	Chemistry I Practical I	3 3	3 2
II	CH224 CH2P1	Chemistry II Practical II	3 3	3 2
III	CH325 CH3P1	Chemistry III Practical III	3 3	3 2
IV	CH425 CH4P1	Chemistry IV Practical IV	3 3	3 2
V	CH5126 CH5P1 CH5226 CH5P2 CH5326 CH5P3	Chemistry V-1 Practical V-1 Chemistry V-2 Practical V-2 Chemistry V-3 Practical V-3	3 3 3 3 3 3	3 2 3 2 3 2
VI	CH6126 CH6P1 CH6226 CH6P2 CH6326 CH6P3	Chemistry VI-1 Practical VI-1 Chemistry VI-2 Practical VI-2 Chemistry VI-3 Practical VI-3	3 3 3 3 3 3	3 2 3 2 3 2

Name of the Degree Program	B.Sc.
Discipline Core	Chemistry
Total Credits for the Program	128

Assessment: Weightage for assessments (in percentage)

Type of Course	Formative Assessment / IA	Summative Assessment
Theory	40	60
Practical	60	40

<u>SEP Syllabus: B.Sc. Chemistry – 1st Semester</u>

I SEMESTER THEORY (CH 124)

Semester	**I**
Paper code	**CH 124**
Paper title	**Chemistry I**
Number of teaching hours per week	**3**
Total number of teaching hours per semester	**45**
Number of credits	**3**

Note: 1. Text underlined, bold and in italics corresponds to self-study.
2. Text within parentheses and italics correspond to recall/review.

ANALYTICAL CHEMISTRY **3 hours**

Errors and treatment of analytical data: Errors - determinate and Indeterminate errors, replicate and outlier data points. Precision and accuracy; ways of expressing accuracy - absolute error, relative error; minimization of errors. Statistical treatment of random errors; mean, median, range, standard deviation and variance.

STOICHIOMETRY **2+1 hours**

(Atomic mass, gram atomic mass, molar mass, formula mass)

Avogadro number, mole concept and chemical equations. Concept of limiting reagents.

PERIODIC TABLE **4+2 hours**

General electronic configurations of s, p, d and f block elements and position of elements in the long form of periodic table. Atomic radius: covalent, metallic and van der Waal's radii, ionic radii. Effective nuclear charge (qualitative treatment); periodic trends in atomic radii; comparison of ionic radii of isoelectronic ions. Ionisation energy and electron affinity – periodic trends; factors affecting ionisation energy and electron affinity, ***successive ionisation energies***. Electronegativity- Pauling scale (only final equation), calculation of electronegativity, ***periodic trends***.

ATOMIC STRUCTURE **12+2 hours**

(Historical development of atomic structure, failure of classical mechanics in the study of subatomic particles: Black body radiation, Photoelectric effect).

de Broglie relation and Heisenberg's uncertainty principle. Thought experiment to understand uncertainty principle. Introduction to the principles of quantum (wave) mechanics: Operators - definition, quantum mechanical operators for position, momentum and energy; eigen functions and eigen values.

Schrödinger equation; Born interpretation of wave function (significance of ψ^2); postulates of quantum mechanics. Quantum mechanical treatment of particle in one- dimensional box: Derivation of expressions for energy and normalized wave functions of a particle in 1D box; energy level diagram. Energy expression for a particle in 3D box (no derivation); degeneracy in a cubic box.

Qualitative explanation of the emergence of quantum numbers and their significance; radial and angular components of the wave functions; radial distribution functions of s and p orbitals.

Shapes of s, p and d orbitals. Polyelectron atoms: electron spin and spin quantum number, (n+l) rule, Pauli's exclusion principle, Aufbau principle, Hund's rule, electronic configuration of atoms (Z = 1 to 30).

Exchange energy, pairing energy, promotional energy; symmetric distribution of electrons in atomic orbitals; prediction of the stable electronic configuration in p and d orbitals.

CHEMICAL BONDING- I **10+2 hours**

Covalent bonding: octet rule, Lewis structures of molecules and ions (when provided with sequence of atoms), formal charge calculation for different atoms in molecules/ions. ***Deviation from octet rule***. Valence bond treatment of hydrogen molecule: qualitative discussion of wave functions, concept of resonance.

Molecular structure: bond length, bond angle, dihedral angle and molecular geometry. Overlapping of atomic orbitals, σ and π bonds.

Hybridisation: sp (BeF_2), sp^2 (BF_3), sp^3 (SiF_4, H_2O, NH_3), sp^3d (PCl_5), sp^3d^2 (SF_6); examples of inorganic molecules (AB_n and AB_nL_m type) with and without π-bonds.

VSEPR theory: application to AB_n and AB_nL_m type molecules/ions (A = s or p block element; n ≤ 7).

Molecular orbital (MO) treatment of hydrogen molecule: linear combination of atomic orbitals, bonding and antibonding orbitals, energy level diagram. MO energy level diagram of homonuclear diatomic molecules and ions (Z ≤ 9): bond order and magnetic behaviour of these molecules and ions, correlation of bond order with bond length and bond strength. MO energy level diagram of heteronuclear diatomic molecules – HF and CO.

Metallic bonding: band theory (qualitative), ***classification of solids into conductors, insulators and semiconductors based on band theory***.

INTRODUCTION TO ORGANIC CHEMISTRY- I **5+2 hours**

Structural formulae: Dash, condensed and bond-line formulae. IUPAC nomenclature of monofunctional and bifunctional organic compounds. ***Radical functional nomenclature, trivial names and structures of common organic compounds***. Resonance theory, curved arrows in resonance structures, rules for writing resonance structures, resonance contribution. ***Concept of hybridisation: sp^3, sp^2, sp;*** **the structure and bond lengths of methane, ethane, ethene and ethyne.**

Physical properties and molecular structures of organic compounds, ionic compounds: ion–ion forces, intermolecular forces (van der Waals forces), boiling points.

References:

1. Principles of Inorganic Chemistry; B. R. Puri; L. R. Sharma and K. C. Kalia; 33rd Edition, Vishal Publishing Co., 2020.
2. Concise Inorganic Chemistry; J. D. Lee; 5th Edition, John Wiley and Sons Ltd; 2014.
3. Chemistry; R. Chang: 10th Edition, McGraw Hill Education India; 2022.
4. Principles of Physical Chemistry; B. R. Puri; L. R. Sharma and M. B. Pathania, 48th Edition, Vishal Publishing Co., 2021.
5. Atkins' Physical Chemistry; P. Atkins and J. Paula; 11th Edition, Oxford University Press, 2018.
6. Physical Chemistry for Chemical and Biological Sciences: Raymond Chang; 1st Indian Edition, Viva Books Pvt. Ltd., 2015.
7. Organic Chemistry; Graham Solomons, C. Fryhle, S. Snyder, 12th Edition, Wiley, 2017.
8. Organic Chemistry; P. Y Bruice, 8th Edition, Pearson Education India, 2020.

Learning Outcomes: At the end of the course, the student should be able to

LO1	Knowledge	**Recall** the concepts of atomic structure, periodic table of elements, chemical bonding in molecules, concepts of stoichiometry and list the types of hybridisations, VSEPR principles, MO theory fundamentals, types of errors, rules for writing electronic configuration, naming organic compounds. **Identify** the different types of orbital overlap: end-to-end (forming sigma bonds) and side-to-side, name the different blocks and families of elements, examples of molecules exhibiting each type of hybridization. **State** the basic principles of VSEPR theory **Define** key concepts in Molecular Orbital (MO) theory, the Octet Rule, bond length, bond angle, dihedral angle.
LO2	Understand	**Explain** the relationship between molecular structure and physical properties, concepts, laws concerning atoms, molecules, atomic structure, chemical bonding, periodic table, stoichiometry, hybridisation concepts, VSEPR theory, and MO theory. **Describe** the process of hybridisation and its significance in determining molecular geometry. **Illustrate** the energy level diagrams of homonuclear diatomic molecules/ions ($Z \leq 9$) and heteronuclear diatomic molecules – HF and CO. **Outline** the differences between conductors, semiconductors and insulators based on band theory.
LO3	Apply	**Apply** the bonding theories in predicting structure, bonding and magnetic properties of molecules, laws and relationships to real chemical systems and compute properties. IUPAC rules to name simple and complex organic compounds, draw Lewis structures for common ions, including polyatomic ions like NH_4^+, SO_4^{2-}, and NO_3^-, draw resonance structures for given molecules. **Calculate** formal charges for atoms within a molecule or ion, empirical and molecular formulas, **Predict** the shapes of molecules based on their hybridisation states, the behaviour of solids as conductors, semiconductors and insulators based on band theory

		Construct MO energy level diagrams for simple diatomic molecules like H_2. **Interpret** the bond order and magnetic behaviour of homonuclear diatomic molecules/ions ($Z \leq 9$) from molecular energy level diagrams. **Relate** bond order with bond length and bond strength.
LO4	Analyse	**Validate** the quality of analytical data using statistical methods **Compare** different resonance structures of a molecule or ion, using formal charges. Compare the molecular geometries of different molecules based on their hybridisation states. **Analyse** the influence of lone pairs versus bonding pairs on predicting molecular shape, the impact of functional groups on reactivity and properties, the effects of resonance on molecular stability and reactivity. **Evaluate** the bond length and magnetic properties of molecules/ ions based on bond order. **Examine** the chances of forming/ stability of a diatomic molecule/ion based on MOT.
LO5	Evaluate	**Predict** stable electronic configuration in p and d orbitals with the help of various energy terms **Construct** molecular shapes using hybridisation concepts for complex molecules and molecular energy level diagrams for homonuclear diatomic molecules/ions (Z: 10-16).
LO6	Create	**Place** hitherto unknown element in the periodic table and predict its physical and chemical properties. **Judge** the effectiveness and limitations of VSEPR and molecular orbital theories in explaining molecular structures and properties. **Justify** the formation of certain molecules like NO, that cannot be successfully explained by either the Lewis electron-pair approach or valence bond theory, on the basis of MOT. **Assess** the bond orders and stability of homonuclear diatomic molecules/ions (Z: 10-16).

I SEMESTER PRACTICALS (CH 1P1)

Semester	**I**
Paper code	**CH 1P1**
Paper title	**Chemistry Practical I**
Number of Lab hrs per week	**3**
Total number of Lab hrs per semester	**33**
Number of credits	**2**

List of Experiments

1. Volumetric calibrations and statistical treatment of data.

2. Estimation of sodium hydroxide using hydrochloric acid.

3. Estimation of sodium hydroxide using potassium hydrogen phthalate.

4. Estimation of potassium permanganate using oxalic acid.

5. Estimation of iron (II) using potassium dichromate by internal indicator method.

6. Estimation of sodium carbonate and sodium bicarbonate in a given mixture.

7-10. RBPT experiments.

11. Demonstration of an auto-titrator during one of the RBPT sessions.

12. Viva/repetition.

Learning Outcomes: At the end of the course, the student should be able to

LO1	Knowledge	**Recall** the mole concept and define errors, accuracy, precision and significant figures. Calculate standard deviation and relate these to the concept of volumetric analysis. **Define** key terms related to volumetric titrations (e.g., titrant, analyte, equivalence point). **List** common indicators used in titrations.
LO2	Understand	**Compare** various ways of expressing concentration and explain the differences in them. **Explain** the principle and significance of volumetric titrations.
LO3	Apply	**Identify** the number of significant figures and solve numerical problems based on mole concept and chemical equations. **Calculate** the concentration of an unknown solution from titration data.
LO4	Analyse	**Apply** the theoretical concepts to develop experimental skills in carrying out volumetric analysis independently and draw inference/suggest a solution. Differentiate between types of titrations (e.g., acid-base, redox).
LO5	Create	**Propose** a research problem based on volumetric analysis, design an experiment and develop a method, discuss in a group and improvise the methodology, carryout independent work and create a personalized mode of presentation of results
LO6	Evaluate	**Assess** the accuracy and precision of titration results. Assess the errors in and calibrate the glassware used for experiments and estimate the amount of chemical substance present in a solution of unknown concentration.

SEP Syllabus: B.Sc Chemistry – 2nd Semester

II SEMESTER THEORY (CH 224)

Semester	**II**
Paper code	**CH 224**
Paper title	**Chemistry II**
Number of teaching hours per week	**3**
Total number of teaching hours per semester	**45**
Number of credits	**3**

Note: 1. Text underlined, bold and in italics corresponds to self-study.
2. Text within parentheses and italics correspond to recall/review.

ACIDS, BASES AND SOLVENTS **5+1 hours**

Theories of acids and bases: Lowry - Brønsted concept, conjugate acid-base pairs, amphiprotic substances, relative strengths of acid-base pairs, solvent system concept of acids and bases, examples. Lewis concept - types of molecules or species that can act as Lewis acids and Lewis bases, Pearson's Hard and Soft Acid - Base concept. Characteristics of hard and soft acids and bases, HSAB principle and applications - stability of complexes, prediction of coordination in complexes of ambidentate ligands, predicting feasibility of a reaction, prediction of hardness and softness. Solvent properties - liquid range, dielectric constant, solvent polarity, classification of solvents. Protic solvents – autoionisation of protic solvents (H_2O, liq. NH_3). Aprotic solvents – classification with examples. Levelling effect of solvents - explanation, levelling solvents and differentiating solvents. Liquid NH_3 - autoionisation, acid-base reactions, solvation, solvolysis (comparison with H_2O in each case)**.** ***Solutions of alkali metals in liquid***

ammonia. Advantages and disadvantages of liq. NH_3 solvent. Liquid SO_2 as solvent - autoionisation and acid base reactions. Anhydrous HF - autoionisation, acid-base reactions.

CHEMICAL BONDING - II **3+1 hours**

Ionic bonding - lattice energy, explanation of melting point of simple ionic solids based on lattice energy. Born - Lande equation (no derivation). Born-Haber cycle for NaCl, ***KBr, KI***, MgO, $CaCl_2$. Covalent character of ionic bonds - polarisation and polarizability, Fajan's rules. Partial ionic character of covalent bonds, calculation based on Pauling electronegativity concept, dipole moment.

THE FIRST LAW OF THERMODYNAMICS **7+2 hours**

Introduction - terminology in thermodynamics - phase, system and surroundings. Types of systems - open, closed and isolated systems; homogeneous and heterogeneous systems, macroscopic properties. State of a system, state variable, extensive and intensive properties, thermodynamic equilibrium. Thermodynamic processes - isothermal, adiabatic, isochoric, isobaric and cyclic. Reversible, irreversible and spontaneous processes. Concept of heat and work, sign convention. State functions and path functions, exact and inexact differentials. Internal energy, first law of thermodynamics - statement and mathematical form. Enthalpy of a system, heat capacity, relation between C_p and C_v. Expression for first law of thermodynamics for isothermal, adiabatic, isochoric and cyclic processes. Work done in i) reversible expansion and compression, ***ii) irreversible isothermal expansion and compression of an ideal gas.*** Zeroth law and absolute temperature scale. Kirchoff's law-statement (no derivation).

GASEOUS STATE **3+1 hours**

The behaviour of real gases: Deviation from ideal gas behaviour. Compressibility factor (Z) and its variation with pressure for different gases. Causes of deviation from ideal behaviour, van der Waals equation of state (no derivation). Critical phenomena – Andrew's isotherms of CO_2, critical constants and their relation with van der Waals constant (no derivation). Joule-Thomson effect. Inversion temperature, application of Joule-Thomson effect.

LIQUID STATE AND LIQUID MIXTURES 5+1 hours

Viscosity, coefficient of viscosity and surface tension of a liquid: definition. Variation of effect of temperature and solute in viscosity and surface tension of a liquid. ***Raoult's law, mathematical formulation***. Vapour pressure curves of ideal and type I solutions, non-ideal solutions and completely miscible liquids. Boiling point - composition curves of completely miscible liquids. Determination of molar mass using elevation in boiling point. Fractional distillation of binary liquid mixtures. Type II and Type III azeotropic mixtures (minimum boiling and maximum boiling azeotropes, e.g. water-ethanol and HCl-H_2O). Solubility of partially miscible liquid pairs; Critical solution temperature (CST), upper critical solution temperature (UCST): phenol-H_2O system, lower critical solution temperature (LCST): triethylamine-H_2O system; lower CST and upper CST: nicotine-H_2O system. Effect of impurity on CST. ***Immiscible liquid pairs: Nernst distribution law, effect of association and dissociation of solute on distribution (derivation).***

INTRODUCTION TO ORGANIC CHEMISTRY - II 6+2 hours

Electronic displacements: Inductive effect, electromeric effect and hyperconjugation, (*resonance)*. Hückel's rule, aromatic, antiaromatic and nonaromatic species with examples. Strengths of organic acid and bases: Comparative study with emphasis on factors affecting pK_a values. Relative strength of aliphatic and aromatic carboxylic acids - acetic acid and chloroacetic acid, ***acetic acid and propionic acid, acetic acid and benzoic acid***. Relative strengths of ammonia, aliphatic and aromatic amines. Types of bond cleavages - homolytic and heterolytic cleavages; reaction intermediates - carbocations, carbanions and free radicals; generation, structure and stability. ***Types of reagents - electrophiles, nucleophiles.*** Types of organic reactions - substitution, addition, elimination and rearrangement: examples.

ALKANES AND CYCLOALKANES **7+1 hours**

<u>Alkanes: Classification of carbon and hydrogen atoms in hydrocarbons. Physical properties of alkanes and cycloalkanes</u>. Nomenclature of monocyclic cycloalkanes. Sigma bonds and bond rotation, meaning of conformations, Newman and Sawhorse projections. Conformational analysis of ethane and butane. Relative stabilities and ring strain of cyclopropane, cyclobutane and cyclopentane. Chair and boat conformations of cyclohexane and substituted cyclohexanes: axial and equatorial hydrogens. Conformational analysis of methyl cyclohexane, 1,3 - diaxial interactions of *tert*-butyl group.

References:

1. Principles of Inorganic Chemistry; B. R. Puri; L. R. Sharma and K. C. Kalia; 33^{rd} Edition, Vishal Publishing Co., 2020.
2. Principles of Physical Chemistry; B. R. Puri; L. R. Sharma and M. S. Pathania, 48^{th} Edition, Vishal Publishing Co., 2021.
3. Atkins' Physical Chemistry; P. Atkins and J. Paula; 11^{th} Edition, Oxford University Press, 2018.
4. Chemical Thermodynamics: Classical, Statistical and Irreversible; J. Rajaram and J. C. Kuriacose; 1^{st} Edition, Pearson Education India, 2013.
5. Physical Chemistry through Problems; S. K. Dogra and S. Dogra; 2^{nd} Edition, New Age International (P) Ltd. Publishers, 2015.
6. Physical Chemistry for Chemical and Biological Sciences: R. Chang; 1^{st} Indian Edition, Viva Books Pvt. Ltd., 2015.
7. Thermodynamics for Chemists, S.Glasstone, EWP, 2008.
8. Organic Chemistry; G. Solomons, C. Fryhle, S. Snyder, 12^{th} Edition, Wiley, 2017.
9. Organic Chemistry; P. Bruice, 8^{th} Edition, Pearson Education India, 2020.
10. Organic Chemistry; B. Mehta and M. Mehta, 2^{nd} Edition, PHI Learning private limited, 2021.
11. Organic Chemistry; Jr. L. G. Wade, J. Simek, M Singh, 9^{th} Edition, Pearson Education India, 2019.
12. Organic Chemistry, J. Clayden, N. Greeves and S. Warren, 2^{nd} Edition, Oxford University Press, 2014.

Learning Outcomes: At the end of the course, the student should be able to

LO1	Knowledge	**Define** macroscopic properties, state variable, extensive and intensive properties, types of systems (open, closed, isolated), Inductive effect, electromeric effect, hyperconjugation, aromatic, antiaromatic and nonaromatic species with examples, homolytic and heterolytic cleavages; reaction intermediates- carbocations, carbanions and free radicals, electrophiles, nucleophiles, and conformations, Inversion temperature, lattice energy **Draw** the structures to represent Newmann and Sawhorse conformations of alkane and cycloalkane. **Recognize** and list the type of electronic displacements in organic molecules, cycloalkane from the nomenclature, the concept of ideal gases and real gases, meaning of ionic bonding **Draw** the structures to represent the electronic displacements, Newmann and Sawhorse conformations, draw resonance/canonical structures for the given molecule, Andrew's isotherms of CO_2, Born-Haber cycle for NaCl, MgO, $CaCl_2$ **State** HSAB principle, First law of thermodynamics, Zeroth law, Kirchoff's law, Raoult's law, Nernst Distribution law. van der Waals equation of state, Joule-Thomson effect, Born-Lande equation, Hückel's rule **List** the characteristics of hard and soft acids and bases, protic and aprotic solvents, the factors affecting the strengths of acids and bases, types of bond cleavage, types of organic reactions, classes of bonded hydrogen atoms, the criteria for the validity of Nernst distribution law, macroscopic properties of the system **Define** Lowry-Brønsted acids and bases, levelling effect of solvents, 'conformations' surface tension, viscosity, coefficient of viscosity, critical solution temperature **Recall** Raoult's law **Identify** Type I, Type II and Type III azeotropic mixtures, state variables **Explain** Type I azeotropic mixture, Type II azeotropic mixture, Type III azeotropic mixture, surface tension of a

		liquid, the effect of solute on the surface tension of a liquid, the effect of temperature on surface tension of a liquid, the effect of temperature on the viscosity of a liquid, the effect of solute on the viscosity of a liquid, the various thermodynamic processes: isothermal, adiabatic, isochoric and cyclic, the concept of heat and work with sign conventions, thermodynamic equilibrium, the relationship between C_p and C_v
LO2	Understand	**Discuss** the solvent system concept of acids and bases, thermodynamic processes, the factors influencing pK_a, the difference between Type I and Type II azeotropic mixtures; the difference between Type II and Type III azeotropic mixtures; the difference between Type I and Type III azeotropic mixtures; the difference between the lower CST and upper CST, causes of deviation of real gases from ideal behaviour, critical constants and their relation with van der Waals constant, applications of Joule-Thomson effect, explanation of melting point of simple ionic solids based on lattice energy **Describe** the relationship between the concentration of phenol in water and CST, the relationship between the concentration of nicotine in water and CST **Predict** the molecule as aromatic, antiaromatic or non-aromatic, predict the product of the reaction based on the type of organic reaction, variation of real gases with pressure **Classify** state functions and path functions, the types of solvents, the types of reactions, types of carbons and hydrogens **Interpret** the mechanism behind how the Type I, Type II and Type III azeotropic mixture plots vary with each other. **Compare** the properties of protic and aprotic solvents, the strengths of organic acids and bases, relative stability of conformations of alkanes and cycloalkanes, ideal and real gases based on their behaviour under different conditions, melting point of different ionic solids **Distinguish** reversible and irreversible processes, electrophiles and nucleophiles, axial and equatorial bonds, exact and inexact differentials, state function and path function, reversible and irreversible processes.

		Understand the relationship between size, shape, mass of molecules with the viscosity of the liquid, the relationship between temperature and viscosity, the relationship between temperature and surface tension **Outline** the concept of lower CST; upper CST; azeotropic mixtures
LO3	Application	**Apply** HSAB principle to predict the stability of complexes, Kirchoff's law to solve problems in thermodynamics, Hückel's rule to cyclic organic molecules, pK_a to order the strengths of acids and base, the data of surface tension values to understand the nature of the liquid the date of viscosity to understand the nature of the liquid, Joule-Thomson effect to different gases, Born-Lande equation to calculate lattice energy of different ionic solids zeroth law to find the absolute temperature scale **Examine** the correctness of electronic displacements and the resultant structures, the relationship between internal energy and enthalpy, the behaviour of different gases under variable pressure conditions **Sketch** the energy profile diagram of conformations of ethane, butane and cycloalkanes **Select** the hard and soft acids and bases from a given list, the electrophiles and nucleophiles from a list of reagents, the most acidic and basic compound, the most stable conformation of the given alkane and cyclohexane **Predict** the feasibility of a reaction using HSAB concept, the stable conformer in the presence of a bulky group, lattice energy of different ionic solids **Relate** C_p and C_v, the stability of cycloalkanes to ring strain, stability of conformations of cyclohexane to the presence of a bulky group and position of the group
LO4	Analysis	**Analyse** work done in irreversible expansion and compression of an ideal gas, reversible isothermal expansion and compression of an ideal gas. Acid-base reactions, the conformational analysis of ethane, butane and cyclohexane, the effect of the presence of bulky groups on the stability of the conformational structure, the deviation of real gases from ideal behaviour, total energy associated with formation of ionic solid based on Born-Haber cycle

		Interpret the nature of the azeotropic mixture by analysing a given plot
LO5	Create/Synthesis	**Construct** energy profile diagram of the given alkane, Andrew's isotherms of given gas, Born-Haber cycle for given ionic solid **Design** a reaction to obtain a certain intermediate for a product from a given compound. **Modify** the pK_a value of a given organic acid by fine tuning the substitutions
LO6	Evaluate	**Evaluate** the reasons for relative acid and base strength, stability of specific conformations of ethane, butane and substituted cyclohexane, the cause of deviation of real gases from ideal behaviour, melting point behaviour of different ionic solids, the effectiveness of the first law of thermodynamics in real world systems **Assess** the behaviour of an aromatic, anti-aromatic and a non-aromatic compound, steric hindrance by methyl and *t*-butyl groups, the behaviour of any gas under given conditions of temperature and pressure, accuracy of the thermodynamic calculations to experiments

II SEMESTER PRACTICALS (CH 2P1)

Semester	**II**
Paper code	**CH 2P1**
Paper title	**Chemistry Practical II**
Number of Lab hrs per week	**3**
Total number of Lab hrs per semester	**33**
Number of credits	**2**

List of experiments

1. Demonstration on mixing behavior of liquids and separation of liquids using their boiling points.
2. Determination of density using specific gravity bottle and viscosity of liquids using Ostwald's viscometer.
3. Determination of the density using specific gravity bottle and surface tension of liquids using stalagmometer.
4. Determination of partition/distribution coefficient of acetic acid in water and butanol.
5. Determination of composition of sucrose solution by viscosity method using Ostwald's viscometer.
6. Determination of CST of phenol- water system.
7. Determination of molar mass of an electrolyte by elevation in boiling point method.
8. Determination of percentage composition of sodium chloride solution by miscibility temperature measurements of phenol – water system.
9. Determination of transition temperature of a salt hydrate by thermometric method.
10. Recrystallisation of organic compounds and determination of purity by melting point.
11. Estimation of purity of aspirin.
12. Repetition/viva.

References

1. Principles of Physical Chemistry, B. R. Puri; L R Sharma and M. S. Pathania, 48th Edition, Vishal Publishing Co., 2021.
2. Physical Chemistry laboratory manual: an interdisciplinary approach, A. Anand, R. Kumari, I. K. International Pvt Ltd.,2019.
3. Experiments in Physical Chemistry, C. W. Garland, J. W. Nibler, D. P. Shoemaker, 8th Edition; McGraw-Hill: New York, 2003.
4. Experimental Physical Chemistry, A. M. Halpern, and G. C. McBane, 3rd Edition; W.H. Freeman and Co.:New York, 2003.

Learning Objective	Cognitive Level	At the end of the semester, the student should be able to
LO1	Knowledge	**Define** surface tension, viscosity, coefficient of viscosity, critical solution temperature, partition coefficient **Recognize** the formation of homogeneous and heterogeneous mixtures, miscible and partially miscible liquids, the conditions under which Nernst distribution law is valid. **State** Nernst distribution law **Identify** the factors affecting the mixing of liquids , viscosity iii) surface tension, recystallisation of solids, CST, partition coefficient
LO2	Understand	**Discuss** the concept of miscibility and immiscibility in liquids, how impurities affect the boiling point of liquids, the difference between the lower CST and upper CST **Interpret** phase behaviour of the phenol-water system with varying concentrations of sodium chloride **Understand** method of using a stalagmometer to determine the surface tension of liquids the relationship between temperature and viscosity, the relationship between temperature and surface tension how to use a specific gravity bottle to measure the density of liquids accurately, the concept of partition coefficient, the concept of a) lower CST; b) upper CST, concept of transition temperature in salt hydrates , relationship between purity and melting point, phase transitions, concept of colligative properties
LO3	Application	**Examine** the composition of a solute in a solution using miscibility temperature measurements, behaviour and properties of binary mixtures, recrystallization conditions to maximize yield and purity **Sketch** temperature-composition graphs, temperature vs. time graphs to determine to determine the transition temperature, viscosity versus concentration graphs

		Relate partition coefficient distribution of a solute between two immiscible solvents, density of liquids with viscosity, miscibility and CST
LO4	Analysis	**Analyse** the relationship between density and viscosity in different liquids, factors affecting surface tension and its implications in various chemical processes , the phase behavior of the phenol-water system, the data to calculate the molar mass and understand its significance in solution chemistry, the thermal properties of salt hydrates and their applications, the effect of temperature on solubility of partially miscible liquids, how different solvents affect the recrystallization process
LO5	Create/Synthesis	**Develop** practical skills in performing distillation and analysing the purity of separated liquids skills in preparing and analysing a two-phase system, skills in using Ostwald's viscometer for compositional analysis skills in interpreting phase diagrams and miscibility data skills in recrystallization to purify compounds proficiency in analysing the purity of aspirin using titration methods
LO6	Evaluate	**Evaluate** partition coefficient and understand its relevance in extraction processes, how impurity affects CST, the practical applications of surface tension measurements in industries

QUESTION PAPER PATTERN-ESE

St. Joseph's University, Bengaluru-27
B.Sc. End Semester Examination
(2024-25 onwards)
CHEMISTRY

Time: 2 hours **Max. Marks: 60**

Instructions

1. Question paper has three Parts. Answer all the Parts.
2. Write chemical equations and diagrams wherever necessary.

PART– A

Answer any **SEVEN** of the following NINE questions. Each question carries **TWO** marks.

(7 x 2 =14)

PART– B

Answer any **SIX** of the following EIGHT questions. Each question carries **SIX** marks.

(6 x 6 = 36)

PART– C

Answer any **TWO** of the following THREE questions. Each question carries **FIVE** marks.

(2 x 5= 10)

Note: The questions must have the weightage of 35% portions from the mid semester exam portion and 65% weightage from the portion covered after mid semester examination.

MID-SEM EXAM PATTERN

St. Joseph's University, Bengaluru-27
B.Sc. Mid Semester Examination
(2024-25 onwards)
CHEMISTRY

Time: 1 hour **Max. Marks: 25**

Instructions

1. Question paper has three Parts. Answer all the Parts.
2. Write chemical equations and diagrams wherever necessary.

PART– A

Answer any **FOUR** of the following SIX questions. Each question carries **TWO** marks.

(4 x 2=8)

PART– B

Answer any **TWO** of the following THREE questions. Each question carries **SIX** marks.

(2 x 6 = 12)

PART– C

Answer any **ONE** of the following TWO questions. Each question carries **FIVE** marks.

(1 x 5= 5)

<u>EVALUATION PATTERN - PRACTICALS</u>

	Weightage in Marks
Formative Assessment (Internal assessment) Practicals	**30 (20 CIA + 10 Viva-voce)**
End semester practical examination (ESPE)	**20**
Total	**50**