# Indrashil University


## Department of Chemistry
## School of Science

## B.Sc. 2025-2029
## Sem III-IV

## Chemistry
## Course Profile

## Academic Year 2026-2027

## B.Sc. Chemistry Semester III
## Course Structure

| Course Code | Course Name | Course Type | L-T-P | Credits |
|---|---|---|---|---|
| **CH2 101** | Organic Chemistry-III: Chemistry of Carbonyls and Derivatives | Major Discipline Core (**MDC**) | 2-0-0 | 2 |
| **CH2 102** | Inorganic Chemistry-II: Chemical Bonding and Molecular Structure | | 2-0-0 | 2 |
| **CH2 103** | Physical Chemistry-II: Thermodynamics and Phase Rules | | 2-0-0 | 2 |
| **CH2 104** | Organic Chemistry-III Laboratory | | 0-0-4 | 2 |
| **CH2 105** | Inorganic Chemistry - II Laboratory | | 0-0-4 | 2 |
| **CH2 106** | Physical Chemistry – II Laboratory | | 0-0-4 | 2 |
| Minor Discipline Elective (**MDE**) | | | | |
| **CH2 107** | Semiconductor Devices | Multi-Disciplinary (**MDS**) | 2-0-0 | 2 |
| **CH2 108** | Semiconductor Devices Laboratory | | 0-0-4 | 2 |
| **CH2 109** | Soft Skills | Ability Enhancement Course (**AEC**) | 2-0-0 | 2 |
| **CH2 110** | Laboratory Operations and Safety Measures | Skill Enhancement Course (**SEC**) | 2-0-0 | 2 |
| **CH2 111** | Vedic Chemistry | Indian Knowledge System (**IKS**) | 2-0-0 | 2 |
| **Total** | | | **14L+0T+ 16P = 30h** | **22** |

## B.Sc. Chemistry Semester IV
## Course Structure

| Course Code | Course Name | Course Type | L-T-P | Credits |
|---|---|---|---|---|
| **CH2 201** | Organic Chemistry-IV: Chemistry of Enolates and Amines | Major Discipline Core (**MDC**) | 2-0-0 | 2 |
| **CH2 202** | Inorganic Chemistry-III: s and p-Block Elements | | 2-0-0 | 2 |
| **CH2 203** | Physical Chemistry-III: Chemical and Ionic Equilibria | | 2-0-0 | 2 |
| **CH2 204** | Organic Chemistry – IV Laboratory | | 0-0-4 | 2 |
| **CH2 205** | Inorganic Chemistry - III Laboratory | | 0-0-4 | 2 |
| **CH2 206** | Physical Chemistry – III Laboratory | | 0-0-4 | 2 |
| **CH2 207** | Application of Semiconducting Materials | Minor Discipline Elective (**MDE**) | 2-0-0 | 2 |
| **CH2 208** | Semiconducting Materials Laboratory | | 0-0-4 | 2 |
| Multi-Disciplinary (**MDS**) | | | | |
| **CH2 209** | Professional Communications | Ability Enhancement Course (**AEC**) | 2-0-0 | 2 |
| **CH2 210** | Software for Scientific Learning | Skill Enhancement Course (**SEC**) | 2-0-0 | 2 |
| **CH2 211** | Renewable Energy | Value Added Course (**VAC**) | 2-0-0 | 2 |
| **Total** | | | **14L+0T+ 16P = 30h** | **22** |

# B.Sc. Chemistry Semester III Detailed Syllabus with CLO

## CH2 101: Organic Chemistry -III: Chemistry of Carbonyls and Derivatives (L-T-P-C: 2-0-0-2)

| | |
|---|---|
| **Program:** B. Sc. Chemistry | **Semester:** III |
| **Course code:** CH2 101 | **Course Name:** Organic Chemistry -III: Chemistry of Carbonyls and Derivatives |

| Lecture (Hours) | Practical (Hours) | Credits | Total Hours | Evaluation Scheme | | | |
|---|---|---|---|---|---|---|---|
| | | | | Component | Exam | Max. Marks | Passing % |
| 2/week | - | 2 | 30 | Lecture | CCE, ESE | 50 | 40 |

**Course Objective:**

- This course deals with understanding the chemistry of carbonyl compounds and Carboxylic Acids, and their Derivatives.
- It covers preparation, physical and chemical properties, and reactivity of carbonyl compounds and carboxylic acid derivatives.
- This course also explains the reaction mechanism of related name reactions.
- Students will an understanding of structure–reactivity relationships and reaction mechanisms in organic chemistry

**Course Outcomes:** At the end of this course, students will be able to:
**CO 1:** Remember the related name reaction of carbonyl compounds and their derivatives
**CO 2:** Understand the mechanism of name reactions related to carbonyl compounds
**CO 3:** Explain the mechanisms of important name reactions such as HVZ reaction, Claisen condensation, Dieckmann condensation, Hofmann bromamide degradation, and Curtius rearrangement.
**CO 4:** Compare the reactivity and interconversion of carboxylic acids, esters, acid chlorides, anhydrides, and amides.

**Syllabus**

| Units | Content | Hours |
|---|---|---|
| **Unit I:** Chemistry of Carbonyl Compounds | **Chemistry of Carbonyl Compounds:** Structure, reactivity, preparation and properties; Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanism; Mechanisms of Benzoin condensation, Knoevenagel condensation, Perkin, Cannizzaro, and Beckmann reaction. Haloform reaction and Baeyer Villiger oxidation, α-β-substitution reactions, oxidations and reductions (Clemmensen, Wolff-Kishner, $LiAlH_4$, $NaBH_4$) | **15** |
| **Unit II:** Carboxylic Acids and their Derivatives | **Carboxylic Acids:** Nomenclature and general properties of Carboxylic Acids**,** preparation and reactions of monocarboxylic acids, effect of substituents on acidic strength. Typical reactions of dicarboxylic acids, hydroxy acids, and unsaturated acids.<br>**Carboxylic Acids Derivatives:** Preparation and reactions of acid chlorides, anhydrides, esters, and amides; Comparative study of nucleophilic substitution at acyl group - Mechanism of acidic and alkaline hydrolysis of esters, Claisen condensation, Dieckmann, Hell–Volhard–Zelinsky (HVZ) Reaction, and Reformatsky reactions, Hofmann-bromamide degradation, and Hunsdiecker Reaction, | **15** |
| **Unit III:** Cycloalkane**s** | **Cycloalkanes:** nomenclature, Preparation and properties of cycloalkanes and their derivatives - Baeyer's strain theory and limitation, Conformations of Cycloalkanes (Chair and boat ), Ring Flipping of Cyclohexane, Cis-Trans Isomerism in Cycloalkanes and their reactivity. | **15** |

**Reading References:**


1. R. T. Morrison; R. N. Boyd; S. K. Bhattacharjee. *Organic Chemistry.* Pearson Education India, New Delhi. 2010, 7th Ed.
2. I. L. Finar. *Organic Chemistry (Volume 1).* Dorling Kindersley (India) Pvt. Ltd., Pearson Education, New Delhi. 1963, 4th Ed.
3. I. L. Finar. *Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products).* Dorling Kindersley (India) Pvt. Ltd., Pearson Education, New Delhi. 2002, 5th Ed.
4. R. M. Acheson. *Introduction to the Chemistry of Heterocyclic Compounds.* John Wiley & Sons, New York. 2008, 3rd Ed.
5. T. W. Graham Solomons; C. B. Fryhle; S. A. Snyder. *Organic Chemistry.* John Wiley & Sons, Inc., Hoboken. 2017, 12th Ed.
6. P. S. Kalsi. *Textbook of Organic Chemistry.* New Age International Publishers, New Delhi. 2000, 1st Ed.
7. J. Clayden; N. Greeves; S. Warren; P. Wothers. *Organic Chemistry.* Oxford University Press, Oxford. 2014, 2nd Ed.
8. J. Singh; S. M. Ali; J. Singh. *Natural Product Chemistry.* Pragati Prakashan, Meerut. 2010, 1st Ed.

## CH2 102: Inorganic Chemistry-II: Chemical Bonding and Molecular Structure (L-T-P-C: 2-0-0-2)

| | |
|---|---|
| **Program:** B. Sc. Chemistry | **Semester:** III |
| **Course Code:** CH2 102 | **Course name:** Inorganic Chemistry-II: Chemical Bonding and Molecular Structure |

| Lecture (Hours) | Practical (Hours) | Credits | Total Hours | Evaluation Scheme | | | |
|---|---|---|---|---|---|---|---|
| | | | | Component | Exam | Max. Marks | Passing % |
| 2/week | - | 2 | 30 | Lecture | CCE, ESE | 50 | 40 |

**Course Objective:**
Understanding different chemical bonding in a molecule.
Explanation of polarity, deformation of ions, and the consequences of deformation.
This course also delivers the idea about VSEPR theory and weak chemical forces, including H-bonding.

**Course Learning Outcomes:** At the end of this course, students will be able to
**CO 1:** Define different bonding patterns in a molecule.
**CO 2:** Predict the geometry of any molecule using VSEPR theory.
**CO 3:** Apply the concept of Fazan's rule, Born-Haber Cycle, Born-Lande equation.
**CO 4:** Analyze different weak intermolecular forces.

### Syllabus

| Units | Content | Hours |
|---|---|---|
| **Unit I:** Covalent interaction, VSEPR rule | Lewis structure, Resonance and resonance energy, Formal charge, multiple bonding (σ and π bond approach), and bond lengths. Covalent character in ionic compounds, polarizing power and polarizability, Fajan's rules and consequences of polarization, bond strength bond order and bond energy relations, effects of hydrogen bond, application, structure of ice, $CuSO_4.5H_2O$, Hybridization of orbitals, Valence Bond theory and its limitations, types of hybridization and shapes of inorganic molecules and ions, VSEPR theory to $NH_3$, $H_3O^+$, $SF_4$, $ClF_3$, $ICl_2^-$, and $H_2O$. Molecular orbital diagrams of diatomic and simple polyatomic molecules $N_2$, $O_2$, $C_2$, $B_2$, $F_2$, CO, NO, and their ions; HCl, $BeF_2$, $CO_2$. | **10** |
| **Unit II:** Ionic interaction | **Ionic Bond**: General characteristics of ionic compounds, melting point, boiling point, hardness, solubility, conductance, radius ratio rule, coordination number, limitation of radius-ratio rule, lattice energy, metallic bond, Ionic character in covalent compounds: Concept of dipole moment, comparison of DM of different molecules, Bond moment. Percentage ionic character from dipole moment and electronegativity difference. Metallic Bond. | **10** |
| **Unit III:** Non-bonding interaction | Van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interactions, and Instantaneous dipole-induced dipole interactions. Factors determining Van der Waal's force, Repulsive forces, Hydrogen bonding: types, applications, Effects of chemical forces. | **10** |

### CO-PO Mapping

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 |
|---|---|---|---|---|---|
| **CO 1** | **3** | **2** | **2** | **-** | **-** |
| **CO 2** | **3** | **2** | **2** | **-** | **1** |
| **CO 3** | **2** | **3** | **3** | **1** | **1** |
| **CO 4** | **3** | **3** | **2** | **1** | **1** |
| **Average** | **2.75** | **2.50** | **2.25** | **0.50** | **0.75** |

**Correlation levels:**
**1 - Low, 2 - Moderate, 3 - High**

**Justification for CO-PO Mapping**

| COs | Justification |
|---|---|
| **CO 1** | Develops understanding of partition coefficients and solvent extraction principles (**PO1**) while strengthening analytical interpretation skills (**PO2, PO3**). |
| **CO 2** | Enhances knowledge of solvent systems and extraction methodologies (**PO1**) and develops analytical ability in selecting suitable separation processes (**PO2, PO3**). |
| **CO 3** | Promotes application of solvent recovery and recycling concepts (**PO2**) and develops problem-solving skills related to sustainable chemical processes (**PO3, PO4**). |
| **CO 4** | Develops understanding of supercritical fluid extraction and advanced separation techniques (**PO1**), while enhancing analytical skills and research awareness (**PO2, PO4**). |

**Reading References:**

J. D. Lee. *Concise Inorganic Chemistry.* Blackwell Science, Oxford. 2008, 5th Ed.
R. P. Sarkar. *General and Inorganic Chemistry, Vol. I & II.* New Central Book Agency, Kolkata. 2012, 1st Ed.
F. A. Cotton; G. Wilkinson; Paul L. Gaus. *Basic Inorganic Chemistry.* Wiley, New York. 2007, 3rd Ed.
Dr. R. L. Madan. *Chemistry for Degree Students.* S. Chand and Company Ltd., New Delhi. 2010, 2nd Ed.

## CH2 103: Physical Chemistry-II: Thermodynamics and Phase Rules (L-T-P-C: 2-0-0-2)

| **Program:** B. Sc. Chemistry | **Semester:** III |
|---|---|
| **Course Code:** CH2 103 | **Course Name:** Physical Chemistry II: Thermodynamics and Phase Rules |

| Lecture (Hours) | Practical (Hours) | Credits | Total Hours | Evaluation Scheme | | | |
|---|---|---|---|---|---|---|---|
| | | | | Component | Exam | Max. Marks | Passing % |
| 2/ week | - | 2 | 30 | Lecture | CCE, ESE | 50 | 40 |

**Course Objectives:**
This course is designed to build a full understanding on the major concepts of Chemical Thermodynamics. It covers principles of classical thermodynamics. Develops understanding of mass, energy, heat, work, efficiency, entropy, enthalpy, Gibbs free energy, ideal and real thermodynamic cycles and processes. The course also covers the first, second, third, and zeroth laws of thermodynamics and concepts in thermochemistry. More emphasis will be given on various free energy functions.

**Course Outcomes:** At the end of this course, students will be able to

**CO1:** Recognize and use the thermodynamic parameters correctly.

**CO2:** Understand the first, second, third, and zeroth laws of thermodynamics.

**CO3:** Apply the knowledge of chemical thermodynamics to interpret the chemical reactions.

**CO4:** Correlate thermodynamics to solve practical problems in physical and chemical systems.

### Syllabus

| Units | Content | Hours |
|---|---|---|
| **Unit I:** Laws of Thermodynamics | Intensive and extensive variables; state and path functions; isolated, closed, and open systems; zeroth law of thermodynamics. Cycles and processes (isobaric, isothermal, isochoric, and adiabatic, reversible, irreversible).<br>**First law:** Concept of heat, work, internal energy, and statement of first law; enthalpy, *H*, the relation between heat capacities, calculations of *Q*, *W*, *U,* and *H* for reversible, irreversible, and free expansion of ideal gases under isothermal and adiabatic conditions.<br>**Second Law:** Concept of entropy, statement of the second law of thermodynamics; molecular interpretation of entropy. Calculation of entropy change for reversible and irreversible processes.<br>**Third Law:** Statement of the third law, calculation of absolute entropy of molecules. | **10** |
| **Unit II:** Thermochemistry | **Thermochemistry:** Heats of reactions: standard states; enthalpy of formation of molecules. Enthalpy of combustion and its applications: calculation of bond energy, bond dissociation energy, qualitative concept of resonance energy, the effect of temperature on the enthalpy of reaction (Kirchhoff's equations). | **10** |
| **Unit III:** Free Energy and Phase Rules | **Free Energy Functions:** Understand E, H, A, G. Gibbs and Helmholtz free energy; Free energy change and spontaneity. Introduction to Maxwell relations and their basic applications.<br>Phase rule: Introduction to Phases and Phase Transitions, Phase Diagrams: One-Component Systems, Thermodynamics of Phase Transitions, Phase Diagrams: Binary Systems. | **10** |

### CO-PO Mapping Table

| COs | PO1 | PO2 | PO3 | PO4 | PO5 |
|---|---|---|---|---|---|
| **CO1** | 3 | 2 | 1 | - | - |

| | | | | | |
|---|---|---|---|---|---|
| **CO2** | 3 | 2 | 2 | - | 1 |
| **CO3** | 2 | 3 | 3 | - | 1 |
| **CO4** | 2 | 3 | 3 | 1 | 2 |
| **Average** | **2.50** | **2.50** | **2.25** | 0.25 | **1.00** |

Correlation levels: 1 - Low, 2 - Moderate, 3 – High

**Justification of CO-PO Mapping**

| COs | Justification |
|---|---|
| **CO1** | Strengthens understanding of thermodynamic concepts and scientific fundamentals. |
| **CO2** | Enhances analytical understanding of thermodynamic laws and processes. |
| **CO3** | Develops scientific reasoning and interpretation of chemical systems. |
| **CO4** | Promotes practical problem-solving and interdisciplinary applications of thermodynamics. |

**Reading References:**

G. W. Castellan. *Physical Chemistry.* Narosa Publishing House, New Delhi. 2004, 3rd Ed.
P. C. Rakshit. *Physical Chemistry.* Levant Books, Kolkata. 2020, 7th Ed.
R. L. Madan. *Chemistry for Degree Students.* S. Chand Publications, New Delhi. 2022, 1st Ed.
Gurdeep Raj. *Advanced Physical Chemistry.* Krishna Prakashan Media, Meerut. 2018, 4th Ed.

## CH2 104: Organic Chemistry-III Laboratory (L-T-P-C: 0-0-4-2)

| | |
|---|---|
| **Program:** B. Sc. Chemistry | **Semester:** III |
| **Course Code:** CH2 104 | **Course Name:** Organic Chemistry-III Laboratory |

| Lecture (Hours) | Practical (Hours) | Credits | Total Hours | Evaluation Scheme | | | |
|---|---|---|---|---|---|---|---|
| | | | | Component | Exam | Max. Marks | Passing % |
| - | 4/week | 2 | 60 | Lab | CCE, ESE | 50 | 40 |

**Course Objectives:**

To develop laboratory skills in the synthesis and purification of organic compounds.
Course focuses on synthesis, transformation, and analysis of organic compounds
To understand the practical applications of important organic name reactions.
Key reaction types: condensation, rearrangement, substitution, oxidation, reduction
To perform classical name reactions: Aldol condensation, Hofmann & Curtius rearrangements, Mannich & Gabriel synthesis and Electrophilic aromatic substitutions
Focus on: Understanding reaction mechanisms, developing experimental techniques
To develop skills in product isolation, recrystallization, and melting point determination.

**Course Outcomes:** At the end of this course, students will be able to

**CO 1:** Recall the names, reagents, conditions, and types of involved in the synthesis of organic compounds.

**CO 2:** Understand the mechanisms of organic reactions and describe their synthetic importance and functional group transformations.

**CO 3:** Perform organic synthesis experiments using appropriate laboratory equipment and prepare compounds

**CO 4:** Interpret reaction outcomes, compare reaction pathways, identify products, evaluate Purity, and analyse selectivity and mechanism differences in multi-step organic reactions.

**Syllabus**

| Sr. No. | Name of the Experiment | Hours |
|---|---|---|
| **1.** | To prepare Chalcones by Aldol Condensation of Acetone and Benzaldehyde | **2** |
| **2.** | To perform Hofmann Degradation of Benzamide to Aniline | **4** |
| **3.** | To prepare Phenylhydrazine from Benzoyl Azide via Curtius Rearrangement | **4** |
| **4.** | To perform the Cannizzaro reaction of benzaldehyde. | **4** |
| **5.** | To perform Mannich condensation reaction with benzaldehyde, aniline and acetophenone | **4** |
| **6.** | To prepare the m-Nitroaniline via Selective Reduction of m-Dinitrobenzene | **4** |
| **7.** | To prepare iodoform ($CHI_3$) from acetone by the haloform reaction. | **4** |
| **8.** | To prepare Carbazole (Dibenzopyrrole). | **4** |

**Reading References**

B. S. Furniss. *Vogel's Textbook of Practical Organic Chemistry.* Pearson Education, New Delhi. 2011, 5th Ed.
A. I. Vogel; A. R. Tatchell; B. S. Furniss; A. J. Hannaford; P. W. G. Smith. *Textbook of Practical Organic Chemistry.* Prentice-Hall, London. 1996, 5th Ed.
A. K. Nad; B. Mahapatra. *An Advanced Course in Practical Chemistry.* New Central Book Agency, Kolkata. 2022, 3rd Ed.
V. K. Ahluwalia; Sunita Dhingra. *Practical Organic Chemistry.* New Central Book Agency, Kolkata. 2017, 1st Ed.
N. K. Vishnoi. *Advanced Practical Organic Chemistry.* Vikas Publishing House, New Delhi. 2009, 3rd Ed.

## CH2 105: Inorganic Chemistry - II Laboratory (L-T-P-C: 0-0-4-2)

| | |
|---|---|
| **Program:** B. Sc. Chemistry | **Semester:** III |
| **Course code:** CH2 105 | **Course name:** Inorganic Chemistry-II Laboratory |

| Lecture (Hours) | Practical (Hours) | Credits | Total Hours | Evaluation Scheme | | | |
|---|---|---|---|---|---|---|---|
| | | | | Component | Exam | Max. Marks | Passing % |
| - | 4/week | 2 | 60 | Lab | CCE, ESE | 50 | 40 |

**Course Objective:**

- Learning and analyzing the various group I and II halides.
- Preparation and estimation of coordination complexes of transition metals like Cu and Ni.
- This course also deals with the determination of water of hydration in a given sample.

**Course Outcomes:** At the end of this course, students will be able to
**CO 1:** Identify the basic radicals for group I and group II metals.
**CO 2:** Understand the preparation and characterization of coordination complexes.
**CO 3:** Demonstrate the formation of Cu and Ni complexes and calculate the yield
**CO 4:** Analyze the water of hydration/ crystallization in coordination compounds.

**Syllabus**

| Sr. No. | Name of the Experiment | Hours |
|---|---|---|
| 1. | To analyze and identify of group-I halides (potassium iodide, lithium chloride, and sodium chloride by flame test | 10 |
| 2. | To analyze and identify the group-II halides (calcium chloride, strontium chloride, barium chloride | 10 |
| 3. | To prepare and characterize tetramine-copper (II) sulfate Complex and calculation of the yield from the stoichiometric equation. | 8 |
| 4. | To prepare and characterize hexamine nickel (II) chloride and calculate the yield from the stoichiometric equation | 8 |
| 5. | To determine the formula of an unknown hydrated sample | 8 |
| 6. | To Separate the given inorganic mixture using the filtration process | 8 |
| 7. | Identification of Carbonate, Sulfate, and Nitrate Ions in Unknown Inorganic Salts Using Chemical Tests. | 8 |
| 8. | To prepare and characterize potash alum KAl (SO4)2·12H2O and calculate the percentage yield from the stoichiometric equation. | 8 |

**CO-PO Mapping Table2**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 |
|---|---|---|---|---|---|
| CO 1 | 2 | 3 | 2 | - | 1 |
| CO 2 | 2 | 3 | 2 | 1 | 1 |
| CO 3 | 3 | 3 | 3 | - | 1 |
| CO 4 | 2 | 3 | 3 | 1 | 1 |
| Average | 2.25 | 3.00 | 2.50 | 0.50 | 1.00 |

**Correlation levels:**

**1 - Low, 2 - Moderate, 3 - High**

**Justification for CO-PO Mapping**

| COs | Justification |
|---|---|
| **CO 1** | Develops knowledge of inorganic salts and qualitative analysis (**PO1**) while strengthening laboratory and analytical skills (**PO2, PO3**). |
| **CO 2** | Enhances understanding of coordination chemistry and synthesis techniques (**PO1, PO2**) and introduces basic research-oriented laboratory practices (**PO4**). |
| **CO 3** | Strengthens stoichiometric calculations, yield determination, and composition analysis, promoting analytical and problem-solving skills (**PO1, PO2, PO3**). |
| **CO 4** | Develops practical competency in separation and quantitative analysis techniques and improves analytical reasoning and scientific investigation skills (**PO2, PO3, PO4**). |

**Reading References:**

G. H. Jeffery; J. Bassett; J. Mendham; R. C. Denney. *Vogel's Textbook of Quantitative Chemical Analysis.* Orient Longman, New Delhi. 1989, 5th Ed.

G. Svehla. *Vogel's Textbook of Macro and Semimicro Qualitative Inorganic Analysis.* Orient Longman, New Delhi. 1982, 5th Ed.

Mala Nath. *Inorganic Chemistry: A Laboratory Manual.* Narosa Publishing House, New Delhi. 2016, 1st Ed.

## CH2 106: Physical Chemistry-II Laboratory (L-T-P-C: 0-0-4-2)

| **Program:** B. Sc. Chemistry | **Semester:** III |
|---|---|
| **Course code:** CH2 106 | **Course name:** Physical Chemistry-II Laboratory |

| Lecture (Hours) | Practical (Hours) | Credits | Total Hours | Evaluation Scheme | | | |
|---|---|---|---|---|---|---|---|
| | | | | Component | Exam | Max. Marks | Passing % |
| - | 2/week | 1 | 60 | Lab | CCE, ESE | 50 | 40 |

**Course Description:** This course is a practical course of Physical Chemistry. Through this course, the students will get an insight into learning by performing hands-on experiments and practical. From this course, they can understand and learn basic thermodynamic parameters like work done, enthalpy, entropy change etc.

**Course Outcomes:** At the end of this course students will be able to
**CO 1:** Identify the first law of thermodynamics.
**CO 2:** Recognize the second law of thermodynamics.
**CO 3:** Estimate property changes of mixing
**CO 4:** Evaluate Hess's law

**Detailed Syllabus**

| Serial no. | Experiment | Hours |
|---|---|---|
| 1. | Demonstration of the first law of thermodynamics using simple household systems | 8 |
| 3. | Experimental demonstration of the second law of thermodynamics with glow sticks | 8 |
| 4. | Determination of the integral heats of dilution of $H_2SO_4$ starting with 10M acid and going down to 5M acid in the order 9M, 8M, 7M, 6M. | 8 |
| 6. | Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide using a coffee mug calorimeter | 8 |
| 7. | Investigation of the solubility of benzoic acid in water and determination of change in enthalpy. | 12 |
| 8. | Determination of enthalpy of hydration of copper sulphate | 8 |
| 9. | Experimental determination of ΔH values of two reactions using the technique of constant pressure calorimeter | 8 |

**List of virtual experiments**

| | |
|---|---|
| 1. | Work done by the system and on the system |
| 2. | Model of a heat engine |
| 3. | Demonstration of adiabatic expansion – cloud in a bottle |

**CO-PO Mapping Table**

| COs | PO1 | PO2 | PO3 | PO4 | PO5 |
|---|---|---|---|---|---|
| **CO 1** | 3 | 2 | 1 | - | - |
| **CO 2** | 3 | 2 | 2 | - | 1 |
| **CO 3** | 2 | 3 | 3 | - | 1 |
| **CO 4** | 2 | 3 | 3 | 1 | 1 |
| **Average** | **2.50** | **2.50** | **2.25** | **0.25** | **0.75** |

Correlation levels: 1 - Low, 2 - Moderate, 3 – High

**Justification of CO-PO Mapping**

| COs | Justification |
|---|---|
| **CO 1** | Builds conceptual understanding of thermodynamic principles. |
| **CO 2** | Develops analytical understanding of entropy and thermodynamic laws. |
| **CO 3** | Enhances experimental and quantitative analysis skills. |
| **CO 4** | Strengthens evaluation and problem-solving abilities in calorimetry and thermochemistry. |

**Reading references:**

B. D. Kholsa, V. C. Garg, Senior Practical Physical Chemistry Delhi: R. Chand, 2018, 18th Edition
B. Viswanathan, P. S. Raghavan Practical Physical Chemistry Navi Mumbai Viva Books Private Limited 2017, 1st Edition
A. K. Nad, B. Mahapatra, A. Ghoshal. An Advanced Course in Practical Chemistry Paperback, l New Central Book Agency P LTD 2012, 3rd Edition
J. N. Gurtu and Amit Gurtu Advanced Physical Chemistry Experiments Pragati Prakashan 2008,

## CH2 107: Semiconductor Devices (L-T-P-C: 2-0-0-2)

| | |
|---|---|
| **Program:** B. Sc. Chemistry | **Semester:** III |
| **Course code:** CH2 107 | **Course name:** Semiconductor Devices |

| Lecture (Hours) | Practical (Hours) | Credits | Total Hours | Evaluation Scheme | | | |
|---|---|---|---|---|---|---|---|
| | | | | Component | Exam | Max. Marks | Passing % |
| 2/week | - | 2 | 30 | Lecture | CCE, ESE | 50 | 40 |

**Course Objectives:** This course is designed to provide students with a fundamental understanding of semiconductor materials and electronic devices by introducing the concepts of lattice vibrations, phonons, Brillouin zones, and the thermal properties of solids. It enables students to understand the operating principles, characteristics, and applications of various semiconductor devices such as LEDs, photodiodes, Zener diodes, tunnel diodes, transistors, FETs, JFETs, BJTs, and MOSFETs. The course further develops the ability to analyze the behavior of solid-state materials and electronic components, thereby establishing a foundation for understanding modern semiconductor technology and its real-world applications.

**Course Outcomes:** At the end of this course students will be able to
**CO 1:** Explain the fundamental concepts of lattice vibrations, phonons, Brillouin zones, and thermal properties of solids relevant to semiconductor materials.
**CO 2:** Describe the operating principles, characteristics, and applications of various semiconductor diodes including LED, photodiode, Zener diode, varactor diode, and tunnel diode.
**CO 3:** Analyze the characteristics and operational behavior of different transistor configurations and semiconductor devices such as FETs, JFETs, BJTs, and MOSFETs.
**CO 4:** Apply the principles of semiconductor physics and electronic devices to interpret device performance and solve problems related to modern electronic and optoelectronic systems.

### Detailed Syllabus

| Units | Content | Hours |
|---|---|---|
| **Unit I:** Lattice Vibrations | Elastic and atomic force constant, Brillouin zone, Dispersion relation, Dynamics of a chain of atoms, chain of two types of atoms, optical and acoustic modes, Phonons, Momentum of phonon, interaction of light with ionic crystals, inelastic collision of photon by phonon, Einstein's and Debye's theories of specific heat of solids. | **18** |
| **Unit II:** Semiconductor Diodes | Drift of Carriers in Electric and Magnetic Fields, Principal and Application of Light Emitting Diode, Photodiode, Varactor Diode, Zener Diode, Tunnel Diode Illustrative examples and related problems, Half – wave and full – wave rectifier, efficiency, | **12** |
| **Unit III:** Transistors | Characteristics of npn and pnp transistor, active and saturation region, common emitter, common base and common collector configuration, input and output characteristics, basics of field effect transistor (FET) and junction field effect transistor (JFET), Bi-polar junction transistor (BJT), Metal oxide semiconductor field effect transistor (MOSFET), difference between the FET, JFET, BJT and MOSFET | **15** |

### CO–PO Mapping Table

| COs | PO1 | PO2 | PO3 | PO4 | PO5 |
|---|---|---|---|---|---|
| **CO 1** | **3** | **2** | **-** | **-** | **-** |
| **CO 2** | **3** | **2** | **2** | **-** | **-** |
| **CO 3** | **3** | **3** | **3** | **-** | **-** |
| **CO 4** | **2** | **3** | **3** | **-** | **-** |
| **Average** | **2.75** | **2.5** | **2.0** | **-** | **-** |

**CO–PO Justification Table**

| CO | Justification |
|---|---|
| **CO1** | This outcome develops fundamental scientific understanding of semiconductor materials, lattice structures, and electronic devices. It also strengthens technical knowledge and analytical skills required for studying semiconductor systems and their applications. (**PO1, PO2**) |
| **CO2** | Understanding phonons, semiconductor diodes, and related concepts enhances scientific knowledge and analytical abilities. It also promotes critical thinking required for interpreting material properties and device behavior. (**PO1, PO2, PO3**) |
| **CO3** | Analysis of the physical properties of solid materials requires strong conceptual understanding, technical competence, and problem-solving skills. Students learn to evaluate material behavior using scientific principles and analytical methods. (**PO1, PO2, PO3**) |
| **CO4** | Applying the concepts of diodes and transistors to practical situations develops scientific reasoning, technical expertise, and critical problem-solving ability. This enables students to understand and address real-world challenges involving semiconductor devices. (**PO1, PO2, PO3**) |

**Reading References:**

R. K. Puri; V. K. Babbar. *Solid State Physics.* S. Chand & Co. Ltd., New Delhi. 2010, 1st Ed.
V. K. Mehta. *Principles of Electronics.* S. Chand & Co. Ltd., New Delhi. 2014, 7th Ed.
Arthur Beiser. *Concepts of Modern Physics.* Tata McGraw-Hill, New Delhi. 2002, 6th Ed.
Charles Kittel. *Introduction to Solid State Physics.* John Wiley & Sons, New York. 2018, 8th Ed.
S. M. Sze; Kwok K. Ng. *Physics of Semiconductor Devices.* Wiley, New York. 1996, 2nd Ed.
P. Bhattacharya. *Semiconductor Opto-Electronic Devices.* Prentice Hall, New Delhi. 1996, 2nd Ed.
M. K. Achuthan; K. N. Bhat. *Fundamentals of Semiconductor Devices.* McGraw Hill Education, New Delhi. 2007, 1st Ed.
J. Allison. *Electronic Engineering Materials and Devices.* McGraw Hill Education, New Delhi. 1990, 1st Ed.

## CH2 108: Semiconductor Devices Laboratory (L-T-P-C: 0-0-4-2)

| | |
|---|---|
| **Program:** B. Sc. Chemistry | **Semester:** III |
| **Course code:** CH2 108 | **Course name:** Semiconductor Devices Laboratory |

| Lecture (Hours) | Practical (Hours) | Credits | Total Hours | Evaluation Scheme | | | |
|---|---|---|---|---|---|---|---|
| | | | | Component | Exam | Max. Marks | Passing % |
| - | 2/week | 1 | 60 | Lab | CCE, ESE | 50 | 40 |

**Course Objectives:** This laboratory course is designed to provide practical exposure to semiconductor devices and electronic instrumentation through hands-on experiments involving transistors, logic gates, rectifiers, Hall-effect measurements, and electrical measuring instruments. The course enables students to understand the operating principles and performance characteristics of semiconductor devices, develop skills in circuit design and verification, and apply experimental techniques for determining important physical and electrical parameters. It also enhances analytical, problem-solving, and experimental competencies required for understanding and utilizing semiconductor materials and electronic systems in real-world applications.

**Course Outcomes:** At the end of this course students will be able to
CO 1: Demonstrate the operation and characteristics of semiconductor devices and electronic instruments through laboratory experiments and data acquisition.
CO 2: Perform experiments to analyze and interpret the electrical characteristics of transistors, rectifiers, and semiconductor materials using appropriate measurement techniques.
CO 3: Design, construct, and verify basic electronic circuits using logic gates and integrated circuits for specific functional applications.
CO 4: Evaluate experimental data to determine important physical and electrical parameters such as Hall coefficient, figure of merit, resistance, and radiation characteristics, and interpret their significance in semiconductor and electronic systems.

### Detailed Syllabus

| Experiment No. | Content | Hours |
|---|---|---|
| 1 | Study of frequency response of a single PNP Transistor using common emitter transistor amplifier. | 10 |
| 2 | Design the electrical circuit of different logic gates with the help of various types of ICs and verify the truth table for the same. | 10 |
| 3 | (a) Determination of the Hall voltage developed across the given material and (b) Calculate the Hall coefficient of the same material. | 12 |
| 4 | Analyze the half wave and full wave rectifier output circuit using a capacitor in shunt as a filter. | 8 |
| 5 | Study and verify the Stefan's Law of radiation (The law states that the amount of energy radiated through unit time from the surface of a black body is directly proportional to the fourth power of its absolute temperature). | 10 |
| 6 | Determination of the given high resistance by the Substitution method. | 10 |

### CO–PO Mapping Table

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 |
|---|---|---|---|---|---|
| **CO1** | 2 | 3 | - | - | - |
| **CO2** | 2 | 3 | 3 | - | - |
| **CO3** | - | 3 | 3 | 2 | - |
| **CO4** | 2 | 3 | 3 | - | - |
| **Average** | 1.5 | 3.0 | 2.25 | 0.5 | |

**Justification Table for CO-PO Mapping**

| CO | Justification |
|---|---|
| **CO1** | Demonstrating the operation and characteristics of semiconductor devices develops scientific understanding and strengthens technical and experimental skills required for laboratory investigations. (**PO1, PO2**) |
| **CO2** | Performing and interpreting experiments on semiconductor devices enhances analytical competence, technical proficiency, and problem-solving abilities through data-driven investigations. (**PO1, PO2, PO3**) |
| **CO3** | Designing and verifying electronic circuits using logic gates and ICs develops technical expertise, critical thinking, teamwork, and communication skills essential for engineering applications. (**PO2, PO3, PO4**) |
| **CO4** | Evaluation of experimental observations and determination of device parameters require scientific knowledge, analytical reasoning, and systematic problem-solving skills for understanding semiconductor systems. (**PO1, PO2, PO3**) |

**Reading reference:**

Harnam Singh; P. S. Hemne. *B.Sc. Practical Physics.* S. Chand & Co., New Delhi. 2000, 1st Ed.
C. L. Arora. *B.Sc. Practical Physics.* S. Chand & Co., New Delhi. 2010, Revised Ed.
P. R. Sasi Kumar. *Practical Physics.* PHI Learning Pvt. Ltd., New Delhi. 2011, 1st Ed.
Dinesh V. Kala. *Physics Practical Manual for UG & PG.* Dinesh Publication, New Delhi. 2020, 1st Ed.

## CH2 109: Soft Skills (L-T-P-C: 2-0-0-2)

| | |
|---|---|
| **Program:** B. Sc. Chemistry | **Semester:** III |
| **Course code:** CH2 109 | **Course name:** Soft Skills |

| Lecture (Hours) | Practical (Hours) | Credits | Total Hours | Evaluation Scheme | | | |
|---|---|---|---|---|---|---|---|
| | | | | Component | Exam | Max. Marks | Passing % |
| 2/week | - | 2 | 30 | Lecture | CCE, ESE | 50 | 40 |

**Course Objectives**

After completing this course, students will be able to:
Develop self-awareness, confidence, and a professional identity through reflective practices.
Apply goal-setting and productivity strategies for personal and career development.
Demonstrate effective interpersonal, teamwork, and workplace communication skills.
Utilize creative thinking and problem-solving approaches to address professional challenges.
Develop digital communication competencies and understand responsible use of emerging technologies.
Exhibit professional etiquette, leadership qualities, and career readiness skills required by modern organizations.

**Course Outcomes:**

Upon successful completion of this course, students will be able to:

**CO 1:** Evaluate personal strengths, weaknesses, and professional aspirations through self-assessment and reflective practices.

**CO 2:** Apply goal-setting, time management, and productivity techniques to enhance personal and professional effectiveness.

**CO 3:** Demonstrate effective communication, active listening, teamwork, and networking skills in academic and workplace settings.

**CO 4:** Employ emotional intelligence, adaptability, and resilience in managing interpersonal and professional challenges.

**CO 5:** Apply creative thinking, innovation, and AI-enabled problem-solving techniques to address real-world situations.

**CO 6:** Demonstrate professional etiquette, digital professionalism, presentation skills, and career readiness competencies required in contemporary workplaces.

**Detailed Syllabus**

| Units | Content | Hours |
|---|---|---|
| **Unit - I**<br>Self-Awareness and Personal Branding | SWOT Analysis and Self-Assessment<br>Understanding Personality Traits and Behavioral Styles<br>Self-Esteem and Confidence Building<br>Growth Mindset and Continuous Learning<br>Personal Branding in the Digital Age<br>Professional Identity and Online Reputation Management<br>Positive Attitude and Resilience | 10 |
| **Unit - II**<br>Goal Setting, Productivity and Workplace Communication | SMART Goal Setting and Career Planning<br>Time Management and Productivity Tools<br>Managing Stress and Work-Life Balance<br>Active Listening and Effective Feedback<br>Emotional Intelligence in Professional Life<br>Teamwork and Collaboration Skills<br>Networking and Relationship Building<br>Workplace Communication Skills | 10 |
| **Unit - III**<br>Creativity, AI-Era Skills and Corporate Etiquette | Design Thinking and Creative Problem Solving<br>Lateral Thinking and Innovation<br>AI-Assisted Productivity and Responsible Use of AI Tools<br>Digital Communication and Virtual Collaboration<br>Professional Email Writing and Business Correspondence<br>Corporate and Cross-Cultural Etiquette<br>Presentation Skills and Executive Presence | 10 |

| | | |
|---|---|---|
| | Interview Skills, Group Discussions and Career Readiness | |

**CO-PO Mapping Table**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 |
|---|---|---|---|---|---|
| **CO 1** | **1** | **1** | **2** | **3** | **-** |
| **CO 2** | **1** | **2** | **2** | **3** | **-** |
| **CO 3** | **-** | **1** | **2** | **3** | **-** |
| **CO 4** | **-** | **1** | **2** | **3** | **1** |
| **CO 5** | **2** | **2** | **3** | **1** | **1** |
| **CO 6** | **-** | **1** | **1** | **3** | **-** |
| **Average** | **0.67** | **1.33** | **2.00** | **2.67** | **0.33** |

**Correlation levels:**
**1 - Low, 2 - Moderate, 3 - High**

**Justification for CO-PO Mapping**

| COs | Justification |
|---|---|
| **CO 1** | This CO develops self-awareness through self-assessment, SWOT analysis, and reflective practices. It supports critical thinking and self-evaluation abilities (PO3) while fostering lifelong learning, personal growth, and professional development (**PO4**). |
| **CO 2** | This CO enables students to apply goal-setting, time management, and productivity techniques for personal and professional effectiveness. It strengthens analytical and planning abilities (**PO2**), problem-solving skills (**PO3**), and promotes continuous learning and self-management (**PO4**). |
| **CO 3** | This CO enhances communication, active listening, teamwork, and networking skills, contributing to effective collaboration and professional interactions. It supports analytical communication abilities (**PO2**), collaborative problem-solving (**PO3**), and professional excellence through communication and teamwork (**PO4**). |
| **CO 4** | This CO develops emotional intelligence, adaptability, and resilience required to manage interpersonal and professional challenges. It enhances problem-solving and decision-making capabilities (**PO3**) while promoting ethical behavior, leadership qualities, and lifelong learning (**PO4**). |
| **CO 5** | This CO promotes creative thinking, innovation, and AI-enabled problem-solving approaches. It strengthens scientific and technical understanding (**PO1**), analytical competency (**PO2**), and critical thinking and innovative problem-solving skills (**PO3**). It also encourages the responsible use of technology for societal benefits (**PO5**). |
| **CO 6** | This CO develops professional etiquette, digital professionalism, presentation skills, and career readiness competencies. It enhances professional communication and workplace effectiveness (**PO2**), supports logical presentation and decision-making skills (**PO3**), and strongly contributes to communication, leadership, ethical conduct, and lifelong learning (**PO4**). |

**Reading references:**

Jeff Butterfield. *Soft Skills for Everyone.* Cengage Publications, Boston. 2020, 2nd Ed.
Barun K. Mitra. *Personality Development and Soft Skills.* Oxford University Press India, New Delhi. 2016, 2nd Ed.
Edward de Bono. *Lateral Thinking: Creativity Step by Step.* Harper Perennial, New York. 2015, Reissue Ed.

## CH2 110: Laboratory Operations and Safety Measures (L-T-P-C: 2-0-0-2)

| | |
|---|---|
| **Program:** B. Sc. Chemistry | **Semester:** III |
| **Course code:** CH2 110 | **Course name:** Laboratory Operations and Safety Measures |

| Lecture (Hours) | Practical (Hours) | Credits | Total Hours | Evaluation Scheme | | | |
|---|---|---|---|---|---|---|---|
| | | | | Component | Exam | Max. Marks | Passing % |
| 2/week | - | 2 | 30 | Lecture | CCE, ESE | 50 | 40 |

**Course Description:** This course deals with understanding of various chemical operations in the laboratory. This course also explains the handling of chemicals and materials with proper guide and regulations. This course also delivers essential safety measures required in chemical laboratories.

**Course Learning Outcomes:** At the end of this course students will be able to

**CO 1:** Understand the safe working practices in a chemistry laboratory.

**CO 2:** Handle safely different glass apparatus.

**CO 3:** Analyze the chemicals and equipment safety in the laboratory.

**CO 4:** Apply protocols and methods for instruments in the laboratory.

### Syllabus

| Units | Content | Hours |
|---|---|---|
| **Unit: I** Safety Measures | Includes design of a lab Do's and Don'ts chart, chemical classification and labeling, MSDS preparation, and safety symbol identification. Covers recognition of incompatible chemicals, handling and storage of compressed gas cylinders, and shelf reagent storage guidelines. Involves study of exposure limits, hazard classification, safe disposal protocols, and review of institutional safety policies, audits, and inspections. | **10** |
| **Unit: II** Laboratory Instruments | Covers the handling and use of common laboratory apparatus—glass, plastic, and metal—including cleaning, drying, and calibration of volumetric equipment. Involves the identification and assembly of lab setups, the use of heating devices (burners, hot plates, mantles, muffle furnaces), and stirring tools (magnetic stirrers, shakers, heating/cooling baths). Includes types of filter papers, use of analytical balances, melting point apparatus, distillation/reflux assemblies, safety in handling flammable solvents, and preparation of laboratory reagents. | **10** |
| **Unit: III** Chemical Handling | Students must handle chemicals safely by reading labels and MSDS for hazard info, wearing a lab coat, gloves, and goggles, and working in ventilated areas or fume hoods. Label all containers clearly, never pipette by mouth, and always add acid to water, not the reverse. Avoid direct contact, wash hands after use, and never return unused chemicals to original containers. Dispose of waste properly and know the locations of safety equipment. Report any spills or accidents immediately to the supervisor. | **10** |

### CO-PO Mapping Table

| CO | PO1 | PO2 | PO3 | PO4 | PO5 |
|---|---|---|---|---|---|
| **CLO1** | 2 | 3 | 1 | 2 | 2 |
| **CLO2** | 2 | 3 | 2 | 2 | 1 |
| **CLO3** | 2 | 3 | 3 | 2 | 2 |
| **CLO4** | 2 | 3 | 3 | 2 | 2 |
| **Average** | **2.00** | **3.00** | **2.25** | **2.00** | **1.75** |

**Correlation levels: 1 - Low, 2 - Moderate, 3 – High**

**Justification of CO-PO Mapping**

| CO | Justification |
|---|---|
| **CO 1** | Develops safe laboratory practices and professional responsibility. |
| **CO 2** | Enhances technical competency in handling laboratory apparatus. |
| **CO 3** | Strengthens analytical skills and safety awareness in chemical laboratories. |
| **CO 4** | Promotes proper laboratory protocols and sustainable scientific practices. |

**Reading references:**

D. A. Skoog; D. M. West; F. J. Holler. *Fundamentals of Analytical Chemistry.* Saunders College Publishing, USA. 1991, 2nd Ed.

J. Mendham; R. C. Denney; J. D. Barnes; M. J. K. Thomas. *Vogel's Textbook of Quantitative Chemical Analysis.* Pearson Education, New Delhi. 2002, 6th Ed.

B. S. Furniss; A. J. Hannaford; P. W. G. Smith; A. R. Tatchell. *Vogel's Textbook of Practical Organic Chemistry.* Longman Scientific and Technical, Longman Group Ltd., UK. 1989, 5th Ed.

## CH2 111: Vedic Chemistry (L-T-P-C: 2-0-0-2)

| | |
|---|---|
| **Program:** B. Sc. Chemistry | **Semester:** IV |
| **Course Code:** CH2 211 | **Course Name:** Vedic Chemistry |

| Lecture (Hours) | Practical (Hours) | Credits | Total Hours | Evaluation Scheme | | | |
|---|---|---|---|---|---|---|---|
| | | | | Component | Exam | Max. Marks | Passing % |
| 2/week | - | 2 | 30 | Lecture | CCE, ESE | 50 | 40 |

**Course Objectives:**

- Understand the scientific basis of traditional Indian chemical practices.
- Analyze ancient technologies using modern chemical principles.
- Appreciate indigenous knowledge systems in metallurgy, medicine, textiles, and materials.
- Develop critical thinking about historical scientific developments in India.

**Course Outcomes:** At the end of this course students will be able to

**CO 1:** Understand the Ancient Chemistry developed in India.
**CO 2:** Learn about the contribution of Indian civilization towards development of Modern Chemistry
**CO 3:** Know about the rich cultural heritage which our ancestors have left in Chemistry in the form of Ayurveda or traditional practices for good health and well-being and utilize this knowledge in their practical life

**Detailed Syllabus**

| Units | Content | Hours |
|---|---|---|
| **Unit I:** Introduction to History of Chemistry in India | Concept of science in ancient India**.** Sources of scientific knowledge: Vedas, Arthashastra, Rasaratnakara, Charaka Samhita**;** Development of Rasayanshastra; Contributions of Nagarjuna**;** Comparison with Greek and Chinese alchemy | **5** |
| **Unit II:** Material applications of Chemistry | **Metallurgy in Ancient India;** Extraction and purification of metals; Iron Pillar of Delhi Copper, bronze, brass technologies**;** Coinage and alloy chemistry**. Chemistry in Architecture and Art,:**Lime mortar and ancient cement; Temple construction materials**;** Ajanta and Ellora pigmentsGlass and ceramic technology**;** Terracotta and pottery chemistry. **Textile and Dye Chemistry;** Natural dyes: Indigo, turmeric, madder; Mordants and fixation chemistry**;** Indigo fermentation process**;** Kalamkari and block printing**;** Eco-friendly dyeing methods | **13** |
| **Unit III:** Chemistry for Medicine and General well-being | **Ayurveda and Rasayanshastra:** Preparation of Bhasmas (metallic preparations)**;** Mercury chemistry in Rasayanshastra**;** Fermentation processes in Ayurvedic medicines**;** Plant-based drugs and phytochemistry**;** Detoxification processes (Shodhana). **Food Chemistry and Traditional Practices:** Fermented foods (Idli, Dosa, Kanji); Use of spices – antimicrobial chemistry; Preservation techniques (pickling, salting)**;** Traditional cookware (brass, copper, clay). **Environmental Chemistry in Traditional Practices:** Water purification methods; Use of ash and natural cleaning agents, Panchagavya and bio-manures**;** Sustainable resource management. | **12** |

**Reading references:**

1. Pramod K. Nayar. *An Introduction to Cultural Studies.* Viva Books, New Delhi. 2008, 1st Ed.
2. S. S. Sastri. *Indian Culture: A Compendium of Indian History, Culture and Heritage.* Notion Press, Chennai. 2021, 1st Ed.
3. Nitin Singhania. *Indian Art and Culture.* McGraw Hill Education, Chennai. 2021, 3rd Ed.

## B.Sc. Chemistry Semester IV
## Detailed syllabus
## CH2 201: Organic Chemistry -III: Chemistry of Enolates and Amines (L-T-P-C: 2-0-0-2)

| | |
|---|---|
| **Program:** B. Sc. Chemistry | **Semester:** IV |
| **Course code:** CH2 201 | **Course Name:** Organic Chemistry -IV: Chemistry of Enolates and Amines |

| Lecture (Hours) | Practical (Hours) | Credits | Total Hours | Evaluation Scheme | | | |
|---|---|---|---|---|---|---|---|
| | | | | Component | Exam | Max. Marks | Passing % |
| 2/week | - | 2 | 30 | Lecture | CCE, ESE | 50 | 40 |

**Course Objectives:**

- Understand enols, enolates, and amines in terms of structure and reactivity
- Learn keto–enol tautomerism and enolate formation (kinetic vs. thermodynamic)
- Explore mechanisms of aldol, Claisen, and Michael reactions
- Study amines: structure, nomenclature, basicity, and synthesis
- Apply mechanistic concepts to predict products and design simple organic syntheses.

**Course Outcomes:** At the end of this course students will be able to

**CO 1:** Remembered the concepts of enolate chemistry, enamines, and the structure and classification of amines.
**CO 2:** Understand the factors governing enolate formation, stability, and amine basicity.
**CO 3:** Apply enolate reactivity in designing aldol and Claisen-type syntheses.
**CO 4:** Interpret stereoselectivity and conjugate addition in Michael reactions.
**CO 5:** Classify and predict the behavior of primary to quaternary amines.
**CO 6:** Demonstrate knowledge of amine synthesis and their key reactions

**Syllabus**

| Units | Content | Hours |
|---|---|---|
| **Unit I:** Enolate Chemistry | Acidity of α-Hydrogens, Keto–Enol Tautomerism; Enolate Ions and Enolate equivalents; Enolate Formation from aldehydes, ketones and esters; E- vs Z-enolates; enolates as ambident nucleophiles (can attack via α-carbon or oxygen); Thermodynamic vs Kinetic Enolates; Factors Affecting Enolate Reactivity; Resonance stabilization of enolates; General reactivity toward electrophiles; Control using base and temperature; Introduction to **Enamines and their synthetic applications** | **15** |
| **Unit II:** Applications of Enolate Chemistry | Synthetic applications of enolates in carbon–carbon bond-forming reactions; aldol reactions; how to control aldol reactions of esters, aldehydes and ketones; Claisen condensations and its variants and related name reaction; Alkylation of Enolates; use of enolates in Michael reactions | **15** |
| **Unit III:** Structure and Reactivity of Amines | Nomenclature and structure classification of amines; basicity and reactivity of amines; factors influencing basicity; aryl vs alkyl amines; synthesis of amines (reductive amination; gabriel synthesis; hofmann bromamide rearrangement); reactions of amines (**Mannich Reaction** and its applications, acylation, alkylation, diazotization; aryldiazonium salts and Sandmeyer reactions; electrophilic aromatic substitution in aromatic amines like aniline (activation, ortho/para directing effects), **Carbylamine Test** and **Hinsberg Test** for amine identification, Introduction to azo dyes from diazonium salts | **15** |

**Reading References:**

1. I. L. Finar. *Organic Chemistry, Volume I & II.* Dorling Kindersley (India) Pvt. Ltd., Pearson Education, New Delhi. 2002, 5th Ed.
2. R. K. Bansal. *Heterocyclic Chemistry.* New Age International Publishers, New Delhi. 2010, 5th Ed.
3. R. M. Acheson. *An Introduction to the Chemistry of Heterocyclic Compounds.* John Wiley & Sons, New York. 2008, 3rd Ed.
4. William Templeton. *An Introduction to the Chemistry of Terpenoids and Steroids.* Oxford University Press, Oxford. 1966, 1st Ed.
5. Kenneth Walter Bentley. *The Alkaloids.* Interscience Publishers (Wiley), New York. 1957, 1st Ed.

## CH2 202: Inorganic Chemistry-III: s and p-Block Elements (L-T-P-C: 2-0-0-2)

| **Program:** B. Sc. Chemistry | **Semester:** IV |
|---|---|
| **Course code:** CH2 202 | **Course name:** Inorganic Chemistry-III: s and p-Block Elements |

| Lecture (Hours) | Practical (Hours) | Credits | Total Hours | Evaluation Scheme | | | |
|---|---|---|---|---|---|---|---|
| | | | | Component | Exam | Max. Marks | Passing % |
| 2/week | - | 2 | 30 | Lecture | CCE, ESE | 75 | 40 |

**Course Objective:**

The concept of periodicity related to old and modern periodic table.
This course delivers the details study of Slater's rule and calculates the effective nuclear charge of individual ion.
This course also focuses the concept of different radii, lattice energy, hydrides, crown ether, cause and effect of inert pair effect.

**Course Learning Outcomes:** At the end of this course students will be able to

**CO 1:** Define general electronic configuration of s, p, d and f-block elements.
**CO 2:** Elaborate discussion of different types of radii.
**CO 3:** Calculate the effective nuclear charge by using Slater's rule.
**CO 4:** Summarize the physical and chemical properties of gr-I & II metals, inert pair effect.

**Syllabus**

| Units | Content | Hours |
|---|---|---|
| **Unit I:** Periodicity of Elements | General electronic configuration of s, p, d, f-block elements, periodicity, Concept of old and modern periodic table, the long form of the periodic table. Detailed discussion of the following properties of the elements, with reference to s & p-block. (a) Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in the periodic table, effects (b) Atomic radii (van der Waals) (c) Ionic and crystal radii. (d) Covalent radii (octahedral and tetrahedral), metallic. (e) Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy. (f) Electron gain enthalpy, trends of electron gain enthalpy, abnormality, factors that affect the value of E.A. (g) Electronegativity, factors, trends, Mulliken's scales. Variation of electronegativity with bond order, partial charge, hybridization, and group electronegativity | **12** |
| **Unit II:** Physical and chemical properties of gr-I & II metals | Characteristic flame color, complexation of alkali ions (crown ether), Inert pair effect: cause & effect, Relative stability of different oxidation states, diagonal relationship, and anomalous behavior of the first member of each group. Allotropy and catenation. Complex formation tendency of s and p block elements. Lattice energy Basic beryllium acetate and nitrate. | **12** |
| **Unit III:** Hydrides | Hydrides and their classification: ionic, covalent, and interstitial. Bonding, preparation and structure of different hydrides. Borohydrides, Banana bond, concept of 2c-3e, 3c-2e, 2c-2e and 2c-1e bond | **06** |

**CO-PO Mapping Table2**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 |
|---|---|---|---|---|---|
| **CO 1** | **2** | **3** | **2** | **-** | **1** |
| **CO 2** | **2** | **3** | **2** | **1** | **1** |
| **CO 3** | **3** | **3** | **3** | **-** | **1** |
| **CO 4** | **2** | **3** | **3** | **1** | **1** |

| | | | | | |
|---|---|---|---|---|---|
| **Average** | **2.25** | **3.00** | **2.50** | **0.50** | **1.00** |

**Correlation levels:**
**1 - Low, 2 - Moderate, 3 - High**

**Justification for CO-PO Mapping**

| COs | Justification |
|---|---|
| **CO 1** | Develops knowledge of inorganic salts and qualitative analysis while enhancing laboratory skills and analytical reasoning (**PO1, PO2, PO3**). |
| **CO 2** | Strengthens understanding of inorganic synthesis and characterization techniques and introduces research-oriented laboratory practices (**PO1, PO2, PO4**). |
| **CO 3** | Enhances stoichiometric calculations, yield determination, and composition analysis, promoting analytical and problem-solving abilities (**PO1, PO2, PO3**). |
| **CO 4** | Develops competency in separation and quantitative analysis techniques while improving analytical reasoning and scientific investigation skills (**PO2, PO3, PO4**). |

**Reading references:**

R. L. Madan. *Chemistry for Degree Students.* S. Chand Publications, New Delhi. 2016, 1st Ed.
R. P. Sarkar. *General and Inorganic Chemistry.* New Central Book Agency, Kolkata. 2011, 3rd Ed.
J. D. Lee. *Concise Inorganic Chemistry.* Oxford University Press, Oxford. 2008, 5th Ed.
F. A. Cotton; G. Wilkinson; Paul L. Gaus. *Basic Inorganic Chemistry.* Wiley, New York. 2007, 3rd Ed.
N. N. Greenwood; A. Earnshaw. *Chemistry of the Elements.* Pergamon Press, Oxford. 1989, 1st Ed.

## CH2 203: Physical Chemistry-III: Chemical and Ionic Equilibria (L-T-P-C: 3-0-0-3)

| | |
|---|---|
| **Program:** B. Sc. Chemistry | **Semester:** IV |
| **Course code:** CH2 203 | **Course name:** Physical Chemistry-III Chemical and Ionic Equilibria |

| Lecture (Hours) | Practical (Hours) | Credits | Total Hours | Evaluation Scheme | | | |
|---|---|---|---|---|---|---|---|
| | | | | Component | Exam | Max. Marks | Passing % |
| 2/week | - | 2 | 60 | Lecture | CCE, ESE | 50 | 40 |

### Course Objectives:

This course aims to provide a fundamental understanding of ionic equilibrium, chemical equilibrium, and chemical kinetics. It focuses on concepts such as ionization, pH, buffer solutions, solubility product, equilibrium constants, and thermodynamic aspects of equilibrium. The course also introduces reaction kinetics, rate laws, reaction mechanisms, temperature dependence of reaction rates, and theories of reaction rates to develop analytical and problem-solving skills in physical chemistry.

**Course Outcomes:** At the end of this course students will be able to
**CO 1:** Explain the concepts of ionic equilibrium, pH, buffer solutions, salt hydrolysis, and solubility product.
**CO 2:** Apply thermodynamic principles to chemical equilibrium and equilibrium constant calculations.
**CO 3:** Analyze reaction kinetics, rate laws, and mechanisms of simple and complex reactions.
**CO 4:** Interpret the effect of temperature and activation energy on reaction rates using collision theory and Arrhenius equation.

**Syllabus**

| Units | Content | Hours |
|---|---|---|
| **Unit I:** Ionic equilibrium | **Ionic equilibrium:** Strong, moderate, and weak electrolytes, degree of ionization, factors affecting the degree of ionization, ionization constant, and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect; dissociation constants of mono- and diprotic acids,-pH calculations for simple acid-base systems. Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis, Buffer solutions; Henderson-Hasselbatch equation and its applications; buffer capacity, buffer range, buffer action. Solubility and solubility product of sparingly soluble salts – applications of solubility product principle. Theory of acid-base indicators; selection of indicators and their limitations. Applications of ionic equilibrium in biological, environmental, and industrial systems. | **12** |
| **Unit II:** Chemical equilibrium | **Chemical equilibrium:** Criteria of thermodynamic equilibrium, degree of advancement of reaction, chemical equilibria in ideal gases, Relationship between Gibbs free energy and equilibrium constant. Equilibrium constants and their quantitative dependence on temperature, pressure, and concentration; thermodynamic derivation of relations between the various equilibrium constants $K_p$, $K_c$, and $K_x$. Le Chatelier's principle. | **10** |
| **Unit III:** Industrial applications | Ammonia synthesis (Haber process) – optimization via pressure/temperature, Sulfuric acid production (Contact process) – role of catalyst, temperature, and gas-phase equilibria. nitric acid manufacture (Ostwald process) and equilibrium considerations; industrial applications of Le Chatelier's principle; equilibrium in environmental systems such as atmospheric and aquatic chemistry. | **08** |

**CO-PO Mapping Table**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 |
|---|---|---|---|---|---|
| **CO 1** | **3** | **3** | **2** | **-** | **1** |
| **CO 2** | **3** | **2** | **3** | **-** | **-** |
| **CO 3** | **3** | **3** | **3** | **-** | **-** |
| **CO 4** | **3** | **2** | **2** | **-** | **-** |
| **Average** | **3** | **2.5** | **2.5** | **-** | **1** |

**Correlation levels:**
**1 - Low, 2 - Moderate, 3 - High**

**Justification for CO-PO Mapping**

| CO | Justification |
|---|---|
| **CO 1** | This CO develops fundamental understanding of ionic equilibrium, pH, buffers, and solubility concepts, strengthening scientific knowledge and analytical skills (**PO1, PO2**). |
| **CO 2** | Application of thermodynamic principles and equilibrium calculations enhances conceptual understanding, quantitative analysis, and problem-solving ability (**PO1, PO2, PO3**). |
| **CO 3** | Study of reaction kinetics, rate laws, and mechanisms improves analytical thinking, interpretation skills, and scientific problem-solving ability (**PO2, PO3**). |
| **CO 4** | Understanding the influence of temperature and activation energy on reaction rates develops scientific reasoning and analytical competence with applications in chemical and industrial processes (**PO1, PO2, PO5**). |

**Reading References:**

R. L. Madan. *Chemistry for Degree Students.* S. Chand Publications, New Delhi. 2016, 1st Ed.
B. R. Puri; L. R. Sharma. *Principles of Physical Chemistry.* Vishal Publishing Co., Jalandhar. 2020, 49th Ed.
G. W. Castellan. *Physical Chemistry.* Narosa Publishing House, New Delhi. 2004, 3rd Ed.
Gurdeep Raj. *Advanced Physical Chemistry.* Krishna Prakashan Media, Meerut. 2018, 4th Ed.

## CH2 204: Organic Chemistry-III Laboratory (L-T-P-C: 0-0-4-2)

| | |
|---|---|
| **Program:** B. Sc. Chemistry | **Semester:** IV |
| **Course code:** CH2 204 | **Course name:** Organic Chemistry-III Laboratory |

| Lecture (Hours) | Practical (Hours) | Credits | Total Hours | Evaluation Scheme | | | |
|---|---|---|---|---|---|---|---|
| | | | | Component | Exam | Max. Marks | Passing % |
| - | 2/week | 1 | 30 | Lab | CCE, ESE | 25 | 40 |

**Course Objectives:**

- Gain hands-on experience with enolate and amine chemistry
- Demonstrate the synthesis and characterization of important organic compounds through condensation, substitution, acylation, and diazotization reactions.
- Synthesize and aliphatic amines, understand reaction mechanisms
- To provide hands-on experience in the synthesis, isolation, purification, and characterization of organic compounds.
- To train students in safe laboratory practices, accurate experimental techniques, and proper documentation of experimental results.

**Course Learning Outcomes:** At the end of this course, students will be able to
**CO 1**: Perform key organic reactions involving enolates and amines using standard lab techniques.
**CO 2**: Analyze mechanisms of aldol, Claisen, and electrophilic substitution reactions.
**CO 3**: Classify and identify amines through qualitative tests.
**CO 4**: Monitor and interpret reactions using chromatographic and analytical methods.
**CO 5**: Perform laboratory experiments safely and accurately, including product isolation, purification, and determination of physical properties.

**Syllabus**

| Sr. No. | Name of the Experiment | Hours |
|---|---|---|
| **1** | To demonstrate keto–enol tautomerism using acetylacetone | **3** |
| **2** | To perform Claisen–Schmidt condensation: Synthesis of chalcone. | **3** |
| **3** | To synthesize α,β-unsaturated ketone from a base-catalyzed aldol condensation between acetone and benzaldehyde | **3** |
| **4** | To perform the Self-claisen condensation: Synthesis of ethyl acetoacetate | **3** |
| **5** | To perform Michael addition: 1,4-conjugate addition of enolate to methyl vinyl ketone or cyclo | **3** |
| **6** | To perform the Diazotization reaction: Preparation of methyl orange from sulfanilic acid | **3** |
| **7** | To perform the Acylation of aniline to form acetanilide | **3** |
| **8** | To perform the Synthesis of primary amine via Gabriel phthalimide synthesis | **3** |
| **9** | To perform: Electrophilic substitution in aniline: Bromination of aniline to 2,4,6- 2,4,6-tribromoaniline | **3** |

**Reading References:**

B. S. Furniss. *Vogel's Textbook of Practical Organic Chemistry.* Pearson Education, New Delhi. 2011, 5th Ed.
A. I. Vogel; A. R. Tatchell; B. S. Furniss; A. J. Hannaford; P. W. G. Smith. *Textbook of Practical Organic Chemistry.* Prentice-Hall, London. 1996, 5th Ed.
A. K. Nad; B. Mahapatra. *An Advanced Course in Practical Chemistry.* New Central Book Agency, Kolkata. 2022, 3rd Ed.
V. K. Ahluwalia; Sunita Dhingra. *Practical Organic Chemistry.* New Central Book Agency, Kolkata. 2017, 1st Ed.
N. K. Vishnoi. *Advanced Practical Organic Chemistry.* Vikas Publishing House, New Delhi. 2009, 3rd Ed.

## CH2 205: Inorganic Chemistry III Laboratory (L-T-P-C: 0-0-4-2)

| | |
|---|---|
| **Program:** B. Sc. Chemistry | **Semester:** IV |
| **Course code:** CH2 205 | **Course name:** Inorganic Chemistry III Laboratory |

| Lecture (Hours) | Practical (Hours) | Credits | Total Hours | Evaluation Scheme | | | |
|---|---|---|---|---|---|---|---|
| | | | | Component | Exam | Max. Marks | Passing % |
| - | 2/week | 2 | 60 | Lab | CCE, ESE | 50 | 40 |

**Course Objective:** This practical course covers

- Learning and analyzing the water of crystallization of various salts of Gr-I & II.
- Determine the percentage of purity of Gr-I salt.
- This course deals separation of metal ions gravimetrically.
- This course also deals with the exchange capacity of cation exchange resin and the separation of different amino acids by chromatographic techniques.

**Course Outcomes:** At the end of this course, students will be able to

**CO 1:** Analyzing water of crystallization and calculating the percentage of purity

**CO 2:** Separate different ions gravimetrically.

**CO 3:** Determine the exchange capacity of ion exchange resins.

**CO 4:** Identify different amino acids by chromatographic techniques.

**Syllabus**

| Sr. No. | Name of the Experiment | Hours |
|---|---|---|
| 1 | To determine and calculate the water of crystallization of a given salt. $BaCl_2\ 2H_2O$, $Mg.SO_4\ 7H_2O$, $CuSO_4.\ 5H_2O$ | 8 |
| 2 | To determine the Percentage of Purity of a given salt ($Na_2CO_3$, $NaHCO_3$) | 8 |
| 3 | To separate a mixture of $Ni^{2+}$ & $Fe^{2+}$ by complexation with DMG and extract the $Ni^{2+}$-DMG complex in chloroform, and determine its concentration by spectrophotometry | 8 |
| 4 | To determine the exchange capacity of cation exchange resins and anion exchange resins. | 8 |
| 5 | To separate the amino acids from organic acids by ion exchange chromatography. | 8 |
| 6 | To separate different metal ions from their binary mixture by TLC | 8 |
| 7 | Determination of $Fe^{3+}$ concentration by UV-Visible spectrophotometry using potassium thiocyanate. | 8 |
| 8 | To separate and identify a mixture of dyes by paper chromatography and determine their Rf values. | 8 |

**CO-PO Mapping Table**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 |
|---|---|---|---|---|---|
| CO 1 | 3 | 3 | 2 | - | 1 |
| CO 2 | 2 | 3 | 3 | 1 | 1 |
| CO 3 | 2 | 3 | 2 | 1 | 1 |
| CO 4 | 2 | 3 | 2 | - | 1 |
| Average | 2.25 | 3.00 | 2.25 | 0.50 | 1.00 |

**Correlation levels:**
**1 - Low, 2 - Moderate, 3 - High**

**Justification for CO-PO Mapping**

| COs | Justification |
|---|---|

| | |
|---|---|
| **CO 1** | Develops understanding of water of crystallization and purity analysis while strengthening quantitative laboratory and calculation skills (**PO1, PO2**). |
| **CO 2** | Enhances practical competency in gravimetric separation, solvent extraction, and spectrophotometric analysis, promoting analytical and problem-solving skills (**PO2, PO3, PO4**). |
| **CO 3** | Develops technical skills in ion-exchange processes and determination of resin exchange capacity, with exposure to analytical investigation (**PO2, PO4**). |
| **CO 4** | Strengthens understanding of chromatographic separation techniques and identification of amino acids and metal ions, enhancing analytical skills (**PO1, PO2, PO3**). |

**Reading references:**

G. H. Jeffery; J. Bassett; J. Mendham; R. C. Denney. *Vogel's Textbook of Quantitative Chemical Analysis.* Orient Longman, New Delhi. 1989, 5th Ed.

G. Svehla. *Vogel's Textbook of Macro and Semimicro Qualitative Inorganic Analysis.* Orient Longman, New Delhi. 1982, 5th Ed.

Mala Nath. *Inorganic Chemistry: A Laboratory Manual.* Alpha Science International Ltd., Oxford. 2016, 1st Ed.

## CH2 206: Physical Chemistry-III Laboratory (L-T-P-C: 0-0-4-2)

| | |
|---|---|
| **Program:** B. Sc. Chemistry | **Semester:** IV |
| **Course code:** CH2 206 | **Course name:** Physical Chemistry-III Laboratory |

| Lecture (Hours) | Practical (Hours) | Credits | Total Hours | Evaluation Scheme | | | |
|---|---|---|---|---|---|---|---|
| | | | | Component | Exam | Max. Marks | Passing % |
| - | 4/week | 2 | 60 | Lab | CCE, ESE | 50 | 40 |

**Course Objective:** This course introduces students to fundamental experiments in chemical and ionic equilibrium, including pH measurements, buffer preparation, acid-base titrations, solubility product determination, and equilibrium constant calculations, providing hands-on experience in understanding dynamic equilibrium systems relevant to both academic and industrial chemistry.

**Course outcomes:**

**CO 1:** Analyze acid-base equilibria, buffer systems, and solubility equilibria through laboratory experiments and interpretation of results.

**CO 2:** Calculate and interpret equilibrium constants using experimental data under varying system conditions

**CO3:** Apply safe laboratory practices and accurate data handling techniques in equilibrium-based experiments.

**CO 4:** Evaluate the effect of changing experimental conditions based on Le Chatelier's principle.

**Syllabus**

| Sr. No. | Name of the Experiment | Hours |
|---|---|---|
| 1 | To prepare buffer solutions of different pH<br>Sodium acetate-acetic acid<br>Ammonium chloride-ammonium hydroxide | 4 |
| 2 | To perform the pH-metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base. | 6 |
| 3 | To determine the dissociation constant of a weak acid. | 6 |
| 4 | To study the shift in equilibrium in the reaction of ferric and thiocyanate ions. | 8 |
| 5 | To validate the Le Chatelier's Principle using simple laboratory methods | 8 |
| 6 | To investigate the effect of Temperature on Equilibrium Constant (Van't Hoff Equation) | 8 |
| 7 | To determine the Unfavorable Reaction through a Coupled Favorable Reaction | 8 |
| 8 | To determine the pKa of a Polyprotic Acid (e.g., Phosphoric Acid) via pH Titration | 6 |
| 9 | To determine the solubility product for the sparingly soluble salts. | 6 |

**CO-PO Mapping Table**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 |
|---|---|---|---|---|---|
| CO 1 | 3 | 3 | 2 | - | - |
| CO 2 | 3 | 2 | 3 | - | - |
| CO 3 | 2 | 3 | 1 | 3 | 3 |
| CO 4 | 3 | 3 | 3 | - | - |
| Average | 2.75 | 2.75 | 2.25 | 0.75 | 0.75 |

**Correlation levels: 1 - Low, 2 - Moderate, 3 – High**

**Justification for CO-PO Mapping**

| CO | Justification |
|---|---|

| | |
|---|---|
| **CO 1** | This CO develops conceptual understanding of acid-base equilibria, buffer systems, and solubility equilibria through laboratory experiments, strengthening scientific knowledge and analytical skills (**PO1, PO2**). Experimental interpretation also enhances problem-solving ability (**PO 3**). |
| **CO 2** | Calculation and interpretation of equilibrium constants improve quantitative analysis, technical competence, and scientific problem-solving skills (**PO 1, PO 2, PO 3**). |
| **CO 3** | Application of safe laboratory practices and proper data handling develops technical laboratory competence and promotes ethical responsibility and professional conduct (**PO 2, PO 4**). |
| **CO 4** | Evaluation of changes in equilibrium conditions based on Le Chatelier's principle enhances conceptual understanding, analytical reasoning, and critical thinking ability (**PO 1, PO 2, PO 3**). It also provides awareness of industrial and environmental applications of equilibrium systems (**PO 5**). |

**Reading References:**

B. D. Khosla; V. C. Garg; Adarsh Gulati. *Senior Practical Physical Chemistry.* R. Chand & Co., New Delhi. 2018, 1st Ed.
B. Viswanathan; P. S. Raghavan. *Practical Physical Chemistry.* Viva Books Private Limited, Navi Mumbai. 2017, 1st Ed.
A. K. Nad; B. Mahapatra; A. Ghoshal. *An Advanced Course in Practical Chemistry (Paperback).* New Central Book Agency Pvt. Ltd., Kolkata. 2022, 3rd Ed.
B. Viswanathan; P. S. Raghavan. *Practical Physical Chemistry.* Viva Books, New Delhi. 2012, 1st Ed.
J. N. Gurtu; Amit Gurtu. *Advanced Physical Chemistry Experiments.* Pragati Prakashan, Meerut. 2011, 1st Ed.

## CH2 207: Application of Semiconducting Materials (L-T-P-C: 2-0-0-2)

| | |
|---|---|
| **Program:** B. Sc. Chemistry | **Semester:** IV |
| **Course code:** CH2 207 | **Course name:** Application of Semiconducting Materials |

| Lecture (Hours) | Practical (Hours) | Credits | Total Hours | Evaluation Scheme | | | |
|---|---|---|---|---|---|---|---|
| | | | | Component | Exam | Max. Marks | Passing % |
| 2/week | - | 2 | 30 | Lecture | CCE, ESE | 50 | 40 |

**Course Objectives:** This course is designed to provide students with a comprehensive understanding of semiconductor-based photonic and memory devices and their technological applications. The course introduces the principles, operation, and characteristics of photodiodes, solar cells, LEDs, diode lasers, and optical gain mechanisms, along with various memory technologies such as SRAM, DRAM, CMOS, PMOS, NMOS, magnetic, optical, and ferroelectric memories. It further develops students' understanding of charge-coupled devices (CCD), sensors, and actuators, enabling them to relate semiconductor device physics to modern electronic, optoelectronic, sensing, and information storage systems.

**Course Outcomes:** At the end of this course students will be able to
CO1: Explain the fundamental principles, construction, and operating characteristics of photonic semiconductor devices such as photodiodes, solar cells, LEDs, and diode lasers.
CO2: Analyze the concepts of optical gain, population inversion, threshold conditions for lasing, and the performance characteristics of semiconductor photonic devices.
CO3: Describe the structure, operation, and applications of various semiconductor memory devices including SRAM, DRAM, CMOS, PMOS, NMOS, magnetic, optical, and ferroelectric memories.
CO4: Evaluate the applications of semiconductor devices such as CCDs, sensors, actuators, and memory systems in modern electronic and optoelectronic technologies.

### Detailed Syllabus

| Units | Content | Hours |
|---|---|---|
| **UNIT I:** Photonic Device | Radiative and non-radiative transition, absorption and emission, Diode photodetectors, solar cell, Light Emitting Diode (LED), diode laser (condition for population inversion, in active region), optical gain and threshold current for lasing, relation between optical gain and threshold current. | 22.5 |
| **UNIT II:** Memory Devices | Static and Dynamic Random-Access memories (SRAM and DRAM), difference between SRAM and DRAM, Complementary Metal Oxide Semiconductor (CMOS), P-Channel MOS (PMOS) and N-Channel MOS (NMOS), Nonvolatile – NMOS, Magnetic, Optical and Ferroelectric Memories, Charge Coupled Devices (CCD), Application in Sensor and Actuator Devices. | 22.5 |

### CO-PO Mapping Table

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 |
|---|---|---|---|---|---|
| **CO1** | 3 | 2 | - | - | - |
| **CO2** | 3 | 3 | 2 | - | - |
| **CO3** | 3 | 2 | 2 | - | - |
| **CO4** | 2 | 3 | 3 | 2 | - |
| **Average** | 2.75 | 2.5 | 1.75 | 0.5 | - |

### Justification for CO-PO Mapping Table

| CO | Justification |
|---|---|

| | |
|---|---|
| **CO1** | Understanding photodiodes, solar cells, LEDs and diode lasers develops scientific knowledge and technical competence in semiconductor photonic devices. (PO1, PO2) |
| **CO2** | Analysis of optical gain, population inversion and lasing conditions enhances conceptual understanding, analytical reasoning and problem-solving skills. (PO1, PO2, PO3) |
| **CO3** | Studying semiconductor memory technologies develops scientific knowledge and analytical ability to compare and evaluate different memory systems. (PO1, PO2, PO3) |
| **CO4** | Evaluation of CCDs, sensors, actuators and memory systems promotes analytical thinking, application-oriented problem solving and communication of technological concepts. (PO2, PO3, PO4) |

**Reading References**

R. K. Puri; V. K. Babbar. *Solid State Physics.* S. Chand & Co. Ltd., New Delhi. 2010, 1st Ed.
V. K. Mehta. *Principles of Electronics.* S. Chand & Co. Ltd., New Delhi. 2014, 7th Ed.
Arthur Beiser. *Concepts of Modern Physics.* Tata McGraw-Hill, New Delhi. 2002, 6th Ed.
R. K. Gaur; S. L. Gupta. *Engineering Physics.* Dhanpat Rai Publications, New Delhi. 2012, Revised Ed.
Charles Kittel. *Introduction to Solid State Physics.* John Wiley & Sons, New York. 2018, 8th Ed.
S. M. Sze; Kwok K. Ng. *Physics of Semiconductor Devices.* Wiley, New York. 1996, 2nd Ed.
P. Bhattacharya. *Semiconductor Opto-Electronic Devices.* Prentice Hall of India, New Delhi. 1996, 2nd Ed.
M. K. Achuthan; K. N. Bhat. *Fundamentals of Semiconductor Devices.* McGraw Hill Education, New Delhi. 2007, 1st Ed.
J. Allison. *Electronic Engineering Materials and Devices.* McGraw Hill Education, New Delhi. 1990, 1st Ed.

## CH2 208: Semiconducting Materials Laboratory (L-T-P-C: 0-0-2-1)

| | |
|---|---|
| **Program:** B. Sc. Chemistry | **Semester:** IV |
| **Course code:** CH2 208 | **Course name:** Semiconducting Materials Laboratory |

| Lecture (Hours) | Practical (Hours) | Credits | Total Hours | Evaluation Scheme | | | |
|---|---|---|---|---|---|---|---|
| | | | | Component | Exam | Max. Marks | Passing % |
| - | 2/week | 2 | 60 | Practical | CCE, ESE | 50 | 40 |

**Course Objectives:** This laboratory course is designed to provide practical understanding of optical and semiconductor-based technologies through experiments involving interference, diffraction, polarization, optical fibers, and precision optical instruments. The course enables students to develop experimental skills in measuring important optical parameters such as wavelength, specific rotation, numerical aperture, and refractive properties. It also strengthens their ability to analyze optical phenomena, interpret experimental observations, and apply the principles of photonics and semiconductor-based optical systems to modern communication, sensing, and measurement technologies.

**Course Outcomes:** At the end of this course students will be able to
CO 1: Demonstrate proficiency in conducting optical experiments and recording experimental data using various optical and semiconductor-based instruments.
CO 2: Analyze the principles of interference, diffraction, polarization, and optical fiber transmission through experimental investigations and data interpretation.
CO 3: Apply theoretical concepts of optics and semiconductor-based photonic systems to determine important parameters such as wavelength, numerical aperture, specific rotation, and radius of curvature.
CO 4: Evaluate the performance and characteristics of optical devices and experimental systems, and interpret their applications in communication, sensing, and measurement technologies.

### Detailed Syllabus

| Experiment No. | Content | Hours |
|---|---|---|
| 1 | Determination of the radius of curvature of a given plano-convex lens using the phenomenon of interference of light viz. Newton's rings. | 10 |
| 2 | Determination of the specific rotation of sugar solution using Laurent's half shade. | 10 |
| 3 | Estimation of numerical aperture of an optical fiber. | 10 |
| 4 | Study the concept of diffraction of light using a diffraction grating spectrometer and measure the wavelengths of certain lines in the spectrum of the mercury arc lamp. | 10 |
| 5 | Understanding of the intensity distribution due to diffraction from single slit and to determine the slit width (d). | 10 |
| 6 | Measurement of the angle of deviation (d) with angle of incidence (i) and to find the angle of minimum deviation (D) from i-d curve. | 10 |

### CO-PO Mapping Table

| CO/PO | PO1 | PO2 | PO3 | PO4 | PO5 |
|---|---|---|---|---|---|
| **CO1** | 2 | 3 | - | - | - |
| **CO2** | 3 | 3 | 2 | - | - |
| **CO3** | 2 | 3 | 3 | - | - |
| **CO4** | 2 | 3 | 3 | 2 | - |
| **Average** | 2.25 | 3.0 | 2.0 | 0.5 | - |

### Justification for CO-PO Mapping Table

| COs | Justification |
|---|---|

| | |
|---|---|
| **CO 1** | Performing optical experiments and recording data develops scientific understanding of optical systems and strengthens technical and experimental skills required for laboratory investigations. (PO1, PO2) |
| **CO 2** | Analysis of interference, diffraction, polarization and optical fiber characteristics enhances conceptual understanding, analytical reasoning and scientific problem-solving ability. (PO1, PO2, PO3) |
| **CO 3** | Application of optical principles to determine physical parameters develops technical competence, quantitative analysis skills and the ability to solve practical scientific problems. (PO1, PO2, PO3) |
| **CO 4** | Evaluation of optical devices and communication systems promotes analytical thinking, application-oriented learning and effective communication of scientific observations and results. (PO2, PO3, PO4) |

**Reference books:**

V. K. Mehta. *Principles of Electronics.* S. Chand & Co. Ltd., New Delhi. 2007, Revised Ed.
P. R. S. Kumar. *Practical Physics.* PHI Learning Pvt. Ltd., New Delhi. 2011, 1st Ed.
Harnam Singh; P. S. Hemne. *Practical Physics.* S. Chand & Co. Ltd., New Delhi. 2000, 1st Ed.
S. K. Ghosh. *Advanced Practical Physics.* New Central Book Agency (NCBA), Kolkata. 2010, 1st Ed.

## CH2 209: Professional Communication (L-T-P-C: 2-0-0-2)

| | |
|---|---|
| **Program:** B. Sc. Chemistry | **Semester: IV** |
| **Course code:** CH2 209 | **Course name:** Professional Communication |

| Lecture (Hours) | Practical (Hours) | Credits | Total Hours | Evaluation Scheme | | | |
|---|---|---|---|---|---|---|---|
| | | | | Component | Exam | Max. Marks | Passing % |
| 2/week | - | 2 | 30 | Lecture | CCE, ESE | 50 | 40 |

**Course Objectives:** This course is designed to:

- Develop students' ability to communicate effectively in scientific, academic, and professional environments.
- Familiarize students with scientific writing, research documentation, patent drafting, and ethical publication practices.
- Enhance professional communication skills including report writing, presentations, leadership, and workplace interactions.
- Strengthen students' confidence, professional image, and interpersonal effectiveness through personality enhancement activities.
- Prepare students for higher education and career opportunities through professional ethics, resume development, and workplace readiness.

**Course Outcomes:**
At the end of this course, students will be able to
**CO 1:** Prepare scientific and academic documents such as research papers, abstracts, and patent drafts using appropriate formats, referencing styles, and ethical practices.
**CO 2:** Demonstrate effective professional communication through report writing, presentations, public speaking, and workplace documentation.
**CO 3:** Apply leadership, teamwork, negotiation, and conflict management skills in academic and professional settings.
**CO 4:** Exhibit professional behavior through effective self-presentation, body language, social etiquette, and ethical workplace conduct.
**CO 5:** Develop career readiness competencies by creating professional portfolios, resumes, and demonstrating confidence in professional interactions.

**Detailed Syllabus**

| Units | Content | Hours |
|---|---|---|
| **Unit - I**<br>Scientific and Academic Communication | Principles of Scientific and Technical Writing<br>Structure of Research Papers (IMRAD Format)<br>Abstract, Introduction, Methodology, Results, and Discussion Writing<br>Basics of Patent Drafting and Intellectual Property Rights<br>Citation, Referencing Styles, and Plagiarism Prevention | **10** |
| **Unit - II**<br>Professional Communication and Workplace Skills | Foundation of Creative Expression<br>Public Speaking<br>Report Writing and Meeting Documentation<br>Presentation Design and Delivery Techniques<br>Leadership and Team Coordination<br>Conflict Management and Negotiation Skills | **10** |
| **Unit - III**<br>Professional Image and Personality Enhancement | Personal Grooming and Self-Presentation<br>Body Language and Social Etiquette<br>Building Self-Confidence and Positive Image<br>Professional Ethics and Workplace Conduct<br>Building a Professional Portfolio and Resume | **10** |

**CO-PO Mapping Table**

| | PO 1 | PO 2 | PO 3 | PO 4 | PO 5 |
|---|---|---|---|---|---|
| **CO 1** | **2** | **2** | **2** | **3** | **-** |
| **CO 2** | **-** | **2** | **1** | **3** | **-** |
| **CO 3** | **-** | **1** | **2** | **3** | **-** |
| **CO 4** | **-** | **1** | **1** | **3** | **1** |
| **CO 5** | **-** | **2** | **1** | **3** | **-** |
| **Average** | **0.40** | **1.60** | **1.40** | **3.00** | **0.20** |

**Correlation levels:**
**1 - Low, 2 - Moderate, 3 - High**

**Justification for CO-PO Mapping**

| COs | Justification |
|---|---|
| **CO 1** | This CO develops students' to prepare scientific documents, research papers, and patent drafts, (**PO1**), analytical and technical skills (**PO2**), and critical thinking (**PO3**). It also promotes professional communication and ethical conduct (**PO4**). |
| **CO 2** | This CO enhances professional communication skills through report writing, presentations, public speaking, and workplace documentation. It develops communication and documentation competencies (**PO2**), supports logical organization and presentation of ideas (**PO3**), and strongly contributes to effective communication and professional excellence (**PO4**). |
| **CO 3** | This CO develops leadership, teamwork, negotiation, and conflict management skills required in professional environments. It contributes to collaborative working abilities (**PO2**), problem-solving and decision-making skills (**PO3**), and promotes leadership, teamwork, and professional responsibility (**PO4**). |
| **CO 4** | This CO strengthens professional behavior through self-presentation, body language, social etiquette, and ethical workplace conduct. It enhances interpersonal effectiveness (**PO2**), supports informed decision-making and behavioral awareness (**PO3**), and strongly aligns with ethics, communication, and professional development (**PO4**). It also encourages responsible citizenship and social awareness (**PO5**). |
| **CO 5** | This CO develops employability and career readiness through portfolio development, resume writing, and professional interactions. It enhances professional competency and workplace preparedness (**PO2**), supports career planning and decision-making abilities (**PO3**), and contributes significantly to lifelong learning, communication, and professional excellence (**PO4**). |

**Reading References:**

Meenakshi Raman; Sangeeta Sharma. *Technical Communication: Principles and Practice.* Oxford University Press, New Delhi. 2015, 2nd Ed.
C. L. Bovee; J. V. Thill; M. Chaturvedi. *Business Communication Today.* Pearson Education, New Delhi. 2010, 11th Ed.
Barun K. Mitra. *Personality Development and Soft Skills.* Oxford University Press, New Delhi. 2011, 1st Ed.
TED Talks. *Ideas Worth Spreading.* Available at: https://www.ted.com/talks

**CH2 210: Software for Scientific Learning (L-T-P-C: 2-0-0-2)**

| | |
|---|---|
| **Program:** B. Sc. Chemistry | **Semester:** IV |
| **Course Code:** CH2 210 | **Course Name:** Software for Scientific Learning |

| Lecture (Hours) | Practical (Hours) | Credits | Total Hours | Evaluation Scheme | | | |
|---|---|---|---|---|---|---|---|
| | | | | Component | Exam | Max. Marks | Passing % |
| 2/week | - | 2 | 30 | Lecture | CCE, ESE | 50 | 40 |

**Course Objectives:**

This course introduces digital and computational tools used in modern chemistry, including chemical structure drawing, molecular visualization, chemical databases, and scientific data management. It covers basic computational chemistry concepts, molecular modeling, spectroscopy data interpretation, and the use of software for data analysis, graphing, and statistical evaluation. The course also emphasizes research data organization, FAIR data principles, reference management, publication-quality scientific reporting, and research integrity.

**Course Outcomes:** At the end of this course, students will be able to

**CO 1:** Identify and use basic scientific software relevant to chemical data analysis and simulation.

**CO 2:** Interpret experimental data through digital tools

**CO 3:** Prepare technical reports and presentations using appropriate software

**CO 4:** Demonstrate digital literacy by integrating online resources

**Syllabus**

| Units | Content | Hours |
|---|---|---|
| **Unit I:** Chemical Information Tools | Introduction to scientific software in chemistry, File formats and extensions (.mol, .cml, .csv, .pdb), Drawing and visualization tools. SMILES notation, IUPAC name generation, 2D to 3D structure conversion. Reference management software: Citation styles and bibliography management (EndNote). Introduction to Electronic Lab Notebooks (ELNs) and lab data organization. Chemical databases and information retrieval (PubChem, ChemSpider, SciFinder, Reaxys). Introduction to molecular descriptors and chemical identifiers (InChI and InChIKey). Basics of FAIR data principles (Findable, Accessible, Interoperable and Reusable). | **10** |
| **Unit II:** Molecular Modeling and Spectral Analysis Tools | Introduction to computational chemistry software: Avogadro, GaussView, ORCA Viewers (theoretical overview), Geometry optimization and energy minimization, Overview of spectroscopy interpretation software: MestReNova, Spekwin32, JSpecView, Reading IR, NMR, UV-Vis spectra (basic interpretation from raw files). Introduction to molecular orbitals, HOMO-LUMO concepts and electron density visualization. open-source computational chemistry tools. | **10** |
| **Unit III:** Scientific Data Handling | Scientific data types and analysis: Tabular, graphical, and time-series data, Using spreadsheets in chemistry: Microsoft Excel, Google Sheets for titration, kinetics, and thermodynamics data. Introduction to scientific graphing tools: Origin, GraphPad Prism, Error Analysis. Basic statistical analysis: mean, standard deviation, confidence intervals and uncertainty. Data sharing, research integrity and plagiarism awareness. Preparation of publication-quality graphs and tables. | **10** |

**Reading references:**

Prof. Dr. Stefan Bienz. *Short Manual to the Chemical Drawing Program ChemDraw®.* University of Zurich, Switzerland. 2016, User Manual.

RMIT University Library. *EndNote: A Beginner's Guide.* Library Subject Guide, RMIT University, Melbourne. 2020.

James W. Zubrick. *Spreadsheet Applications in Chemistry Using Microsoft Excel.* John Wiley & Sons, New York. 2004, 1st Ed.
K. V. Raman. *Computers in Chemistry.* Tata McGraw-Hill Publishing Co. Ltd., New Delhi. 2003, 1st Ed.

## CH2 211: Renewable Energy (L-T-P-C: 2-0-0-2)

| | |
|---|---|
| **Program:** B. Sc. Chemistry | **Semester:** IV |
| **Course code:** CH2 111 | **Course name:** Renewable Energy |

| Lecture (Hours) | Practical (Hours) | Credits | Total Hours | Evaluation Scheme | | | |
|---|---|---|---|---|---|---|---|
| | | | | Component | Exam | Max. Marks | Passing % |
| 2/week | - | 2 | 30 | Lecture | CCE, ESE | 50 | 40 |

**Course Description:** This course deals with understanding of energy resources: Global Status, Types, and Challenges. Conventional and non-conventional energy sources: Applications and environmental impact. Fundamental and applications of solar energy systems.

**Course Learning Outcomes:** At the end of this course students will be able to
**CO 1:** Understand the basic of alternative sources of energy
**CO 2:** Understand the energy harvesting and its applications using wind and hydro, biomass, piezoelectric material etc.
**CO 3:** Conceptual understanding and importance of solar cell
**CO 4:** Understand the electromagnetic energy harvesting and its applications

**Detailed Syllabus**

| Unit | Content | Hours |
|---|---|---|
| **Unit I:** Energy Resources: Global Status, Types, and Challenges | Energy Sources and Classification, Energy Sources, World Energy Status, World Energy Status and Energy Demand Scenario, Availability of conventional and non-conventional energy resources, Comparison of various conventional energy systems, Advantages and disadvantages of conventional energy sources, Alternate sources of energy, Fossil Fuels and Their Limitations, Fossil fuels, Nuclear Energy and Its Limitations, nuclear energy and their limitations. Hydrogen Energy and Fuel Cell Technologies | 10 |
| **Unit II:** Non-Conventional Energy Sources: Technologies, Applications, and Environmental Impact | Need of renewable energy, Fundamentals of Wind energy, Wind Turbines and different electrical machines in wind turbines, Tidal Energy, Ocean Thermal Energy Conversion, Biomass Energy and Biochemical Conversion, biomass, biochemical conversion, biogas generation, geothermal energy tidal energy, Hydroelectricity. Grid interconnection topologies, Hydropower resources, environmental impact of hydro power sources. Energy Storage Technologies, Advantages and limitations of non-conventional energy sources. | 10 |
| **Unit III:** Fundamentals and Applications of Solar Energy Systems | Solar energy and its importance, storage of solar energy, solar pond and non-convective solar pond, applications of solar pond and solar energy, solar water heater, flat plate collector, solar distillation, solar cooker, solar green houses, solar cell, absorption air conditioning. Need and characteristics of photovoltaic systems. | 10 |

**Reading References:**

B. H. Khan. *Non-Conventional Energy Sources.* McGraw Hill Education, New Delhi. 2017, 2nd Ed.
G. D. Rai. *Non-Conventional Energy Sources.* Khanna Publishers, New Delhi. 2011, 5th Ed.
M. P. Agarwal. *Solar Energy.* S. Chand & Co. Ltd., New Delhi. 2005, 1st Ed.
Suhas P. Sukhatme. *Solar Energy: Principles of Thermal Collection and Storage.* Tata McGraw-Hill Publishing Co. Ltd., New Delhi. 2008, 3rd Ed.
Godfrey Boyle. *Renewable Energy: Power for a Sustainable Future.* Oxford University Press, Oxford. 2012, 3rd Ed.
Godfrey Boyle. *Renewable Energy: Power for a Sustainable Future.* Oxford University Press, Oxford, in association with The Open University. 2004, 2nd Ed.
J. Balfour; M. Shaw; S. Jarosek. *Photovoltaics.* Lawrence J. Goodrich Publications, USA. 2001, 1st Ed.

Dr. P. Jayakumar. *Solar Energy: Resource Assessment Handbook.* Ministry of New and Renewable Energy (MNRE), Government of India. 2009, 1st Ed.

**~:The End:~**