
# MUSLIM ARTS COLLEGE

## (Autonomous)

(Accredited by NAAC with B+ grade & Affiliated to ManonmaniamSundaranar University, Tirunelveli; Recognized US 2(f) 12 (B) of UGC Act.)

Thiruvithancode, Kanyakumari District, Tamil Nadu - 629174.

# DEPARTMENT OF CHEMISTRY

**CBCS SYLLABUS**

Learning Outcome-based Curriculum Framework for

**CHEMISTRY (M.Sc.)**

*Applicable for students admitted from June 2026 as per the Resolutions of the Academic Council Meeting held on 01.06.2026*

## Vision

- To excel in chemical education, research, and service, addressing the needs of industry and society through effective teaching and learning.

## Mission

- To provide quality education in chemical sciences
- To promote research and innovation
- To prepare students to address global environmental and scientific challenges
- To support industry-oriented learning and applications

## Academic and Professional Attributes of the Graduates

1. **Advanced Knowledge in Chemical Sciences**
   Demonstrate comprehensive knowledge of Organic, Inorganic, Physical, Analytical and Applied Chemistry with a strong understanding of contemporary developments in chemical sciences.
2. **Scientific and Analytical Thinking**
   Apply scientific principles, analytical reasoning and problem-solving skills to investigate chemical phenomena and interpret experimental data.
3. **Laboratory Competence**
   Perform laboratory experiments safely and accurately using modern analytical instruments, standard laboratory techniques and appropriate research methodologies.
4. **Research and Innovation**
   Design, conduct and evaluate research projects, analyze scientific data, and contribute innovative solutions to challenges in chemistry and allied disciplines.
5. **Computational and Digital Skills**
   Utilize computational tools, chemical databases, molecular modeling software and digital technologies for data analysis, scientific communication and research applications.
6. **Ethical and Environmental Responsibility**
   Uphold professional ethics, laboratory safety, environmental sustainability and responsible use of chemicals in academic, industrial and societal contexts.
7. **Communication and Scientific Writing**
   Communicate scientific concepts effectively through oral presentations, technical reports, research publications and professional interactions.
8. **Leadership and Teamwork**
   Demonstrate leadership, interpersonal skills and the ability to work collaboratively in multidisciplinary research teams, industries and academic environments.
9. **Professional Competence and Employability**
   Develop competencies required for careers in research laboratories, chemical industries, pharmaceuticals, quality control, environmental management, higher education and entrepreneurship.
10. **Lifelong Learning and Global Perspective**
    Engage in continuous professional development, adapt to emerging scientific advancements and contribute to national and global scientific and technological progress.

## PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

| PEOs | Upon completion of the M.Sc. Chemistry programme, graduates will be able to | Mapping with Mission |
|---|---|---|
| **PEO1** | Demonstrate advanced knowledge and technical competence in Organic, Inorganic, Physical, Analytical and Applied Chemistry to solve scientific and industrial problems effectively. | M1 & M2 |
| **PEO2** | Apply critical thinking, analytical skills and research methodologies to investigate chemical problems, develop innovative solutions and contribute to scientific advancement. | M2 & M3 |
| **PEO3** | Exhibit professional ethics, environmental responsibility, laboratory safety practices and effective communication skills while working individually and in multidisciplinary teams. | M3 & M4 |
| **PEO4** | Pursue lifelong learning, higher education, entrepreneurship and professional careers in academia, research organizations, chemical industries and allied sectors through continuous skill development and innovation. | M2 & M4 |

## Programme Outcomes (POs)

| POs | Upon completion of the M.Sc. Chemistry programme, graduates will be able to | Mapping with PEOs |
|---|---|---|
| **PO1: Disciplinary Knowledge** | Demonstrate comprehensive and advanced knowledge of Organic, Inorganic, Physical, Analytical and Applied Chemistry, integrating theoretical concepts with laboratory practices. | PEO1 |
| **PO2: Critical Thinking** | Analyze chemical problems critically, interpret experimental results and apply scientific principles to develop logical and evidence-based solutions. | PEO1, PEO2 |
| **PO3: Problem Solving** | Apply chemical knowledge, computational tools and modern analytical techniques to solve academic, industrial and environmental problems effectively. | PEO1, PEO2 |
| **PO4: Analytical Reasoning** | Evaluate scientific information, interpret analytical and instrumental data, and draw valid conclusions through systematic reasoning. | PEO2 |
| **PO5: Research Competency** | Design and conduct independent research, formulate hypotheses, analyze experimental data and communicate research findings using appropriate scientific methods. | PEO2, PEO4 |
| **PO6: Modern Tools and Lifelong Learning** | Utilize modern laboratory instruments, computational software and digital technologies while engaging in continuous learning and professional development. | PEO2, PEO4 |
| **PO7: Ethics and Environmental Responsibility** | Practice professional ethics, laboratory safety, environmental sustainability and responsible use of chemicals in academic, industrial and societal settings. | PEO3 |

| | | |
|---|---|---|
| **PO8: Scientific Communication** | Communicate scientific knowledge effectively through technical writing, research publications, presentations and professional interactions. | PEO3, PEO4 |
| **PO9: Leadership and Teamwork** | Demonstrate leadership qualities, interpersonal skills and the ability to work effectively as an individual and in multidisciplinary teams. | PEO3, PEO4 |
| **PO10: Professional and Societal Engagement** | Apply chemical knowledge for societal benefit through innovation, entrepreneurship, quality assurance, industrial applications and sustainable development. | PEO3, PEO4 |

## Programme Specific Outcomes (PSOs)

| PSOs | Upon completion of the M.Sc. Chemistry programme, graduates will be able to | Mapping with POs |
|---|---|---|
| **PSO1** | Demonstrate advanced knowledge of Organic, Inorganic, Physical, Analytical and Applied Chemistry, and apply fundamental principles to understand chemical processes and solve complex scientific problems. | PO1, PO2, PO4 |
| **PSO2** | Perform qualitative and quantitative chemical analyses using modern laboratory techniques, sophisticated analytical instruments and computational tools with accuracy and precision. | PO2, PO3, PO4, PO6 |
| **PSO3** | Design, execute and interpret experimental research by applying appropriate scientific methodologies, data analysis and critical evaluation to address contemporary challenges in chemical sciences. | PO2, PO5, PO6, PO8 |
| **PSO4** | Apply chemical knowledge to industrial processes, pharmaceuticals, materials science, environmental monitoring, quality assurance and sustainable technologies while adhering to professional ethics and laboratory safety. | PO3, PO7, PO9, PO10 |
| **PSO5** | Demonstrate effective scientific communication, leadership, teamwork and professional competence required for careers in research, higher education, chemical industries, entrepreneurship and allied sectors. | PO6, PO8, PO9, PO10 |
| **PSO6** | Integrate interdisciplinary knowledge, innovation and lifelong learning to develop sustainable solutions for scientific, industrial and societal needs at national and global levels. | PO3, PO5, PO7, PO10 |

## Mapping of Programme Outcomes (POs) and Programme Specific Outcomes (PSOs)

| POs / PSOs | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 |
|---|---|---|---|---|---|---|
| **PO1: Disciplinary Knowledge** | 3 | 2 | 2 | 2 | 1 | 2 |
| **PO2: Critical Thinking** | 3 | 3 | 3 | 2 | 2 | 2 |
| **PO3: Problem Solving** | 2 | 3 | 2 | 3 | 2 | 3 |
| **PO4: Analytical Reasoning** | 3 | 3 | 3 | 2 | 2 | 2 |
| **PO5: Research Competency** | 2 | 2 | 3 | 2 | 2 | 3 |
| **PO6: Modern Tools and Lifelong Learning** | 2 | 3 | 3 | 2 | 3 | 3 |
| **PO7: Ethics and Environmental Responsibility** | 1 | 2 | 2 | 3 | 2 | 3 |
| **PO8: Scientific Communication** | 2 | 2 | 3 | 2 | 3 | 2 |
| **PO9: Leadership and Teamwork** | 1 | 2 | 2 | 3 | 3 | 2 |
| **PO10: Professional and Societal Engagement** | 2 | 2 | 2 | 3 | 3 | 3 |

**•3 – High Correlation •2 – Moderate Correlation •1 – Low Correlation**

## COURSES OFFERED

## SEMESTER I

| Part | Course Code | Title of the Course | Credits | Hours / Week |
|---|---|---|---|---|
| **Core Course -I** | NMCH11 | Organic Reaction Mechanism-I | 4 | 6 |
| **Core Course - II** | NMCH12 | Structure and Bonding in Inorganic Compounds | 4 | 6 |
| **Core Course - PI** | NMCHP1 | Organic Chemistry Practical - I | 4 | 4 |
| **Core Course - PII** | NMCHP2 | Physical Chemistry Practical | 2 | 4 |
| **Elective Course - I** | NECH11 | Nanomaterials and Nanotechnology | 3 | 5 |
| **Elective Course - II** | NECH12 | Molecular Spectroscopy | 3 | 5 |
| **Total** | | | **20** | **30** |

## SEMESTER I

## CORE COURSE I: ORGANIC REACTION MECHANISM - I

**Course Code:**

| Subject Code | Category | L | T | P | S | Credits | Inst. Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | CIA | External | Total |
| NMCH11 | **Core** | Y | Y | - | - | 4 | 5 | 25 | 75 | 100 |

**Pre-requisite**

Basic concepts of organic chemistry

**Learning Objectives**

The course aims to:

1. To understand the feasibility and the mechanism of various organic reactions.
2. To comprehend the techniques in the determination of reaction mechanisms.
3. To understand the concept of stereochemistry involved in organic compounds.
4. To correlate and appreciate the differences involved in the various types of organic reaction mechanisms.
5. To design feasible synthetic routes for the preparation of organic compounds.

**Course Outcomes (COs)**

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

| CO No. | Course Outcomes | BT Level |
|---|---|---|
| CO1 | To recall the basic principles of organic chemistry. | K1 |
| CO2 | To understand the formation and detection of reaction intermediates of organic reactions. | K2 |
| CO3 | To predict the reaction mechanism of organic reactions and stereochemistry of organic compounds. | K3 |
| CO4 | To apply the principles of kinetic and non-kinetic methods to determine the mechanism of reactions. | K3 |
| CO5 | To design and synthesize new organic compounds by correlating the stereochemistry of organic compounds. | K6 |

**Bloom's Taxonomy Levels**

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

**Course Content**

| Units | Contents | No. of Hours |
|---|---|---|
| I | **Methods of Determination of Reaction Mechanism:** Reaction intermediates, The transition state, Reaction coordinate diagrams, Thermodynamic and kinetic requirements of reactions, Hammond postulate. **Methods of determining mechanism:** Kinetic methods of determination: Rate law – Primary and secondary isotope effect. **Non Kinetic methods of determination:** Testing and Trapping of intermediates, Isotopic labeling, Cross–over experiment, Product analysis and stereo chemical evidence. **Effect of structure on reactivity:** Hammett and Taft equations. Linear free energy relationship, substituent and reaction constants. | 15 |
| II | **AROMATIC AND ALIPHATIC ELECTROPHILIC SUBSTITUTION: Aromaticity:** Aromaticity in benzenoid, non-benzenoid, heterocyclic compounds and annulenes. **Aromatic electrophilic substitution:** Orientation and reactivity of di- and polysubstituted phenol, nitrobenzene and halobenzene, partial rate factor Reactions involving nitrogen electrophiles: nitration, nitrosation and diazonium coupling; Sulphur electrophiles: sulphonation; Halogen electrophiles: chlorination and bromination; Carbon electrophiles: Friedel Crafts alkylation, acylation and arylation reactions. **Aliphatic electrophilic substitution Mechanisms:** SE2 and SEi, SE1-Mechanism and evidences. | 15 |
| III | **AROMATIC AND ALIPHATIC NUCLEOPHILIC SUBSTITUTION**: **Aromatic nucleophilic substitution:** Mechanisms - $S_NAr$, $S_N1$ and Benzyne mechanisms - Evidences - Reactivity, Effect of structure, leaving group and attacking nucleophile. Reactions: Oxygen and Sulphur nucleophiles, Bucherer and Rosenmund reactions, Von Richter, Sommelet-Hauser and Smiles rearrangements. **Aliphatic Nucleophilic Substitution:** $S_N1$, ion pair, $S_N2$ mechanisms and evidences. Aliphatic nucleophilic substitutions at an allylic carbon, aliphatic trigonal carbon and vinyl carbon. $S_N1'$ $S_N2'$ and $S_Ni'$ mechanism and evidences, Swain- Scott, Grunwald-Winstein relationship - Ambident nucleophiles. | 15 |
| IV | **Stereochemistry-I:** Introduction to molecular symmetry and chirality – axis, plane, center, alternating axis of symmetry. Optical isomerism due to asymmetric and dissymmetric molecules with C, N, S based chiral centers. Optical purity, prochirality, enantiotopic and diastereotopic atoms, groups, faces, axial and planar chirality, chirality due to helical shape, methods of determining the configuration. **Racemic modifications:** Racemization by thermal, anion, cation, reversible formation, epimerization, mutarotation. D, L system, Cram's and Prelog's rules: R, S-notations, proR, proS, side phase and re phase Cahn-Ingold Prelog rules, absolute and relative configurations. Configurations of allenes, spiranes, biphenyls, cyclooctene, helicene, binaphthyls, ansa and cyclophanic compounds, exo-cyclic alkylidene- | 15 |

| | | |
|---|---|---|
| | cycloalkanes. Topicity and prostereoisomerism, chiral shift reagents and chiral solvating reagents. Criteria for optical purity: Resolution of racemic modifications, asymmetric transformations, asymmetric synthesis, destruction. Stereoselective and stereospecific synthesis. | |
| **V** | **Stereochemistry-II:** Conformation and reactivity of acyclic systems, intramolecular rearrangements, neighbouring group participation, chemical consequence of conformational equilibrium - Curtin-Hammett Principle. Stability of five and six-membered rings: mono-, di- and polysubstituted cyclohexanes, conformation and reactivity in cyclohexane systems. Fused and bridged rings: bicyclic, poly cyclic systems, decalins and Brett's rule. Optical rotation and optical rotatory dispersion, conformational asymmetry, ORD curves, octant rule, configuration and conformation, Cotton effect, axial haloketone rule and determination of configuration. | **15** |
| | **Total** | **75** |

| S. No. | Text Book |
|---|---|
| 1 | J. March and M. Smith, Advanced Organic Chemistry, 5th edition, John-Wiley and Sons.2001. |
| 2 | E. S. Gould, Mechanism and Structure in Organic Chemistry, Holt, Rinehart and Winston Inc., 1959. |
| 3 | P.S.Kalsi, Stereochemistry of carbon compounds, 8th edition, New Age International Publishers, 2015. |
| 4 | P. Y. Bruice, Organic Chemistry, 7th edn, Prentice Hall, 2013. |
| 5 | J.Clayden, N. Greeves, S. Warren, Organic Compounds, 2ndedition, Oxford University Press, 2014. |

| S. No. | Reference Books |
|---|---|
| 1 | F.A. Carey and R.J. Sundberg, Advanced Organic Chemistry Part-A and B, 5th edition, Kluwer Academic / Plenum Publishers, 2007. |
| 2 | D. G. Morris, Stereochemistry, RSC Tutorial Chemistry Text 1, 2001. |
| 3 | N.S. Isaacs, Physical Organic Chemistry, ELBS, Longman, UK, 1987. |
| 4 | E. L. Eliel, Stereochemistry of Carbon Compounds, Tata-McGraw Hill, 2000. |
| 5 | I. L. Finar, Organic chemistry, Vol-1 & 2, 6th edition, Pearson Education Asia, 2004. |

| S. No. | Web Resources |
|---|---|
| 1 | https://sites.google.com/site/chemistryebookscollection02/home/organic |
| 2 | https://www.organic |

## Mapping with Programme Outcomes

| CO / PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 2 | 2 | 2 | 1 | 2 | 1 | 1 | 1 | 1 |
| **CO2** | 3 | 3 | 2 | 3 | 2 | 2 | 1 | 2 | 1 | 1 |
| **CO3** | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 1 |
| **CO4** | 2 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 2 |
| **CO5** | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 2 |

**3 – Strong, 2 – Medium, 1 - Low**

## Mapping with Programme Specific Outcomes

| CO / PSO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 |
|---|---|---|---|---|---|---|
| **CO1** | 3 | 2 | 1 | 1 | 1 | 1 |
| **CO2** | 3 | 3 | 2 | 2 | 2 | 1 |
| **CO3** | 3 | 3 | 3 | 2 | 2 | 2 |
| **CO4** | 3 | 3 | 3 | 3 | 2 | 2 |
| **CO5** | 3 | 3 | 3 | 3 | 3 | 3 |
| **Weightage** | **15** | **14** | **12** | **11** | **10** | **9** |
| **Weighted Percentage of Course Contribution to PSOs** | **3.0** | **2.8** | **2.4** | **2.2** | **2.0** | **1.8** |

**Mapping Scale: 3 – Strong Correlation, 2 – Moderate Correlation, 1 – Low Correlation**

**FIRST YEAR - SEMESTER I**

**CORE II - STRUCTURE AND BONDING IN INORGANIC COMPOUNDS**

| Subject Code | Category | L | T | P | S | Credits | Inst. Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | CIA | External | Total |
| NMCH12 | **Core** | Y | Y | - | - | 4 | 5 | 25 | 75 | 100 |

**Learning Objectives**

The course aims to:

1. To determine the structural properties of main group compounds and clusters.
2. To gain fundamental knowledge on the structural aspects of ionic crystals.
3. To understand structures and bonding in inorganic polymers and metal clusters.
4. To study the effect of point defects and line defects in ionic crystals.
5. To evaluate the structural aspects of solids.

## Course Outcomes

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

| CO No. | Course Outcomes | BT Level |
|---|---|---|
| **CO1** | To predict the geometry of main group compounds and clusters. | **K2** |
| **CO2** | To explain about the packing of ions in crystals and apply the radius ratio rule to predict the coordination number of cations. | **K4** |
| **CO3** | To understand the various types of ionic crystal systems and analyze their structural features. | **K2** |
| **CO4** | To explain the crystal growth methods. | **K4** |
| **CO5** | To understand the various types of defects in crystals. | **K2** |

## Bloom's Taxonomy Levels

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

**Course Content**

| Units | Contents | No. of Hours |
|---|---|---|
| **I** | **CHEMICAL BONDING**<br>**Valence Bond theory:** Lewis structure – Concepts and VB theory of H2 molecule - Stereochemistry of hybrid orbitals – Calculation of s and p characters of equivalence and nonequivalence of hybrid orbitals - VSEPR theory. **M.O. theory** – Linear combination of Atomic orbitals ( s – s, s – p, d – p, p – p and d – d overlapping) – σ , π ,δ and quadruple bond. – M.O. diagrams of hetero nuclear diatomic molecules (CO, NO, HF) and triatomic molecules ($BeH_2$, $H_2O$, $CO_2$) – Walsh diagrams – Structure and hybridization - Bents rule and apicophilicity. **Ionic Bond:** Lattice energy - Born-Lande equation, Born Haber cycle and Kapustinskii equation. | **15** |
| **II** | **Structure of main group compounds and clusters:** Structure of silicates - applications of Pauling's rule of electrovalence - isomorphous replacements in silicates – ortho, meta and pyro silicates – one dimensional, two dimensional and three-dimensional silicates. Structure of silicones, Structural and bonding features of B-N, S-N and P-N compounds; Poly acids – types, examples and structures; Borane cluster: | **15** |

| | | |
|---|---|---|
| | Structural features of closo, nido, arachano and klado; carboranes, hetero and metalloboranes; Wade's rule to predict the tructure of borane cluster; main group clusters –zintl ions. | |
| **III** | **Solid state chemistry – I:** Ionic crystals: Packing of ions in simple, hexagonal and cubic close packing, voids in crystal lattice, Radius ratio, Crystal systems and Bravais lattices, Symmetry operations in crystals, glide planes and screw axis; point group and space group. X-ray diffraction technique: Bragg's law, Powder diffraction method – Principle and Instrumentation. | **15** |
| **IV** | **Solid state chemistry – II:** Structural features of the crystal systems: Rock salt, zinc blende & wurtzite, fluorite and anti-fluorite, rutile and anatase, cadmium iodide and nickel arsenide; Spinels -normal and inverse types and perovskite structures. Crystal Growth methods: From melt and solution (hydrothermal, sol-gel methods) – principles and examples. | **15** |
| **V** | **Band theory and defects in solids**: Band theory – features and its application of conductors, insulators and semiconductors, Intrinsic and extrinsic semiconductors; Defects in crystals – point defects (Schottky, Frenkel, metal excess and metal deficient) and their effect on the electrical and optical property; Linear defects and its effects due to dislocations and colour centers. | **15** |
| | **Total** | **75** |

| **S. No.** | **Text Book** |
|---|---|
| 1 | A R West, Solid state Chemistry and its applications, 2ndEdition (Students Edition), John Wiley & Sons Ltd., 2014. |
| 2 | A K Bhagi and G R Chatwal, A textbook of inorganic polymers, Himalaya Publishing House, 2001. |
| 3 | L Smart, E Moore, Solid State Chemistry – An Introduction, 4th Edition, CRC Press, 2012. |
| 4 | K. F. Purcell and J. C. Kotz, Inorganic Chemistry; W.B. Saunders company: Philadelphia, 1977. |
| 5 | J. E. Huheey, E. A. Keiter and R. L. Keiter, Inorganic Chemistry; 4th ed.; Harper and Row: NewYork, 1983. |

| **S. No.** | **Reference Books** |
|---|---|
| 1 | D. E. Douglas, D.H. McDaniel and J. J. Alexander, Concepts and Models in Inorganic Chemistry, 3rd Ed, 1994. |
| 2 | R J D Tilley, Understanding Solids - The Science of Materials, 2nd edition, Wiley Publication, 2013. |
| 3 | C N R Rao and J Gopalakrishnan, New Directions in Solid State Chemistry, 2nd Edition, Cambridge University Press, 199. |
| 4 | T. Moeller, Inorganic Chemistry, A Modern Introduction; John Wiley: New York, 1982. |
| 5 | D. F. Shriver, P. W. Atkins and C.H. Langford; Inorganic Chemistry; 3rd ed.; Oxford |

| | |
|---|---|
| | University Press: London, 2001. |

| S. No. | Web Sources |
|---|---|
| 1 | https://ocw.mit.edu/courses/3-091-introduction-to-solid-state-chemistry-fall-2018/video_galleries/lecture-videos/ |

## Mapping with Programme Outcomes

| CO / PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 2 | 2 | 3 | 1 | 2 | 1 | 1 | 1 | 1 |
| **CO2** | 3 | 3 | 3 | 3 | 2 | 2 | 1 | 2 | 1 | 1 |
| **CO3** | 3 | 3 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 1 |
| **CO4** | 2 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 2 |
| **CO5** | 2 | 2 | 2 | 3 | 2 | 2 | 3 | 2 | 1 | 2 |

**3 – Strong, 2 – Medium , 1 – Low**

## Mapping with Programme Specific Outcomes

| CO / PSO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 |
|---|---|---|---|---|---|---|
| **CO1** | 3 | 2 | 1 | 1 | 1 | 1 |
| **CO2** | 3 | 3 | 2 | 2 | 2 | 1 |
| **CO3** | 3 | 3 | 3 | 2 | 2 | 2 |
| **CO4** | 3 | 3 | 3 | 3 | 2 | 2 |
| **CO5** | 2 | 2 | 2 | 3 | 2 | 3 |
| **Weightage** | **14** | **13** | **11** | **11** | **9** | **9** |
| **Weighted Percentage of Course Contribution to PSOs** | **2.8** | **2.6** | **2.2** | **2.2** | **1.8** | **1.8** |

**Mapping Scale: 3 – Strong Correlation, 2 – Moderate Correlation, 1 – Low Correlation**

## FIRST YEAR - SEMESTER I

## CORE COURSE PI– ORGANIC CHEMISTRY PRACTICAL-I

| Subject Code | Category | L | T | P | S | Credits | Inst. Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | CIA | External | Total |
| NMCHP1 | **Core** | - | - | Y | Y | 4 | 4 | 25 | 75 | 100 |

### Learning Objectives

The course aims to:

1. To understand the concept of separation, qualitative analysis and preparation of organic compounds.
2. To develop analytical skill in the handling of chemical reagents for separation of binary and ternary organic mixtures.
3. To analyze the separated organic components systematically and derivative them suitably.

### Course Outcomes

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

| CO No. | Course Outcomes | BT Level |
|---|---|---|
| **CO1** | To explain the basic separation procedures of organic mixtures. | **K2** |
| **CO2** | To select the separation methods to separate the organic mixtures. | **K2** |
| **CO3** | To classify the functional groups using systematic procedure. | **K5** |
| **CO4** | To determine the physical properties of organic compounds. | **K4** |
| **CO5** | To analyze the separated organic components systematically and derivative them suitably. | **K4** |

### Bloom's Taxonomy Levels

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

## Course Content

| S.No | Contents | No. of Hours |
|---|---|---|
| | **INVERTEBRATES**<br>**A. Qualitative analysis of Organic** mixture (at least six two component mixtures):<br>• Separation of organic mixtures<br>• Elemental analysis<br>• Functional group(s) identification<br>• Preparation of derivatives<br>• Physical properties determination (melting point and boiling point) for both components and their derivatives.<br>Analysis may be performed in micro (or) macro scale depending upon the conditions of the laboratory.<br>**B. For Class work:**<br>Three component mixtures (Separation) | **60** |
| | **Total** | **60** |

| S. No. | Text Books |
|---|---|
| **1** | A.I. Vogel, Elementary Practical Organic Chemistry: Small Scale Preparations, Qualitative Organic Analysis, Quantitative Organic Analysis, Pearson Education, 2011. |
| **2** | K. Bansal Raj, Laboratory Manual of Organic Chemistry, New Age International, 2009. |
| **3** | V. Venkateswaran, R. Veeraswamy and A. R. Kulandaivelu, Basic Principles of Practical Chemistry, Sultan Chand & Sons, 2004. |
| **4** | V.K. Ahluwalia, and R. Aggarwal, Comprehensive Practical Organic Chemistry, Universities Press, 2004 |
| **S. No.** | **Reference Works** |
| **1** | R.G. Engel, D.L. Pavia, G.M. Lampman and G.S. Kriz, A Microscale approach to Organic Laboratory, 5th edition,Paperback – International Edition, 2012. |
| **2** | P.B. Cranwell, L.M. Harwood, and C. J. Moody, Experimental Organic Chemistry, 3rd edn, Wiley-Blackwell, 2017. |
| **3** | J. Leonard, B. Lygo and G. Procter, Advanced Practical Organic Chemistry, 3rd edn, CRC Press, 2013. |
| **S. No.** | **Web Sources (URL)** |
| **1** | https://ocw.mit.edu/courses/3-091-introduction-to-solid-state-chemistry-fall-2018/video_galleries/lecture-videos/ |

## Mapping with Programme Outcomes

| CO / PSO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 |
|---|---|---|---|---|---|---|
| **CO1** | 2 | 3 | 1 | 1 | 1 | 1 |
| **CO2** | 2 | 3 | 2 | 2 | 2 | 1 |
| **CO3** | 3 | 3 | 2 | 2 | 2 | 2 |
| **CO4** | 3 | 3 | 3 | 2 | 2 | 2 |
| **CO5** | 3 | 3 | 3 | 3 | 3 | 2 |

**3 – Strong, 2 – Medium, 1 - Low**

## Mapping with Programme Specific Outcomes

| CO / PSO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 |
|---|---|---|---|---|---|---|
| **CO1** | 2 | 3 | 1 | 1 | 1 | 1 |
| **CO2** | 2 | 3 | 2 | 2 | 2 | 1 |
| **CO3** | 3 | 3 | 2 | 2 | 2 | 2 |
| **CO4** | 3 | 3 | 3 | 2 | 2 | 2 |
| **CO5** | 3 | 3 | 3 | 3 | 3 | 2 |
| **Weightage** | **13** | **15** | **11** | **10** | **10** | **8** |
| **Weighted Percentage of Course Contribution to PSOs** | **2.6** | **3.0** | **2.2** | **2.0** | **2.0** | **1.6** |

**Mapping Scale: 3 – Strong Correlation, 2 – Moderate Correlation, 1 – Low Correlation**

## FIRST YEAR - SEMESTER I

## CORE COURSE PII– PHYSICAL CHEMISTRY PRACTICAL

| Subject Code | Category | L | T | P | S | Credits | Inst. Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | CIA | External | Total |
| NMCHP2 | **Core** | Y | - | Y | Y | 2 | 4 | 25 | 75 | 100 |

### Learning Objectives

The course aims to:

1. To understand the principle of conductivity experiments through conductometric titrations.
2. To evaluate the order of the reaction, temperature coefficient and activation energy of the reaction by following pseudo first order kinetics.
3. To construct the phase diagram of two component system forming congruent melting solid and find its eutectic temperatures and compositions.

### Course Outcomes

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

| CO No. | Course Outcomes | BT Level |
|---|---|---|
| **CO1** | To recall the principles associated with various physical chemistry experiments. | **K1** |
| **CO2** | To explain the principles of conductometric titrations and estimate the strength of solutions. | **K5** |
| **CO3** | To observe and record systematically the readings in all the experiments. | **K2** |
| **CO4** | To calculate and process the experimentally measured values and compare with graphical data. | **K4** |
| **CO5** | To interpret the experimental data scientifically to improve students' efficiency for societal developments. | **K6** |

### Bloom's Taxonomy Levels

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

## Course Content

| S.No. | Contents | No. of Hours |
|---|---|---|
| I | **Conductivity Experiments**<br>1. Determination of equivalent conductance of a strong electrolyte & the verification of DHO equation.<br>2. Verification of Ostwald's Dilution Law & Determination of pKa of a weak acid.<br>3. Verification of Kohlrausch's Law for weak electrolytes.<br>4. Determination of the equivalent conductance of a weak acid at different concentrations and verifying Ostwald dilution law.<br>5. Calculation of the dissociation constant of the acid. Determination of the equivalent conductance of a strong electrolyte at different concentrations and examining the validity of the Onsager's theory as limiting law at high dilutions.<br>6. Conductometric titration of a mixture of HCl and $CH_3COOH$ Vs NaOH.<br>7. Conductometric titration of $NH_4Cl$ Vs NaOH.<br>8. Conductometric titration of $CH_3COONa$ Vs HCl. | |
| II | **Kinetics**<br>1. Study the kinetics of acid hydrolysis of an ester; determine the temperature coefficient and also the activation energy of the reaction.<br>2. Study the kinetics of the reaction between acetone and iodine in acidic medium by half-life method and determine the order with respect to iodine and acetone. | |
| III | **Phase diagram**<br>Construction of phase diagram for a simple binary system<br>1. Naphthalene-phenanthrene<br>2. Benzophenone- diphenyl amine. | |
| | **Total** | **60** |

| S. No. | Text Books |
|---|---|
| 1 | B. Viswanathan and P.S.Raghavan, Practical Physical Chemistry, Viva Books, New Delhi, 2009. |
| 2 | Sundaram, Krishnan, Raghavan, Practical Chemistry (Part II), S. Viswanathan Co. Pvt., 1996. |
| 3 | V.D. Athawale and Parul Mathur, Experimental Physical Chemistry, New Age International (P) Ltd., New Delhi, 2008. |
| | E.G. Lewers, Computational Chemistry: Introduction to the Theory and Applications of Molecular and Quantum Mechanics, 2nd Ed., Springer, New York, 2011. |
| **S. No.** | **Reference Works** |
| 1 | J.B.Yadav, Advanced Practical Physical Chemistry, Goel Publishing House, 2001. |
| 2 | G.W. Garland, J.W. Nibler, D.P. Shoemaker, Experiments in Physical Chemistry, 8th edition, McGraw Hill, 2009. |

| | |
|---|---|
| **3** | J.N. Gurthu and R. Kapoor, Advanced Experimental Chemistry, S. Chand and Co., 1987. |
| **4** | Shailendra K Sinha, Physical Chemistry: A laboratory Manual, Narosa Publishing House Pvt, Ltd., New Delhi, 2014. |
| **5** | F. Jensen, Introduction to Computational Chemistry, 3rd Ed., Wiley-Blackwell. |
| **S. No.** | **Web Sources (URL)** |
| **1** | https://web.iitd.ac.in/~nkurur/2015-16/Isem/cmp511/lab_handout_new.pdf |

## Mapping with Programme Outcomes

| CO / PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 2 | 2 | 2 | 1 | 2 | 1 | 1 | 1 | 1 |
| **CO2** | 2 | 3 | 3 | 3 | 2 | 2 | 1 | 2 | 2 | 1 |
| **CO3** | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 1 |
| **CO4** | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 |
| **CO5** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 |

**3 – Strong, 2 – Medium, 1 - Low**

## Mapping with Programme Specific Outcomes

| CO / PSO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 |
|---|---|---|---|---|---|---|
| **CO1** | 2 | 2 | 1 | 1 | 1 | 1 |
| **CO2** | 2 | 3 | 2 | 2 | 2 | 1 |
| **CO3** | 2 | 3 | 2 | 2 | 2 | 2 |
| **CO4** | 3 | 3 | 3 | 2 | 2 | 2 |
| **CO5** | 3 | 3 | 3 | 3 | 3 | 3 |
| **Weightage** | **12** | **14** | **11** | **10** | **11** | **9** |
| **Weighted Percentage of Course Contribution to PSOs** | **2.4** | **2.8** | **2.2** | **2.0** | **2.2** | **1.8** |

**Mapping Scale: 3 – Strong Correlation, 2 – Moderate Correlation, 1 – Low Correlation**

**SEMESTER I**

**ELECTIVE COURSE-I (EC-I)**

**NANO MATERIALS AND NANO TECHNOLOGY**

| Subject Code | Category | L | T | P | S | Credits | Inst. Hours | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | CIA | External | Total |
| NECH11 | Elective- I | Y | Y | - | - | 2 | 2 | 25 | 75 | 100 |

## Learning Objectives

The course aims to:

1. To understand the concept of nano materials and nano technology..
2. To understand the various types of nano materials and their properties.
3. To understand the applications of synthetically important nano materials.
4. To correlate the characteristics of various nano materials synthesized by new technologies.
5. To design synthetic routes for synthetically used new nano materials.

## Course Outcomes

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

| CO No. | Course Outcomes | BT Level |
|---|---|---|
| **CO1** | To explain methods of fabricating nanostructures. | **K4** |
| **CO2** | To relate the unique properties of nanomaterials to reduce dimensionality of the material. | **K5** |
| **CO3** | To describe tools for properties of nanostructures. | **K6** |
| **CO4** | To discuss applications of nanomaterials. | **K4** |
| **CO5** | To understand the health and safety related to nanomaterial. | **K2** |

## Bloom's Taxonomy Levels

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

## Course Content

| Unit | Contents | No. of Hours |
|---|---|---|
| **I** | **Introduction of nanomaterials and nanotechnologies:** Introduction-role of size, classification-0D, 1D, 2D, 3D. Consolidation of Nano powders. Features of nanostructures, Background of nanostructures. Techniques of synthesis of nanomaterials- Bottom –Up, Top–Down, Tools of the nanoscience. Applications of nanomaterials and technologies. | **6** |

| | | |
|---|---|---|
| **II** | **Synthetic Methods:** Bonding and structure of the nanomaterials, Predicting the Type of Bonding in a Substance crystal structure. Metallic nanoparticles, Surfaces of Materials, Nanoparticle Size and Properties. Synthesis- Physical and chemical methods - inert gas condensation, arc discharge, laser ablation, sol-gel, solvothermal and hydrothermal-CVD-types, metallo organic, plasma enhanced, and low-pressure CVD. Microwave assisted and electrochemical synthesis. | **6** |
| **III** | **Mechanical Properties of Nanomaterials:** Mechanical properties of materials, theories relevant to mechanical properties.Techniques to study mechanical properties of nanomaterials, adhesion and friction, thermal properties of nanomaterials Nanoparticles: gold and silver, metal oxides: silica, iron oxide and alumina - synthesis and properties. | **6** |
| **IV** | **Electrical Properties of Nanomaterials:** Electrical properties, Conductivity and Resistivity, Classification of Materials based on Conductivity, magnetic properties, electronic properties of materials. Classification of magnetic phenomena. Semiconductor materials – classification-Ge, Si, GaAs, SiC, GaN, GaP, CdS,PbS. Identification of materials as p and n –type semiconductor-Hall effect -quantum and anomalous, Hall voltage - interpretation of charge carrier density. **Applications of semiconductors:** p-n junction as transistors and rectifiers, photovoltaic and photogalvanic cell. | **6** |
| **V** | **Nano Composites:** Nano thin films, nanocomposites. Application of nanoparticles in different fields. Core-shell nanoparticles - types, synthesis, and properties. Nanocomposites - metal- ceramic- and polymer-matrix composites-applications. Characterization – SEM, TEM and AFM - principle, instrumentation and applications. | **6** |
| | **Total** | **30** |

| **S. No.** | **Text Book** |
|---|---|
| 1 | S.Mohan and V. Arjunan, Principles of Materials Science, MJP Publishers, 2016. |
| 2 | Arumugam, Materials Science, Anuradha Publications,2007. |
| 3 | Giacavazzo et. al., Fundamentals of Crystallography, International Union of Crystallography. Oxford Science Publications, 2010 |
| 4 | Woolfson, An Introduction to Crystallography, Cambridge University Press, 2012. |
| 5 | James F. Shackelford and Madanapalli K. Muralidhara, Introduction to Materials Science for Engineers. 6th ed., PEARSON Press, 2007. |

| **S. No.** | **Reference Books** |
|---|---|
| 1 | C. N. R. Rao, A. Müller and A. K. Cheetham (Eds.), The Chemistry of Nanomaterials: Synthesis, Properties and Applications, Wiley-VCH, 2nd Edition, 2006. |
| 2 | Charles P. Poole Jr. and Frank J. Owens, Introduction to Nanotechnology, John Wiley & Sons, 2003. |
| 3 | T. Pradeep, Nano: The Essentials – Understanding Nanoscience and Nanotechnology, |

| | |
|---|---|
| | McGraw-Hill Education, 2007. |
| 4 | G uozhong Cao and Ying Wang, Nanostructures and Nanomaterials: Synthesis, Properties and Applications, 2nd Edition, World Scientific Publishing, 2011. |

| S. No. | Web Resources |
|---|---|
| 1 | http://xrayweb.chem.ou.edu/notes/symmetry.html |
| 2 | http://www.uptti.ac.in/classroom-content/data/unit%20cell.pdf |

**MAPPING OF COURSE OUTCOMES WITH PROGRAMME OUTCOMES (POs)**

| CO / PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 2 | 2 | 2 | 1 | 2 | 1 | 1 | 2 | 1 |
| **CO2** | 2 | 3 | 3 | 2 | 2 | 2 | 1 | 2 | 2 | 1 |
| **CO3** | 2 | 3 | 3 | 3 | 2 | 3 | 2 | 2 | 2 | 2 |
| **CO4** | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 3 | 2 |
| **CO5** | 1 | 2 | 2 | 2 | 2 | 2 | 3 | 2 | 2 | 3 |

**3** – Strong Correlation, **2** – Moderate Correlation, **1** – Low Correlation.

**MAPPING OF COURSE OUTCOMES WITH PROGRAMME SPECIFIC OUTCOMES (PSOs)**

| CO / PSO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 |
|---|---|---|---|---|---|---|
| **CO1** | 2 | 2 | 2 | 1 | 1 | 1 |
| **CO2** | 2 | 3 | 2 | 2 | 2 | 2 |
| **CO3** | 2 | 3 | 3 | 2 | 2 | 2 |
| **CO4** | 2 | 2 | 3 | 3 | 2 | 3 |
| **CO5** | 1 | 2 | 2 | 3 | 2 | 3 |
| **Weightage** | **9** | **12** | **12** | **11** | **9** | **11** |
| **Weighted Percentage of Course Contribution to PSOs** | **1.8** | **2.4** | **2.4** | **2.2** | **1.8** | **2.2** |

**3** – Strong Correlation, **2** – Moderate Correlation, **1** – Low Correlation

# FIRST YEAR – SEMESTER I

## ELECTIVE COURSE-II: MOLECULAR SPECTROSCOPY

| Subject Code | Category | L | T | P | S | Credits | Inst. Hours | CIA | External | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| NECH12 | Elective- II | Y | Y | - | - | 3 | 5 | 25 | 75 | 100 |

**Learning Objectives**

The course aims to:

1. To understand the influence of rotation and vibrations on the spectra of the polyatomic molecules.
2. To study the principle of Raman spectroscopy, ESR spectroscopy and fragmentation patterns in Mass spectroscopy.
3. To highlight the significance of Franck-Condon principle to interpret the selection rule, intensity and types of electronic transitions.
4. To interpret the first and second order NMR spectra in terms of splitting and coupling patterns using correlation techniques such as COSY, HETCOR, NOESY.
5. To carry out the structural elucidation of molecules using different spectral techniques.

**Course Outcomes**

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

| CO No. | Course Outcomes | BT Level |
|---|---|---|
| CO1 | To understand the importance of rotational and Raman spectroscopy. | K2 |
| CO2 | To apply the vibrational spectroscopic techniques to diatomic and polyatomic molecules. | K3 |
| CO3 | To evaluate different electronic spectra of simple molecules using electronic spectroscopy. | K5 |
| CO4 | To outline the NMR, 13C NMR, 2D NMR – COSY, NOESY, Introduction to 31P, 19F NMR and ESR spectroscopic techniques. | K6 |
| CO5 | To develop the knowledge on principle, instrumentation and structural elucidation of simple molecules using Mass Spectrometry, EPR and Mossbauer Spectroscopy techniques. | K6 |

**Bloom's Taxonomy Levels**

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

## Course Content

| Unit | Contents | No. of Hours |
|---|---|---|
| I | **Rotational and Raman Spectroscopy:** Rotational spectra of diatomic and polyatomic molecules. Intensities of rotational spectral lines, effect of isotopic substitution. Non-rigid rotators. Classical theory of the Raman effect, polarizability as a tensor, polarizability ellipsoids, quantum theory of the Raman effect, Pure rotational Raman spectra of linear and asymmetric top molecules, Stokes and anti-Stokes lines. Vibrational Raman spectra, Raman activity of vibrations, rule of mutual exclusion, rotational fine structure-Q and S branches, Polarization of Raman scattered photons. | 6 |
| II | **Vibrational Spectroscopy:** Vibrations of molecules, harmonic and anharmonic oscillators- vibrational energy expression, energy level diagram, vibrational wave functions and their symmetry, selection rules, expression for the energies of spectral lines, computation of intensities, hot bands, effect of isotopic substitution. Diatomic vibrating rotor, vibrational-rotational spectra of diatomic molecules, P, R branches, breakdown of the Born-Oppenheimer approximation. Vibrations of polyatomic molecules – symmetry properties, overtone and combination frequencies. Influence of rotation on vibrational spectra of polyatomic molecule, P, Q, R branches, parallel and perpendicular vibrations of linear and symmetric top molecules. | 6 |
| III | **Electronic spectroscopy:** Electronic spectroscopy of diatomic molecules, Frank-Condon principle, dissociation and predissociation spectra. $\pi \rightarrow \pi^*$, $n \rightarrow \pi^*$ transitions and their selection rules. Photoelectron Spectroscopy: Basic principles, photoelectron spectra of simple molecules, Xray photoelectron spectroscopy (XPS). Lasers: Laser action, population inversion, properties of laser radiation, examples of simple laser systems. | 6 |
| IV | **NMR and Mass Spectrometry:** Chemical shift, Factors influencing chemical shifts: electronegativity and electrostatic effects; Mechanism of shielding and deshielding. Spin systems: First order and second order coupling of AB systems, Simplification of complex spectra. Spin-spin interactions: Homonuclear coupling interactions - AX, AX2, AB types. Vicinal, germinal and long-range coupling-spin decoupling. Nuclear Overhauser effect (NOE), Factors influencing coupling constants and Relative intensities. 13C NMR and structural correlations – DEPT. Brief introduction to 2D NMR – COSY, NOESY and HETCOR. Introduction to 31P, 19F NMR. **Mass Spectrometry:** Ionization techniques- Electron ionization (EI),chemical ionization (CI), desorption ionization (FAB/MALDI), electro spray ionization (ESI), isotope abundance, molecular ion, fragmentation processes of organic molecules, deduction of structure through mass spectral fragmentation, high resolution. Effect of isotopes on the appearance of mass spectrum. Structural elucidation of organic compounds by combined spectral techniques. | 6 |
| V | **ESR and Mossbauer Spectroscopy:** ESR spectroscopy Characteristic features of ESR spectra, line shapes and line widths; ESR spectrometer. The g value and the hyperfine coupling parameter (A), origin of hyperfine interaction. Interpretation of ESR spectra and structure elucidation of organic radicals using ESR spectroscopy; Spin orbit coupling and significance of g-tensors, zero/non-zero field splitting, Kramer's | 6 |

| | | |
|---|---|---|
| | degeneracy, application to transition metal complexes (having one to five unpaired electrons) including biological molecules and inorganic free radicals. ESR spectra of magnetically dilute samples. **Principle of Mossbauer spectroscopy:** Doppler shift, recoil energy. Isomer shift, quadrupole splitting, magnetic interactions. Applications: Mossbauer spectra of high and low-spin Fe and Sn compounds. | |
| | **Total** | **30** |

| S. No. | Text Books |
|---|---|
| 1 | C. N. Banwell and E. M. McCash, Fundamentals of Molecular Spectroscopy, 4th Ed., Tata McGraw Hill, New Delhi, 2000. |
| 2 | R. M. Silverstein and F. X. Webster, Spectroscopic Identification of Organic Compounds, 6th Ed., John Wiley & Sons, New York, 2003. |
| 3 | W. Kemp, Applications of Spectroscopy, English Language Book Society, 1987. |
| 4 | D. H. Williams and I. Fleming, Spectroscopic Methods in Organic Chemistry, 4th Ed., Tata McGraw-Hill Publishing Company, New Delhi, 1988. |
| 5 | R. S. Drago, Physical Methods in Chemistry; Saunders: Philadelphia, 1992. |

| S. No. | Reference Books |
|---|---|
| 1 | P.W. Atkins and J. de Paula, Physical Chemistry, 7th Ed., Oxford University Press, Oxford, 2002. |
| 2 | I. N. Levine, Molecular Spectroscopy, John Wiley & Sons, New York, 1974. |
| 3 | A. Rahman, Nuclear Magnetic Resonance-Basic Principles, Springer-Verlag, New York, 1986. |
| 4 | K. Nakamoto, Infrared and Raman Spectra of Inorganic and coordination Compounds, PartB: 5th ed., John Wiley& Sons Inc., New York, 1997. |
| 5 | J. A. Weil, J. R. Bolton and J. E. Wertz, Electron Paramagnetic Resonance; Wiley Interscience, 1994. |

| S. No. | Web Resources |
|---|---|
| 1 | https://onlinecourses.nptel.ac.in/noc20_cy08/preview |
| 2 | https://www.digimat.in/nptel/courses/video/104106122/L14.html |

**MAPPING OF COURSE OUTCOMES WITH PROGRAMME OUTCOMES (POs)**

| CO / PO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 2 | 2 | 2 | 1 | 2 | 1 | 2 | 2 | 1 |
| **CO2** | 3 | 2 | 3 | 2 | 2 | 2 | 1 | 2 | 2 | 1 |
| **CO3** | 2 | 2 | 3 | 3 | 2 | 2 | 1 | 2 | 3 | 1 |
| **CO4** | 2 | 2 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 2 |
| **CO5** | 2 | 2 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 2 |

## Mapping Scale

**3** – Strong Correlation, **2** – Moderate Correlation, **1** – Low Correlation

**MAPPING OF COURSE OUTCOMES WITH PROGRAMME SPECIFIC OUTCOMES (PSOs)**

| CO / PSO | PSO1 | PSO2 | PSO3 | PSO4 | PSO5 | PSO6 |
|---|---|---|---|---|---|---|
| **CO1** | 3 | 2 | 1 | 1 | 2 | 1 |
| **CO2** | 3 | 2 | 2 | 1 | 2 | 1 |
| **CO3** | 2 | 3 | 2 | 1 | 3 | 1 |
| **CO4** | 2 | 3 | 3 | 1 | 3 | 2 |
| **CO5** | 2 | 3 | 2 | 2 | 3 | 2 |
| **Weightage** | **12** | **13** | **10** | **6** | **13** | **7** |
| **Weighted Percentage of Course Contribution to PSOs** | **2.4** | **2.6** | **2.0** | **1.2** | **2.6** | **1.4** |

## Mapping Scale

**3** – Strong Correlation, **2** – Moderate Correlation, **1** – Low Correlation